INSTRUCTION MANUAL

Serial Number 002288

TYPE

565

OSCILLOSCOPE

Tektronix, Inc.

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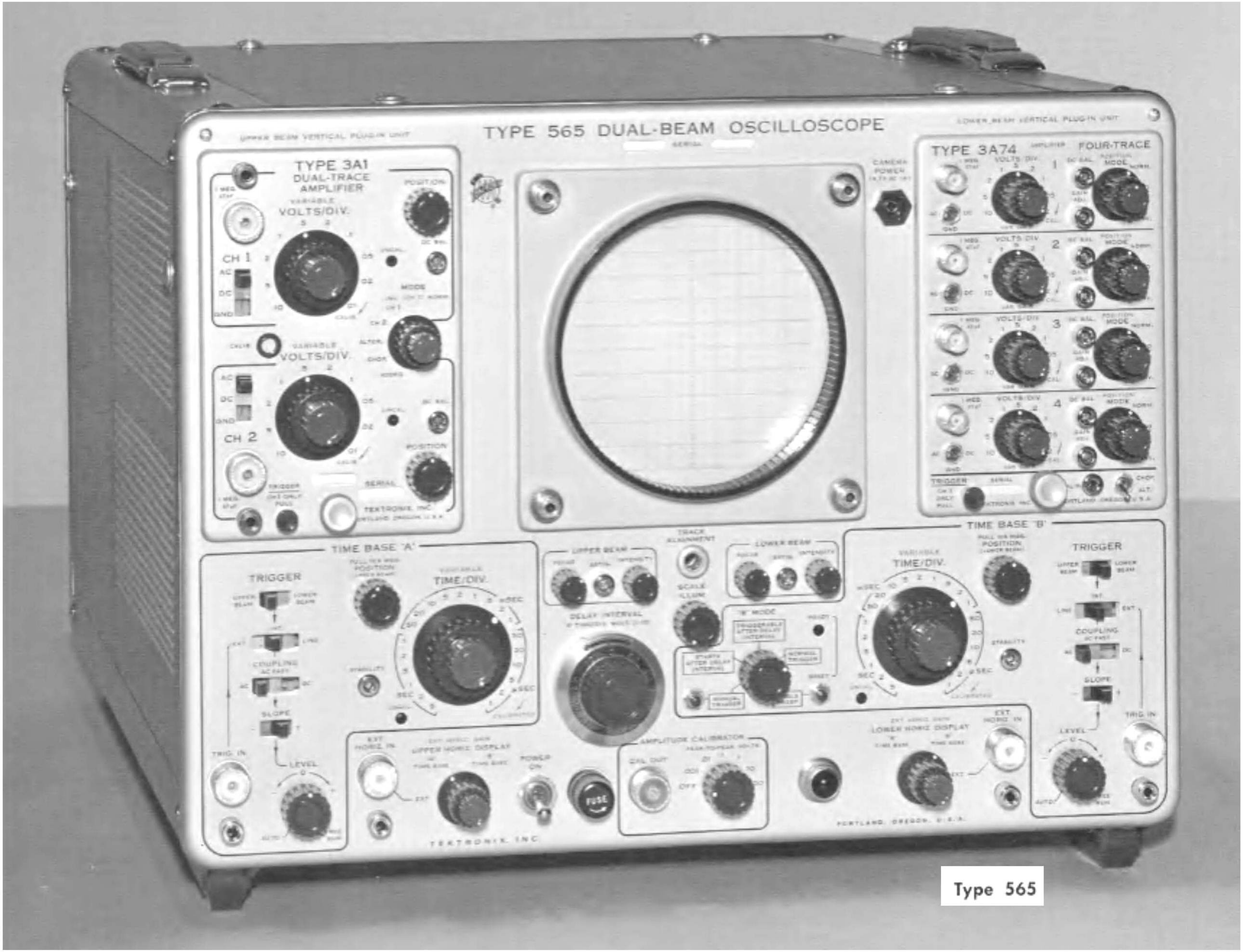
TYPE 565 DUAL-BEAM OSCILLOSCOPE
TYPE 3A1
DUAL-TRACE
AMPLIFIER
TYPE 3A74
FOUR-TRACE
TIME BASE 'A'
TIME BASE 'B'
TRIGGER
TIME/DIV.
VOLTS/DIV.
TEKTRONIX, INC.

Type 565

SECTION 1
CHARACTERISTICS

The Type 565 is a dual-beam oscilloscope; essentially two oscilloscopes in one cabinet. Two internal horizontal and two plug-in vertical deflection systems permit independent operation of the two cathode-ray tube (crt) beams. Either of the two time-base generators can control the sweep of either or both of the beams.

Each vertical deflection system utilizes any of the Tektronix non-sampling signal amplifier plug-in units intended for use with 560-Series instruments. The choice of plug-in units depends on the application and those used need not be the same type.

Special circuits in the Type 565 Oscilloscope permit an accurate, continuously variable delay in the presentation of a sweep from 10 microseconds to 50 seconds after receipt of a fast rise triggering impulse. This feature permits expanded observation of a small portion of the normal sweep, accurate measurement of signal jitter, precise time measurement and many other uses.

VERTICAL DEFLECTION SYSTEM

The characteristics of both vertical channels are those of the plug-in units used. The capacitances of the two vertical deflection plate systems of the cathode-ray tube are equalized to assure uniform plug-in unit high frequency response.

HORIZONTAL DEFLECTION SYSTEM

Sweep Rates—Time Base 'A' and Time Base 'B'

Calibrated sweep rates of 1 microsecond to 5 seconds per division in 21 steps. An uncalibrated control permits sweep rates to be varied continuously between 1 microsecond and about 12 seconds per division.

Sweep rate accuracy (with 10X MAG. turned off):

Upper Beam driven by Time Base 'A' and Lower Beam driven by Time Base 'B'; within 3%.

Both beams driven by Time Base 'A'; Lower Beam sweep rate is accurate within 4%.

Both beams driven by Time Base 'B'; Upper Beam sweep rate is accurate within 4%.

Simultaneous crossed operation not recommended (Upper Beam driven by Time Base 'B' and Lower Beam driven by Time Base 'A').

10X Magnifier—Upper and Lower Beam

Provides a horizontal magnification of X10 of the center 1-centimeter portion of the unmagnified crt display when the internal time base generators provide the horizontal deflection. Extends the fastest sweep rate of either beam to 0.1 microsecond per division. Magnified sweep rates are accurate within 5% except in simultaneous crossed operation.

External Horizontal Inputs—Upper and Lower Beams

Deflection Factor—Continuously variable from zero to at least 10 major graticule-divisions deflection per volt.

Maximum Input Voltage—300 volts, rms.

Frequency Response—Dc to at least 350 kc (—3 db) at maximum sensitivity.

Approximate Input Characteristics—Resistance, 100 kilohms.

TRIGGERING—TIME BASES 'A' and 'B'

Trigger Signal Sources

Upper or lower Beam vertical signal, external signals, or power line signal.

Triggering Modes

AC, AC Fast, DC, and Automatic.

Triggering Signal Requirements

Internal—Depends upon the plug-in unit. Dc to 1-megacycle sinewave; typically, signals which produce 0.3 major graticule division vertical deflection will provide stable triggering with proper setting of the LEVEL control. Above 1-megacycle, increased signal amplitude is required.

External—Dc to 1-megacycle sinewave; less than 1-volt to 15-volts, peak, depending upon the LEVEL control setting. Above 1-megacycle, greater signal voltage is required. (Sweeps will trigger on signals greater than 15 volts peak, but the LEVEL control operates over a range of about + and — 15 volts.)

Delayed Sweep

See Section 2, "Starts After Delay Interval".

CATHODE RAY TUBE (crt)

Type—T5650-2-1 Aluminized.

Phosphor—Type P2 standard; P31 is recommended for fast sweep rate, low duty-cycle applications. P1, P7, and P11, P31 phosphors optional.

Internal Unblanking

Dc coupled to blanking deflection plates.

External Intensity (Z axis) Modulation — Upper and Lower Beams

Ac coupled to crt control grids through rear panel input jacks. Input time constant depends on INTENSITY control setting and external circuit impedance; typically about 3.5 milliseconds at normal intensity with low external impedance.

Typically, a 10 volt peak-to-peak signal will produce visible intensity modulation.

Dual Trace Chopped Blanking

Crt circuit permits vertical plug-in units with multi-trace blanking to turn off the display while switching between input channels.

Useable Viewing Area

10 by 10 centimeters. 10-centimeter total vertical deflection consists of 8 centimeters for each beam with 6 centimeters common to both beams.

Graticule Markings

Internally marked in 10 vertical and 10 horizontal 1-centimeter (major) divisions. 2-millimeter markings (minor divisions) on the vertical centerline and on the horizontal centerlines of both the Upper and Lower Beam; 4 centimeters from top and bottom.

Graticule Illumination

Variable edge lighting.

Alignment

Traces are parallel to one another within ¼ major division per 10 major divisions when both traces are vertically positioned at the center of the crt.

AMPLITUDE CALIBRATOR

Output Signal

Square waves at about 1,000 cycles.

Output Voltage

1 millivolt to 100 volts in decade steps.

Accuracy

Peak-to-peak amplitude within 3% of indicated voltage as measured between center jack and the shield portion of the CAL. OUT connector. Accuracy is degraded somewhat if CAL. OUT is connected to loads under 1-megohm.

OTHER CHARACTERISTICS

Output Signals Available

CAUTION

The voltage at the following rear-panel output connectors may exceed —100 volts during instrument turn-on and warm-up:

LOWER VERT. SIG. OUT

LOWER HORIZ. SIG. OUT

UPPER VERT. SIG. OUT

UPPER HORIZ. SIG. OUT

External devices which could be damaged by this voltage should be disconnected during turn-on and warm-up of the Type 565.

Current drain from the following rear-panel output connectors must not exceed 2 milliamps (total—due to dc level plus signal peak):

DEL'D TRIG. OUT

A differentiated, positive-going pulse at least 8 volts in amplitude, occurring at the end of the delay interval ('A' TIME/DIV. multiplied by DELAY INTERVAL dial setting). No dc output between pulses.

'A' + GATE OUT

An approximate 20-volt peak-to-peak positive-going pulse with same duration as 'A' sweep. No dc output between pulses.

$R = \frac{20}{2 \times 10^3} = 10K\Omega$

'B '+ GATE OUT

An approximate 20-volt peak-to-peak positive-going pulse with same duration as 'B' sweep. No dc output between pulses.

UPPER and LOWER HORIZ. SIG. OUT

An approximate 5-volt sawtooth when the horizontal deflection is produced by either time-base generator. Output dc level between sweeps is about +1 to +2 volts.

A dc-coupled signal of at least 0.05 volt per major division of horizontal deflection when the deflection is produced by an external signal. Dc level of output signal depends on dc level of input signal. Output voltage swing limited to between about +1 and +15 volts. Dc output with no input is about +2 volts.

UPPER and LOWER VERT. SIG. OUT

Dc coupled*. Obtained from the internal triggering signal output of the vertical plug-in unit and therefore depends on plug-in unit in respect to signal amplitude, dc level, and frequency response.

Signal amplitude is typically 2 to 4 volts per major division of displayed signal.

Dc signal level is within about ±20 volts when beam is positioned within vertical limits of graticule.

CAMERA POWER (on front panel)

Front-panel connector providing 6.3 volts ac from power transformer, fused at 1 amp.

Power Supplies

Electronically regulated for stable operation with as much as —10% to +7% variation from design-center line voltage. Power supply voltages are available at the AUX. POWER JACK on the rear of the instrument. See Section 2 for power capabilities.

*Except when using a Type 2A50 Plug-In Unit.

Line Voltage Requirements

The instrument is wired for the design-center line voltage indicated on a metal tag on the instrument rear panel. Changes can be made in the internal wiring to permit operation with design-center line voltages of 110, 117, 124, 220, 234, or 248 volts. The transformer primary connections for each voltage is indicated on the diagram attached to the power transformer. Fan connections are indicated in Fig. 1-1. The line fuse (on the front panel) is a 6.25 amp slow-blowing type for 110, 117, 124 volts and 3 amp slow-blowing type for 220, 234, and 248 volts.

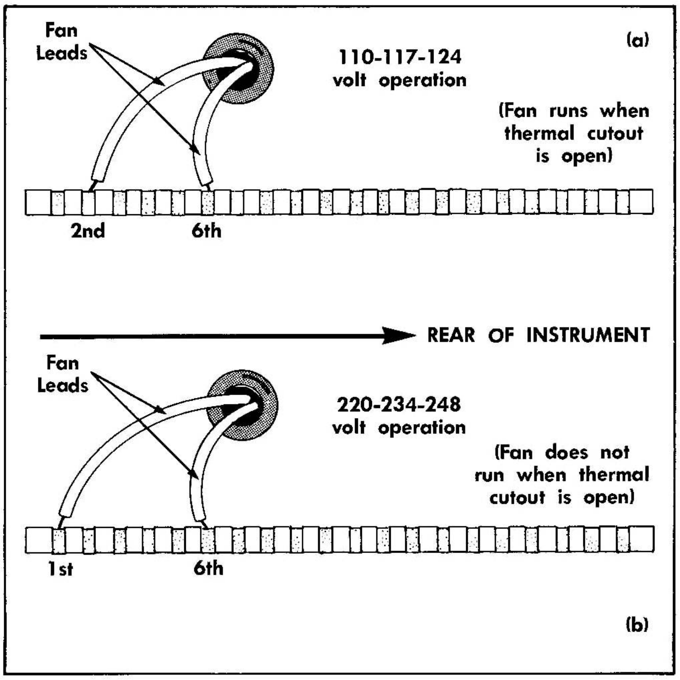

Fig. 1-1. Fan power connections.

Line Frequency

50 to 60 cycles.

Power Consumption

Maximum of about 600 watts including plug-in unit power consumption and excluding loads connected to the AUX. POWER JACK.

Ventilation

Forced filtered air. The self-resetting thermal relay interrupts instrument power in the event of overheating. In instruments equipped with ac fans, the fan will continue to run during thermal interruption if the instrument is wired for design-center line voltages of 125 vac and below.

Construction

Four-piece, blue vinyl finished cabinet, aluminum-alloy chassis, and photo-etched, anodized front panel.

Dimensions

Width : 17 inches

Height: 13½ inches

Depth: 23⅜ inches

Weight: 62 pounds

SECTION 3
CIRCUIT DESCRIPTION

General

This portion of the Instruction Manual presents a detailed discussion of the Type 565 circuitry operation. This discussion refers to various block diagrams inserted in the text, and to the circuit diagrams in the back of this manual.

BLOCK DIAGRAM

A functional block diagram of the Type 565 Oscilloscope is shown in Fig. 3-1. The relationship of the circuits in each block to those in other portions of the instrument is discussed in the detailed description of that circuit.

TIME BASE TRIGGER

General

Time Base 'A' Trigger and Time Base 'B' Trigger circuits are identical except for component reference numbers on the schematics. The following circuit description pertains to both circuits, but reference numbers for Time Base 'A' Trigger are used.

For best triggering stability, the Time Base Generator requires a trigger pulse that is representative of the selected triggering signal frequency, but otherwise consistent in amplitude and wave-shape. Available triggering signals often vary in amplitude, waveshape, and frequency, and thus cannot be used directly to trigger the time base. The Trigger circuit is essentially a waveshaping circuit that converts a sample of the input signal into a pulse having a reasonably constant risetime and amplitude. Hence, frequency is the only variable characteristic remaining in the output trigger pulse.

The block diagram, Fig. 3-2, shows the two basic elements of the trigger circuit. The Trigger Input Amplifier amplifies (and when desired, inverts) the incoming triggering signal and applies it to the input grid of the Trigger Multivibrator. The Trigger Multivibrator is essentially a switch that is either on or off, depending on the instantaneous voltage level at its input. Its square wave output is applied to the Time Base Generator where it is differentiated to form positive and negative pulses. The negative pulses trigger the Time Base Generator while the positive pulses are clipped and not used.

For the following description, refer to the Time Base 'A' Trigger schematic in the back of this manual.

Trigger Input Amplifier

The TRIGGER source switches are used to select the appropriate trigger signal from one of four sources: upper beam vertical plug-in unit (UPPER BEAM), lower beam vertical plug-in unit (LOWER BEAM), TRIG. IN connector (EXT.), or line-frequency signal from the power transformer (LINE). The selected signal is then applied to the COUPLING switch. (Information about the automatic mode, AUTO., of trigger operation is given later in this circuit description).

The COUPLING switch permits the operator to accept or reject certain characteristcs of the triggering signal. In the DC position, the coupling capacitors are shorted, coupling both dc and ac signals to the Trigger Input Amplifier. In the AC position, C7 and C8 in parallel are placed in the signal path. An RC circuit consisting of C7-C8 and R12 is thus formed which blocks dc and attenuates ac signals below about 20 cycles. In the AC FAST position, C8 alone is placed in the signal path and R12 is placed in parallel with R10. This RC network blocks dc and rejects ac signals below 1000 cycles. The TRIGGER source and COUPLING switches are wired so the AC FAST function is bypassed when the LINE source is used.

The signal from the COUPLING switch is applied to the SLOPE switch through R15-C15. (R15 and C15 prevent high amplitude positive signals from drawing excessive grid current from V24.) The SLOPE switch determines whether or not the triggering signal will be inverted by the Trigger Input Amplifier. When the SLOPE switch is set to —, the signal is applied to the grid of V24A and will not be inverted. For example, a positive-going signal at the grid of V24A will cause a positive-going change in the common cathode circuit. The fixed voltage at the grid of V24B and the positive going change at its cathode reduce the current through V24B. This results in a positive-going change in plate voltage; hence, no inversion.

If the SLOPE switch is in the + position, the signal is applied to the grid of V24B. In this case, V24B inverts the signal in the manner characteristic of a single stage, plate-loaded amplifier.

The SLOPE switch also serves another function, it applies a dc voltage from the LEVEL control to whichever grid of V24 is not connected to the COUPLING switch. (The need for this dc voltage is explained in the Trigger Multivibrator portion of this circuit description. At this point, however, the important consideration is the effect the dc voltage has on the amplified trigger signal at the plate of V24B.)*

The voltage at the junction of R19 and R20 can be varied between about +15 and —15 volts by adjusting the LEVEL control. This voltage controls the average voltage at the plate of V24B and the triggering signal either adds to or subtracts from that average. Thus, in addition to being an amplifier, the Trigger Input Amplifier is also a voltage comparator. (V24 is a voltage comparator rather than a difference amplifier since R24 and C24 balances the gain of V24A to that of V24B.) This composite signal is applied to the input grid of the Trigger Multivibrator.

The Trigger Multivibrator is disabled unless R47 is grounded. If the UPPER HORIZ. DISPLAY switch, LOWER HORIZ. DISPLAY switch, or 'B' MODE switch is set for a function in which the operation of Time Base 'A' is required, then R47 will be grounded.

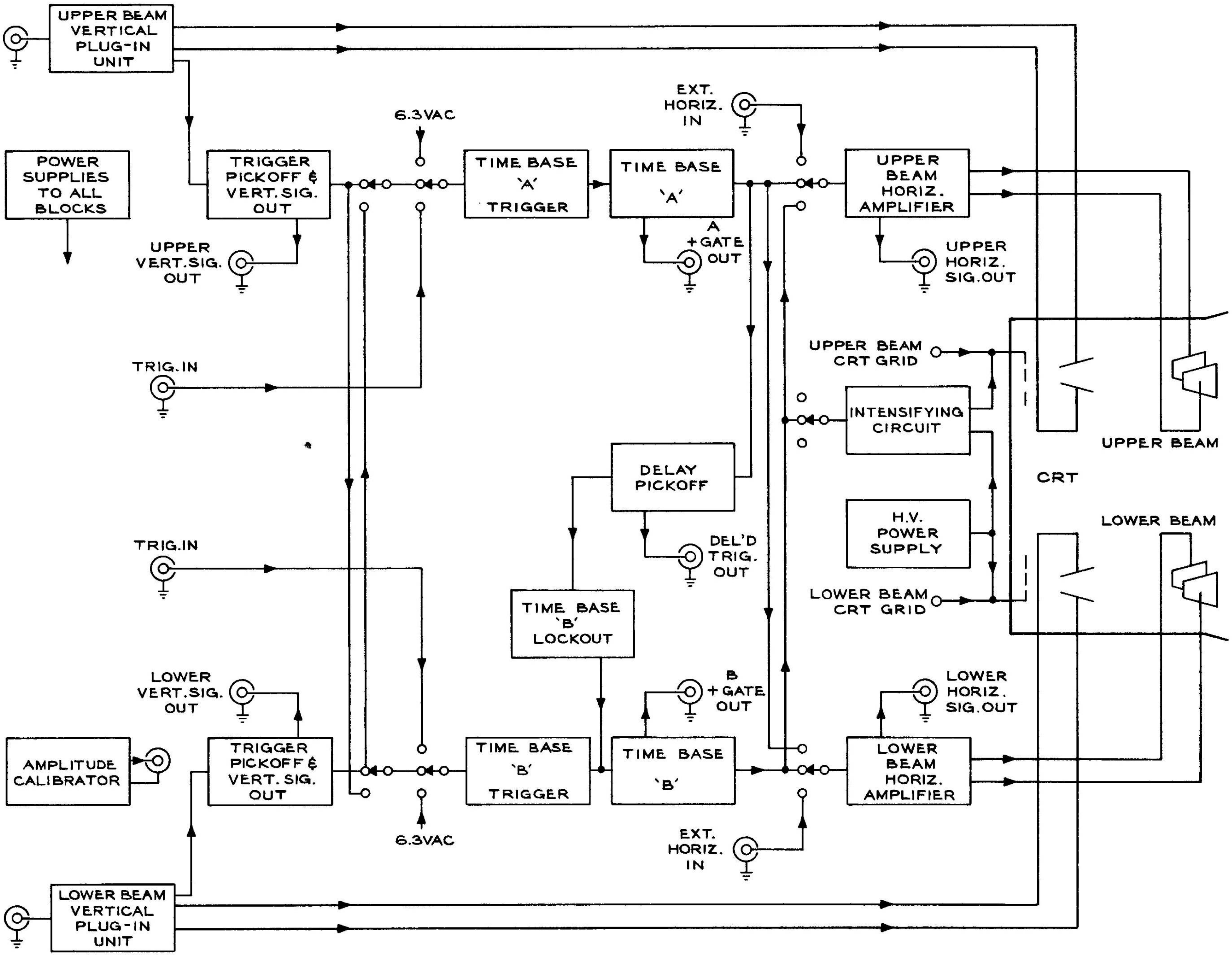

Fig. 3-1. Functional block diagram of the Type 565 Oscilloscope.

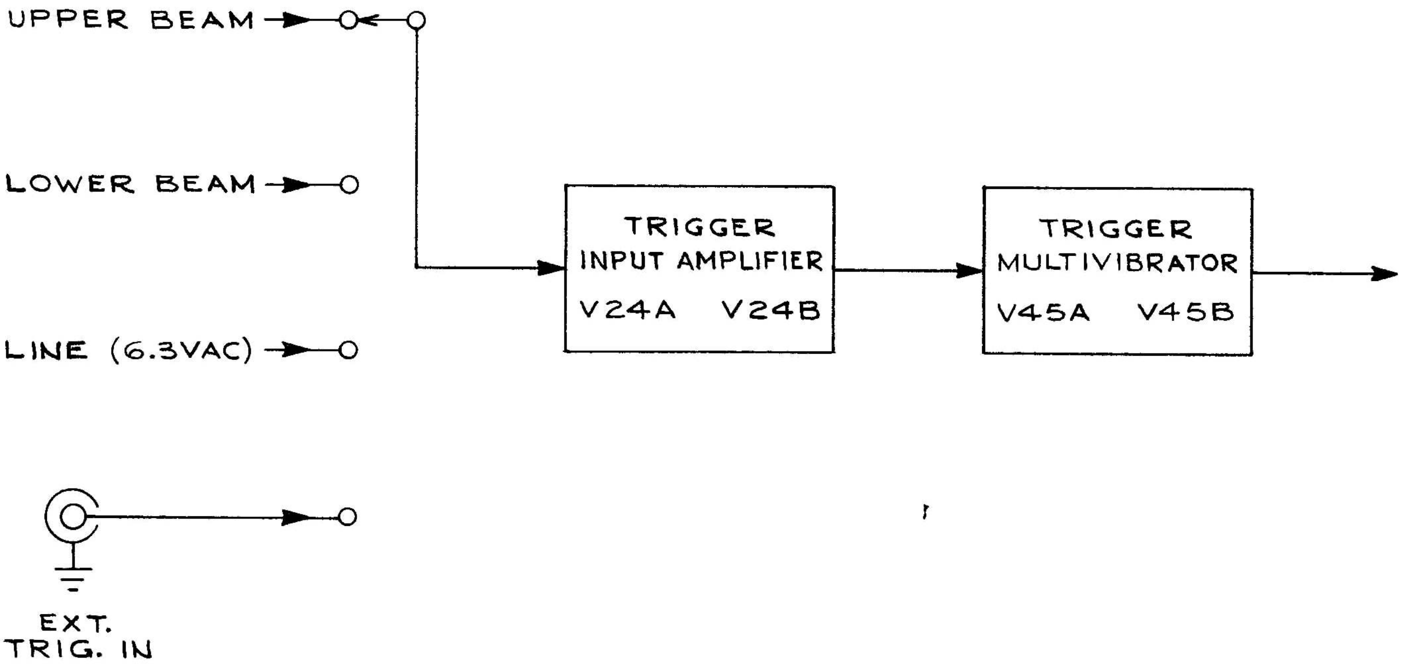

Fig. 3-2. Time Base 'A' Trigger.

Trigger Multivibrator

The Trigger Multivibrator, V45, is a typical bistable Schmitt circuit. When the voltage at the grid of V45A is above a certain level, V45A conducts and V45B is cut off. In this state, the output voltage at the plate of V45B is +300 volts. When the voltage at the grid of V45A is below a certain level, V45B conducts and V45A is cutoff. The output voltage at the plate of V45B is then about +293 volts. The transition from one state to the other occurs very rapidly, regardless of how slowly the input voltage passes the trip-level. Thus, the output of the Trigger Multivibrator is a square pulse of about 7 volts amplitude. The following example illustrates the sequence of events.

When a negative-going voltage change reaches about +111 volts at the input grid, the plate of V45A rises and carries the grid of V45B with it. V45B is driven into conduction (see Fig. 3-3). Since the cathode resistor R47 is common to both tubes, the conduction of V45B tends to raise the cathode voltage of V45A. This further reduces the current flow through V45A and compounds the original action of the input signal. V45A and V45B rapidly change conduction states; V45A cuts off and V45B conducts. The voltage at the plate of V45B drops sharply. This voltage step is applied to a differentiating network in the Time Base Generator and becomes the negative-going trigger pulse required to start the time base action.

As the input signal continues into the positive-going portion of a cycle, the grid of V45A rises beyond +111 volts to about +113 volts before the Trigger Multivibrator resets to its previous state. This approximate 2 volt difference in switching levels is the hysteresis range of the circuit.

As Fig. 3-3 and the previous description suggest, there are two basic requirements that must be met if the Trigger Multivibrator is to generate an output pulse. First, the amplified signal at the grid of V45A must have enough amplitude to overcome the hysteresis of the circuit; that is, about 2 volts peak to peak, or more. Second, the signal must be superimposed on a dc voltage that will permit it to cross the upper and lower hysteresis limits of the circuit; that is, about +111 volts and +113 volts. This second requirement is met through the use of the LEVEL control mentioned previously. Figures 3-4 and 3-5 illustrate the consequence of improper LEVEL control adjustment. In both cases, the signal amplitude is adequate to produce triggering, but the dc level of the signal is incorrect.

Automatic Triggering—Automatic triggering may be selected by placing the LEVEL control in the AUTO. position. This changes circuit operation as follows:

A section of the AUTO. switch in the input coupling circuit selects AC coupling, regardless of the position of the COUPLING switch, so the average voltage of the triggering signal is reduced to zero. The junction of R19 and R20 is grounded so the amplifier will be balanced.

C31 is inserted between V24B and V45A and the Trigger Multivibrator is converted into an astable or free-running form by providing positive feedback to the input grid. In the absence of an input signal, the multivibrator free-runs at about 50 cps; a frequency determined primarily by C31 and R40. An incoming signal having a frequency greater than about 50 cps will force the multivibrator to run at the signal frequency.

Resistance added in the plate circuit of V45A increases the circuit gain and reduces the hysteresis to considerably less than 2 volts. This permits low amplitude signals to produce stable automatic triggering.

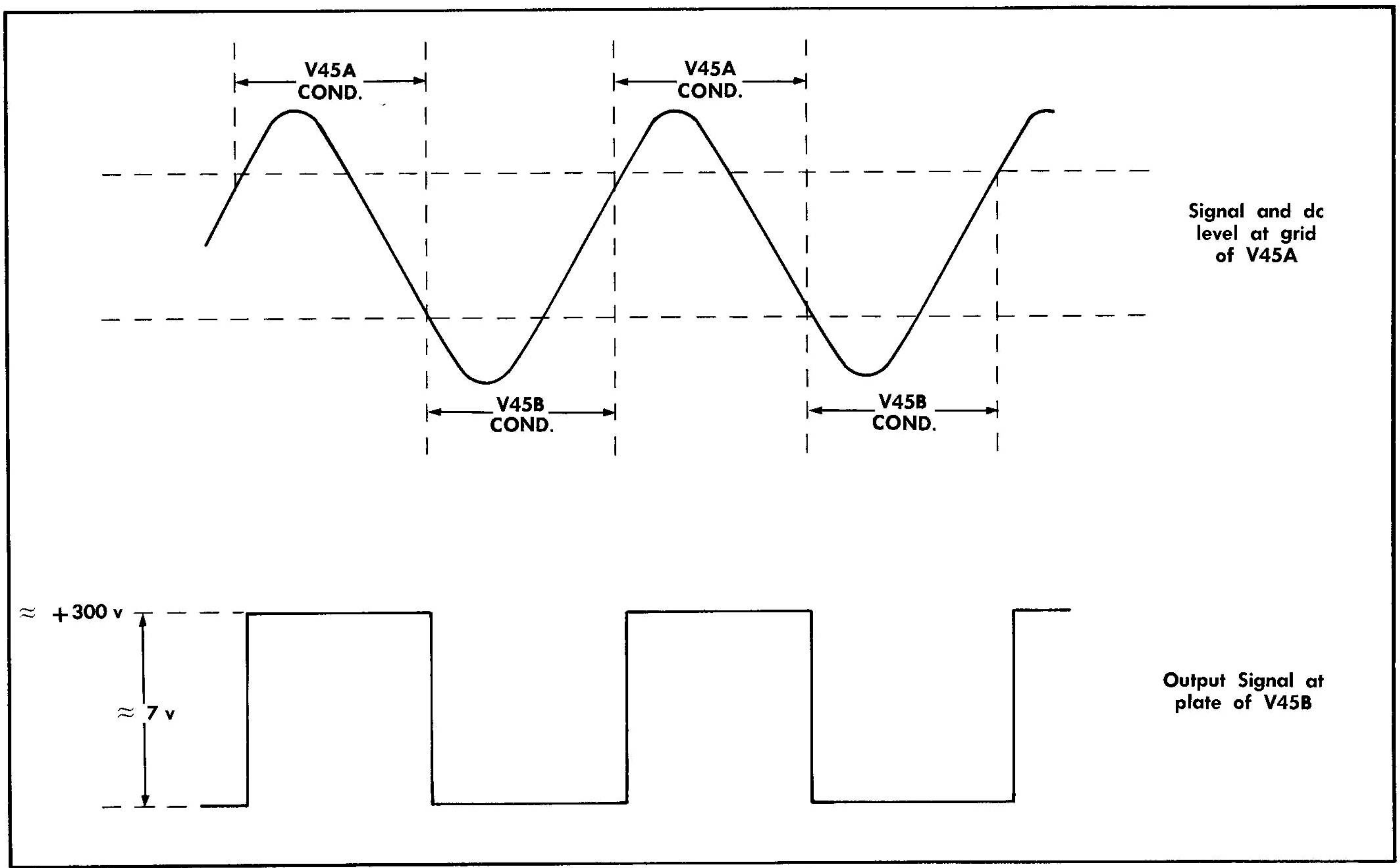

Fig. 3-3. Correct LEVEL control setting.

TIME BASE GENERATORS

The following description pertains to both time bases, but circuit reference numbers for Time Base 'A' are used. The additional circuitry in Time Base 'B' is described in a later portion of this section under the title "Time Base 'B' Lockout".

The Time Base Generator produces four output signals (see Fig. 3-6):

1. a positive-going sawtooth which can be coupled to either or both horizontal amplifiers by the appropriate setting of the Horizontal Display switches. The sawtooth output is also permanently connected to the Delay Pickoff circuit (Time-Base 'A' only).

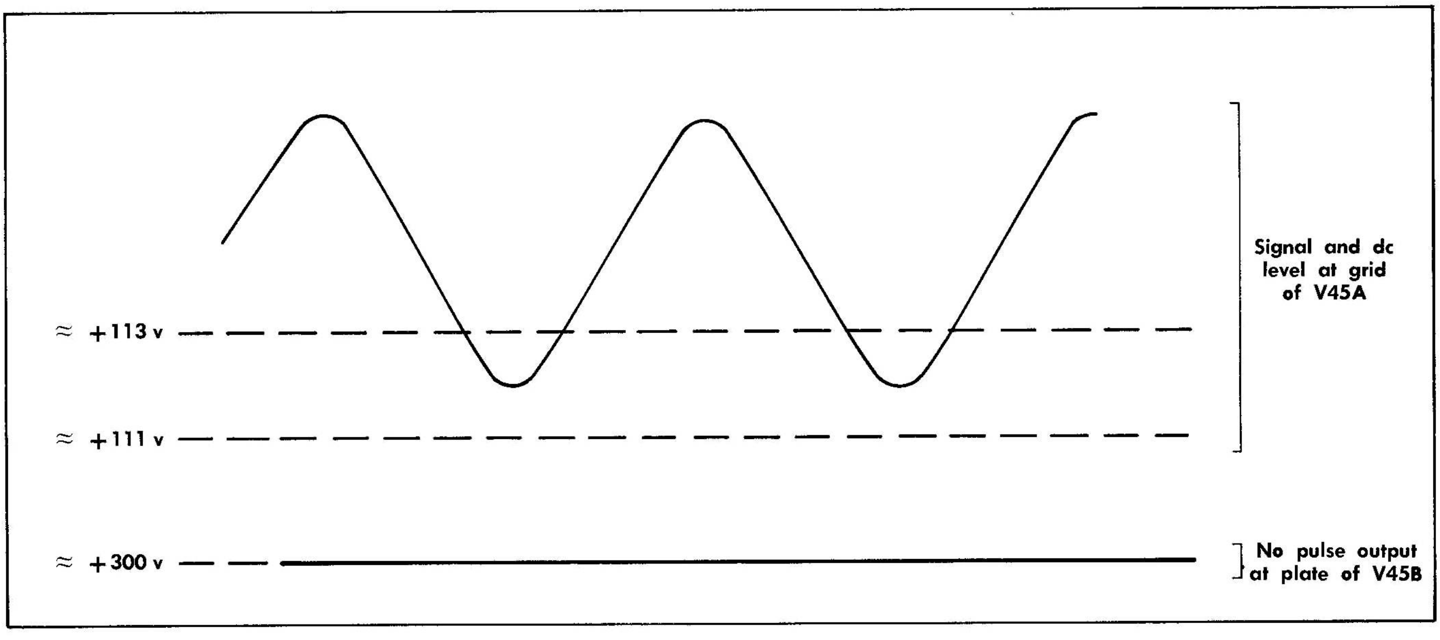

Fig. 3-4. Incorrect LEVEL control setting.

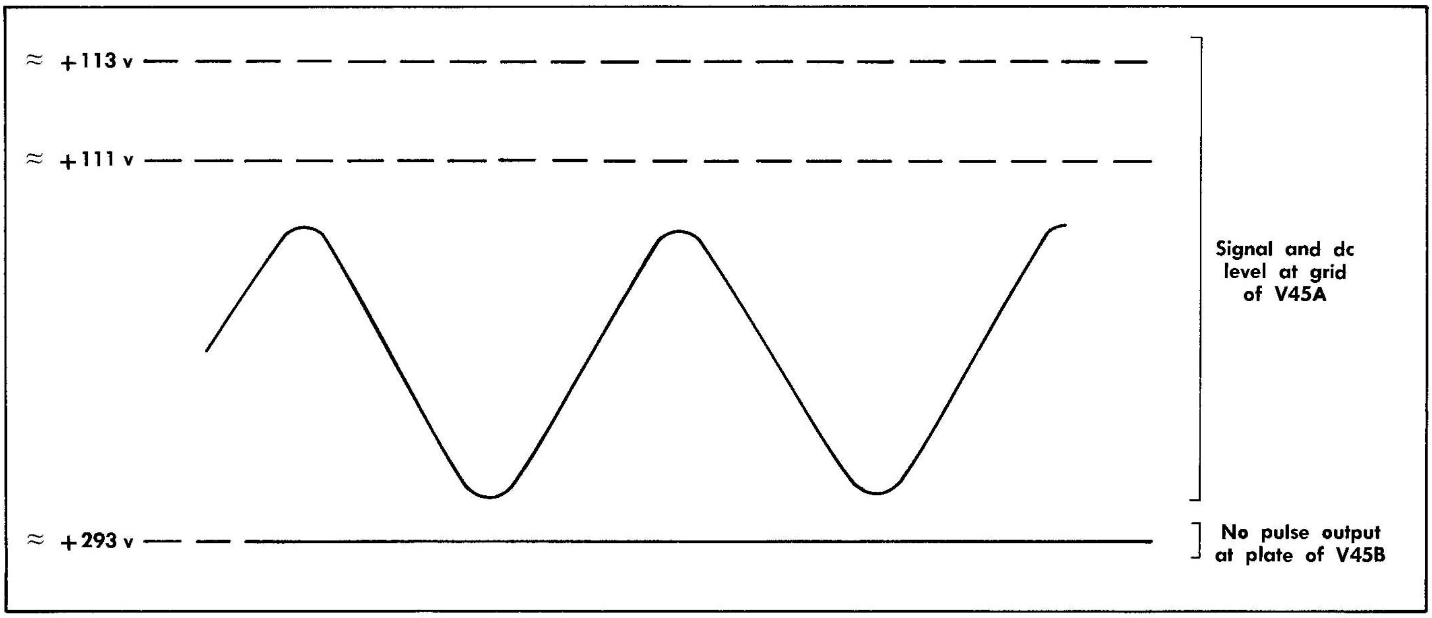

Fig. 3-5. Incorrect LEVEL control setting.

2. a positive-going unblanking pulse having the same duration as the sawtooth rise. Coupled to the Crt Circuit by the Horizontal Display switches to unblank the beam(s) being deflected by Time Base 'A'.

3. a positive-going pulse (+ GATE OUT) having the same duration as the sawtooth rise. Coupled to a rear panel connector for external use.

4. a negative-going multi-trace sync pulse having the same duration as the sawtooth rise. Coupled to the appropriate Vertical Plug-In Unit(s) by the Horizontal Display switches. The trailing edge of the pulse causes multi-trace plug-in units, operating in the alternate mode, to switch channels.

In most applications, each cycle of events is started by a trigger pulse from the Time Base Trigger circuit. However it is also possible to either disable the generator or to make it free run; that is—the end of one cycle will cause the next cycle to begin. The desired mode of operation will be obtained through the appropriate setting of the STABILITY and LEVEL (FREE RUN position) controls. (See Section 2.)

The block diagram, Fig. 3-6, shows the basic elements of the Time Base Generator. The Sweep Gating Multivibrator is an electronic switch which turns the Disconnect Diodes on and off. When the Disconnect Diodes are back-biased, the Miller Runup begins to produce a sawtooth signal. A sample of the sawtooth is fed back to the Sweep Gating Multivibrator through the Holdoff Circuit. When the sawtooth sample reaches a predetermined amplitude, the Sweep Gating Multivibrator resets, switching the Disconnect Diodes on. The Miller Runup then resets, forming the retrace or falling portion of the sawtooth. A sample of the sawtooth retrace is fed back to the Sweep Gating Multivibrator, but is delayed by the Holdoff Circuit. This delay prevents the generator from beginning the next sawtooth until the circuits have stabilized.

In the following detailed circuit description, refer to the Time Base 'A' Generator schematic in the back of the manual. Unless otherwise stated, the STABILITY control is set for triggered operation and the LEVEL control is set to midrange.

Quiescent Conditions

In the quiescent state; that is, when the generator is triggerable but no sweep is being generated, the circuit conditions are as follows:

Sweep Gating Multivibrator—V135A is conducting and V145A is cut off. The STABILITY control sets the grid voltage of V135A at about —50 volts. The approximate +25 volts at the plate is coupled to the cathode follower, V135B, and divided to about —55 volts at the grid of V145A. Since the grid of V135A is about 5 volts more positive than the grid of V145A, V135A demands all available current from the common cathode circuit. With no current through V145A, its plate voltage is determined by the current through R147 and the disconnect diodes.

The voltage at the cathode of V135B (about +35 volts) is coupled to the Crt Circuit to blank the appropriate beam. This same voltage is divided to about —25 volts and applied to the grid of V193A. Thus, V193A is cut off and the voltage at the 'A' + GATE OUT connector is zero.

Disconnect Diodes—V152A and V152B are conducting. V152A clamps the sawtooth output bus (the cathode of V161B) at about —3.5 volts to provide a stable, repeatable, starting voltage for the sawtooth. V152B clamps the grid of V161A at about —2.5 volts.

Miller Runup—Since the grid of V161A is clamped at about —2.5 volts, the tube conducts heavily and the plate voltage is about +30 volts. The plate voltage is coupled to the grid of V161B by the voltage divider, B167 and R167. This type of voltage divider reduces the dc level by about 60 volts, but does not attenuate variations of the input voltage.

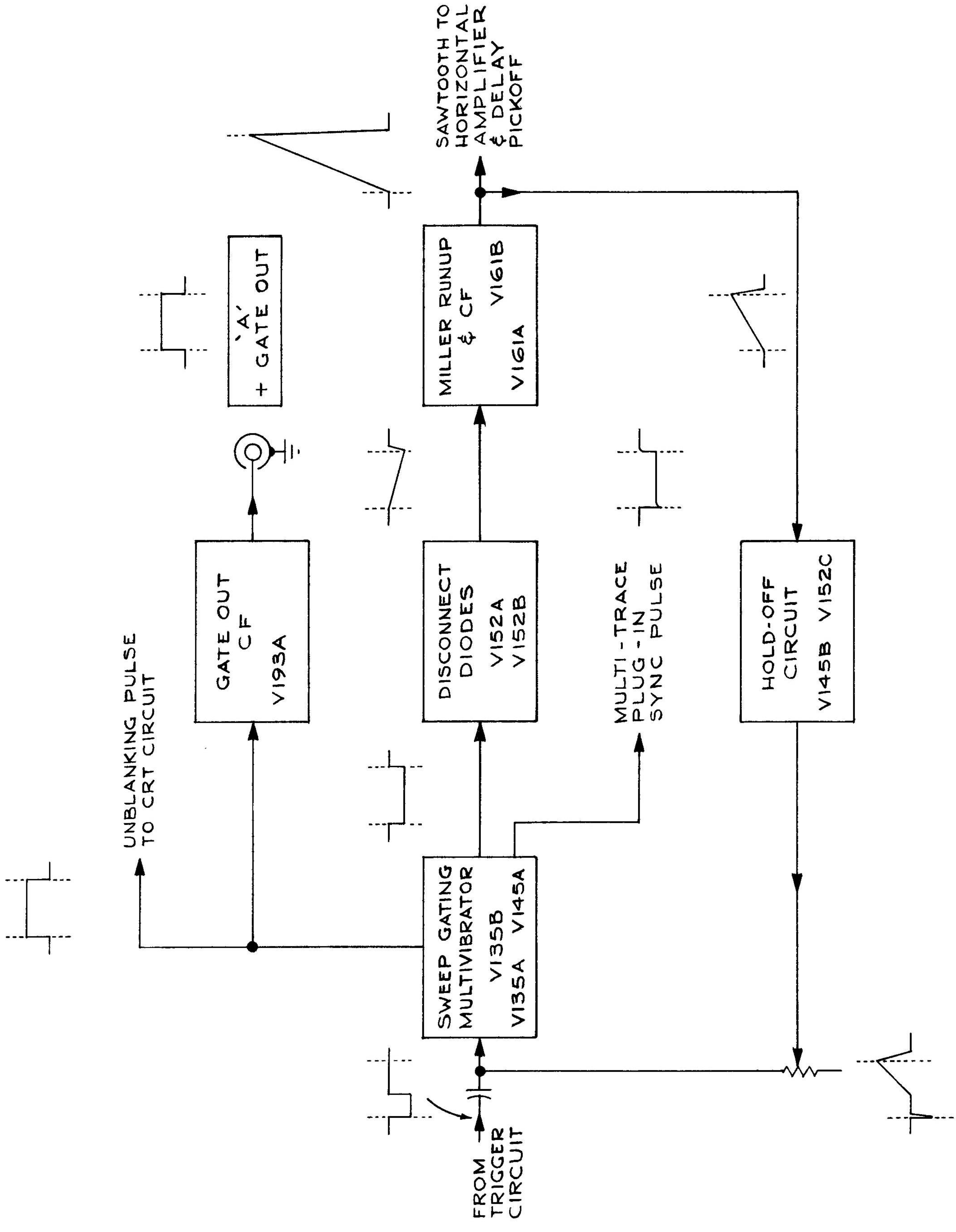

Fig. 3-6. Time Base 'A' Generator.

Hold-Off Circuit—V152C is conducting and V145B is cut off. The voltage divider network, R177, R178, and R179, applies about —65 volts to the plate of V152C. Thus V152C conducts through R181 and sets the grid voltage of V145B at about —65 volts. V145B is cut off since its cathode voltage is about —50 volts; the same as the voltage at the grid of V135A.

Cycle of Operation

When a negative-going pulse is received from the Trigger Circuit at the grid of V135A, the Sweep-Gating Multivibrator switches. Multivibrator action starts by V135A amplifying the trigger pulse. The positive-going pulse at the plate of V135A is coupled to the grid of V145A by the cathode follower, V135B. V145A is driven into conduction, causing a positive-going voltage change in the common cathode circuit. This is positive feedback to the cathode of V135A which further reduces its conduction. Thus, the original action is compounded and the circuit rapidly switches. V145A conducts and V135A is cut off. V145A conducts more heavily than did V135A. Therefore, the common cathode voltage is about 25 volts more positive than it was in the quiescent state, and V135A remains deep in cut off after the trigger pulse has ended.

When V135A cuts off, the voltage at the cathode of V135B rises sharply from about +25 to about +128 volts. This voltage step is coupled to the Crt Circuit and the + Gate Out Cathode Follower. The crt is thus unblanked and the beginning of the plus gate pulse is formed.

With V145A now in conduction, its plate voltage has switched to a new level; about —6 volts. This negative voltage step cuts off conduction in the Disconnect Diodes. The current through the timing resistor, R160, is now diverted and begins to charge the timing capacitor, C160. As the timing capacitor charges, the grid of V161A goes negative. The greatly amplified positive-going change at the plate of V161A is coupled to the grid of V161B through the neon lamp, B167. The neon lamp lowers the dc level of the signal by about 60 volts, but does not reduce the signal amplitude. The cathode of V161B provides the sawtooth output signal plus feedback to two points within the time base generator.

Feedback to the timing capacitor opposes the negative-going change at the grid of V161A. This action persists throughout the period of the sawtooth and limits the total change in grid voltage to less than one volt. Since the voltage drop across the timing resistor is held nearly constant, the current through the resistor is essentially a constant value. This constant current flows into the timing capacitor and the voltage across the capacitor increases at a very linear rate. The rate of rise of the sawtooth is a function of the RC time constant of the timing resistor and capacitor.

An attenuated sample of the positive-going output sawtooth is applied to the plate of V152C in the Hold-Off Circircuit. The steady rise in voltage at the cathode of V152C charges the hold-off capacitor while raising the grid voltage on V145B. When the sawtooth has reached about one-half its final amplitude, V145B begins to conduct. As the sawtooth continues to rise, the cathode of V145B and the grid of V135A also rise. V135A will begin to conduct when its grid has risen about 20 volts. The plate voltage on V135A and the grid voltage on V145A drop and the cathode current no longer required by V145A is assumed by V135A. This positive feedback rapidly drives V135A into heavy conduction and V145A into cut off.

The negative-going voltage step at the cathode of V135B blanks the crt and forms the end of the + Gate Out pulse. The positive going voltage step at the screen grid of V145A is coupled to the appropriate vertical plug-in unit to cause a multi-trace plug-in unit, operating in the "alternate" mode, to switch channels.

When V145A cuts off, its plate voltage rises sharply to about —3 volts and brings V152B into conduction. The grid voltage on V161A rises and its plate voltage drops, carrying the grid and cathode of V161B with it. When the cathode of V161B drops to about —3.5 volts, V152A conducts to clamp the sawtooth output bus at that voltage level.

A sample of the falling voltage at the cathode of V161B is coupled to the plate of V152C, cutting off its conduction. While the hold-off capacitor was charged through the diode, it must discharge through a large resistor, R181. This retarded discharge (holdoff) delays the fall in voltage at the grid (and hence, the cathode) of V145B. The STABILITY control voltage divider network cuts off V145B when its cathode drops to about —50 volts. Thus, V135A is reduced from a state of heavy conduction to its original quiescent (triggerable) state.

Triggerable pulses which may arrive at the grid of V135A while the sweep is in progress have no effect since V135A is already deep in cut off. When V135A is driven into heavy conduction at the peak of the sawtooth, trigger pulses still have no effect because their fixed amplitude is too low to bring V145A out of cut off. The Hold-Off Circuit extends this period of insensitivity and thus blocks the start of the next cycle until the circuits have stabilized. Hold off time is required for stable triggering and is related to the timing capacitor being used. The proper holdoff capacitor is selected by the TIME/DIV. switch (see the Timing Switch schematic).

Special Component Functions—C141 assures that the Sweep-Gating Multivibrator will switch rapidly from one conduction state to the other. R187 and R189 isolate the shunt capacitance of the unblanking cables from the Sweep-Gating Multivibrator so its switching speed is not degraded. C165 aids V161B in charging the shunt capacitance in its cathode circuit at the fastest sweep rates. C167 insures that the voltage divider consisting of B167 and R167 will have the proper frequency response. The SWEEP LENGTH control, R178, is set during calibration for the proper sawtooth amplitude. D131 clips the positive-going portion of the triggering signal and C130 bypasses it to ground.

STABILITY control—Fig. 3-7 shows the relationship between the voltage at the Sweep-Gating Multivibrator input grid and the sawtooth output of the time base. Normally, the STABILITY control is set near mid-range so the voltage at the Sweep-Gating Multivibrator input grid will be at the level represented by E_2 in Fig. 3-7. This voltage level is about 2 volts above the trip level (E_1) required to cause the multivibrator to switch states. An incoming trigger from the Time Base Trigger circuit will drive the grid below the trip level. The multivibrator will immediately switch states and a sawtooth cycle will begin.

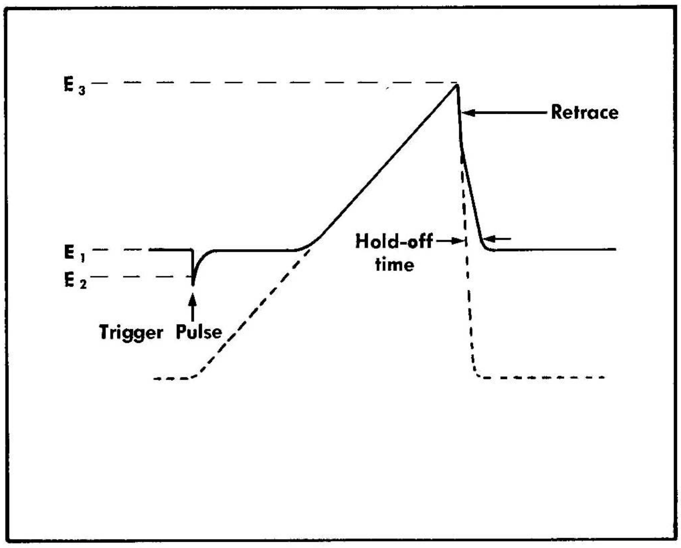

Fig. 3-7. Time and amplitude relationships between the Sweep-Gating Multivibrator input grid signal (solid line) and the time base sawtooth output (dashed line).

When the output sawtooth has reached about one-half of its final amplitude, the Hold-Off Cathode Follower begins to conduct and raises the voltage on the Sweep-Gating Multibrator input grid. The voltage continues to rise until it reaches the reset level represented by E_3. At this level, the multivibrator resets to its previous state and the retrace portion of the sawtooth begins. The falling voltage at the input grid of V135A is retarded by the Hold-Off circuit, but finally stabilizes at the quiescent level, E_2. The entire circuit is then ready for the next trigger pulse.

As you will note from the foregoing description and Fig. 3-7, the stability voltage at the Sweep Gating Multivibrator input grid must be at the correct level for triggered operation to occur. As the STABILITY control is turned counterclockwise, the quiescent voltage will become more positive than E_2. The amplitude of the trigger pulses will then be insufficient to drive the grid through the trip level E_1. Since the time base will not operate, this condition is referred to as "lockout". As the STABILITY control is turned clockwise, the voltage becomes more negative than the trip level E_2, and the Sweep-Gating Multivibrator will switch without waiting for a trigger pulse. As the sawtooth cycle thus initiated carries the input grid of the multivibrator through the retrace and hold-off period, the voltage will again fall below the trip level. Thus, another cycle will be initiated. The sweep generation will repeat without the need for trigger pulses as long as the voltage from the STABILITY control is sufficiently negative. This condition is referred to as 'free run' and can also be obtained by setting the LEVEL control to the FREE RUN position (provided UPPER HORIZ. DISPLAY is set to 'A' TIME BASE).

DELAY PICKOFF

The Delay Pickoff circuit generates a positive-going, differentiated pulse at a predetermined time during each sawtooth produced by Time Base 'A'. The pulse is available at the rear panel for external use and is also coupled to the 'B' MODE switch. The relationship between this pulse and Time Base 'B' is discussed later in this section under "Time Base 'B' Lockout".

Block diagram, Fig. 3-8, shows the four basic sub-circuits in the Delay Pickoff. The sawtooth output of Time Base 'A' is applied to the Difference Amplifier. The Difference Amplifier compares the sawtooth voltage to a variable dc voltage from the DELAY INTERVAL control. If the voltage from the DELAY INTERVAL control is more positive than the instantaneous sawtooth voltage, the Difference Amplifier output will be a low positive voltage. If the sawtooth voltage is the more positive, the output will be a somewhat higher positive voltage. It is important to note that the transition from the lower to the higher output voltage is actually an amplified segment of the input sawtooth as shown on the block diagram.

The Delayed Trigger Multivibrator converts the Difference Amplifier output signal into a fast-rise pulse. This pulse is then differentiated and clipped so only the positive-going pulses appear at the output of the Delayed Trigger Cathode Follower.

The point along the sawtooth rise where the delayed trigger output pulse will occur is determined by the voltage from the DELAY INTERVAL control. If a low voltage is selected, the pulse will occur during the early portion of the rise while the sawtooth voltage is low. If a higher voltage is selected, the pulse will occur at some later time during the rise when the sawtooth voltage is proportionally higher.

The maximum delay that can be obtained is slightly less than the total time duration of the sawtooth rise, which is determined by the setting of the 'A' TIME/DIV. switch. For example, if the 'A' TIME/DIV. switch is set to 1 mSEC, the maximum DELAY INTERVAL dial setting of 10.00 would result in a 10 millisecond delay between the start of the 'A' sawtooth and the delayed trigger pulse output.

The following detailed description refers to the Delay Pickoff schematic in the back of this manual.

Constant Current Tube

V314B is a constant current source for the Difference Amplifier. The voltage divider formed by R325 and R326 applies about —50 volts to the grid. This stable grid voltage and the high resistance in the cathode circuit force a constant 5 ma to flow through the tube. The Difference Amplifier will conduct this fixed current, either through one tube or shared between the two tubes.

Difference Amplifier

In the Difference Amplifier, the cathodes of V314A and V324A are connected together. The tube having the more positive control grid voltage will determine the voltage on the cathodes of both tubes. For example, assume that the DELAY INTERVAL control is set to 4.00. The voltage at the grid of V324A will then be about +36 volts. If Time Base 'A' is in the quiescent state, the voltage at the grid of V314A will about —3.5 volts. Since the grid of V324A is more positive, it will establish the common cathode voltage at about +38 volts. Therefore, V314A is deep into cutoff. V324A conducts and the voltage at its plate is about +121 volts.

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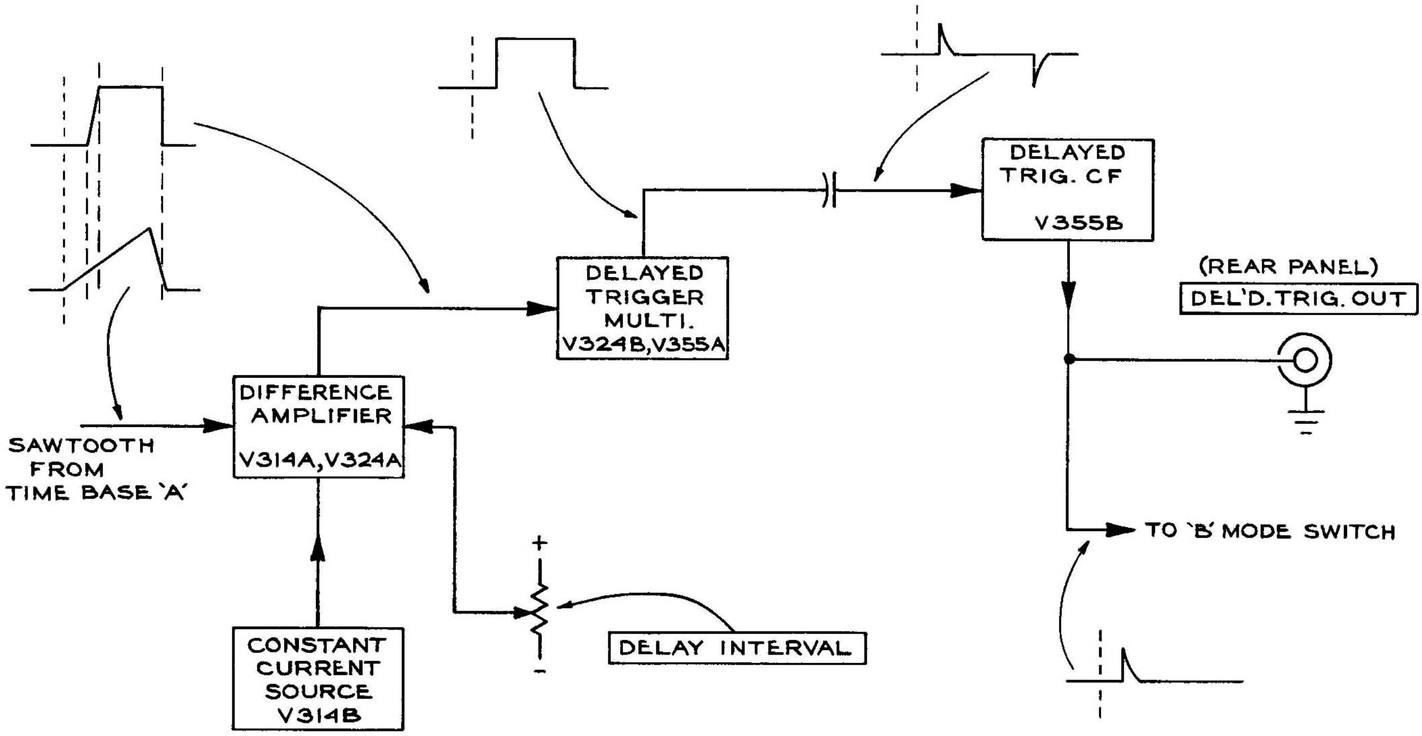

Fig. 3-8. Delay Pickoff.

As V324A cuts off, its plate voltage rises from about +120 age at the grid of V314A rises. Since V314A is deep in cutoff, the rising voltage does not immediately affect the Difference Amplifier. But as the sawtooth voltage rises through the range from about 2.5 volts below to 2.5 volts above the voltage from the DELAY INTERVAL control, V314A comes out of cutoff and into full conduction. The conduction of V314A forces V324 to reduce conduction. Then, as the sawtooth voltage becomes more positive than the DELAY INTERVAL control voltage, the common cathode voltage rises and cuts off conduction in V324A.

As V324A cuts off, its plate voltage rises from about +120 volts to about +200 volts. The elapsed time from the beginning to the end of this voltage change depends upon the Time Base 'A' sweep rate; about 2 seconds at 5 seconds per division and about 0.5 microsecond at 1 microsecond per division. The Delayed Trigger Multivibrator (a Schmitt trigger) converts this variable rate of rise into a voltage step of consistently fast risetime which is independent of the Time Base 'A' sweep rate.

Delayed Trigger Multivibrator

When the voltage at the plate of V324A is at the lower level (about +120 volts), V324B in the Delayed Trigger Multivibrator is cut off and V355A is conducting. As the voltage at the plate of V324A rises to about +170 volts and V324B begins to conduct, the voltage at the plate of V324B drops slightly, lowering the voltage at the grid of V355A. This reduces the current through V355A. However, the voltage at the grid of V324B will not permit the common cathode voltage to drop. Hence, the current given up by V355A is immediately assumed by V324B. This reduces the voltage at the plate of V324B still more, compounding the initial action. Thus, the beginning of conduction in V324B causes the Delayed Trigger Multivibrator to rapidly change states; V324B conducts and V355A cuts off. This produces a fast-rise positive-going voltage step at the plate of V355A.

Delayed Trigger C.F.

The voltage step produced by the Delayed Trigger Multivibrator is differentiated by the network consisting of C354, R354, and R355, and is applied to the grid of V355B. Delayed Trigger Cathode Follower V355B is held near cutoff by R354 and R355. When the delayed trigger pulse appears at the grid, the tube conducts heavily and the pulse is reproduced across R359.

The entire Delay Pickoff circuit resets during the retrace time of the Time Base 'A' sawtooth when the voltage at the plate of V324 drops below about +155 volts. When the differentiated pulse at the grid of V355B subsided, the tube was again near cutoff. Hence, when the negative going reset pulse at the grid of V355B drives the tube deeper into cutoff, very little negative going output signal is produced.

Several important conditions exist at the instant the delayed trigger output pulse occurs:

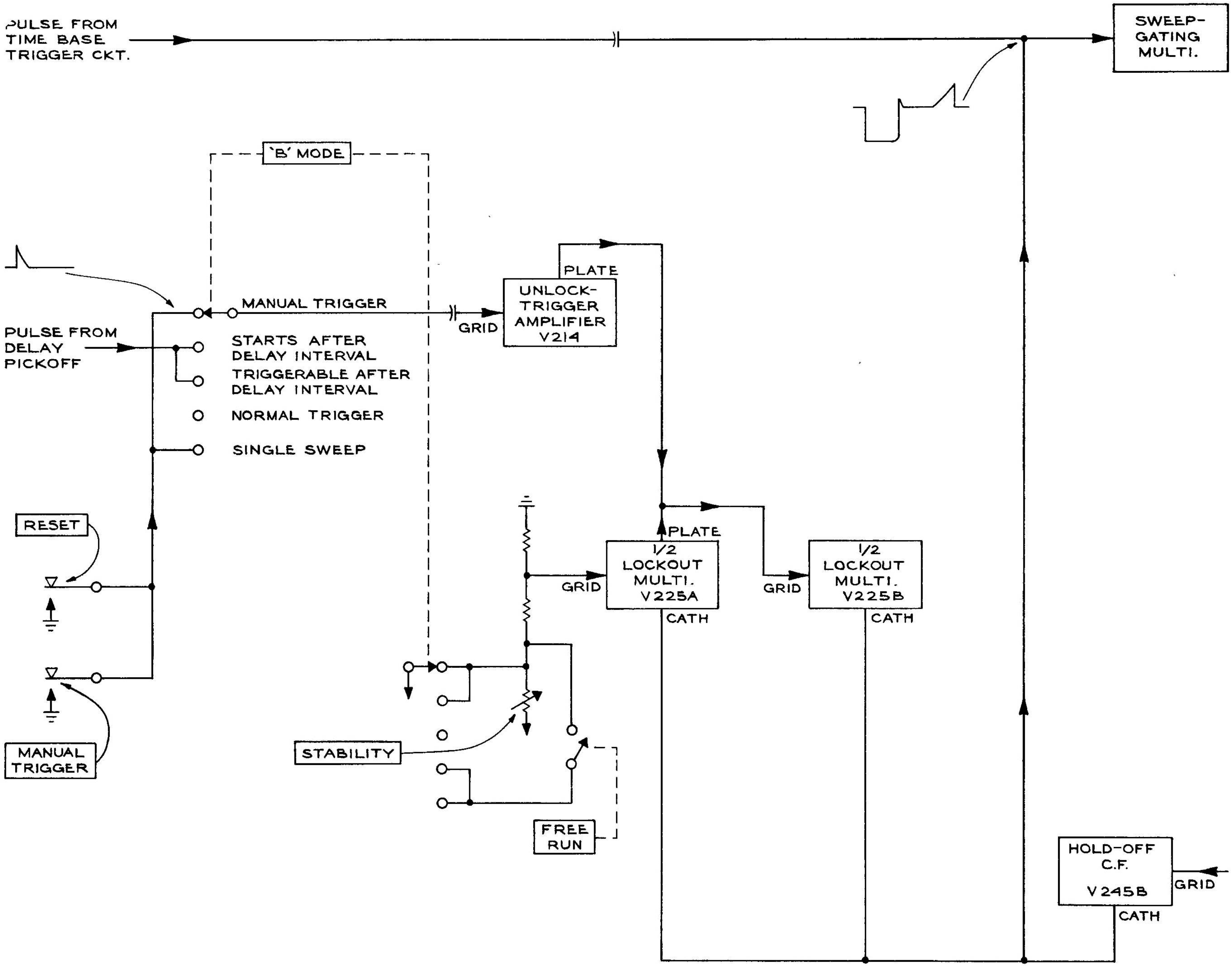

Fig. 3-9. Time-Base 'B' Lockout.

1. The voltage from the DELAY INTERVAL control essentially equals the instantaneous sawtooth voltage.
2. Time Base 'A' trace will have moved as many graticule divisions as the DELAY INTERVAL dial setting (10X MAG. off).
3. The time delay between the start of the 'A' sawtooth and the delayed trigger output pulse will equal the DELAY INTERVAL dial indication times the 'A' TIME/DIV. switch setting.

TIME BASE 'B' LOCKOUT

As previously mentioned in the description of Time Base 'A', the STABILITY control and FREE RUN switch settings determine whether the time base will be inoperative, triggerable, or will free run. Time Base 'B' operates in exactly the same manner when the 'B' MODE switch is set to NORMAL TRIGGER. However, when the 'B' MODE switch is in any other position, there is one additional factor controling Time Base 'B'; the Lockout Multivibrator.

The Lockout Multivibrator is a bistable electronic switch. In one state, it permits the STABILITY control or associated switches to have full control of the time base, just as they do in Time Base 'A'. In the other state, the Lockout Multivibrator over-rides the function of these controls and renders the time base inoperative.

At the beginning of a Time Base 'B' sequence, the Lockout Multivibrator holds the time base in the "Time Base Inoperative" state. A pulse from the Unlock-Trigger Amplifier will switch the multivibrator to the "Time Base Operative" state and Time Base 'B' then either free runs or becomes triggerable. When Time Base 'B' completes one sawtooth, the Lockout Multivibrator resets to the "Time Base Inoperative" state. This sequence repeats for each sawtooth produced by Time Base 'B'.

The following information is closely related to the STABILITY control discussion under "Time Base Generators" in an earlier portion of this section. For better understanding of Time Base 'B' Lockout, the STABILITY control discussion should be read first.

Unless otherwise stated in the following descriptions, the 'B' STABILITY control is set for triggered operation and the 'B' MODE switch places the Lockout Multivibrator into one of the following modes of operation.

Single Sweep Mode

Refer to the block diagrams, Fig. 3-9 and Fig. 3-10 during the following descriptions. Fig. 3-10 represents the signal at the grid of V235A during one cycle of operation as follows:

1. Before t_0, V225B conducts during the "Lockout" period and holds the grid of V235A at voltage level E_1. At this voltage level, the Sweep-Gating Multivibrator cannot be triggered, nor will it free run.

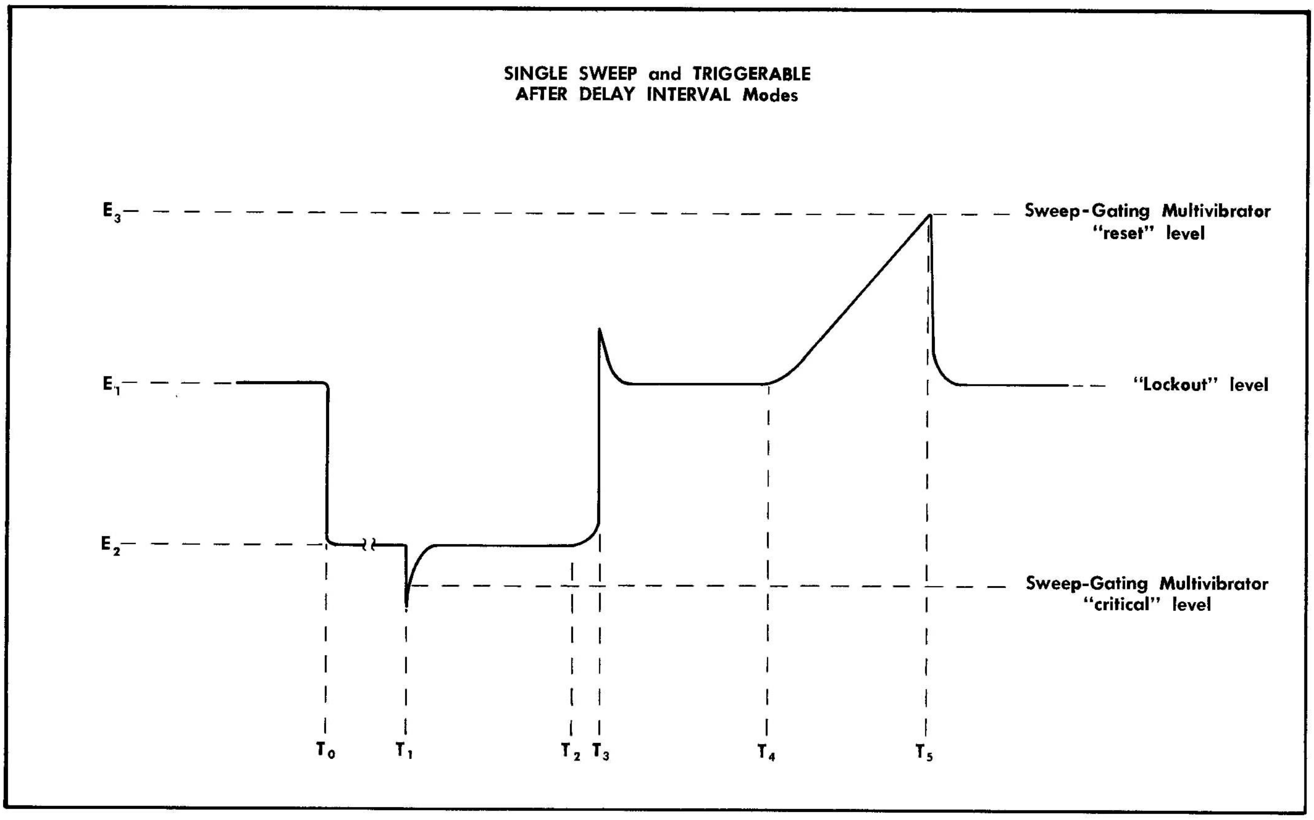

Fig. 3-10. Signal at the grid of V234A.

2. When the Single Sweep RESET button is pushed (t_o), V225B cuts off. The grid voltage of V235A drops sharply to the level where V225A conducts.

3. The STABILITY control determines the voltage (E_2) that V225A applies to the grid of V235A. The time base is now in the normal quiescent state and only requires a pulse from the Time Base Trigger circuit to start the sawtooth. This could occur immediately or at some indefinite later time.

4. When a trigger pulse is received (t_1), the sawtooth cycle will begin.

5. As the sawtooth reaches about one-half its final amplitude, the Hold-Off Cathode Follower, V245B, begins to conduct (t_2) and V225A cuts off (t_3).

6. As V225A cuts off, V225B again comes into conduction (t_3) and raises the grid voltage of V235A to the "Lockout" level (E_1). This voltage level is well below the "reset" level of the Sweep-Gating Multivibrator and therefore has no effect on the output sawtooth now in progress.

7. When the output sawtooth reaches about three-fourths its final amplitude, V245B begins to conduct again (t_4) and V225B cuts off. The sawtooth feedback raises the grid voltage of V235A to the reset level (E_3) and stops the sawtooth (t_5) in the normal manner.

8. As V245B continues to conduct, it reproduces part of the sawtooth retrace at the grid of V235A. But as the voltage approaches the "Lockout" level (E_1) V225B again conducts and V245B cuts off.

9. The voltage at the grid of V235A is now stable at the "Lockout" level (E_1). The cycle is complete and cannot repeat until the Single Sweep RESET button is pushed again.

Triggerable After Delay Interval Mode

This mode differs from the Single Sweep mode in that the "unlocking" pulse comes from the Delay Pickoff Circuit instead of the RESET push button. Also, the Time Base 'B' LEVEL control FREE RUN function is disconnected.

Manual Trigger Mode

The differences between this mode and the Single Sweep mode are as follows:

1. The "unlocking" pulse comes from the MANUAL TRIGGER push button instead of the RESET push button.
2. When the voltage drops at t_o (see Fig. 3-11), it drops to a more negative level (E_4) than in the Single Sweep mode. This level is below the "trip" level of the Sweep-Gating Multivibrator. Hence, the sawtooth cycle begins immediately without waiting for a pulse from the Time Base Trigger circuit. This occurs because the 'B' MODE switch by-passes the STABILITY control and causes V225A to conduct at the lower level.

Starts After Delay Interval Mode

The only difference between this mode and the Manual Trigger mode is that the "unlocking" pulse comes from the Delay Pickoff Circuit instead of the MANUAL TRIGGER push button.

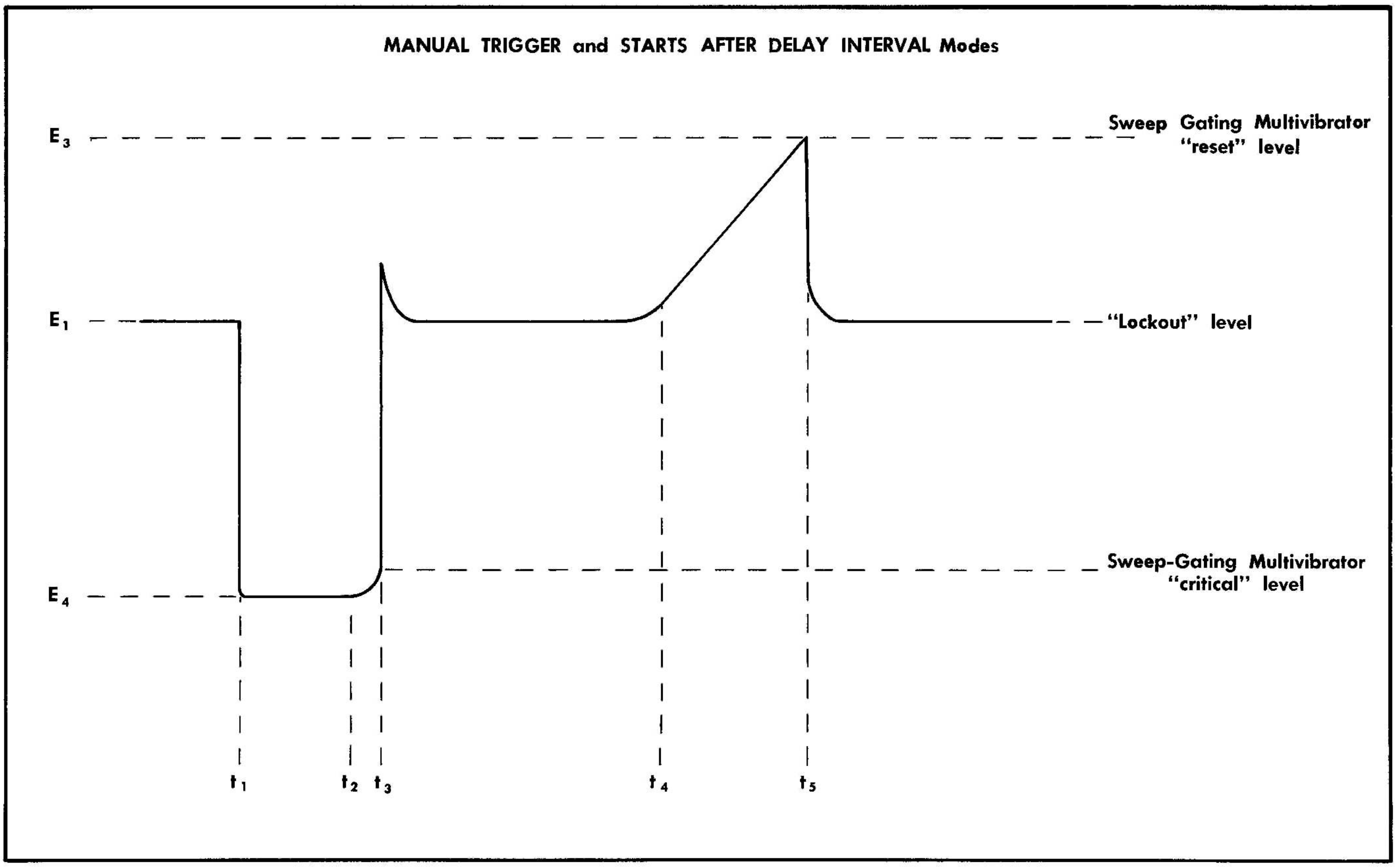

Fig. 3-11. Signal at the grid of V235A.

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Refer to the Time Base 'B' schematic in the back of this manual during the following description. For the remainder of this description, the 'B' MODE switch can be assumed to be set at any position except NORMAL TRIGGER.

Since there are two negative feedback paths between V225A and V225B (pin 6 to pin 9 and pin 8 to pin 7), the two tubes cannot conduct at the same time. When the time base is "locked out", V225B conducts and holds the cathodes of V225A and V245B considerably more positive than their grids. Hence, these two tubes are cut off.

The Unlock-Trigger Amplifier, V214, is self- biased near cutoff. The positive-going "unlocking" pulse applied to the control drives V214 into heavy conduction and produces a high amplitude negative-going pulse at the plate. This pulse is applied to the grid of V225B through C223-R223, driving its cathode considerably more negative than the grid of V225A, causing V225A to suddenly conduct. The voltage at the plate of V225A is already low in the presence of the negative-going pulse from the Unlock—Trigger Amplifier. Therefore, V225A conducts as a triode with its screen grid acting as the triode plate. As the pulse at the plate subsides and the plate voltage tends to rise, a greater portion of the cathode current in V225A flows to the pentode plate. Thus, the voltages at the pentode plate of V225A and at the grid of V225B do not rise after the pulse has subsided. V225A remains in conduction and V225B is cut off.

With V225B now conducting, the common cathode voltage is determined by the switches and STABILITY control in the tube's control grid circuit. This is exactly the same condition that exists when the time base is operated in the NORMAL TRIGGER mode. The time base will either free run or await a trigger pulse, depending upon the switch settings in the grid circuit of V225A.

From this point, the cycle continues to the end of the sawtooth rise as previously described.

At the end of the sawtooth rise, V245B has raised the common cathode voltage so that both V225A and B are cut off. When both tubes are cut off, V225B has the more positive control grid voltage. Hence, as the common cathode voltage goes more negative during the retrace portion of the sawtooth, V225B will come into conduction while V225A is still deep in cutoff. With the cycle completed and V225B conducting, the time base is again "locked out".

The LOCKOUT LEVEL control is adjusted during calibration to set the conduction level of V225B. Whenever V225B conducts, the common cathode voltage should be about half way between the reset and trip voltages of the Sweep-Gating Multivibrator.

The READY lamp lights only when V225B is cut off. The lamp therefore shows the operator whether or not the Sweep Gating Multivibrator is ready to operate.

HORIZONTAL AMPLIFIER

The Upper and Lower Beam Horizontal Amplifiers are nearly identical. The following descriptions apply to both amplifiers, but the Upper Beam Horizontal Amplifier circuit reference numbers are used.

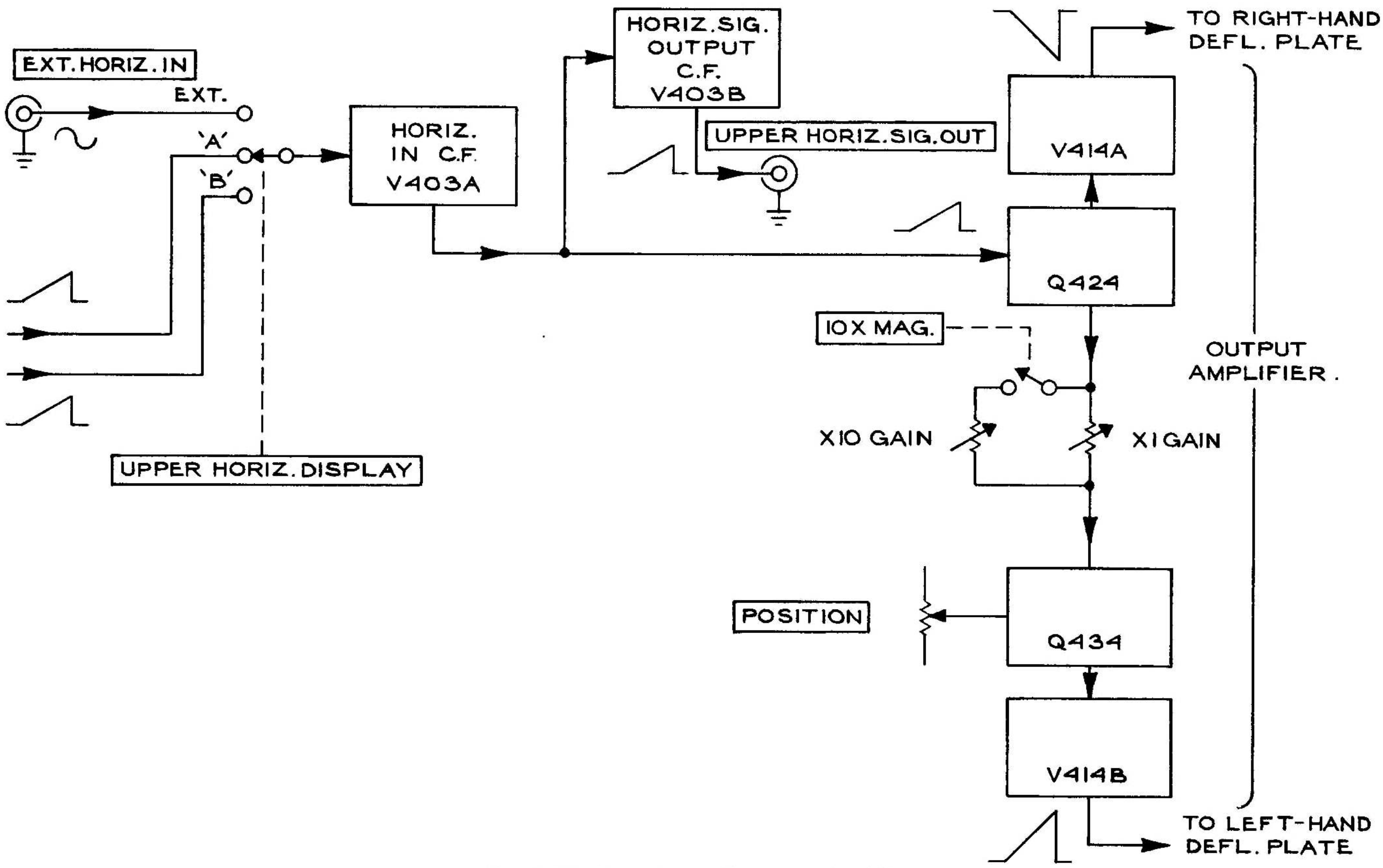


Fig. 3-12. Upper Beam Horizontal Amplifier.

The Horizontal Amplifier input signals can come from Time Base 'A', Time Base 'B', or from an external source. The appropriate signal is selected by setting the Horizontal Display switch.

Each Horizontal Amplifier has two outputs; a push-pull output connected to one pair of CRT horizontal deflection plates and a single-ended output at the rear panel for external use. The operator can increase the gain of the push-pull portion of the amplifier ten times by turning on the ten times magnifier (10X MAG.).

The block diagram, Fig. 3-12, shows the basic sub-circuits in the Horizontal Amplifier. V403A isolates the amplifier from the signal source and provides a low driving impedance for Q424. V403B isolates the amplifier from any reasonable load impedance connected to the rear panel horizontal signal output connector.

Q424, V414A, Q434, and V414B form a paraphase amplifier. The signal applied to Q424 varies the current through both Q424 and Q434. The current variations pass through V414A and B and produce a high amplitude voltage swing at the amplifier output. When the 10X MAG. switch is closed (pulled out) the resistance between the emitters of the transistors is decreased and the gain is increased ten times. The POSITION control determines the dc average voltage difference between the right and left hand deflection plates.

Refer to the Upper Beam Horizontal Amplifier schematic in the back of the manual during the following description.

When the UPPER HORIZ. DISPLAY switch is in the EXTERNAL position, from zero to 100% of an external signal will be applied to the grid of V403A, depending upon the EXT. HORIZ. GAIN control setting. When UPPER HORIZ. DISPLAY is set to 'A' TIME BASE, an attenuated sawtooth signal from Time Base 'A' is applied to the grid of V403A. The fixed attenuator consists of R971 and R975 as shown on the Horizontal Display Switching schematic. When UPPER HORIZ. DISPLAY is set to 'B' TIME BASE, the signal is an attenuated sawtooth from Time Base 'B'. The Time Base 'B' sawtooth passes through variable attenuator R981, R978, and R979. The UPPER BEAM SWEEP BAL. control, R979, is adjusted during calibration so the Time Base 'B' sawtooth will produce the same sweep rate on the crt as the equivalent Time Base 'A' sawtooth.

The Horizontal Input Cathode Follower, V403A, drives the base of Q424 and the grid of V403B. Since V403B is ahead of the Output Amplifier, the UPPER HORIZ. SIG. OUT is not affected by the 10X MAG. switch or the POSITION control.

The grid voltages on V414A and B are fixed at about +8 volts by the divider, R407-R408. Both tubes operate as grounded-grid amplifiers and their cathodes present a low impedance to the transistor collectors.

The transistors operate as a low impedance paraphase amplifier with degenerative emitter coupling. The resistance between the emitters and their current source, the —100 volt supply, is quite high. Because of this high resistance, the total current through the two transistors (and the tubes) is nearly constant and an input signal only reapportions the current. For example, an increase in current through Q424 is offset by a nearly equal decrease in current through Q434.

Fig. 3-13 shows how the input signal increases current through one transistor while equally decreasing current through the other. The input signal is distributed across the series resistances beginning at the internal emitter resistance of Q424 and ending with the internal emitter resistance of Q434. Since the external circuit is balanced for the two transistors, their internal emitter resistances are equal. Hence, the signal voltages developed across the base-emitter junctions will be equal.

Fig. 3-13 shows that the base of Q424 goes positive with respect to its emitter while the emitter of Q434 goes positive with respect to its base. Thus, the two transistors see equal, but opposite phase, input signals. The current increases through Q424 and decreases through Q434. These current variations pass through the tubes and develop the output signal across the plate load resistors.

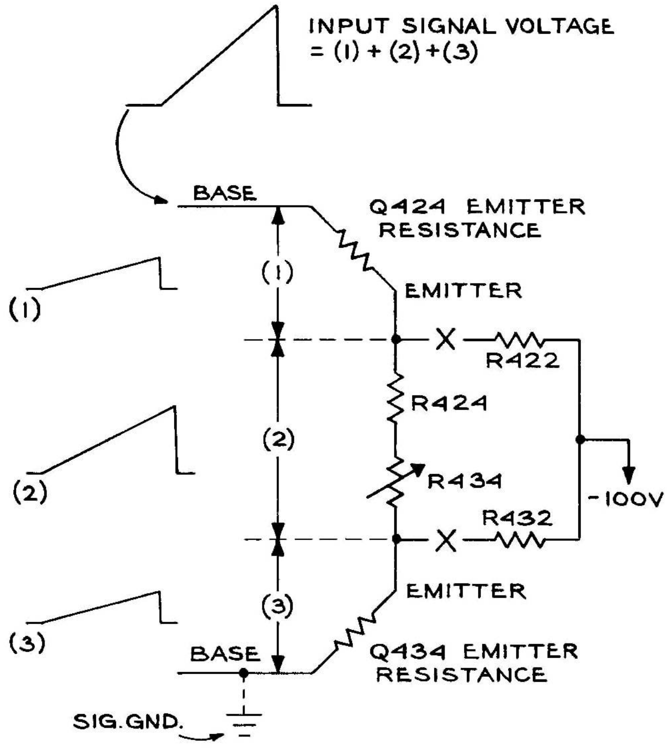


Fig.3-13. Horizontal Output Amplifier paraphase action.

The value of the resistance between the emitters determines the percentage of signal developed across the base-emitter junctions. This degeneration provides control of the amplifier gain.

X1 GAIN, R434, is set during calibration so the beam moves across the crt at the proper rate when the 10X MAG. is turned off. When the 10X MAG. is turned on, the series combination of R421 and R431 is in parallel with R424 and the X1 GAIN control. The emitter coupling resistance is decreased and the amplifier gain is increased. X10 GAIN is set during calibration so the amplifier gain is exactly ten times greater with the 10X MAG. turned on than with it off.

The current source resistors, R422 and R432, are shown disconnected in Fig. 3-13 to illustrate that the signal changes the total current through them very little. However, due to the signal across the emitter coupling resistance, the current through R432 decreases slightly while it increases slightly through R422.

When the transistor base voltages are equal, the transistor currents should also be equal so the beam will be at the horizontal center of the crt. When the 10X MAG. is turned on, the emitter coupling resistance is small and the current will essentially balance. But, when the 10X MAG. is turned off, the greater resistance can cause a current imbalance, if the two halves of the amplifier are not exactly equal. Hence, the SWP. MAG. REGIS., R433, is adjusted during calibration to balance the current with the 10X MAG. turned off. Then, when the beam is at the center of the crt with the 10X MAG. on, it will remain at the center when the 10X MAG. is turned off.

LOW VOLTAGE POWER SUPPLIES

General

The Low Voltage Power Supplies consist of four interdependent, regulated voltage sources. Each supply is capable of maintaining an accurate dc output voltage having a low percentage of ripple, even though the input line voltage and the output load may vary considerably.

—100 Volt Supply

When the design-center voltage is applied to the primary of T601, the voltage across secondary terminals 6 and 11 is about 145 volts rms. This voltage is applied to a conventional full-wave bridge rectifier, D612, producing about 200 volts dc across filter capacitor C611. This voltage is then divided between the load and the series regulator tubes. The block diagram Fig. 3-14 shows the basic elements of the circuit which accomplish this division.

The regulator tubes function as a variable resistor in series with the load. In order to maintain a stable voltage across the load, their plate resistance must be changed as required to offset the effect of a change in line voltage or load current. To accomplish this, the output voltage is constantly compared to a fixed reference voltage by the comparator V636. Any error thus detected is amplified and applied to the series regulators. Their plate resistance is thereby changed and the proper output voltage is restored.

Refer to the Power Supply schematic in the back of this manual. The voltage reference tube V639 applies a stable —85 volts to the 'A' grid of a long-tailed difference amplifier V636. This establishes an essentially constant voltage at the common cathodes of both V636A and V636B. A sample of the supply output voltage is obtained from the —100 VOLTS control, R624. (This sample will always be about —85 volts,

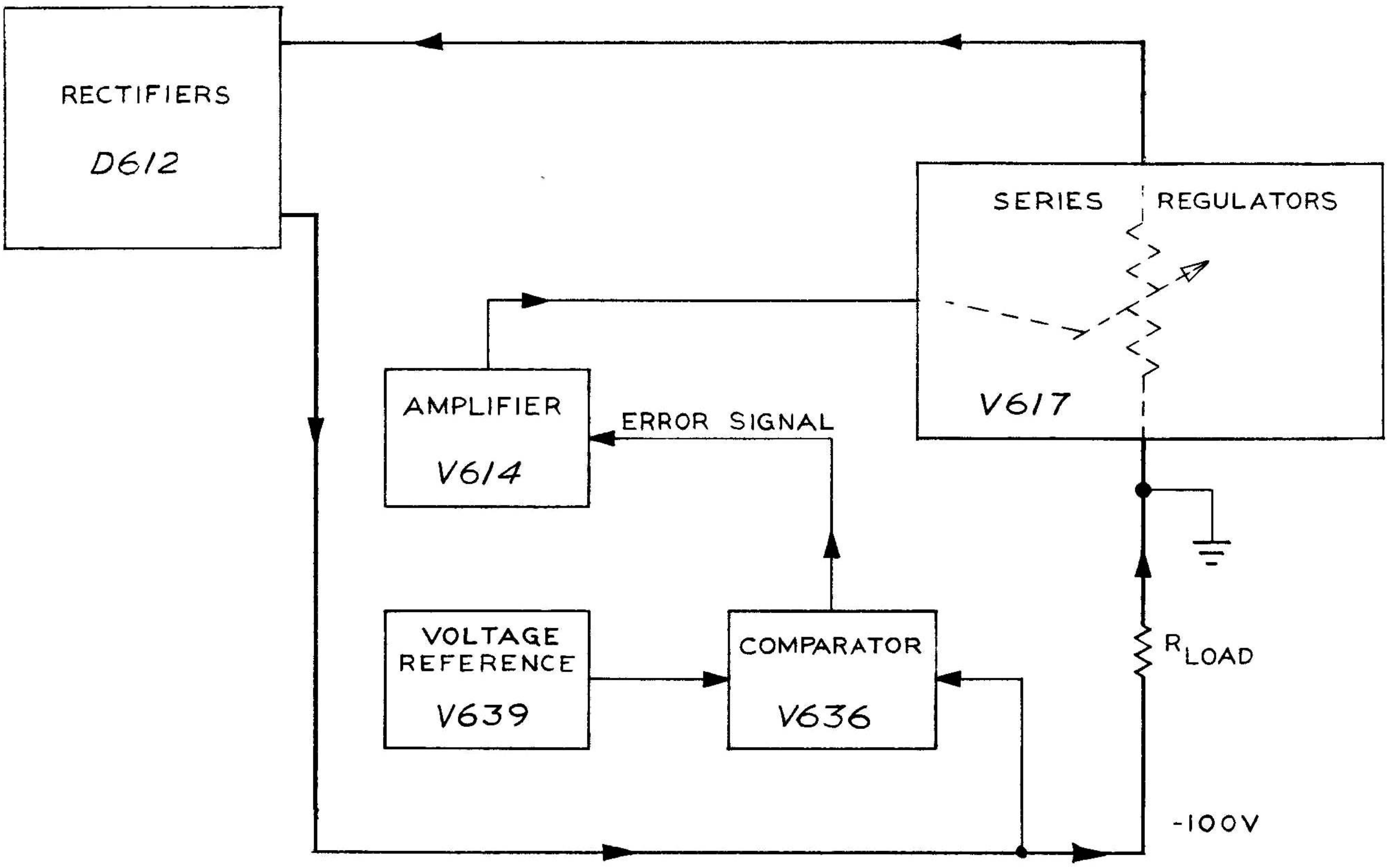


Fig. 3-14. —100-Volt Supply.

since it is the voltage actually being regulated to match the reference voltage. Since the —100 VOLTS control is set so the sample is 85% of the total voltage across R623, R624 and R625, the total voltage will also be regulated.) If a positive-going change occurs in the output voltage, the grid voltage on V636B changes in the positive direction. The current through V636B increases and its plate voltage drops. This negative-going voltage change is applied to the control grid of amplifier V614. The current through V614 decreases and its plate voltage rises, carrying the grids of V617 and V627 positive. The regulator tubes' plate resistance decreases, therefore increasing the current through the load. This results in an increased voltage drop across the load, thus offsetting the error.

Negative-going changes are corrected in the same way except for error signal polarities. Due to the high gain of the amplifier circuits and their ability to respond quickly, the supply in effect corrects for changing line voltage and load conditions before a significant change can occur in the output voltage.

The dc voltage across C611 bears a substantial amount of ripple. A sample of this ripple is applied to the screen grid of V614. The screen grid acts as a second signal grid and aids in eliminating much of the ripple from the supply output. C636 and C629 also aid in eliminating ripple since they offer less attenuation to ac error signals than do the resistive voltage dividers. C626 lowers the supply output impedance.

R626 and R627 are particularly important elements in the —100 volt supply. It would be impractical to pass all of the current required by the load through the series regulator tubes. Since line voltage and load current variation limits are known, the series regulator tubes need only carry enough current to allow for these variations. Hence, R626 carries a substantial amount of the current required by the circuits within the Type 565. R627 serves the same purpose for each of the vertical plug-in units. Depending on the amount of current required by each type of plug-in unit, the connections within the plug-in will be one of the following:

1. No connection to pin 22 of the plug-in unit interconnecting plug (low current demand).
2. A resistor connected between pins 22 and 9 (moderate current demand).
3. A wire connected between pins 22 and 9 (maximum current demand).

+125 Volt Supply

The operation of the +125 volt supply is similar, in most respects, to that of the —100 volt supply.

The —100 volt supply serves as the voltage reference for the +125 volt supply. R673 and R674 are the principle circuit elements that determine the accuracy of the output voltage.

Full-wave rectification of the ac supply voltage is provided by rectifiers D662A and D662B. These two diodes are shared with the +300 volts supply to form half of a full-wave bridge.

+300 Volt Supply

The only significant difference between the +125 and +300 volt supplies is the +420 volt unregulated output associated with the +300 volt supply. This voltage is used in the oscillator portion of the Crt Circuit.

—12.2 Volt Supply

R643 and R644 provide the reference voltage at the base of Q644. Any voltage error at the emitter of Q644 is amplified, but not inverted, and applied to the base of Q654. Q654 amplifies and inverts the error signal, providing the necessary drive for the series regulator Q657. C647 and R647 provide phase correction for Q654, thereby stabilizing the regulator.

The —12.2 volt supply does not employ shunt resistors as do the other three supplies. Instead, all load current passes through the series regulator. Fuse F640 protects Q657 from overload. C657 reduces the supply output impedance.

CRT CIRCUIT

CAUTION

Always make or break voltmeter connections at any of the high-voltage points in the Crt Circuit (except for the HIGH VOLTAGE TEST POINT) while the instrument is turned off. If a connection is made or broken while the power is on, a small arc may occur which will produce voltage and current transients within the circuit. Such transients can destroy one or more of the semiconductor devices in the Crt Circuit.

High Voltage Power Supply

The cathode-ray tube (crt) in the Type 565 Oscilloscope requires an accelerating potential of about 4100 volts. Approximately 200 volts of this is supplied by the low-voltage power supply. The remaining 3900 volts comes from the high-voltage power supply.

The high-voltage power supply consists of an oscillator, a step-up transformer, rectifiers, and circuits which regulate the high voltage (see Fig. 3-15). Transformer T801 steps up the oscillator signal to the required amplitude, and V822 rectifies the signal, producing high voltage dc. This voltage is applied to the crt from several points in a high resistance voltage divider which includes the INTENSITY and FOCUS controls.

Refer to the Crt Circuit schematic in the back of this manual. The oscillator is a modified Hartley which operates at a frequency determined by the primary winding inductance and inter-turn capacitance of transformer T801. Oscillator frequency is not critical and is usually between 30 kc and 50 kc. The voltage on the screen grid of V800 determines the amplitude of the oscillator signal, which in turn determines the value of dc high voltage produced. This property of the circuit is used to establish and maintain the correct high voltage; —3900 volts.

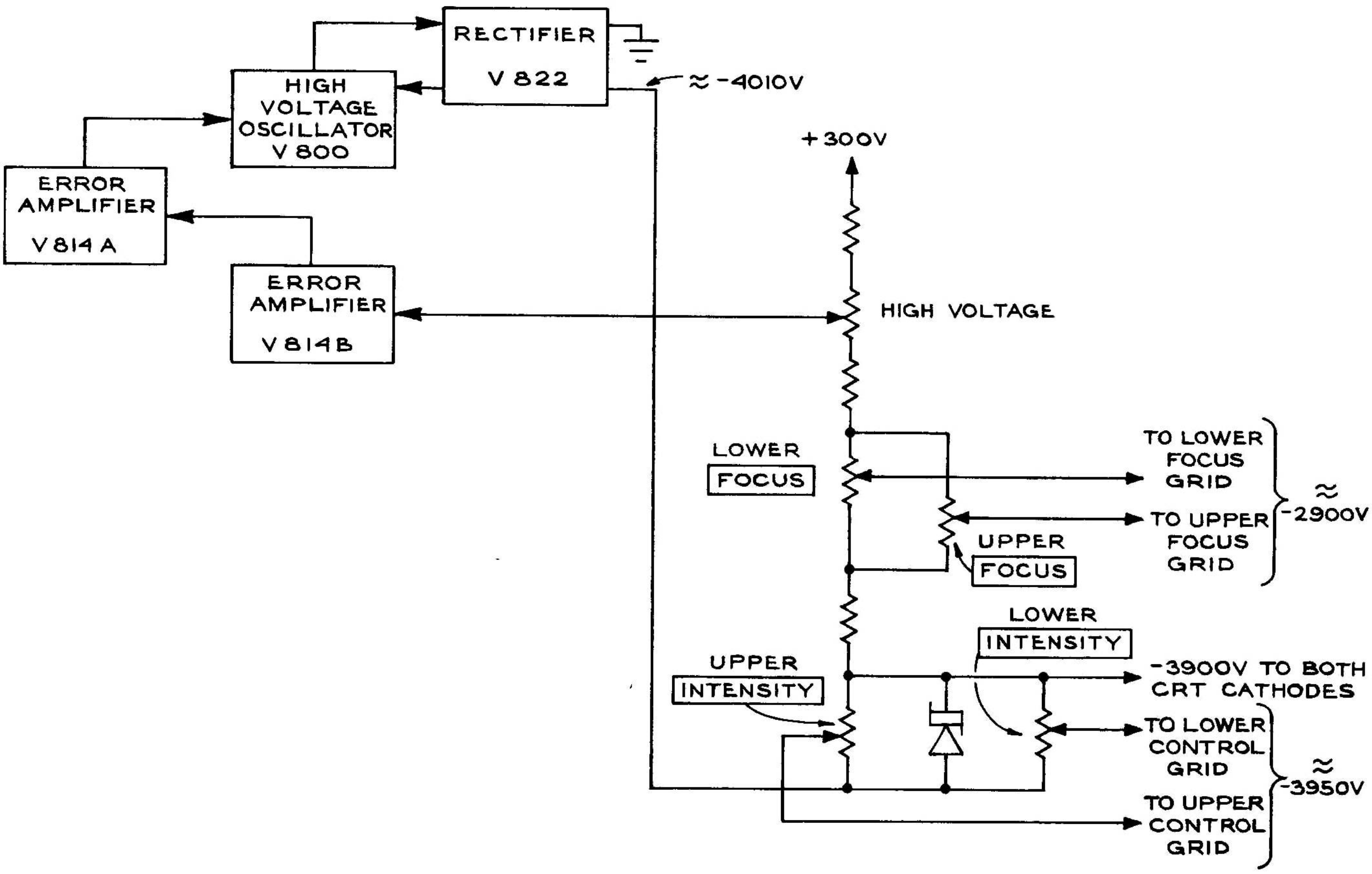


Fig. 3-15. High Voltage Power Supply.

The high voltage is applied to a high resistance voltage divider which includes the INTENSITY, FOCUS, and HIGH VOLTAGE controls. With any particular setting of the HIGH VOLTAGE control, a certain percentage of the total voltage across the voltage divider is applied to the grid of V814B. This grid voltage will always be about —103.5 volts, since it is the voltage actually being regulated. Since the grid voltage is regulated and is a known fraction of the high voltage, the high voltage will also be regulated.

When the voltage at the grid of V814B is —103.5 volts, the voltage at the plate of V814B and the grid of V814A will be about —2 volts. The voltage at the plate of V814A and at the screen of V800 will be about +90 volts. If the high voltage should change, the voltage at the grid of V814B will also change. This change will be amplified by V814B and V814A, thus changing the voltage on the screen of V800. If, for example, the screen voltage is made more positive, the oscillator signal amplitude will increase and a greater dc high voltage will be produced.

Due to C862, the high gain of the error amplifier, and the ability of the circuit to respond quickly, there is rarely any significant variation in the high voltage. This is because the correction for any change begins at nearly the same instant as the change. Thus, a change is stopped and corrected before it can become more significant.

Intensifying Circuit

The Intensifying Circuit operates only when the TRIGGERABLE AFTER DELAY INTERVAL and STARTS AFTER DELAY INTERVAL modes of Time Base 'B' are used. Its only function is to dc couple a positive-going pulse to the upper beam CRT control grid. The normal voltage on this grid is about —3975 volts. The positive-going pulse at the control grid will cause a brightened segment within the upper beam trace. (For more information about the purpose of the brightened trace segment, see "Using the 'B' MODE Switch" in Section 2 of this manual.)

The basic elements of the Intensifying Circuit are shown in Fig. 3-16. Pulse Shaper V834 converts the applied unblanking pulse into alternate positive and negative voltage pulses. These pulses actuate the bistable tunnel-diode switch D845 to produce a negative-going turn-on pulse for Current Switch Q843.

When the Current Switch Q843 is open, the floating 11-volt supply does not produce a voltage drop across R849. The voltage on the upper beam crt control grid during this time depends entirely upon the setting of the INTENSITY control. However, when the Current Switch is closed, current through R849 produces a voltage drop that drives the crt grid more positive. This causes a portion of the upper beam trace to be brightened.

For the following portion of the circuit description, refer to the Crt Circuit schematic in the back of this manual.

The LOWER HORIZ. DISPLAY switch provides a choice between three signal sources for unblanking the crt: 'A' Unblanking, 'B' Unblanking, or +125 volts dc. Each of these signals can cause the Intensifying Circuit to operate.

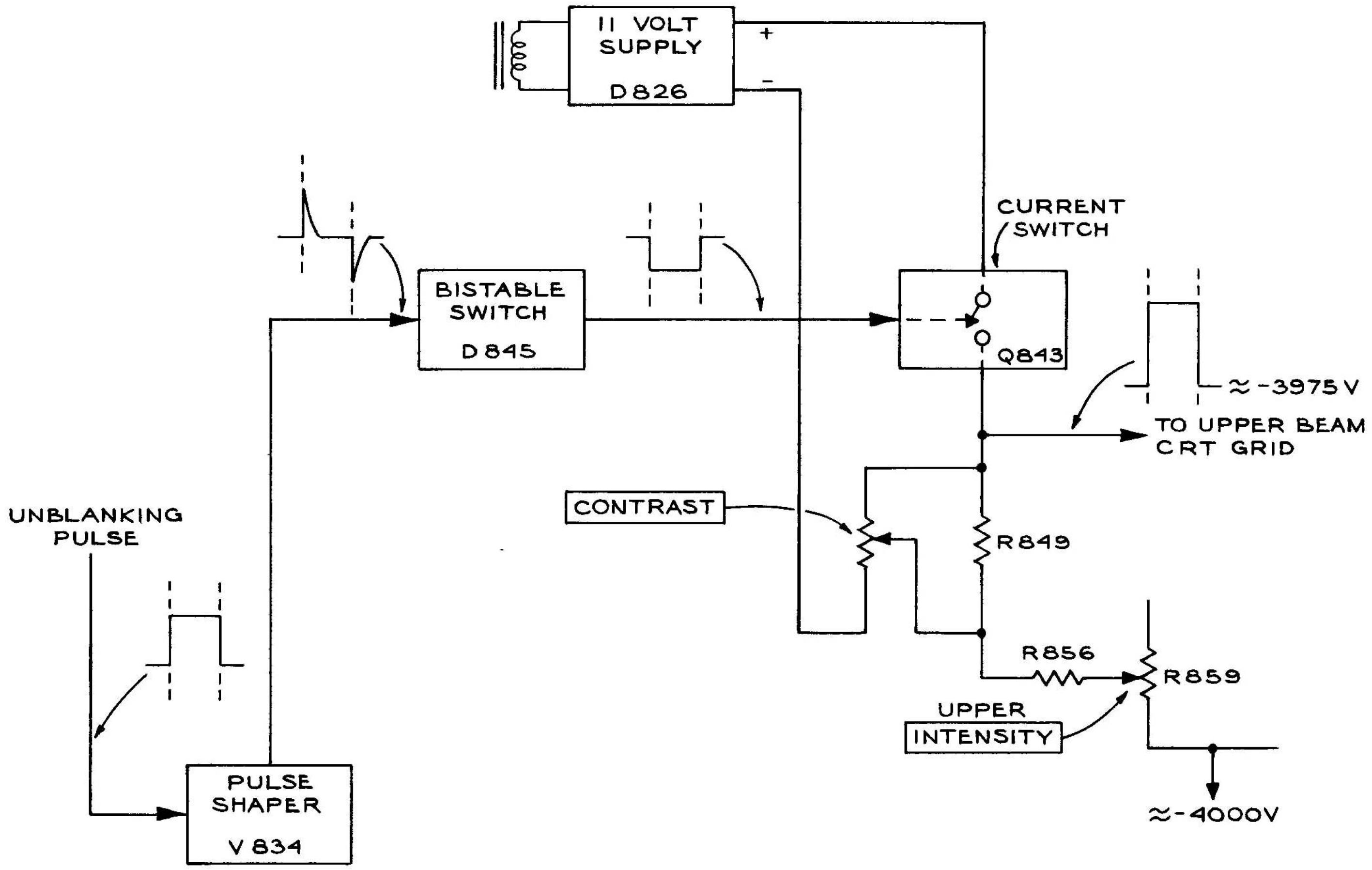


Fig. 3-16. Intensifying Circuit.

However, only the 'B' Unblanking signal will cause the Intensifying Circuit to produce an intensified crt display. Hence, the following description assumes the use of the 'B' Unblanking signal.

If Time Base 'B' is not generating a sweep, the CRT unblanking voltage from the LOWER HORIZ. DISPLAY switch is about +25 volts and V834 is cutoff. When Time Base 'B' is then triggered, the unblanking voltage switches sharply to about +125 volts and V834 conducts heavily. (It is important to note that the circuit operates only with the 'B' MODE switch in the STARTS AFTER DELAY INTERVAL or TRIGGERABLE AFTER DELAY INTERVAL position to provide cathode current for V834.) The sudden surge of current through T841 produces a sharp pulse in the secondary circuit.

The dynamic characteristics of tunnel diode D845 are shown in Fig. 3-17. Prior to the arrival of the pulse, the tunnel diode maintains stable forward conduction at point A on the curve. The voltage across the diode is then about 40 millivolts. This voltage is applied to the base-emitter junction of Q843, but is not sufficient to cause the transistor to conduct. Since there is no current through Q843, there is no voltage drop across R849 and the voltage on the upper beam crt control grid depends only on the setting of the INTENSITY control (usually about —3975 volts at normal trace brightness).

When the pulse is produced in the secondary circuit of T841, the diode is driven through point B on the curve. The diode is unstable at point B and therefore switches rapidly to point C. As the input pulse subsides, the diode is unable to continue operation at point C because R846 cannot satisfy the diode's simultaneous demands for heavy current and high state voltage. Current then diminishes and the diode assumes stable operation at point D.

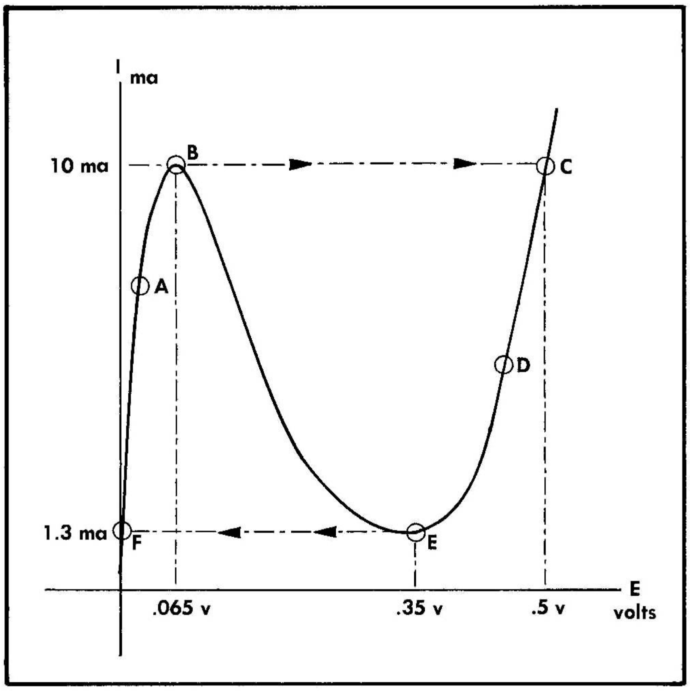


Fig. 3-17. D845 switching characteristics.

With the voltage across the diode now about 400 millivolts, Q843 is turned on. The current path is from the positive end of C828, through Q843, R849, to the CONTRAST control (R848), and to the negative end of C828. The voltage drop thus produced across R849 drives the upper beam crt control grid several volts in the positive direction. This causes an increase in crt beam current and the trace becomes brighter.

When the unblanking pulse ends, V834 is suddenly cutoff, producing a pulse in the secondary circuit with polarity opposite that of the previous pulse. The tunnel diode is driven from operating point D (Fig. 3-17) through point E. The diode is unstable at point E, and therefore switches rapidly to point F. At this point, R846 cannot satisfy the diode's demand for both low current and low state voltage. Therefore, the current increases and the tunnel diode resumes stable operation at point A. The transistor reverts to cutoff, the upper beam crt control grid voltage drops to its previous, more negative value, and the trace dims.

The CONTRAST control provides a means of controlling the amplitude of the intensifying pulse and therefore the amount of brightness increases during the brightened segment of the upper beam trace. This is accomplished in the following manner:

As is true with most switches, transistor Q843 has a very high series resistance when turned off and a very low series resistance when turned on. Therefore, nearly all of the 11-volt supply voltage is dropped across R849 when Q843 is turned off. Hence, by controlling the total voltage across the transistor and resistor, it is possible to control the output pulse amplitude.

The CONTRAST control R848 and R847 form a voltage divider across the 11-volt supply. By turning the CONTRAST control, the operator can vary the voltage across Q843 and R849 between about 2 and 11 volts.

Unblanking

A trace or spot can be obtained on the crt at all times when an external signal is used for horizontal deflection. However, such is not the case when horizontal deflection is provided by one of the time base generators. When the oscilloscope is used in the latter manner, a blanking signal from the time base generator is applied to the crt. This signal turns off the beam during sweep retrace and holds it off until the next sweep begins.

Each of the two crt electron guns has a deflection plate blanking system. A pair of deflection plates, similar to those used for vertical and horizontal deflection, is placed between the control and focus grids in each gun. One plate in each pair is permanently connected to the +125 volt supply. The second plate can be connected to the +125 volt supply or to one of the time base generators, depending on the setting of the horizontal display switches. The beam is constantly unblanked when the +125 volt (EXT.) switch position is used.

If one of the time base generators provides horizontal deflection for a particular beam, that beam will be alternately blanked and unblanked in the following manner:

Between sweeps, the voltage applied to the crt blanking plate by the time base generator will be about +25 to +30 volts With the other plate at +125 volts, the beam is drawn into and absorbed by the more positive plate. Little or no beam current gets past this point. When the time base generator begins a sweep, it quickly increases the voltage on the blanking plate to about +125 volts. Since the blanking plate potentials are then essentially equal, the beam current is released and passes on toward the face of the crt to produce light.

Multi-trace Chopped Blanking

The Type 565 Oscilloscope can be used with multi-trace plug-in units such as the Type 3A74. When this type of plug-in unit is operated in the "chopped" mode, the display may consist of up to four traces per beam. The plug-in forms the display by switching on each information-channel, one at a time, in a rapidly repeating sequence.

The vertical signal information available at the output of the plug-in during the very short time required to switch channels, is of no value in the display. Hence, this information is blanked out.

A pulse from the plug-in unit is available at pin 24 of the plug-in interconnecting jack when switching from one channel to the next. This pulse is coupled through a dc blocking capacitor to the appropriate crt cathode. The pulse momentarily drives the cathode positive and cuts off the beam current until the plug-in has finished switching to the next channel.

Diodes D892 and D882 are dc restorers. They insure equal trace brightness for the chopped and conventional mode. They permit the crt cathodes to be driven positive by the incoming signal, but prevent the cathodes from being driven more negative than the voltage at the HIGH VOLTAGE TEST POINT; —3900 volts.

Intergun Shield and Isolation Shield

Proper adjustment of the INTERGUN SHIELD and ISOLATION SHIELD controls insures that (1) a straight line display will appear as a straight line, regardless of its position on the screen, and that (2) a display which is well focused at the center of the screen will also exhibit good focus at the edge of the screen. These controls also affect the deflection sensitivity and scan limits of the crt.

Trace Alignment

The trace alignment coil surrounds the crt at a point about 6 inches behind the face plate. The plane of the coil is parallel to the plane of the face plate. The TRACE ALIGNMENT control determines the amount and direction of the dc current through the coil. By adjusting this control, the entire display can be rotated a few degrees clockwise or counterclockwise about the axis of the crt.

Display alignment is affected by the earth's magnetic field and may change when the instrument is moved. In such cases, the operator can quickly realign the display with the graticule markings by adjusting the TRACE ALIGNMENT control.

AMPLITUDE CALIBRATOR

The Amplitude Calibrator generates square waves of an accurate peak-to-peak voltage available in six steps at the CAL. OUT connector. The square wave output is positive-going from ground. The frequency is about one kc, rise and fall times are several microseconds, and the duty factor is about 0.5. Because of its intended use, only the peak-to-peak voltage accuracy of the Amplitude Calibrator is given a specific tolerance.

Refer to the block diagram, Fig. 3-18. The Amplitude Calibrator consists of an astable multivibrator, an output cathode follower, and a precision output divider. The multivibrator switches the cathode follower alternately between cutoff and conduction. The cathode follower output voltage is an accurate +100 volts during conduction and zero volts during cutoff. The output divider provides five lower amplitudes from the basic 100 volt square wave. The CAL. OUT voltage is selected by setting the PEAK-TO-PEAK VOLTS switch to the desired value.

Refer to the Amplitude Calibrator schematic diagram in the back of the manual.

V915A and V905 form a conventional astable plate coupled multivibrator. In the multivibrator action, V905 operates as a triode with the screen grid acting as the plate. When V905 conducts, a portion of the cathode current goes to the pentode plate and drops the plate voltage to about —20 volts. This voltage is applied to the grid of V915B. V915B is cutoff and its cathode voltage is zero.

When V905 is cut off, the voltage at its plate is determined by the voltage divider; R909, R910, and R911. The CAL. AMPL. control, R910, is set during calibration so the voltage at the cathode of V915B will be exactly +100 volts when V905 is cut off.

A 0.25 ohm resistor located between the CAL. OUT coax connector and ground is approximately equal to the resistance of the braid of a 42 inch long RG-58A/U coax cable. Its purpose is to cancel any coax braid ground current effects on calibrator voltage accuracy that may exist when the Type 565 AMPLITUDE CALIBRATOR is used as a signal source between the oscilloscope and some other instrument chassis. The ground currents in this case are usually developed in the ac power line third-wire grounding system when the Type 565 and the other instrument chasses are supplied from different convenience outlets.

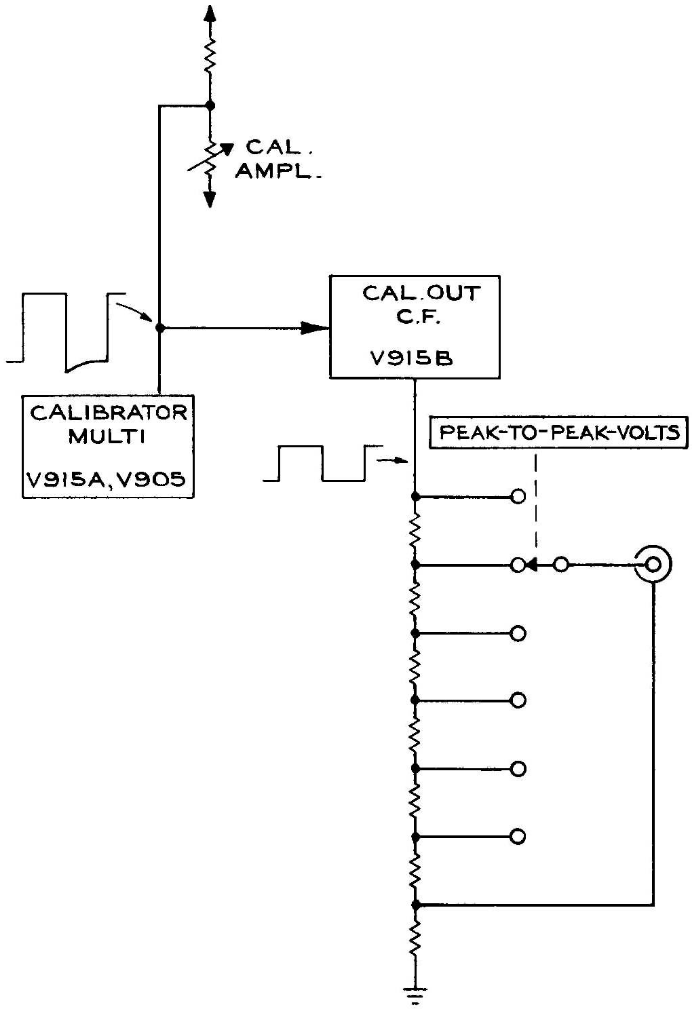
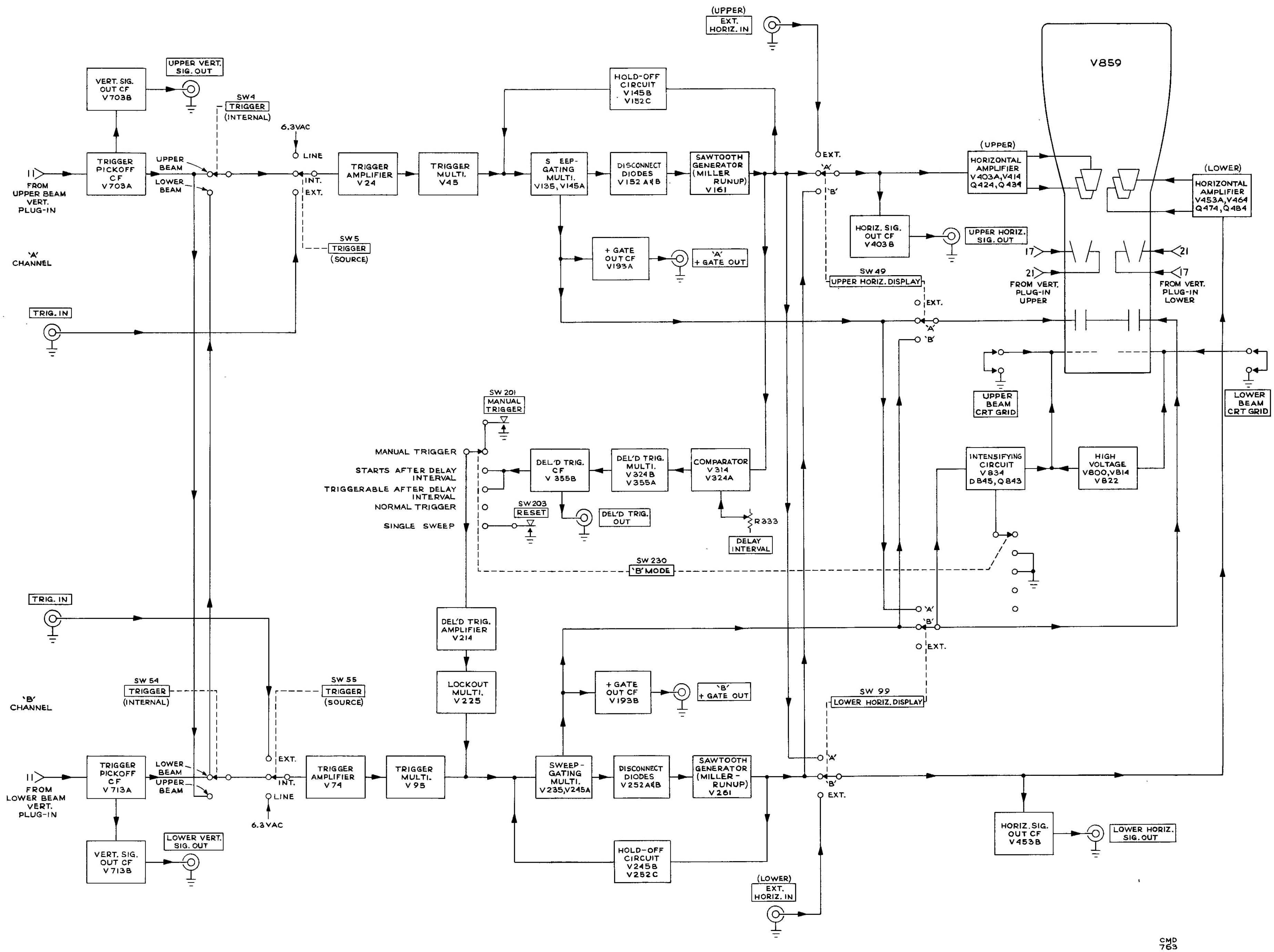


Fig. 3-18. Amplitude Calibrator.

Ⓐ



TYPE 565 OSCILLOSCOPE

BLOCK DIAGRAM

IMPORTANT:
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.

VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

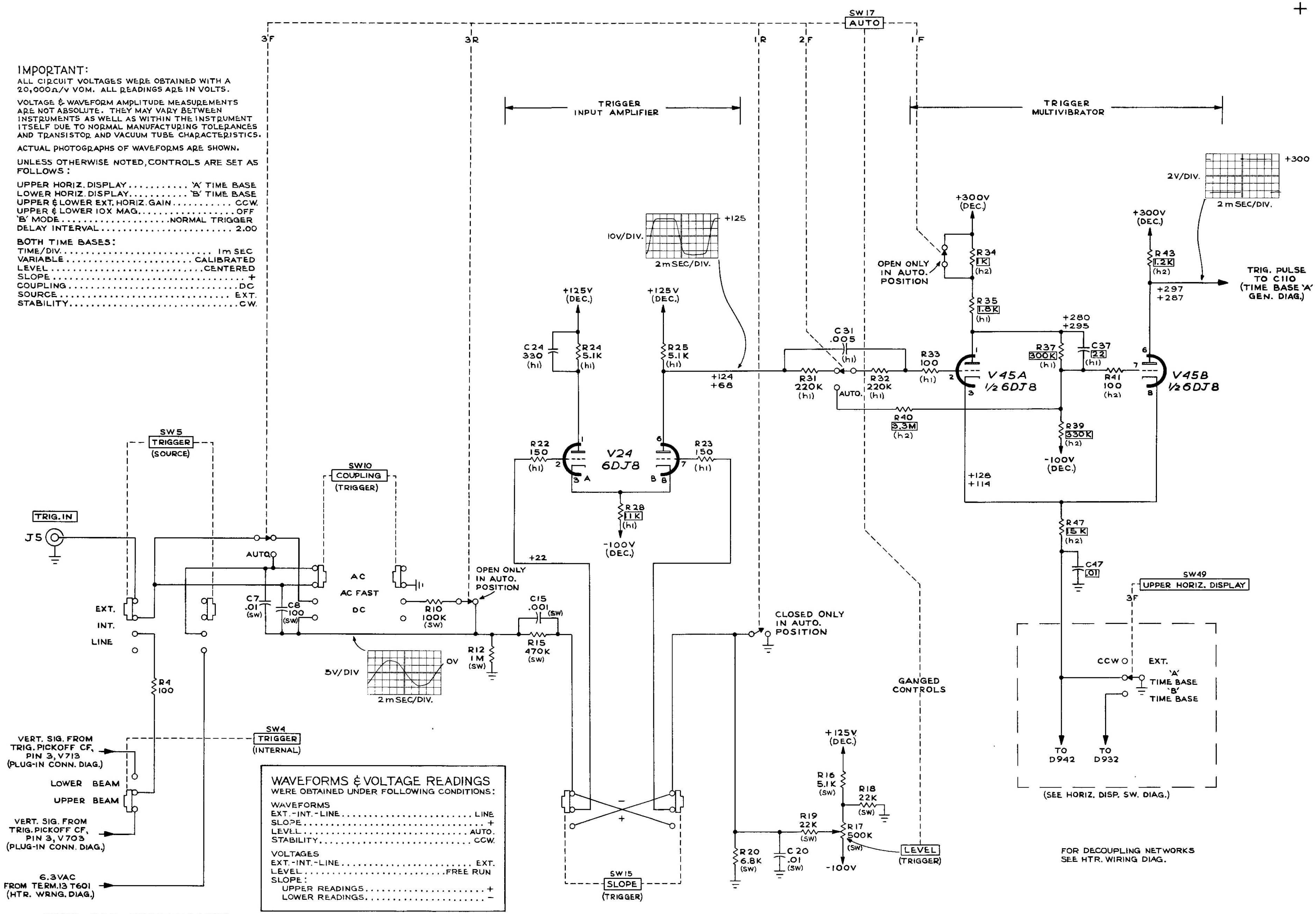
ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

UNLESS OTHERWISE NOTED, CONTROLS ARE SET AS FOLLOWS:

UPPER HORIZ. DISPLAY	'A' TIME BASE
LOWER HORIZ. DISPLAY	'B' TIME BASE
UPPER & LOWER EXT. HORIZ. GAIN	CCW.
UPPER & LOWER 10X MAG.	OFF
'B' MODE	NORMAL TRIGGER
DELAY INTERVAL	2.00

BOTH TIME BASES:

TIME/DIV.	1m SEC
VARIABLE	CALIBRATED
LEVEL	CENTERED
SLOPE	+
COUPLING	DC
SOURCE	EXT.
STABILITY	CW.



WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS:

WAVEFORMS

EXT.-INT.-LINE	LINE
SLOPE	+
LEVEL	AUTO.
STABILITY	CCW.

VOLTAGES

EXT.-INT.-LINE	EXT.
LEVEL	FREE RUN
SLOPE:	
UPPER READINGS	+
LOWER READINGS	-

FOR DECOUPLING NETWORKS SEE HTR. WIRING DIAG.

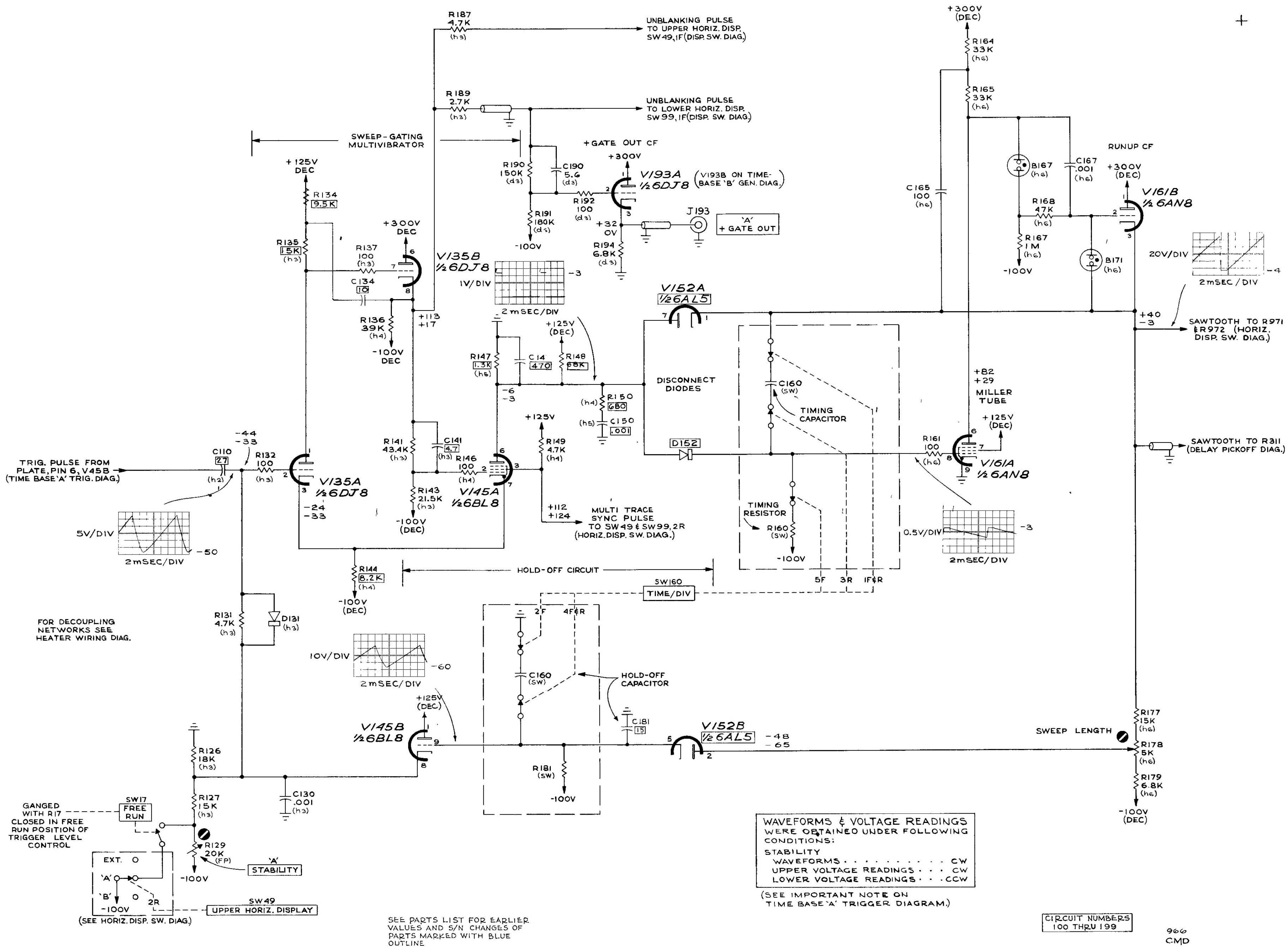
TYPE 565 OSCILLOSCOPE

CIRCUIT NUMBERS 1 THRU 49

CMD 763

TIME BASE 'A' TRIGGER

A

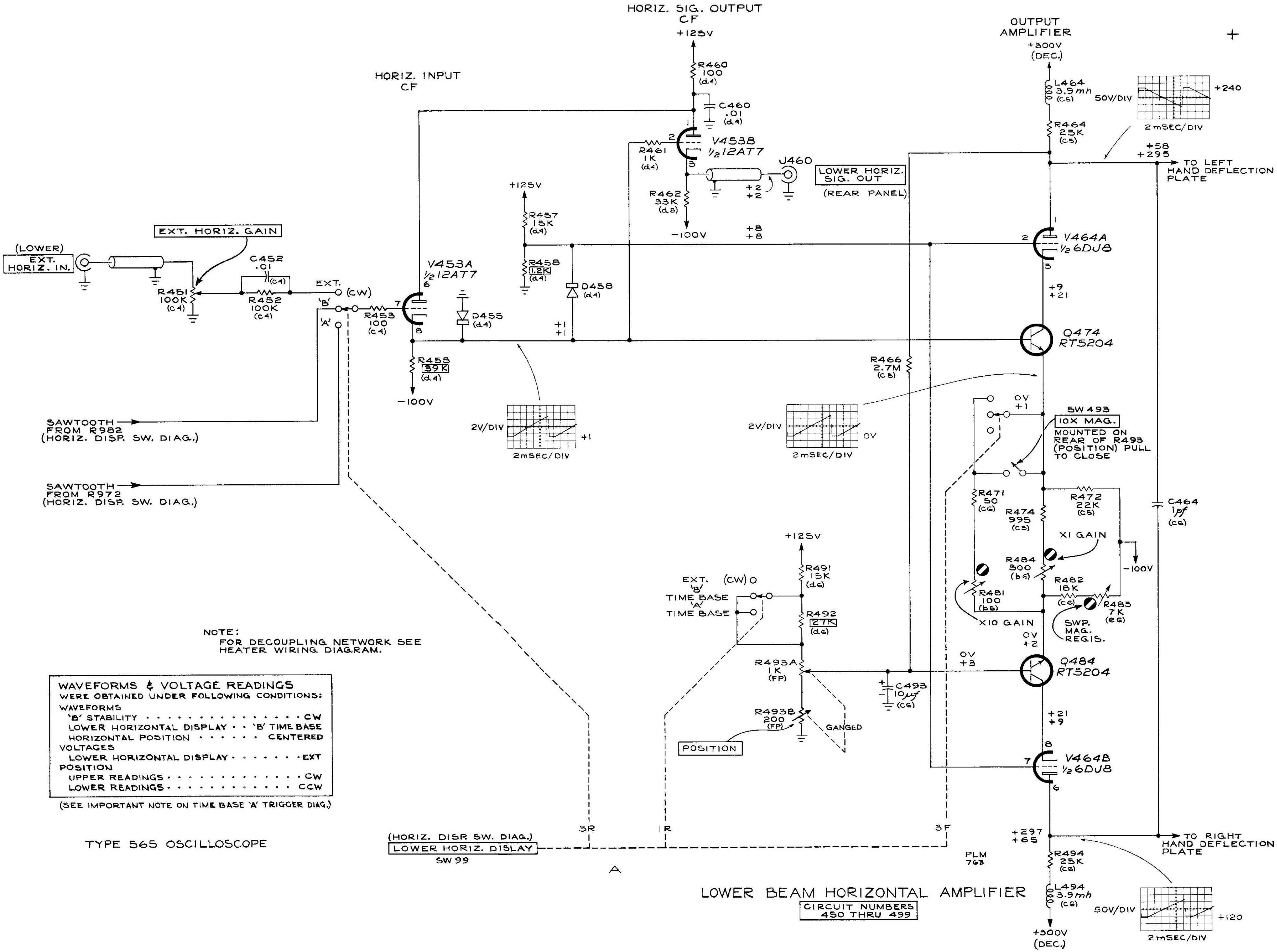


TYPE 565 OSCILLOSCOPE

C

TIME BASE 'A' GENERATOR

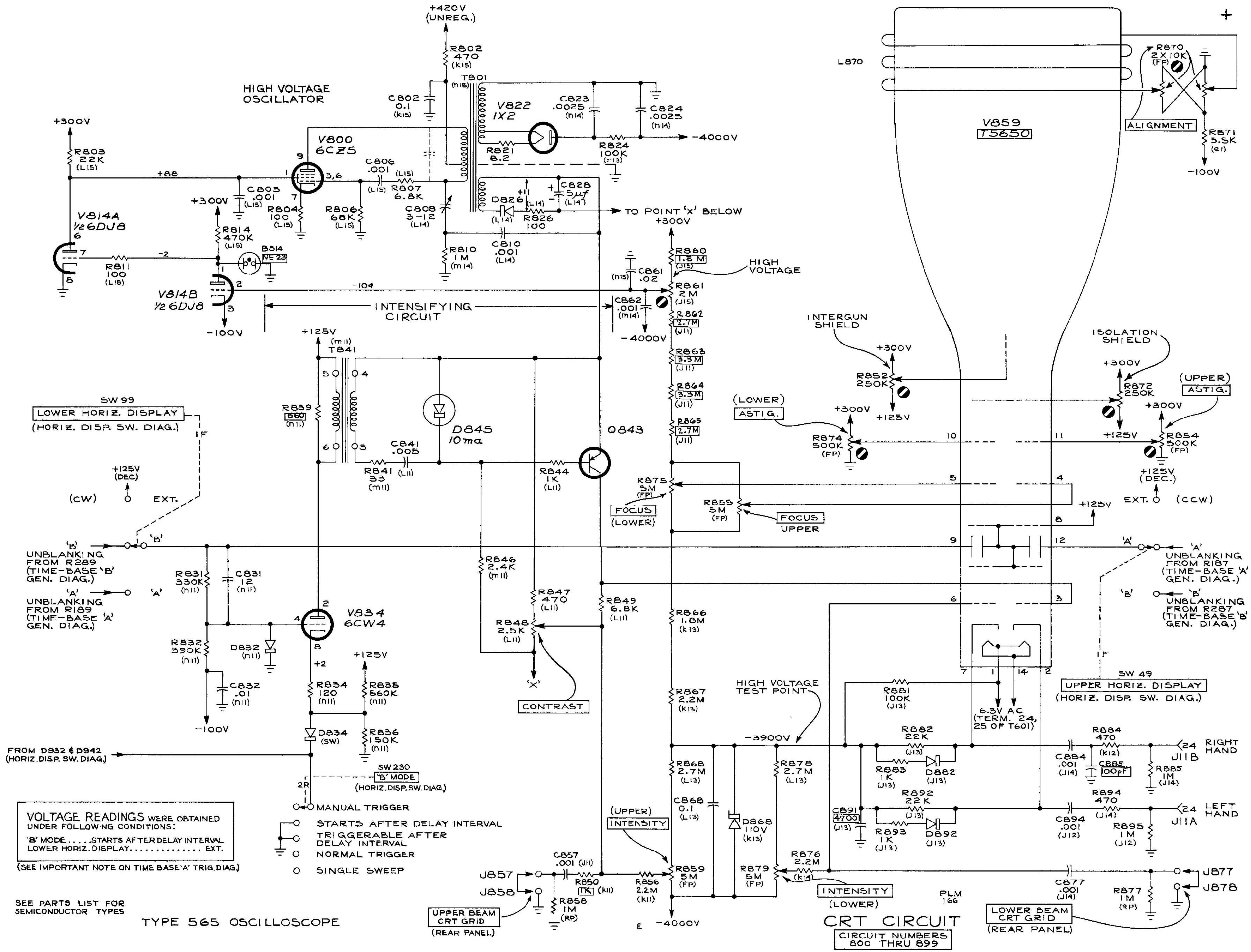
966 CMD



LOWER BEAM HORIZONTAL AMPLIFIER

CIRCUIT NUMBERS
450 THRU 499

TYPE 565 OSCILLOSCOPE



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:
'B' MODE.....STARTS AFTER DELAY INTERVAL
LOWER HORIZ. DISPLAY.............EXT.

(SEE IMPORTANT NOTE ON TIME BASE 'A' TRIG. DIAG.)

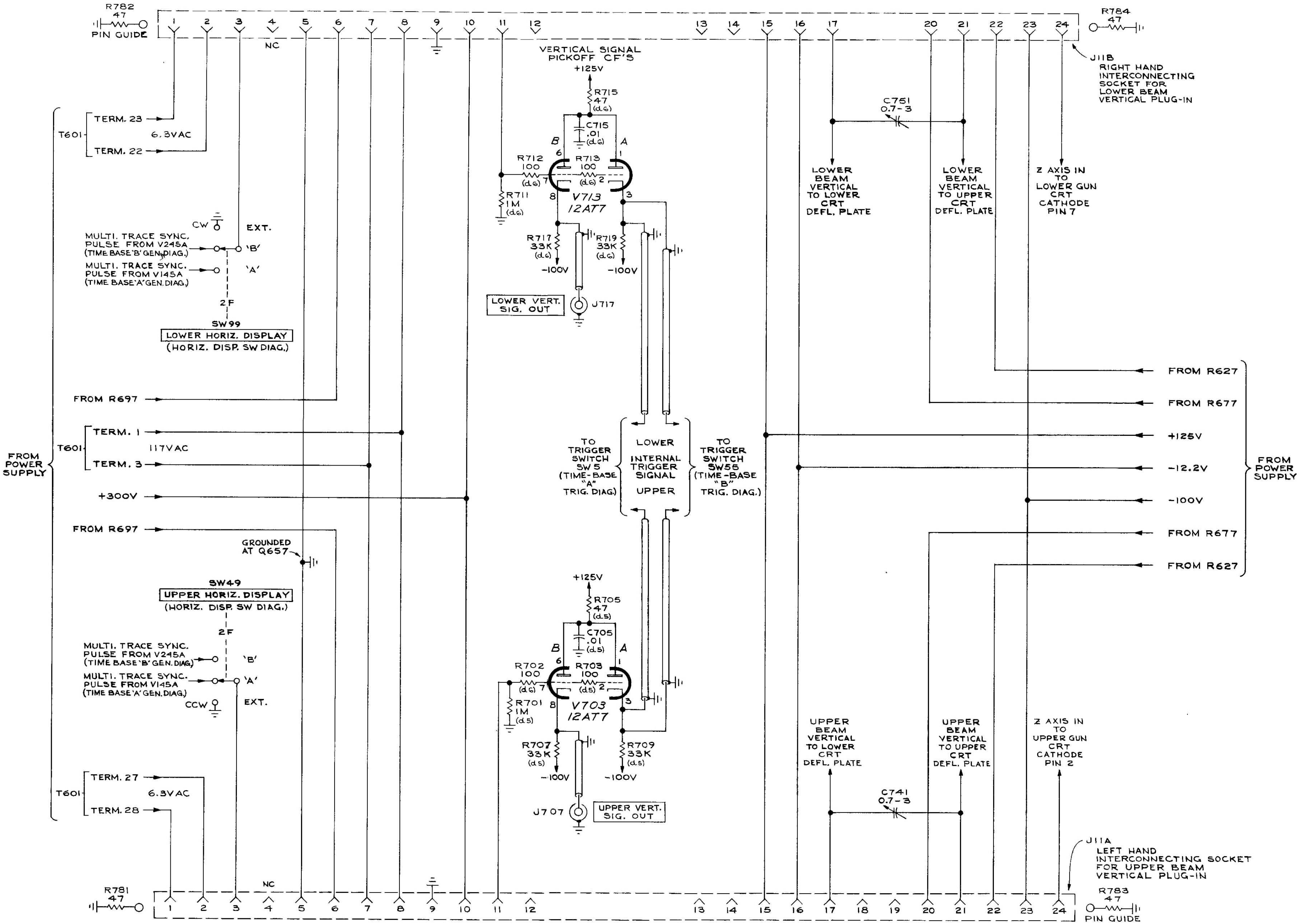
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TYPE 565 OSCILLOSCOPE

PLM 166

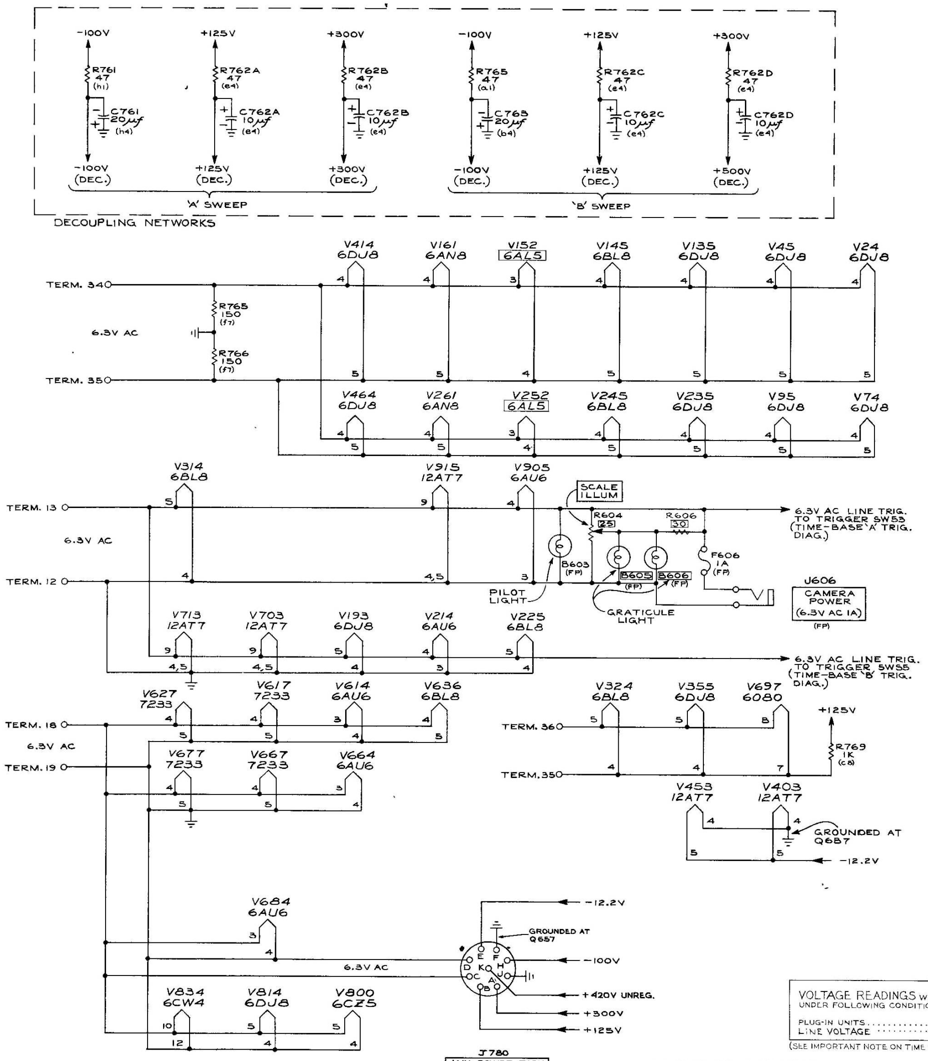
CRT CIRCUIT

CIRCUIT NUMBERS 800 THRU 899



MRH
763

TYPE 565 OSCILLOSCOPE   A   PLUG-IN CONNECTORS



VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

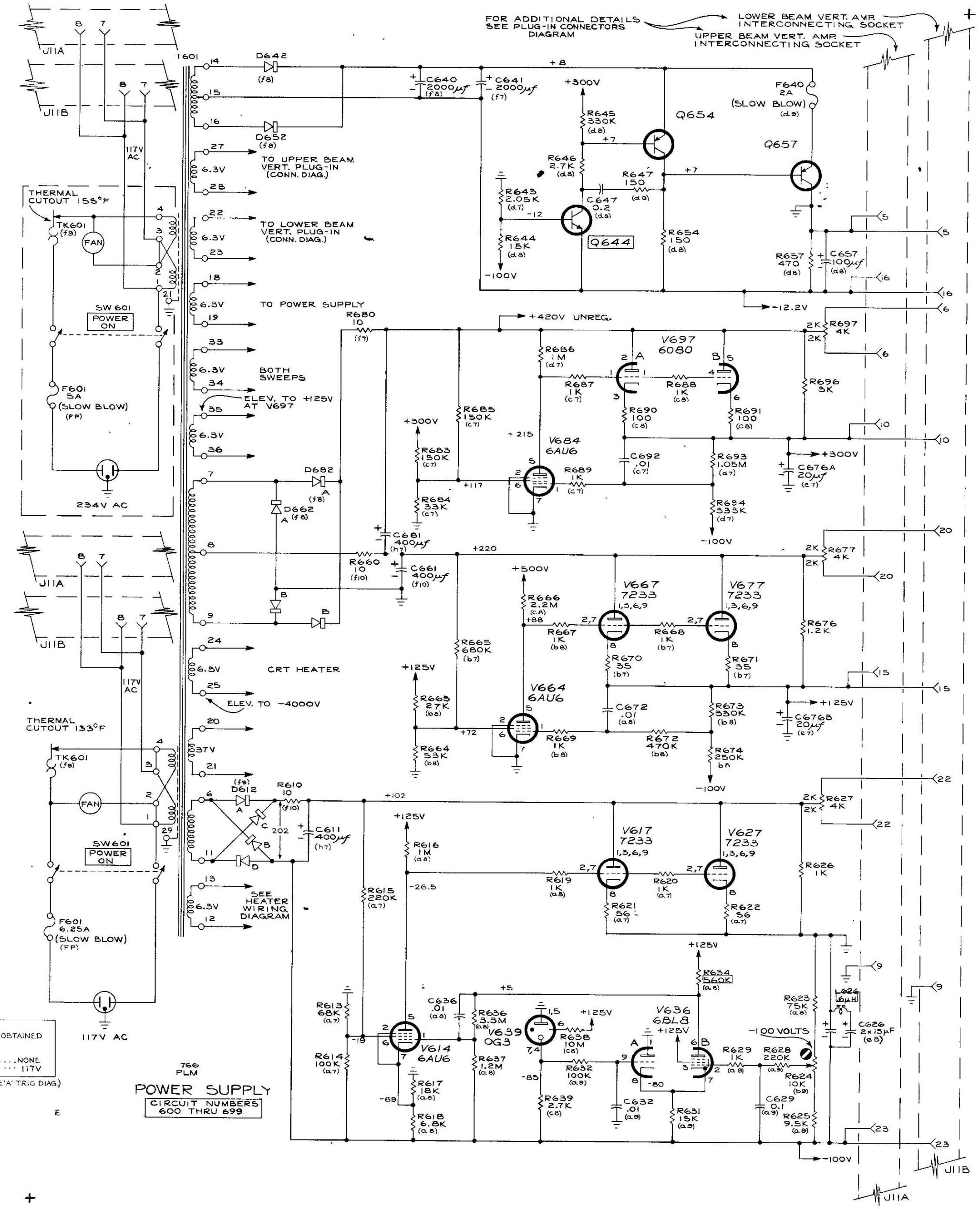
PLUG-IN UNITS .... NONE

LINE VOLTAGE 117V

(SEE IMPORTANT NOTE ON TIME BASE 'A' TRIG DIAG.)

TYPE 565 OSCILLOSCOPE

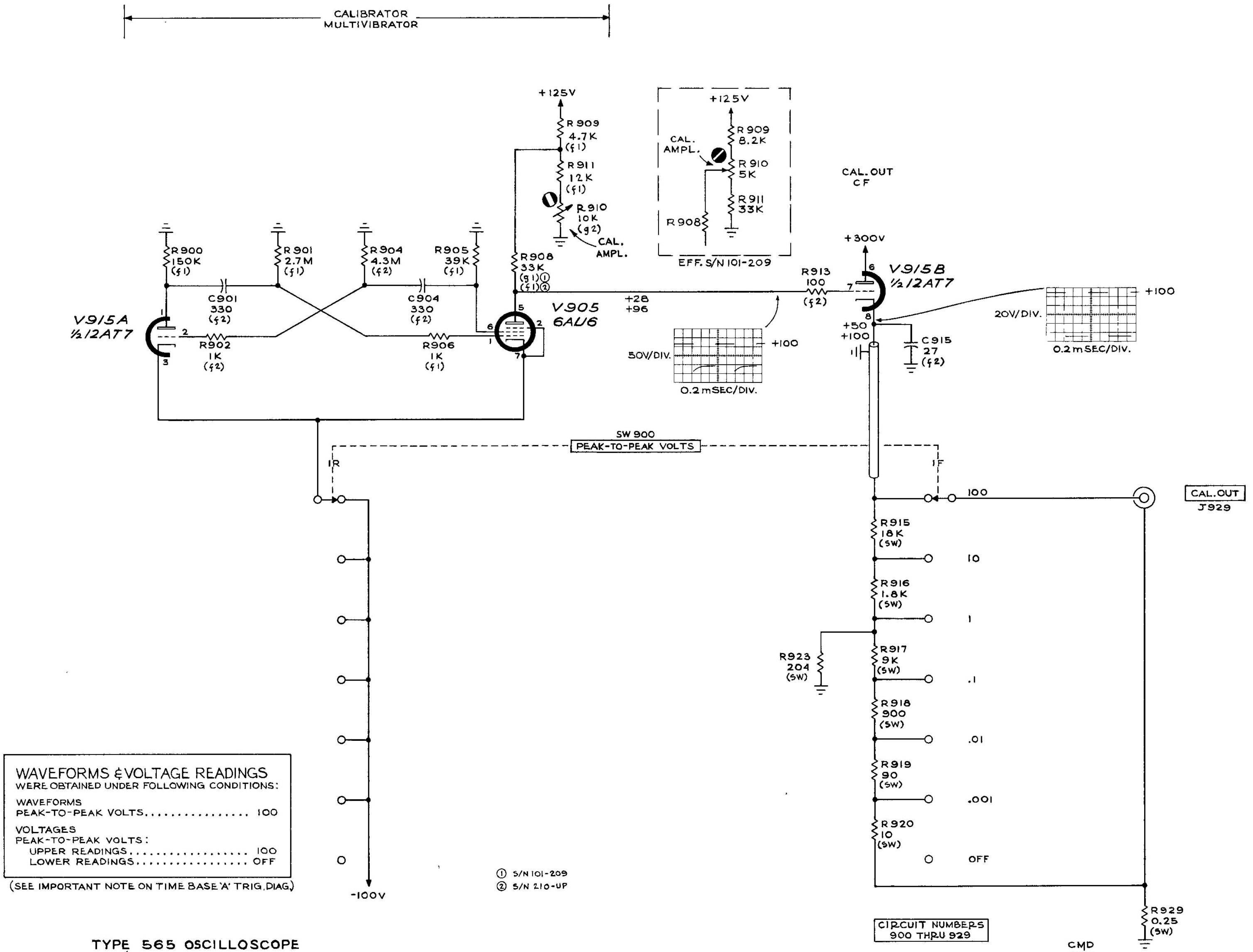
HEATER WIRING



766 PLM

POWER SUPPLY

CIRCUIT NUMBERS 600 THRU 699



TYPE 565 OSCILLOSCOPE

A

AMPLITUDE CALIBRATOR

CMD 763

IMPORTANT:
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.

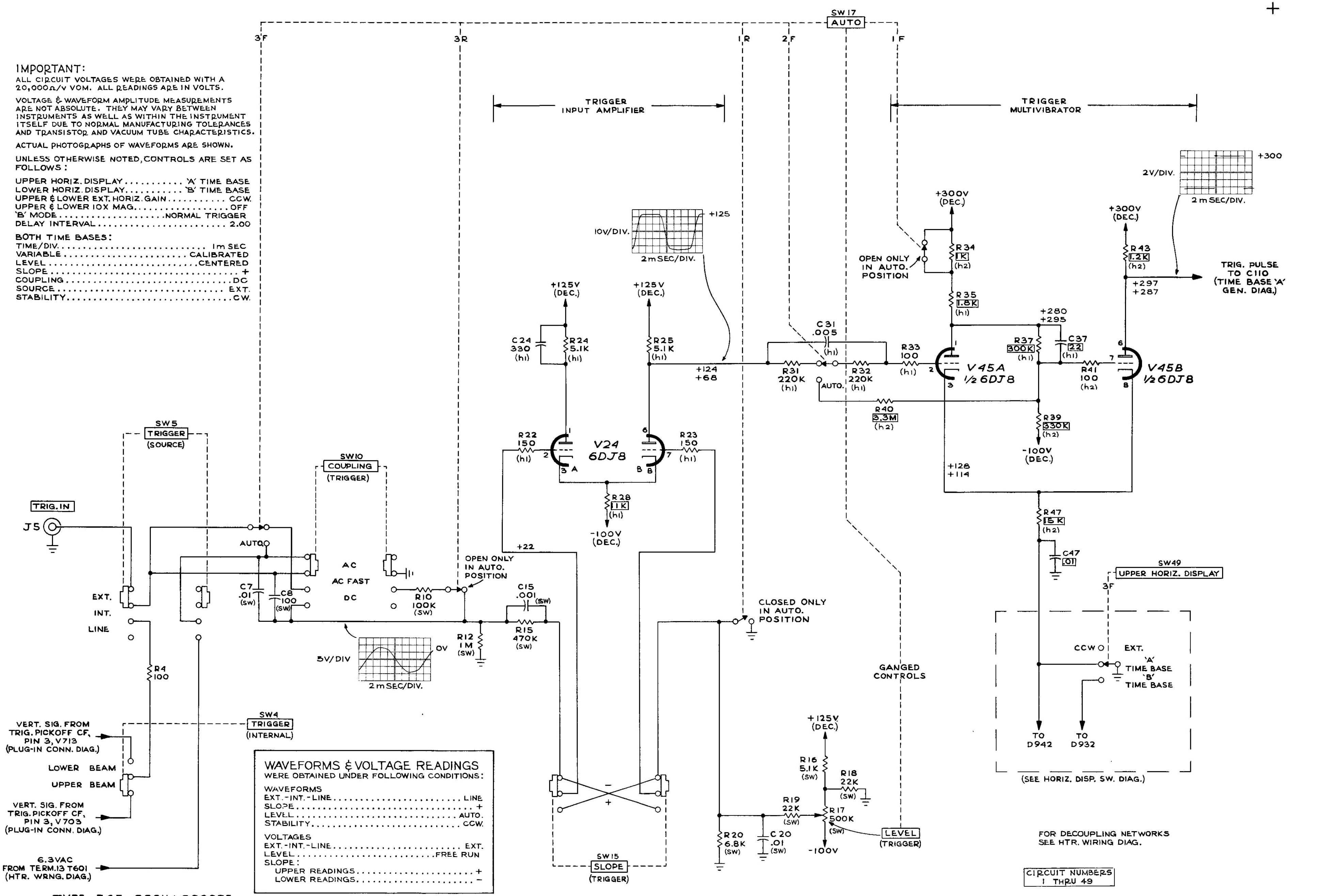
VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

UNLESS OTHERWISE NOTED, CONTROLS ARE SET AS FOLLOWS:

UPPER HORIZ. DISPLAY .... 'A' TIME BASE
LOWER HORIZ. DISPLAY .... 'B' TIME BASE
UPPER & LOWER EXT. HORIZ. GAIN .... CCW.
UPPER & LOWER 10X MAG. .... OFF
'B' MODE .... NORMAL TRIGGER
DELAY INTERVAL 2.00

BOTH TIME BASES:
TIME/DIV. .... 1m SEC
VARIABLE .... CALIBRATED
LEVEL .... CENTERED
SLOPE .... +
COUPLING .... DC
SOURCE .... EXT.
STABILITY .... C.W.



WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS:

WAVEFORMS
EXT.-INT.-LINE .... LINE
SLOPE .... +
LEVEL .... AUTO.
STABILITY .... CCW.

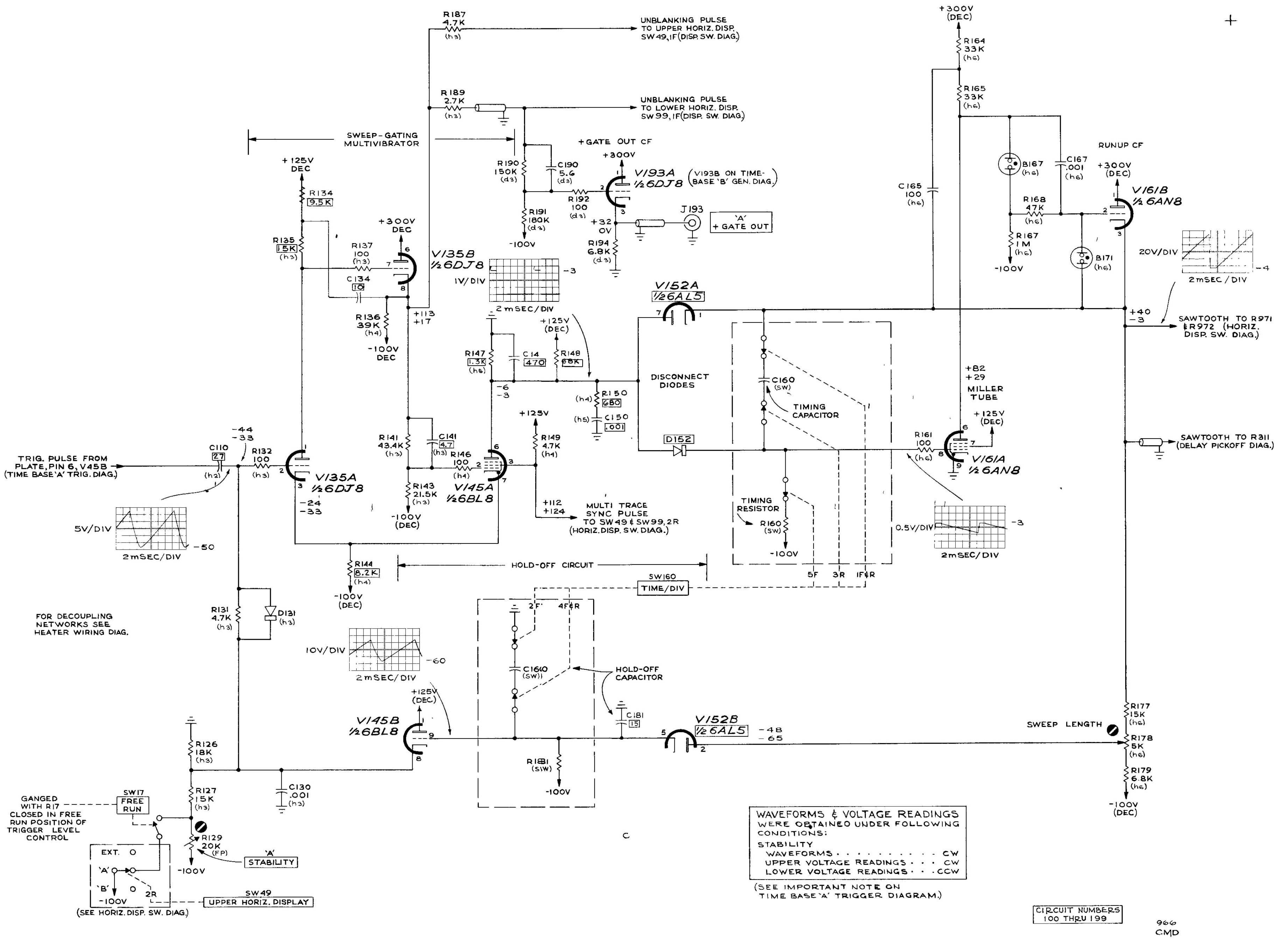
VOLTAGES
EXT.-INT.-LINE .... EXT.
LEVEL .... FREE RUN
SLOPE:
UPPER READINGS .... +
LOWER READINGS .... −

TYPE 565 OSCILLOSCOPE

A

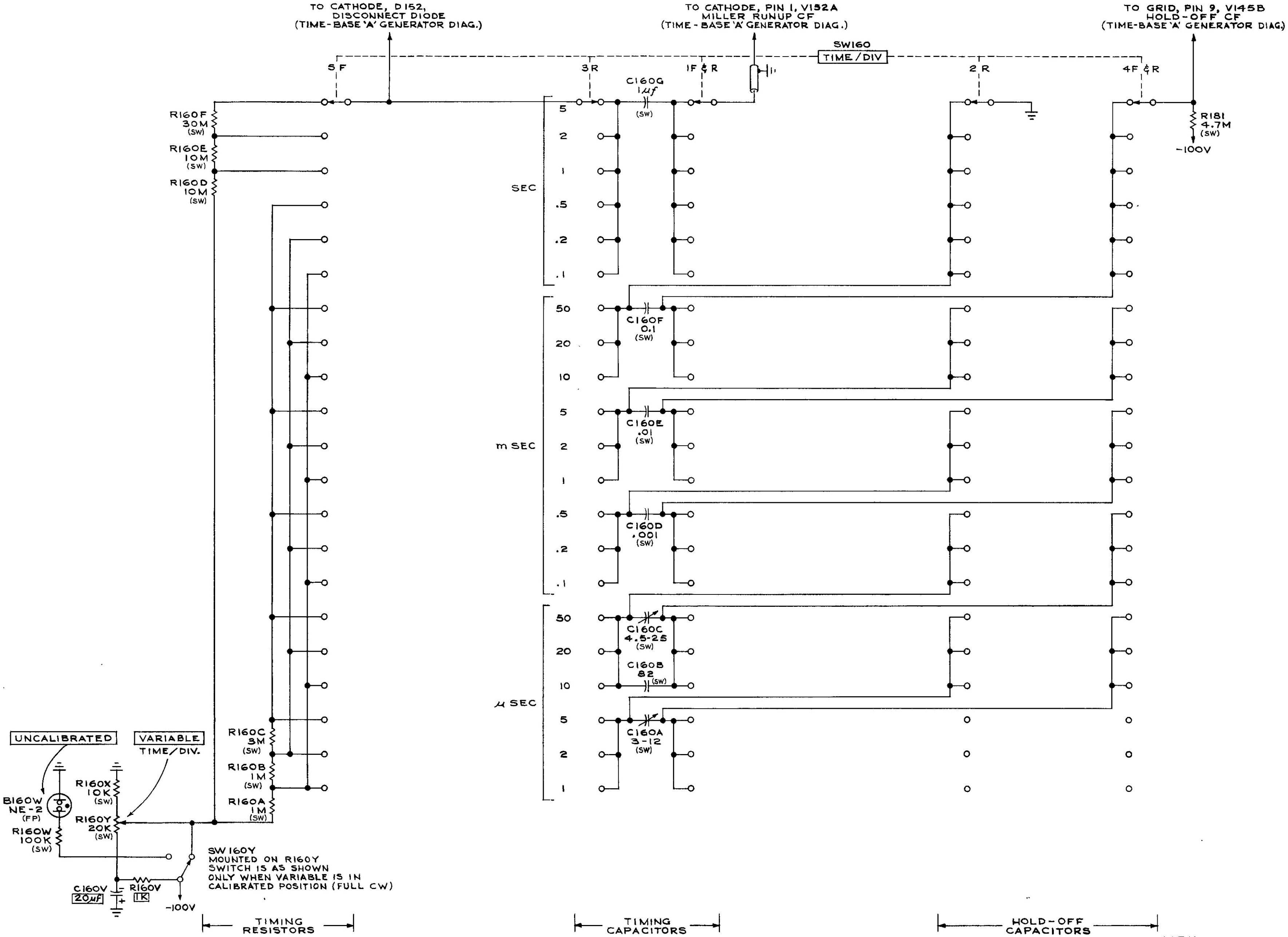
TIME BASE 'A' TRIGGER

CMD
763



TYPE 565 OSCILLOSCOPE

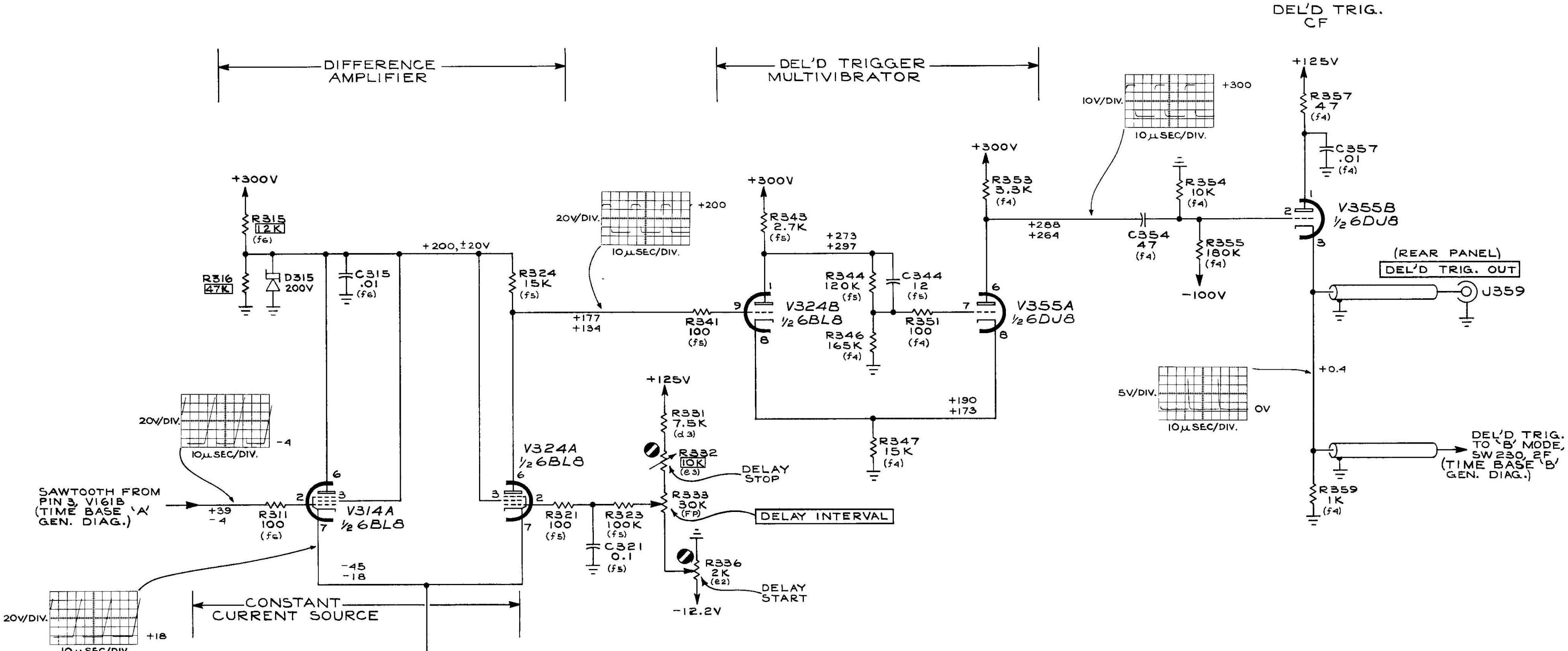
TIME BASE 'A' GENERATOR



TYPE 565 OSCILLOSCOPE

B

TIME-BASE 'A' TIMING SWITCH



WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS:

WAVEFORMS
'A' STABILITY.......................CW.
'A' TIME/DIV.......................1 μSEC

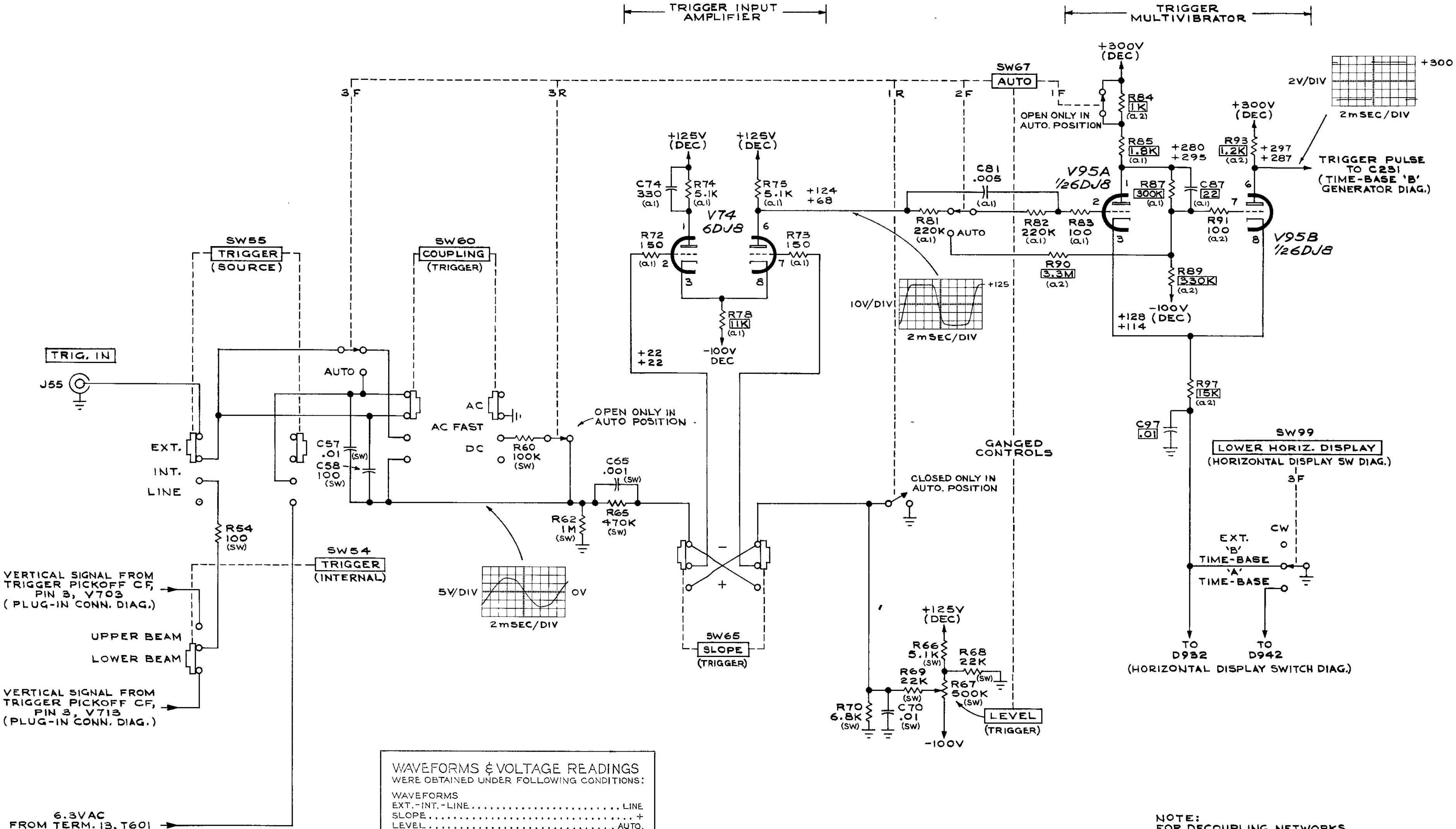
VOLTAGES
'A' TIME/DIV.......................1 μSEC
'A' STABILITY:
UPPER READINGS.......................CW.
LOWER READINGS.......................CCW.

(SEE IMPORTANT NOTE ON TIME BASE 'A' TRIG. DIAG.)

PLM
1163

DELAY PICKOFF

CIRCUIT NUMBERS
300 THRU 359



WAVEFORMS & VOLTAGE READINGS
WERE OBTAINED UNDER FOLLOWING CONDITIONS:

WAVEFORMS
EXT.-INT.-LINE........................LINE
SLOPE..+
LEVEL..AUTO.
STABILITY...................................CCW.

VOLTAGES
EXT.-INT.-LINE........................EXT.
LEVEL..FREE RUN
SLOPE:
UPPER READINGS.........................+
LOWER READINGS.........................-

NOTE:
FOR DECOUPLING NETWORKS
SEE HEATER WIRING DIAGRAM

MRH
763

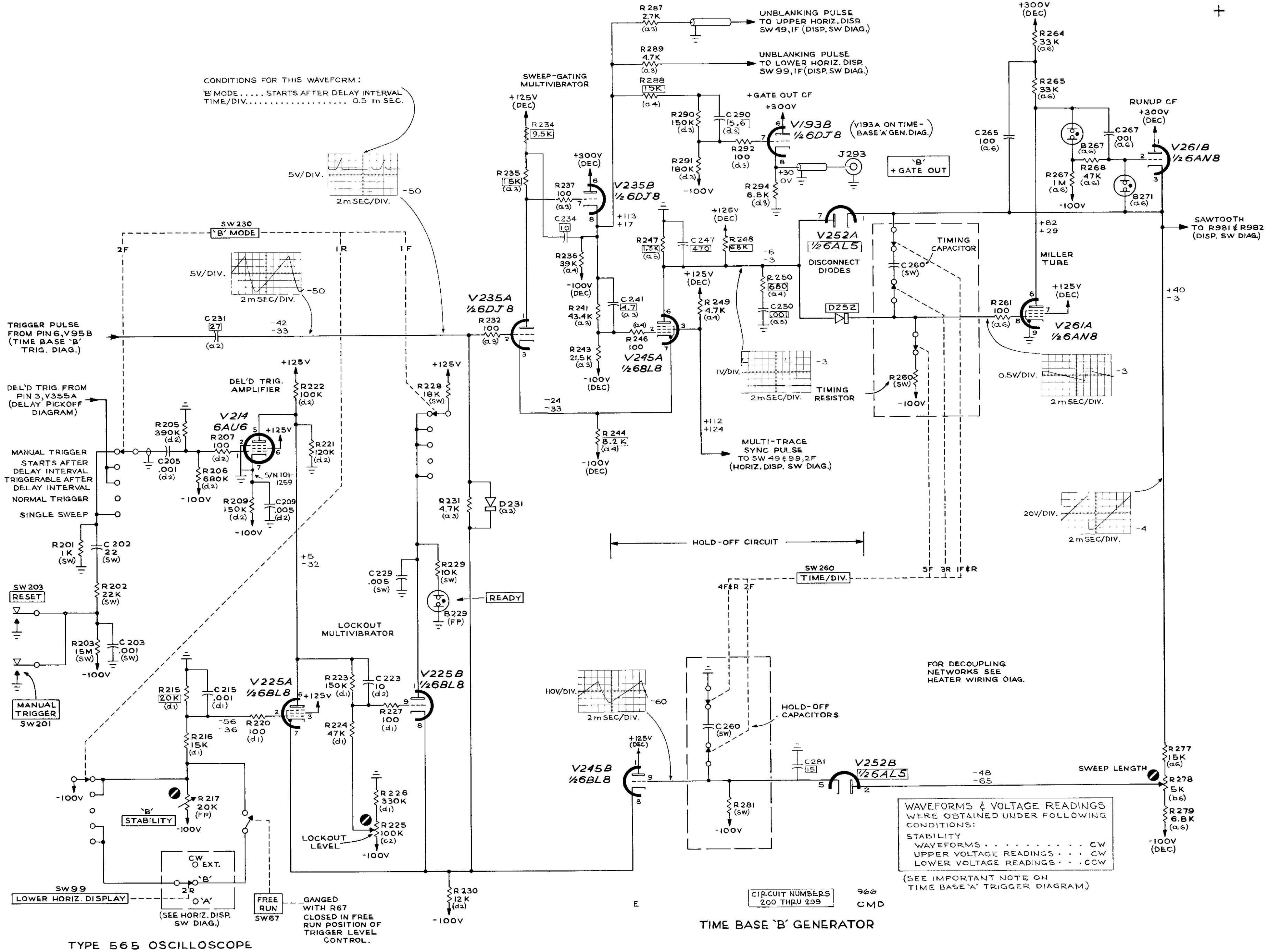
TIME BASE 'B' TRIGGER

CIRCUIT NUMBERS
50 THRU 99

TYPE 565 OSCILLOSCOPE

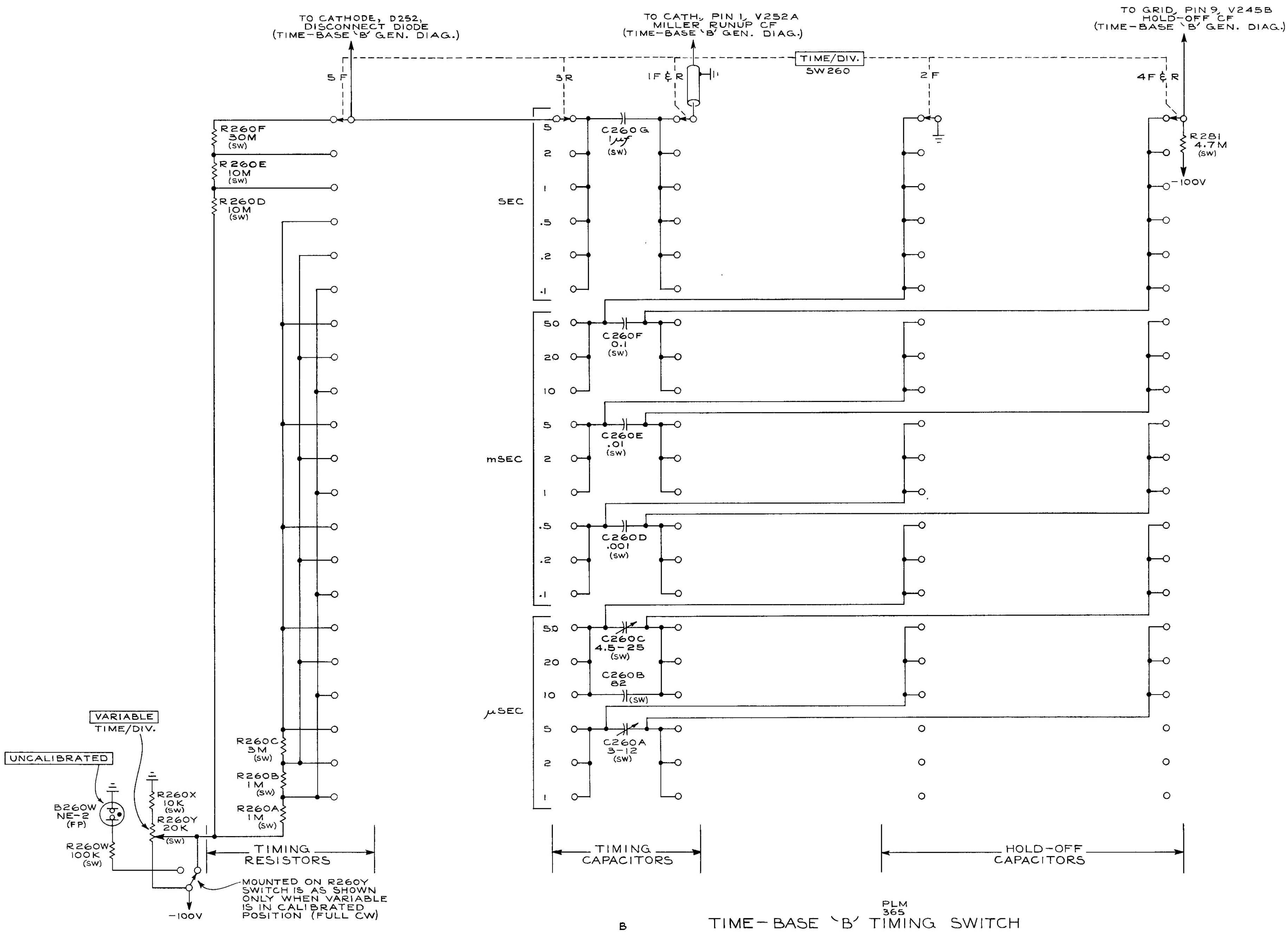
(SEE IMPORTANT NOTE ON TIME BASE 'A' TRIGGER DIAGRAM.)

A



TYPE 565 OSCILLOSCOPE

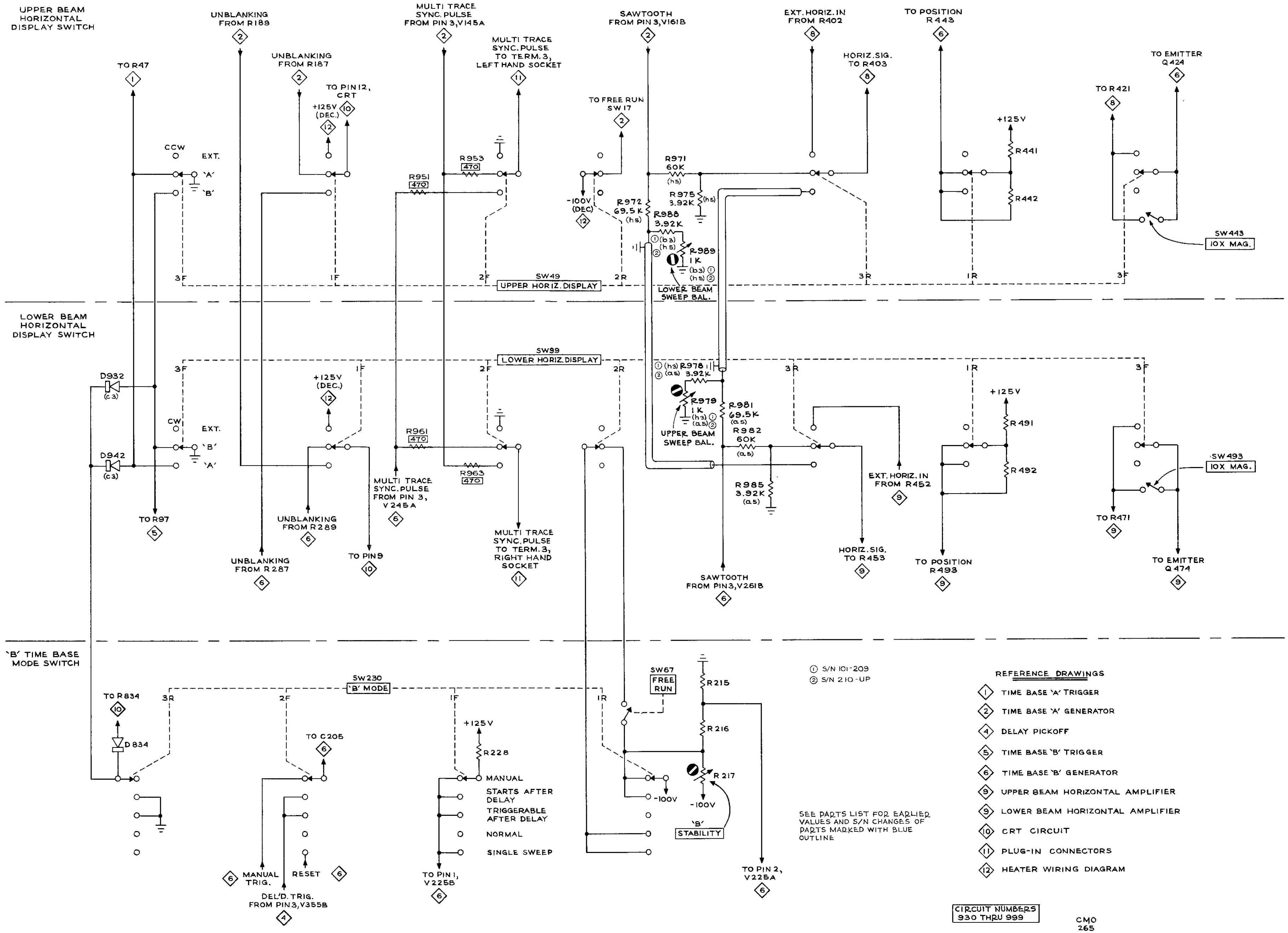
TIME BASE 'B' GENERATOR



PLM 365

B

TIME-BASE 'B' TIMING SWITCH

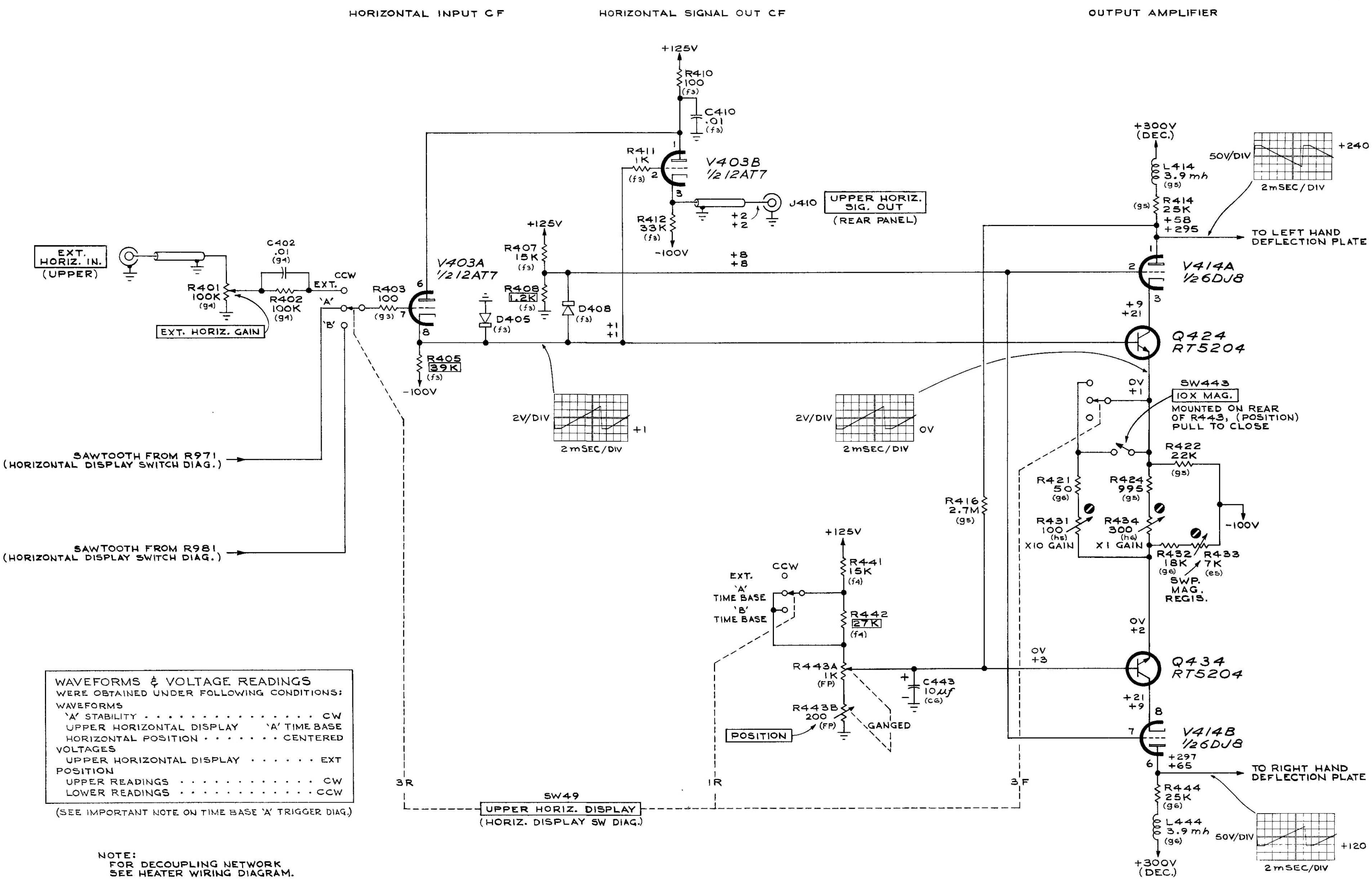


CMO 265

TYPE 565 OSCILLOSCOPE

A2

HORIZONTAL DISPLAY SWITCHING



TYPE 565 OSCILLOSCOPE

A

CIRCUIT NUMBERS 400 THRU 449

MRH 763

UPPER BEAM HORIZONTAL AMPLIFIER

TYPE 565/RM565 TENT SN 2030

PARTS LIST CORRECTION

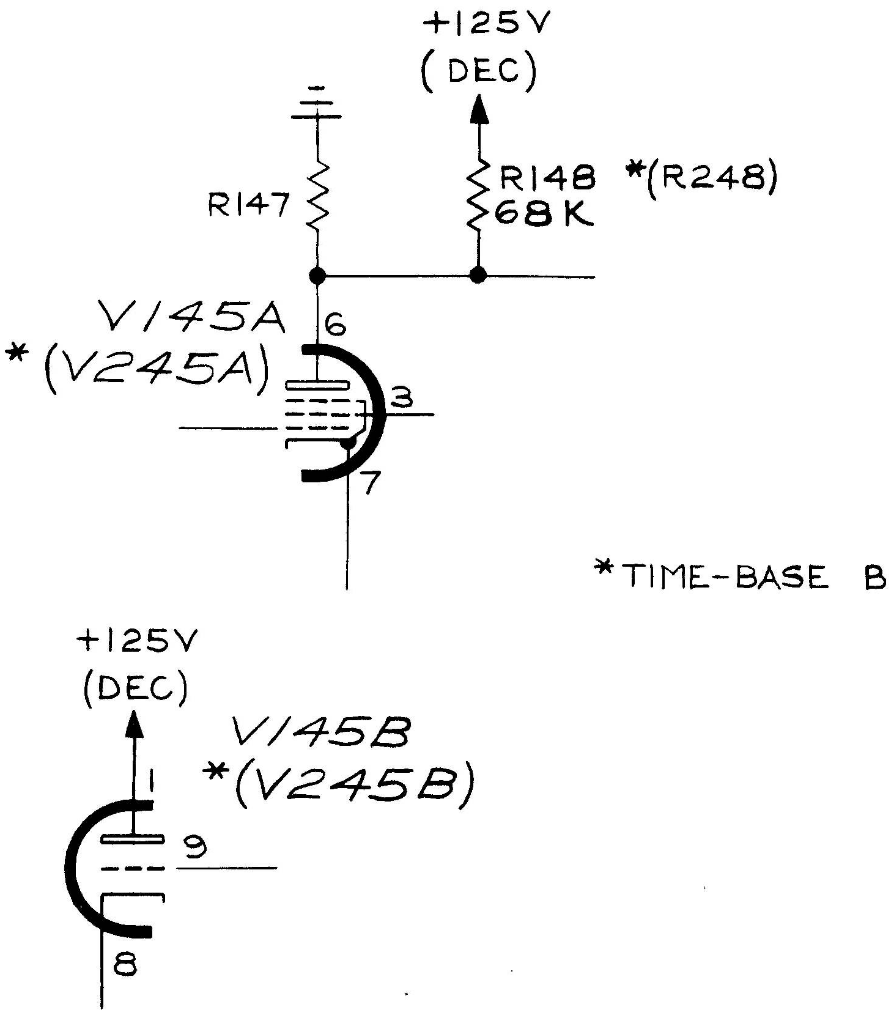
ADD:

R148/R248	302-0683-00	68 kΩ	1/2 W	10%

DELETE:

C281	281-0509-00	15 pF	500 V	10%

SCHEMATIC CORRECTION



PARTIAL TIME-BASE A GENERATOR

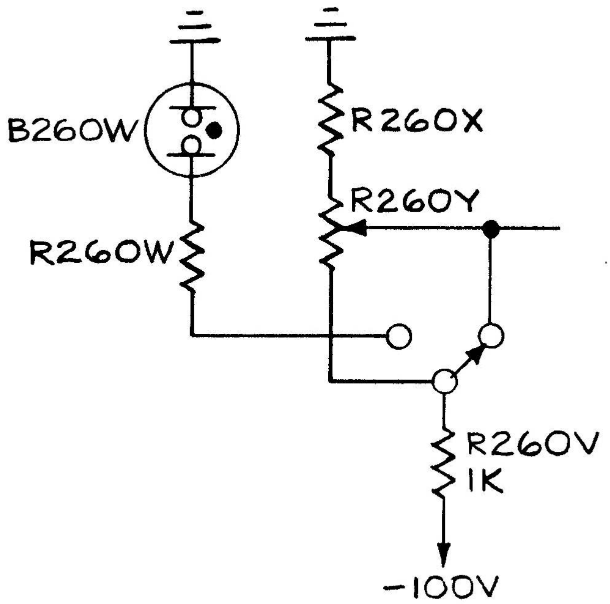
TYPE 565/RM565 TENT SN 2060

PARTS LIST CORRECTION

ADD:

R260V	302-0102-00	1 kΩ	1/2 W	10%

SCHEMATIC CORRECTION



PARTIAL TIME-BASE B TIMING SWITCH DIAGRAM