INSTRUCTION MANUAL

TYPE 533 533A OSCILLOSCOPES

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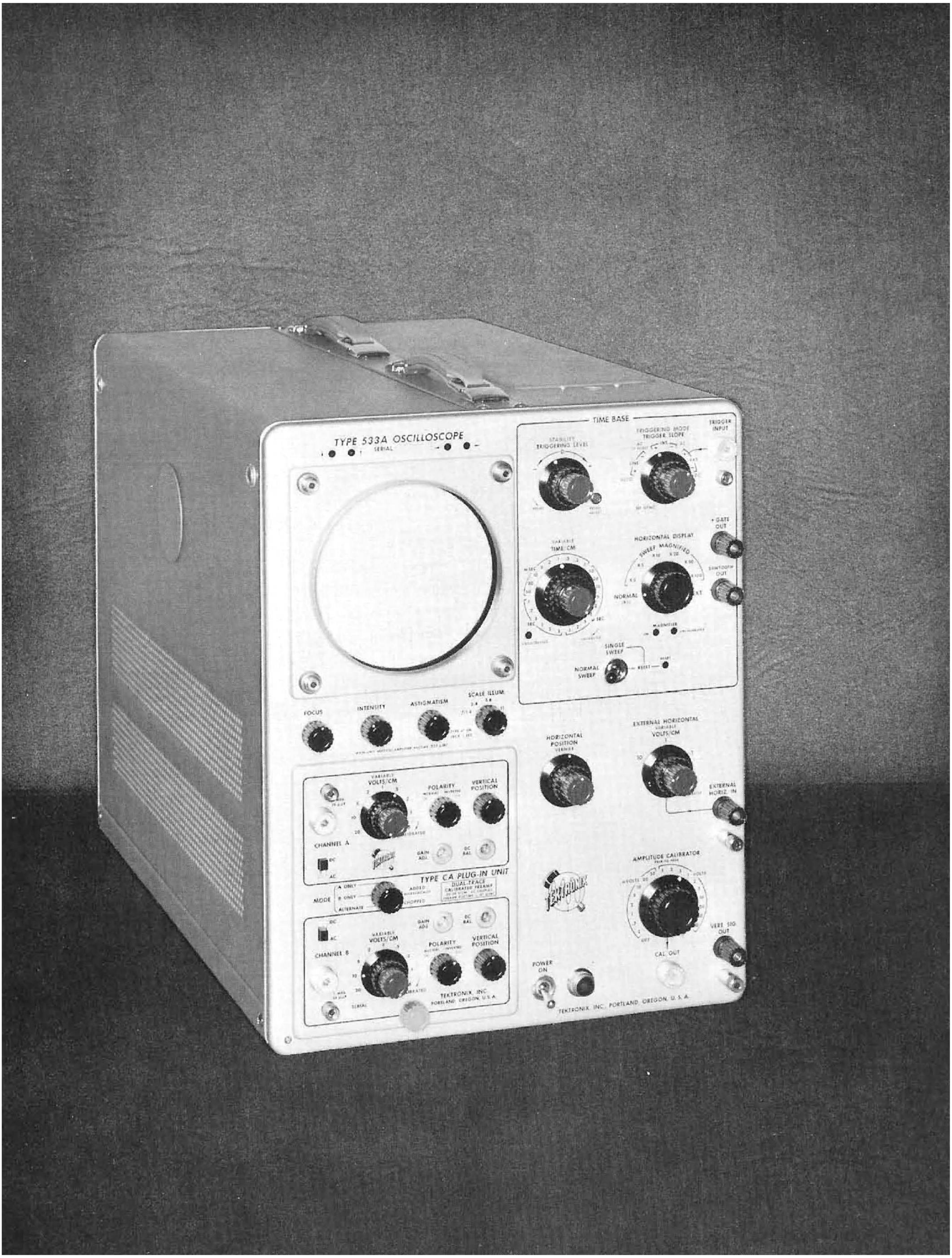
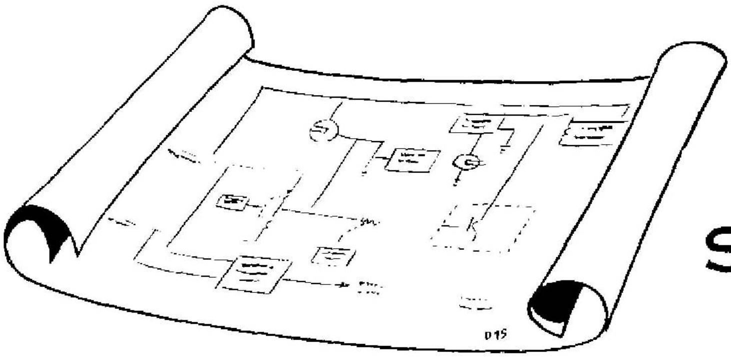

TYPE 533A OSCILLOSCOPE
SERIAL
TIME BASE
TRIGGER INPUT
STABILITY
TRIGGERING LEVEL
TRIGGERING MODE
TRIGGER SLOPE
+ GATE OUT
HORIZONTAL DISPLAY
SWEEP MAGNIFIED
SAWTOOTH OUT
VARIABLE
TIME/CM
NORMAL
EXT
MAGNIFIER
SINGLE SWEEP
NORMAL SWEEP
RESET
FOCUS
INTENSITY
ASTIGMATISM
SCALE ILLUM.
HORIZONTAL POSITION
VERNIER
EXTERNAL HORIZONTAL
VOLTS/CM
EXTERNAL HORIZ. IN
VOLTS/CM
POLARITY
VERTICAL POSITION
CHANNEL A
DC
AC
GAIN ADJ.
DC BAL.
TYPE CA PLUG-IN UNIT
MODE
A ONLY
B ONLY
ALTERNATE
ADDED
CHOPPED
DUAL-TRACE
CALIBRATED PREAMP
CHANNEL B
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.
AMPLITUDE CALIBRATOR
MVOLTS
VOLTS
OFF
CAL. OUT
VERT. SIG. OUT
POWER ON
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.



SECTION 1

SPECIFICATIONS

General

The Tektronix Type 533/533A Oscilloscopes are general purpose instruments well suited to laboratory use. Plug-in preamplifiers are used in the vertical-deflection system, permitting the instruments to be used in many specialized applications, including, among others, wide band, dual trace, low level, differential, maximum frequency response and risetime, and transistor risetime checking. Specifications listed below apply to both the Type 533 and Type 533A, except in cases that are otherwise noted.

Vertical Deflection System

All specifications for the Vertical Deflection System of the Type 533 and 533A Oscilloscopes depend upon the plug-in unit used with the instrument. The following specifications are given assuming that a Type K plug-in unit is used.

Bandpass — DC to 15 mc (down 3 dB ±½ dB at 15 mc).
Risetime — .024 microseconds.
Delay Line — Balanced network Signal Delay — 0.2 μsec.

Horizontal Deflection System

Triggering Modes—Type 533, Automatic, AC Fast, AC Slow, DC and High Frequency Sync. Type 533A, Automatic, AC Low Frequency Reject, AC, DC and High Frequency Sync.
Triggering Signal Requirements
Internal—a signal producing 2 mm of vertical deflection except 4 mm in automatic and DC modes.
External—a signal of .2 volts to 10 volts, peak to peak. (The sweep will trigger on larger signals, but the TRIGGERING LEVEL control operates over a ± 10 volt range.) Automatic mode requires 0.4 V.
Triggering Frequency Range—triggered operation to 5 mc.

Synchronizing Signal Requirements

Internal — a signal producing 2 cm of vertical deflection.
External — a signal of 2 volts.
Synchronizing Frequency Range — synchronized operation 5 mc to 30 mc.

Sweep Rates

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

Continuously variable sweep rates are available from .1 μsec/cm to 12 sec/.cm

Magnifier

Six degrees of sweep magnification are provided; 2, 5, 10, 20, 50 and 100 times. Accuracy within 5% when the magnified sweep does not exceed the maximum calibrated rate of 0.02 microseconds/cm.

Unblanking

DC Coupling

External Horizontal Signal Input

Deflection Factor — Three calibrated ranges, .1 v/cm, 1 v/cm and 10 v/cm. Continuously variable between ranges.
Frequency range — DC to 500 KC in calibrated position.
Input impedance — approximately 40 μμf paralleled by 1 megohm.

OTHER CHARACTERISTICS

Cathode-Ray Tube

Type T533P2 — P1, P7 and P11 phosphors optional.
Accelerating potential — 10,000 volts.
Vertical Deflection Factor — approx. 10 v/cm.
Horizontal Deflection Factor — approx. 28 v/cm.

Voltage Calibrator

Square-wave output at approximately 1 kc.
Output Voltages — 0.2 millivolts to 100 volts peak-to-peak in 18 calibrated steps.
Accuracy — peak-to-peak amplitude of square waves within 3% of indicated voltage.

Power Supplies

Electronically regulated for stable operation with widely varying line voltages and loads.

Line voltage requirements — 108, 115, 122, 216, 230 or 244 v, (±9% on each range) 50 to 60 cycles.

Power — 500 watts with Type CA Plug-In Unit.

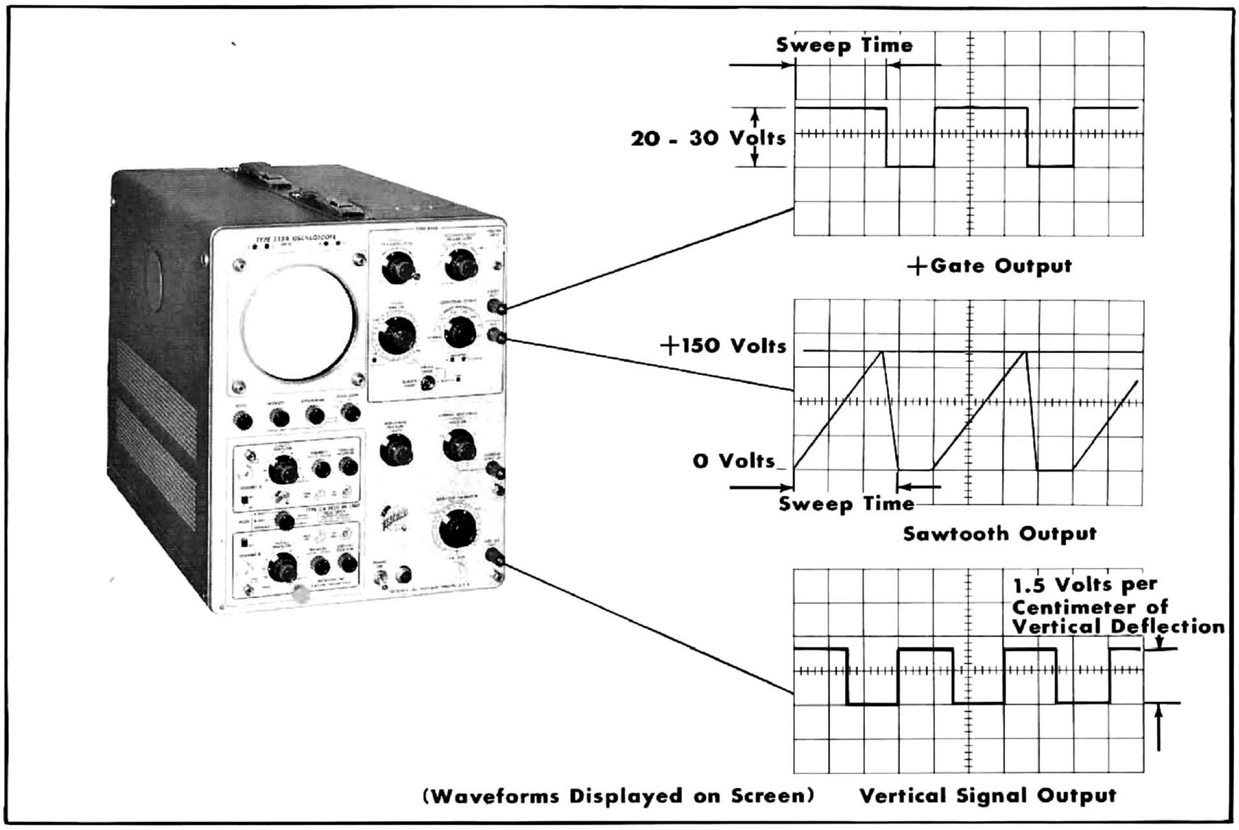


Fig. 1-1. Output waveforms available at the oscilloscope front panel.

Output Waveforms Available

+Gate Output — approximately 20 volts peak-to-peak with same duration as sweep.

Sawtooth Output — Sweep sawtooth waveform, approximately 130 volts peak to peak.

Vertical Signal Output — output from vertical deflection system, approximately 1.5 volts peak to peak per centimeter of vertical deflection.

Mechanical Specifications

Ventilation — filtered, forced air. Thermal relay interrupts instrument power in the event of overheating.

Finish — photoetched, anodized panels. Blue finish, perforated cabinets.

Construction — aluminum alloy chassis and three-piece cabinet.

Dimensions — 24" long, 13" wide, 16¾" high.
Weight — 61½ pounds.

Accessories

2 — Type P6006 Probes, 010-127
1 — BNC to BNC Patch Cord, 012-0087-00
1 — BNC to Banana Jack, 012-0091-00
1 — BNC to Post Jack, 012-0092-00
1—Smoke Gray Filter, 378-0567-00
1 — 3 to 2-Wire Adapter, 103-013
1 — 3-conductor power cord, 161-010
2 — Instruction Manuals

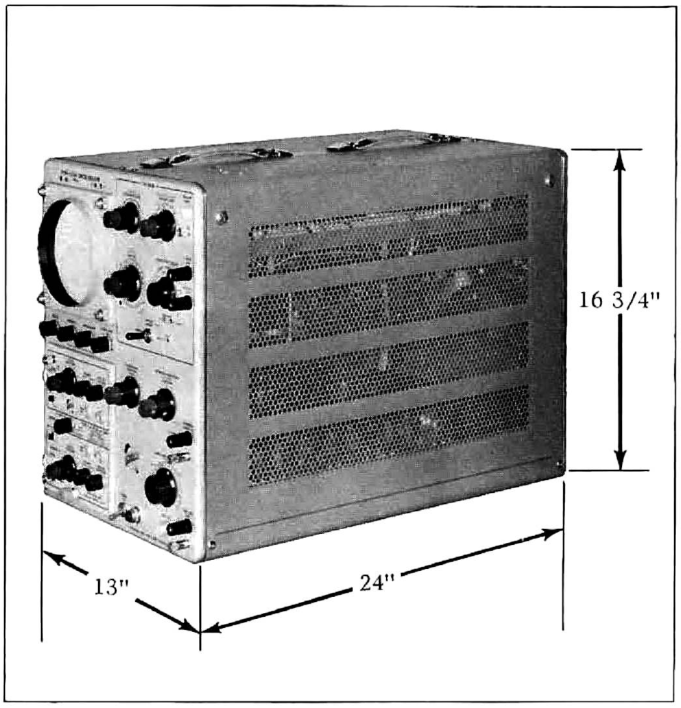


Fig. 1-2. Type 533/533A Oscilloscope dimensions.

TABLE 1
PLUG-IN PREAMPLIFIER CHARACTERISTICS FOR TYPE 533/533A OSCILLOSCOPES

PLUG-IN TYPE	CALIBRATED DEFLECTION FACTOR	PASSBAND	RISETIME	INPUT CAPACITANCE
TYPE A Wide-Band DC Coupled	0.02 v/cm to 20 v/cm	dc to 14 mc	25 nsec	47 pf
TYPE B Wide-Band High-Gain DC Coupled	5 mv/cm to 0.05 v/cm 0.05 v/cm to 20 v/cm	2 c to 10 mc dc to 14 mc	35 nsec 25 nsec	47 pf
TYPE CA Dual-Trace DC Coupled	0.05 v/cm to 20 v/cm	dc to 13 mc	27 nsec	20 pf
TYPE D High-Gain DC Coupled Differential	1 mv/cm to 50 v/cm †	dc to 2 mc	0.18 µsec	47 pf
TYPE E Low-Level AC Coupled Differential	50 µv/cm to 10 mv/cm	0.06 cycles to 60 kc	6 µsec	50 pf
TYPE G DC Wide-Band Coupled Differential	0.05 v/cm to 20 v/cm	dc to 14 mc	25 nsec	47 pf
TYPE H DC Coupled High-Gain Wide-Band	5 mv/cm to 20 v/cm	dc to 11 mc	31 nsec	47 pf
TYPE K Fast-Rise DC Coupled	0.05 v/cm to 20 v/cm	dc to 15 mc	24 nsec	20 pf
TYPE L Fast-Rise High-Gain DC Coupled	5 mv/cm to 2 v/cm 0.05 v/cm to 20 v/cm	3 c to 14 mc dc to 15 mc	25 nsec 24 nsec	20 pf
TYPE N* Pulse Sampling	10 mv/cm	600 mc	0.6 nsec	Input Impedance, 50 ohms
TYPE P* is a fast-rise step-function test signal unit.				
TYPE Q* Strain Gage	10 µstrain/div to 10,000 µstrain/div	dc to 6 kc	60 µsec	Adjustable
TYPE R* Transistor Risetime	0.5 ma/cm to 100 ma/cm		23 nsec	
TYPE S* Semiconductor Diode Recovery	0.05 v/cm and 0.5 v/cm			
TYPE T* Time-Base Generator				
TYPE Z* DC Coupled Differential Comparator	0.05 v/cm to 25 v/cm	dc to 10 mc	35 nsec	24 pf

*More data available on the special-purpose plug-in units in the following paragraphs.
† At sensitivities greater than .05 v/cm, maximum bandpass is less than 2 mc. At 1 mv/cm, it is approximately 350 kc.

Type N

The Type N Sampling Unit is designed for use with Tektronix plug-in type oscilloscopes. The sampling system thus formed permits the display of repetitive signals with fractional nanosecond (10^{-9} second or nsec) risetime. By taking successive samples at a slightly later time at each recurrence of the pulse under observation, the Type N reconstructs the pulse on a relatively long time-base. Specifications of the Type N include a risetime of 0.6 nsec, corresponding to a maximum bandpass of approximately 600 mc; a sensitivity of 10 mv/cm with 2 mv or less noise; and a dynamic range of ±120 mv minimum linear range before overloading results.

Accidental overload of ±4 volts dc is permissible.

Type P

The Type P Plug-In Unit generates a fast-rise step-function test signal of known waveform, simulating the output of an ideally compensated Type K Unit driven with a Tektronix Type 107 Square-Wave Generator. The Type P permits the standardization of the main-unit vertical amplifier transient response of a Tektronix convertible oscilloscope. Risetime of the Type P is approximately 4 nanoseconds when it is used to standardize a Type 530-Series Oscilloscope. Pulse repetition rate is 240 step functions per second, with either positive or negative polarity. Step function amplitude is continuously adjustable between 0 and 3 major graticule divisions.

Type Q

The Type Q Plug-In Unit permits any Tektronix convertible oscilloscope such as the Type 533/533A to be operated with strain gages and other transducers. Excitation voltages for the strain gages and transducers are provided by the plug-in unit. The unit provides high gain, low noise, and extremely low drift. Frequency response of the Type Q Plug-In Unit is DC to 6 kc; risetime is approximately 60 microseconds. Strain sensitivity is calibrated in 10 steps from 10 microstrain per major graticule division to 10,000 microstrain per division, and is continuously variable between steps.

Type R

The Type R Plug-In Unit is a combined power supply and pulse generator which is used to measure the high-frequency characteristics of junction transistors by the pulse-response method. When the Type R is used in an oscilloscope having a delay line; delay time, risetime, storage time, and falltime may be displayed simultaneously. A pushbutton switch connects a front-panel terminal directly to the input of the oscilloscope for observing externally derived waveforms.

Pulse risetime of the Type R Unit is less than 5 nanoseconds, so measurements depend on the risetime of the oscilloscope used. Pulse amplitudes are 8 fixed, calibrated steps from .05 to 10 volts, adjustable between steps. Pulse recurrence frequency is 120 pulses per second.

Type S

The Type S Plug-In Unit is designed for use with Tektronix Wide-Band convertible oscilloscopes. The slower risetime of the Tektronix 530-Series Oscilloscopes will affect the ability of the S Unit to analyze fast semiconductor diodes. Using the Type S, voltage across a test diode is displayed as a function of time.

Certain diode parameters, such as junction resistance, junction capacitance, and the stored charge at the junction, can be measured readily and reliably from the display. Performance of a diode in a particular circuit can be predicted by analyzing the recovery and "turn-on" characteristics. Since it is essentially a means for plotting voltage across an element while passing constant current through it, the unit can be used for other applications as well. For example: observing the junction characteristics of transistors, or measuring the resistance, capacitance or inductance of circuit components.

The Type S offers calibrated forward currents in five fixed steps from 1 to 20 milliamps, and reverse currents calibrated in six steps from 0 to 2 milliamps. Diode shunt capacitance is 9 picofarads, and deflection factors are 0.05 v/cm and 0.5 v/cm, calibrated.

Type T

The Type T Time-Base Generator provides sawtooth sweep voltages from 0.2 μsec/div. The trigger source may be line frequency, external, ac or dc coupled, automatic or high-frequency sync. The triggering point can be on either rising or falling slope of the waveform, and triggering level is adjustable. A signal of 0.2 to 50 volts is required for triggering.

Type Z

The Type Z Plug-In extends the accuracy of oscilloscope voltage measurements. It can be used in three modes of operation: (1) as a conventional preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator. With sensitivity of 50 mv/cm and insertion voltage range of ±100 volts, the effective scale range is ±2000 cm. Maximum resolution of the Type Z Unit is .005%.

As a conventional preamplifier, the Type Z Unit offers a passband of dc to 10 mc for the 533/533A for signals that do not overscan the screen. The deflection factors are 0.05 volts/cm to 25 v/cm in 9 fixed, calibrated steps.

As a differential input preamplifier, the Type Z accepts a common-mode signal level ±100 volts with input attenuation X1, and offers a common-mode rejection ratio of 40,000 to 1. Maximum input signal is 1 volt/7 nsec, or —1 volt/5 nsec.

As a calibrated differential comparator, the Type Z makes available three comparison voltage ranges; from zero to ±1 volt, zero to ±10 volts, and zero to ±100 volts.

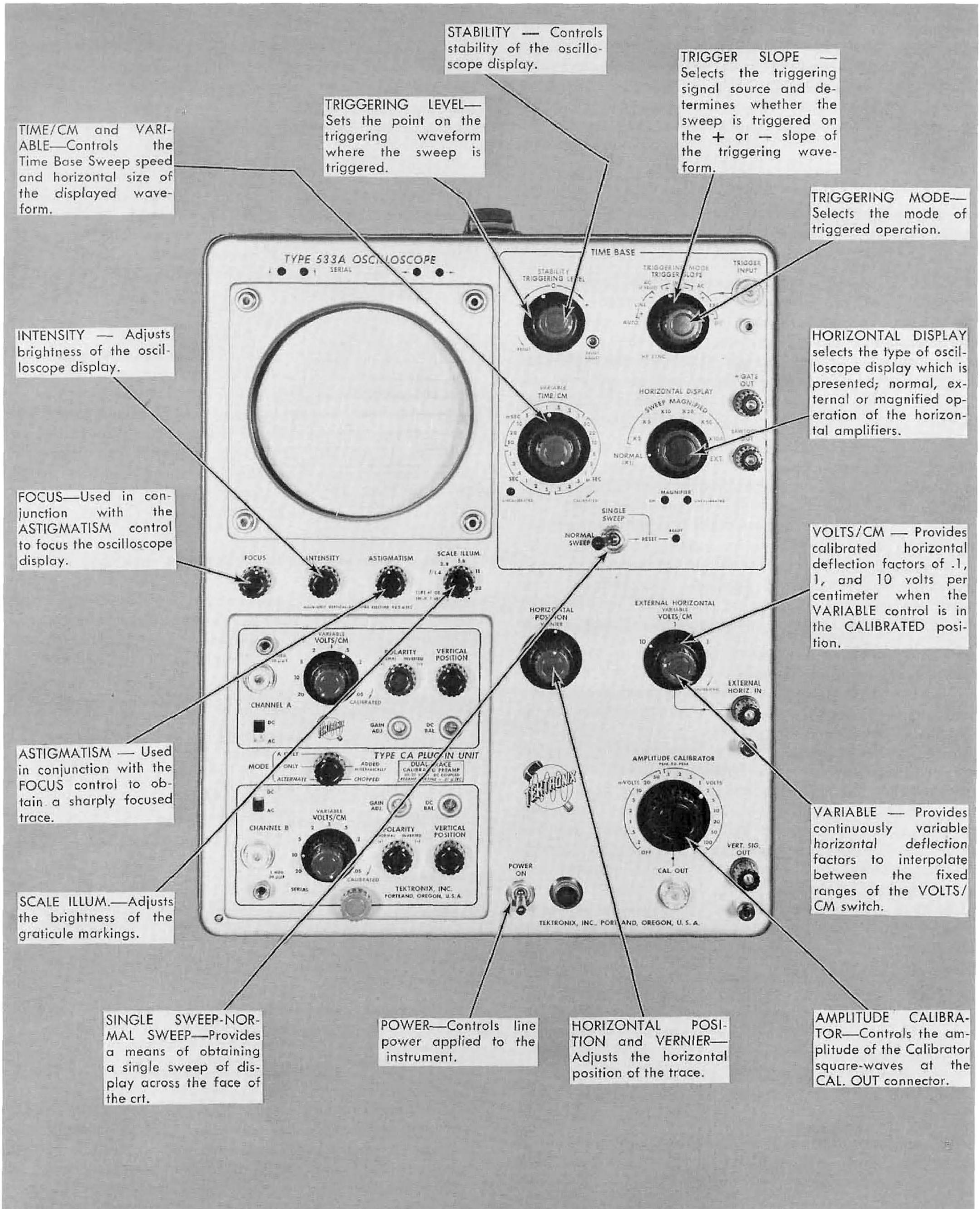
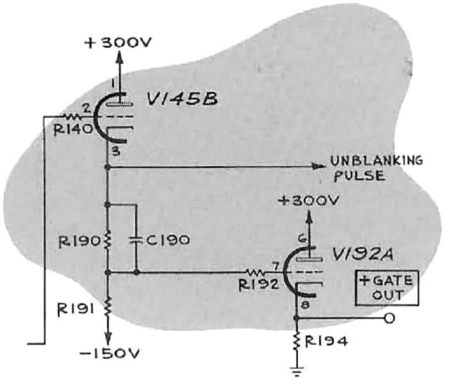


Fig. 2-16. Functions of the Type 533/533A Oscilloscope front panel controls.



SECTION 4

CIRCUIT DESCRIPTION

VERTICAL DEFLECTION SYSTEM

General

The dc-coupled, push-pull, main Vertical Amplifier provides the necessary gain to drive the Delay Line and the vertical deflection plates of the crt. The main units of the Vertical Amplifier are the Input Amplifier Stage V504 and V524; the C.F. Driver Stage, V533A and V543A, and the Output Amplifier Stage, V554 and V564. Other circuits of importance include the Trigger Pickoff Amplifier, V584A and V584B, the Driver Stage, V533A and V543A, the Indicator Amplifiers, V533B and V543B, and the lamps, B536 and B546.

Input Circuit

The signal input from the plug-in unit is coupled through terminals 1 and 3 of the inter-connecting plug to the grids of the Input Amplifiers, V504 and V524. The plate circuit of this stage is compensated for both high-frequency attenuation and dc shift.

High-frequency compensation is provided by the series-shunt peaking coils, L506 and L523. These coils extend the bandwidth of the amplifier by reducing the high-frequency attenuation caused by tube and stray capacitance in the circuit. Additional high-frequency compensation is provided by L526 and L541.

DC shift in the amplifier tubes—a condition whereby the dc (and extremely low-frequency) transconductance is less than at mid-frequencies—is compensated by an ac "boost" network. R507 and C507A in the plate circuit of V504, and R524 and C507B in the plate circuit of V524, shunt the plate load resistors in each circuit. The time constant of the circuit is such that the plate load resistance is 1.6 k in the range from dc to a fraction of a cycle, but reduces to 1.5 k for high frequencies. The slightly higher plate load resistance, in the range from dc to a fraction of a cycle compensates for the slightly reduced transconductance of the tubes in this range. As a result, the gain remains substantially constant from dc to the upper limit of the amplifier.

The Input Amplifiers are coupled to the Output Amplifiers through the Cathode Follower Drivers, V533A and V543A. These Drivers isolate the Input Amplifiers from the Output Amplifiers, V554 and V564.

Output Circuit

The Output Amplifiers, V554 and V564, are the driving source for the Delay Line and the vertical deflection plates of the crt. The gain of this stage is set by means of R570, the GAIN ADJ. control. The GAIN ADJ. control varies the degeneration in the cathode circuit. When this control is adjusted properly, and the VARIABLE control is in the CALIBRATED position, the vertical deflection on the crt agrees with the deflection factor on the plug-in unit.

High frequency compensation is provided by the series-shunt peaking coils, L553 and L563. Like the peaking coils in the input circuit, they also extend the bandwidth of the amplifier by reducing high frequency attenuation caused by stray and tube capacitance in the circuit.

The plate load resistors for the Output Amplifiers are R553 and R563. They are also the terminating resistors for the Delay Lines.

The vertical signal is delayed ¼ microsecond between the input of the Delay Line and the vertical deflection plates.

Beam-Position Indicators

The beam-position indicators, B536 and B546, are located on the front panel above the crt. They indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential across either neon is insufficient to light it. As the beam is positioned up or down the screen, the current through the Indicator Amplifiers (and hence the voltage across the neons) will change. The voltage across one neon will increase, causing it to light. The voltage across the other will decrease, causing it to remain extinguished. The arrow nearest the lighted neon indicates the direction of the beam.

Trigger Pickoff

When internal triggering of the Time Base Generator is desired (black TRIGGER SLOPE knob is either in the + or — INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "pulse" is obtained from the trigger pickoff circuit consisting of the Trigger Pickoff Amplifier V584A and V584B, and Trigger Pickoff Cathode Follower V593A.

This "sample" of the Vertical signal is also ac-coupled through Vertical Signal Out C.F. V593B and C599 to a front-panel binding post labeled VERT. SIG. OUT.

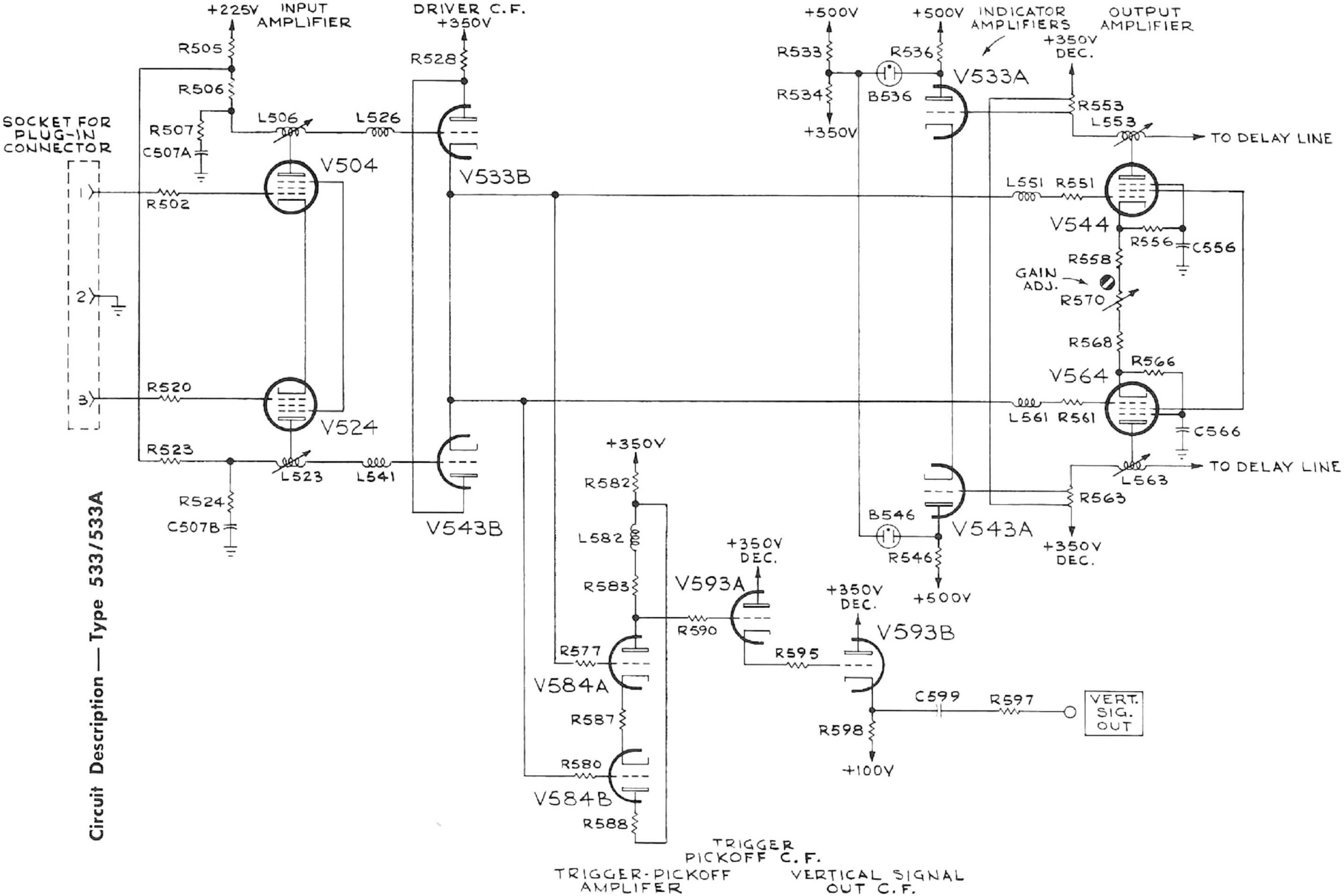


Fig. 4-1. Simplified Type 533/533A Vertical Amplifier.

Delay Line

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

HORIZONTAL DEFLECTION SYSTEM

Time-Base Trigger

General

The Time-Base Trigger develops a pulse which will initiate a cycle of action in the Time Base Generator. To display signals below five megacycles, a TRIGGERING MODE switch allows the operator to select the type of triggered operation most suitable for the waveform to be displayed. A second switch, the TRIGGER SLOPE switch, allows the operator to select the "slope", either positive or negative, which will cause triggered operation of the sweep. To display signals above five megacycles, the Time Base Trigger is bypassed, and the signal is applied to the Sweep-Gating Multivibrator in the Time-Base Generator. No choice of triggering slope is available in this mode.

Trigger-Input Amplifier

Triggering signals may be developed from several sources. The most common source of triggering signals utilizes the internal circuitry of the oscilloscope to sample the signal present in the vertical amplifier. Using an internal source of triggering signal, either triggered operation in the various triggering modes, or synchronized operation, is available.

Triggered or synchronized operation of the time-base circuitry may also be affected from an external source. Operation in any of the available modes is possible with external signals.

In the +Line or —Line positions of the TRIGGER SLOPE switch a voltage at the power line frequency is used to develop the triggering signal.

The Trigger-Input Amplifier is a polarity-inverting, cathode-coupled amplifier. It serves two basic functions in the Time-Base Trigger. First, it provides a source of negative-going signal to drive the following stage. Secondly, by means of the TRIGGERING LEVEL control, it enables the operator to select the signal level at which triggered operation of the Time-Base will occur.

To trigger from a negative-going signal, the grid of the V24A section is connected to the input signal source. The grid of the V24B section is connected to a dc bias source, which is adjustable with the TRIGGERING LEVEL control. This bias voltage establishes the voltage present at the plate under no-signal conditions.

The voltage at the grid of V24A and the voltage at the plate of V24B are in phase with each other; that is, they both go through ac zero in the same direction at the same time. Thus, the V24A section acts as a cathode-follower, and the signal voltage developed across the cathode resistor becomes the input signal to the V24B section.

To trigger from a positive-going signal, the grid of the V24A section is connected to the TRIGGERING LEVEL control, and the grid of the V24B section is connected to the input signal. With this configuration, the voltage at the plate of the V24B section will be 180 degrees out of phase with the input-signal voltage.

In each of the cases outlined above, a negative-going signal is produced at the plate of the V24B section of the Trigger-Input Amplifier irrespective of the polarity of the input signal.

Also, the amplitude of the triggeriing signal necessary to cause operation of the following stage is determined by the setting of the TRIGGERING LEVEL control.

Trigger Multivibrator

The Trigger Multivibrator is a dc-coupled multivibrator. In the quiescent state, ready to receive a signal, the V45A section is conducting and the plate voltage is down. Since the plate is dc-coupled to the grid of the V45B section, that grid is held below cutoff. With the V45B section cut off its plate voltage is up and no output is developed.

The negative-going portion of the signal from the Trigger-Input Amplifier is required to drive the grid of the V45A section down. As the V45A section grid is driven negative, the current flow through the tube is restricted and the voltage at the plate starts to rise.

The rise in voltage at the plate of the V45A section carries the grid of the V45B section in the positive direction.

The cathodes of both sections are coupled together, and follow the action of the grids. With the V45B section grid going in a positive direction, and the cathode in a negative direction, the V45B section starts to conduct. As the V45B section starts to conduct, the cathodes of both sections follow the action of the V45B section grid; hence the cathode voltage starts to rise.

As the V45A section grid goes down and its cathode goes up it stops conducting. As the V45B section conducts, its plate voltage drops, creating a negative step at the output. This transition occurs rapidly, regardless of how slowly the V45A grid falls.

When the signal applied to the grid of the V45A section goes in a positive direction the action described in the previous paragraphs reverses itself. That is, the V45A section wiill start to conduct once more, while the V45B section will be cut off.

In the AUTO. position of the TRIGGERING MODE switch the Trigger Multivibrator is converted from a bistable configuration to a recurrent configuration. This is accomplished by coupling the grid circuit of the V45A section to the grid circuit of the V45B section. In addition, the ac coupling

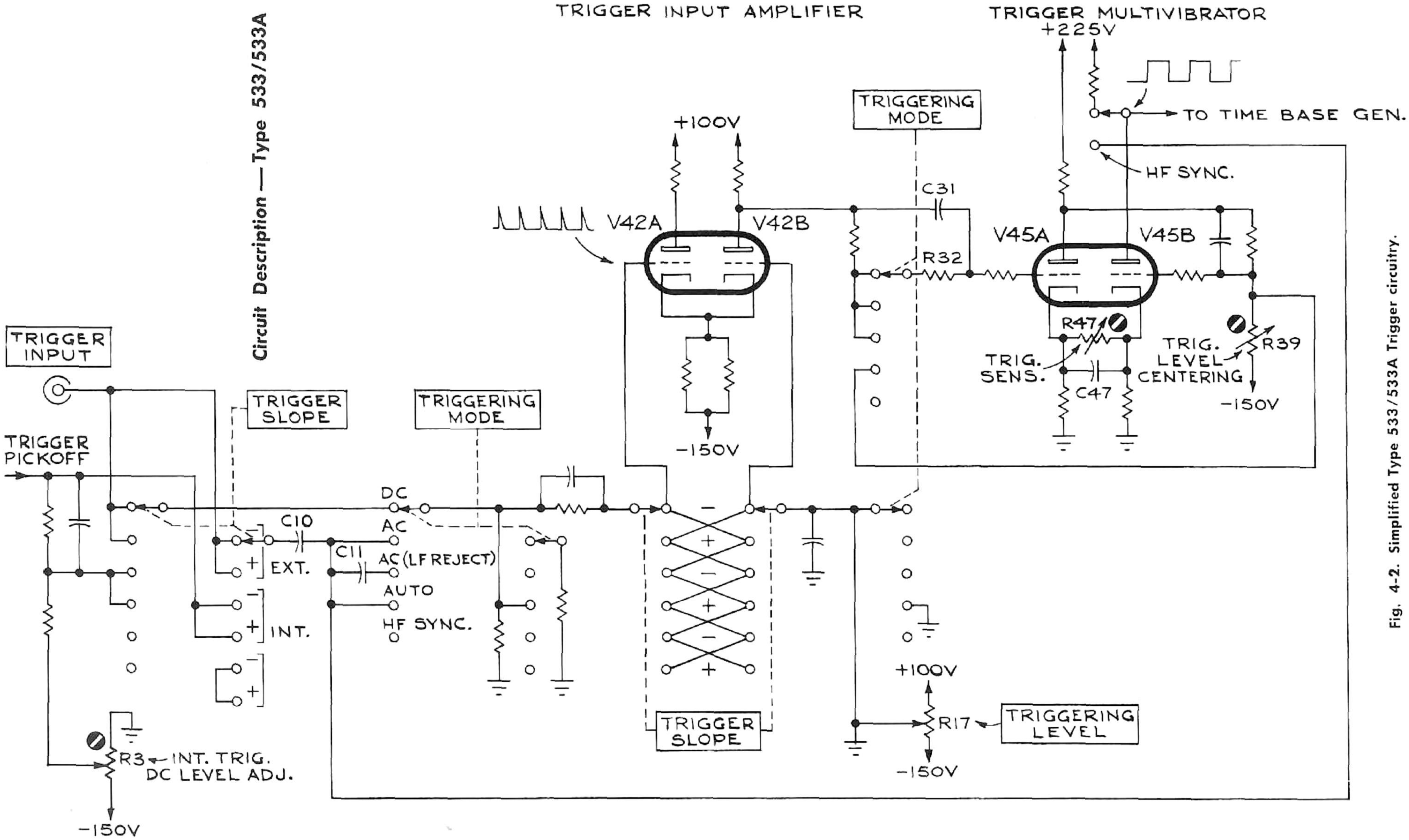


Fig. 4-2. Simplified Type 533/533A Trigger circuitry.

between the grid of the V45A section of the Trigger Multivibrator and the plate of the V24B section of the Trigger-Input Amplifier is replaced by dc coupling.

In the AUTO. triggering mode the Trigger Multivibrator will free run in the absence of a triggering signal. For example, assume that the grid of the V45A section is just being driven into cutoff. The voltage at the plate of the V45A section starts to rise, carrying with it the grid of the V45B section. As the voltage at the grid of the V45B section starts to rise, the V45B section starts to conduct.

The rising voltage at the grid of the V45B section is coupled to the grid of the V45A section through R41. The grid of V45A is prevented from rising immediately by the action of C32, which must be charged sufficiently to raise the voltage at the grid of the V45A section above cutoff.

As the V45A section starts to conduct, its plate voltage drops, which in turn lowers the voltage at the grid of the V45B section. The voltage at the grid of V45A starts dropping exponentially toward cutoff. When the V45A section reaches cutoff, the circuit has completed one cycle of an approximately 50-cycle repetition rate.

The Trigger Multivibrator produces a square-wave which is coupled to the Time-Base Generator. This square wave is differentiated in the Time-Base Generator to produce a sharp, negative-going pulse which is used to trigger the Time-Base Generator in the proper time sequence when triggered operation is desired. For synchronized operation of the Time-Base Generator, the TRIGGER MODE Switch is placed in the HF SYNC position. This couples the signal present at the input of the Time-Base Trigger directly into the Time-Base Generator, and the Time-Base Trigger circuitry is not used in the HF SYNC mode.

Time-Base Generator

General

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

The Time-Base Generator consists of three main circuits; a Sweep-Gating Multivibrator, a Miller Runup Circuit, and a Holdoff Circuit. The Sweep-Gating Multivibrator consists of V135A, V146 and the cathode follower V135B. The essential components of the Miller Runup circuit are the Miller Tube V161, the Runup C.F. V173, the On-Off Diodes V152, the Timing Capacitor C160 and the Timing Resistor R160. The Holdoff circuit consists of the Hold-Off C.F.'s V183A-V133B, the Holdoff Capacitor C180 and the Holdoff Resistors R181-R180. Essential circuitry of the Time-Base Generator is shown in Fig. 4-3.

Sweep-Gating Multivibrator

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

Miller Runup Circuit

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

Sweep Generation

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

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

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

Timing Switch

The linear rise in voltage at the cathode of V173 is used as the sweep time-base. Timing Capacitor C160 and Timing Resistor R160 are selected by the TIME/CM switch SW160.

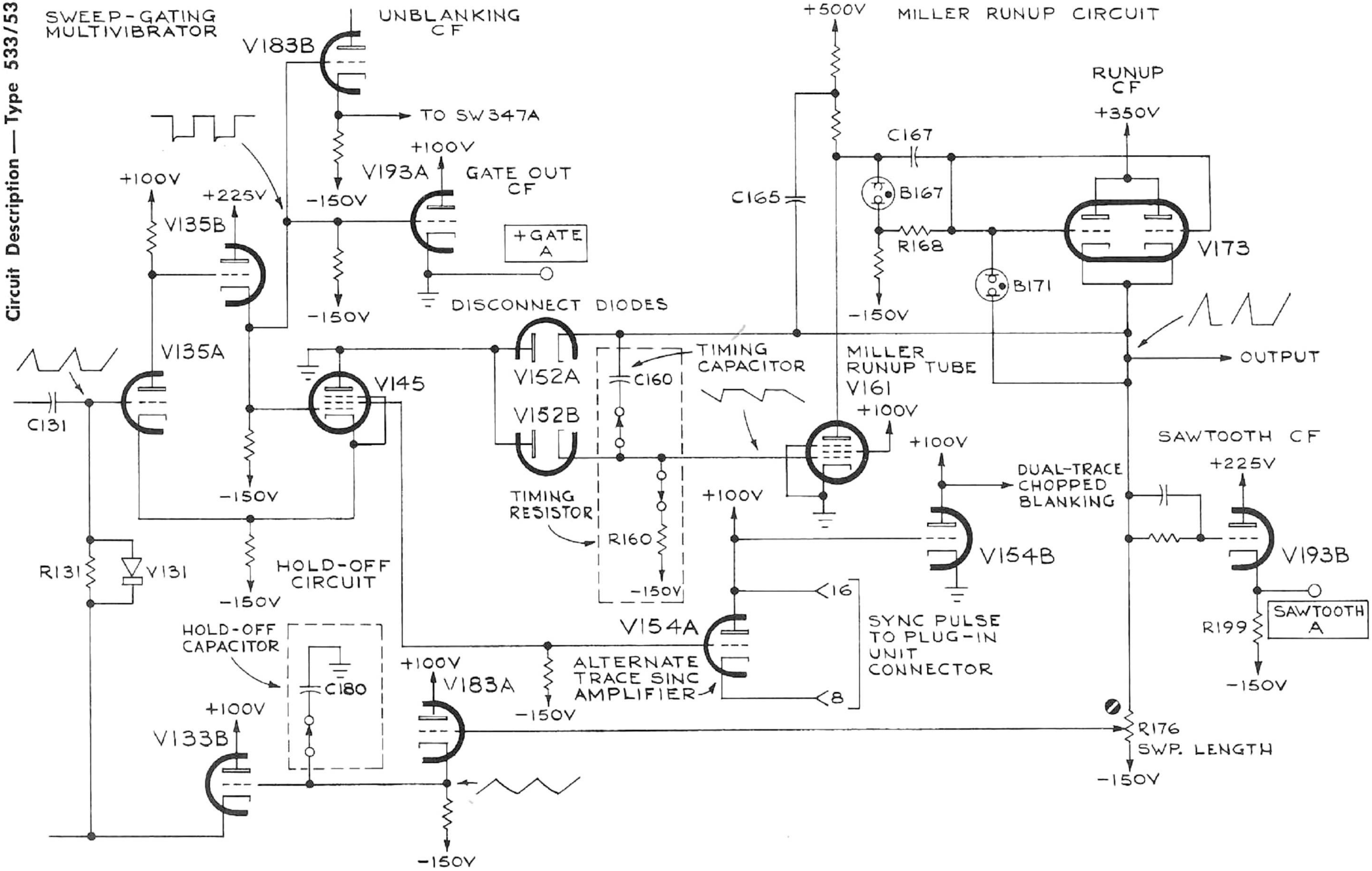


Fig. 4-3. Simplified Type 533/533A Time-Base Generator Circuit.

R160 determines the current that charges C160. By means of the TIME/CM switch both the size of the capacitor being charged and the charging current can be selected to cover a wide range of sawtooth slopes (sweep rates). For high speed sweeps bootstrap capacitor C165 helps supply current to charge the stray capacitance at the plate of the Miller tube, this permits the plate voltage to rise at the required rate.

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

Sweep Length

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

Holdoff

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

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

Stability

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

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

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

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

Single Sweep Operation

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

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

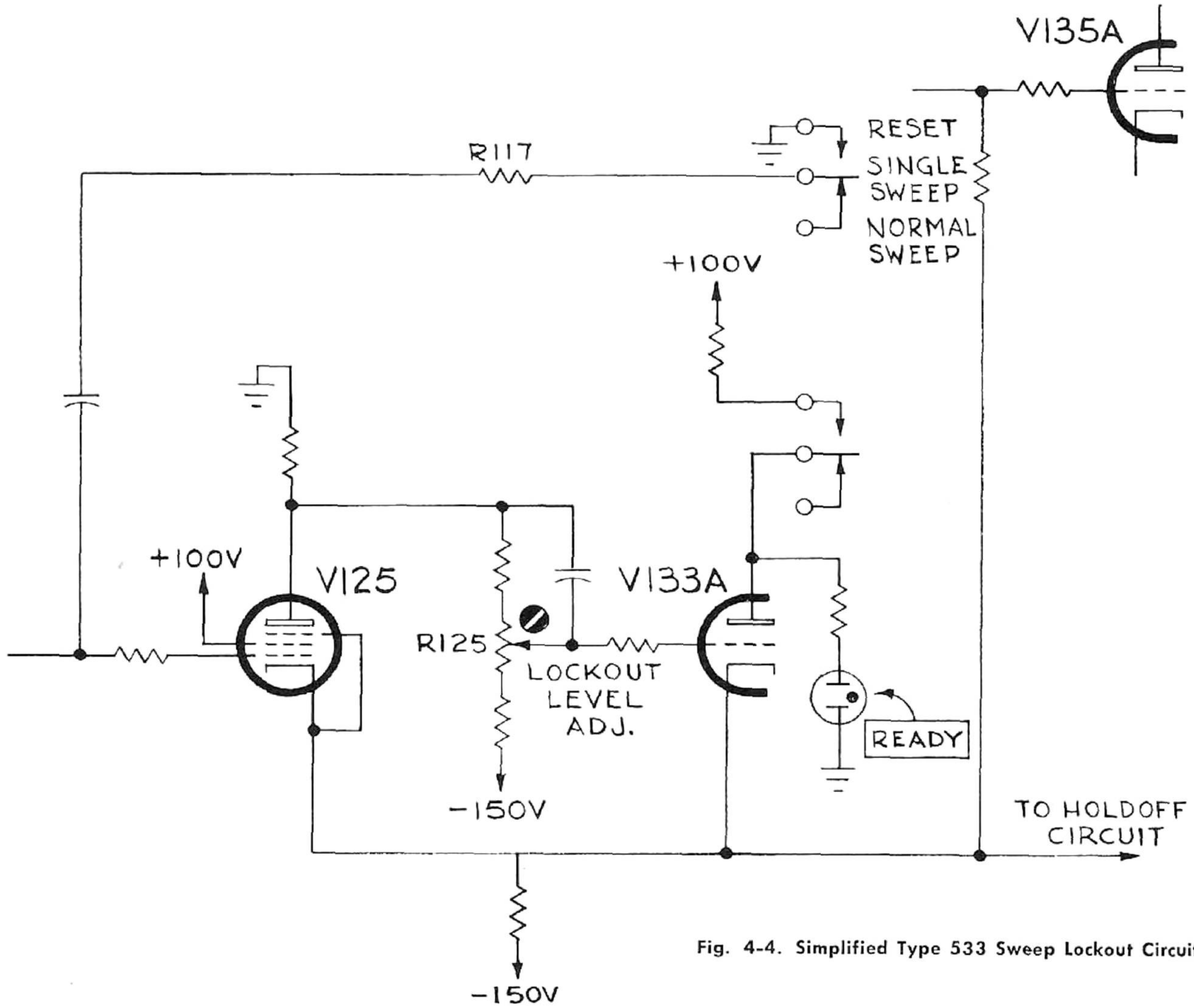


Fig. 4-4. Simplified Type 533 Sweep Lockout Circuit.

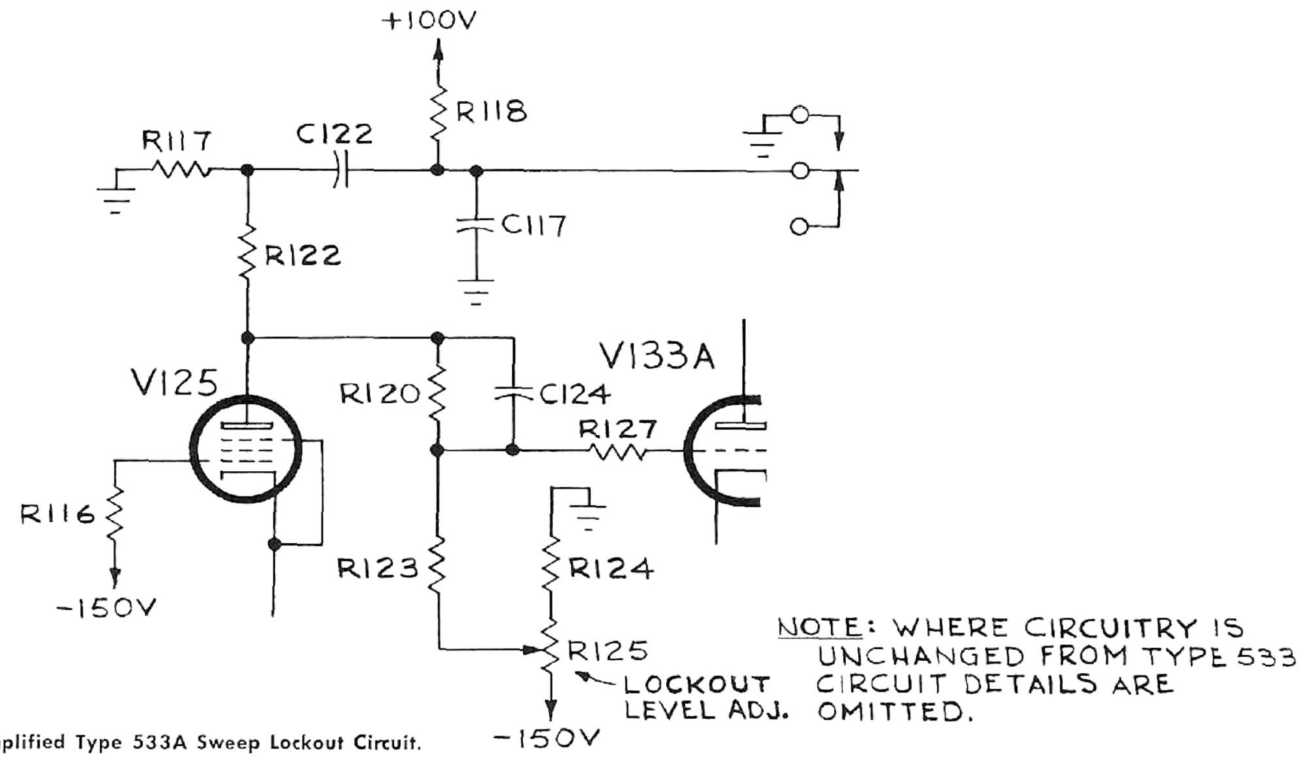


Fig. 4-5. Simplified Type 533A Sweep Lockout Circuit.

There is a slight circuit difference between the Type 533 and Type 533A at this point in the Single Sweep operation. In the Type 533, depressing the RESET switch grounds C121 V125 forces the Lockout Multivibrator into its other stable state with V125 conducting and V133A cut off. With V133A cut off its plate voltage rises and ignites the READY light. With V125 conducting the STABILITY control regains control over the grid level of V135A.

In the Type 533A, the overall circuit operation is the same, except that the RESET switch is connected into the plate circuit of V125, and depressing the button causes a sharp drop in V125 plate voltage, which, through the divider between the plate of V125 and the grid of V133A, again cuts off V133A and flips the Lockout Multivibrator into the stable state with V125 conducting.

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

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

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

Unblanking

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

Output Waveforms

The positive pulse coupled to the crt circuit for unblanking is also coupled through a cathode follower V193B to a front-panel binding post labeled + GATE OUT. This positive gate waveform starts at ground and rises to about +20 volts.

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

Dual-Trace Sync and Blanking

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

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

HORIZONTAL AMPLIFIER

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

Input Circuit

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

Input Amplifier

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

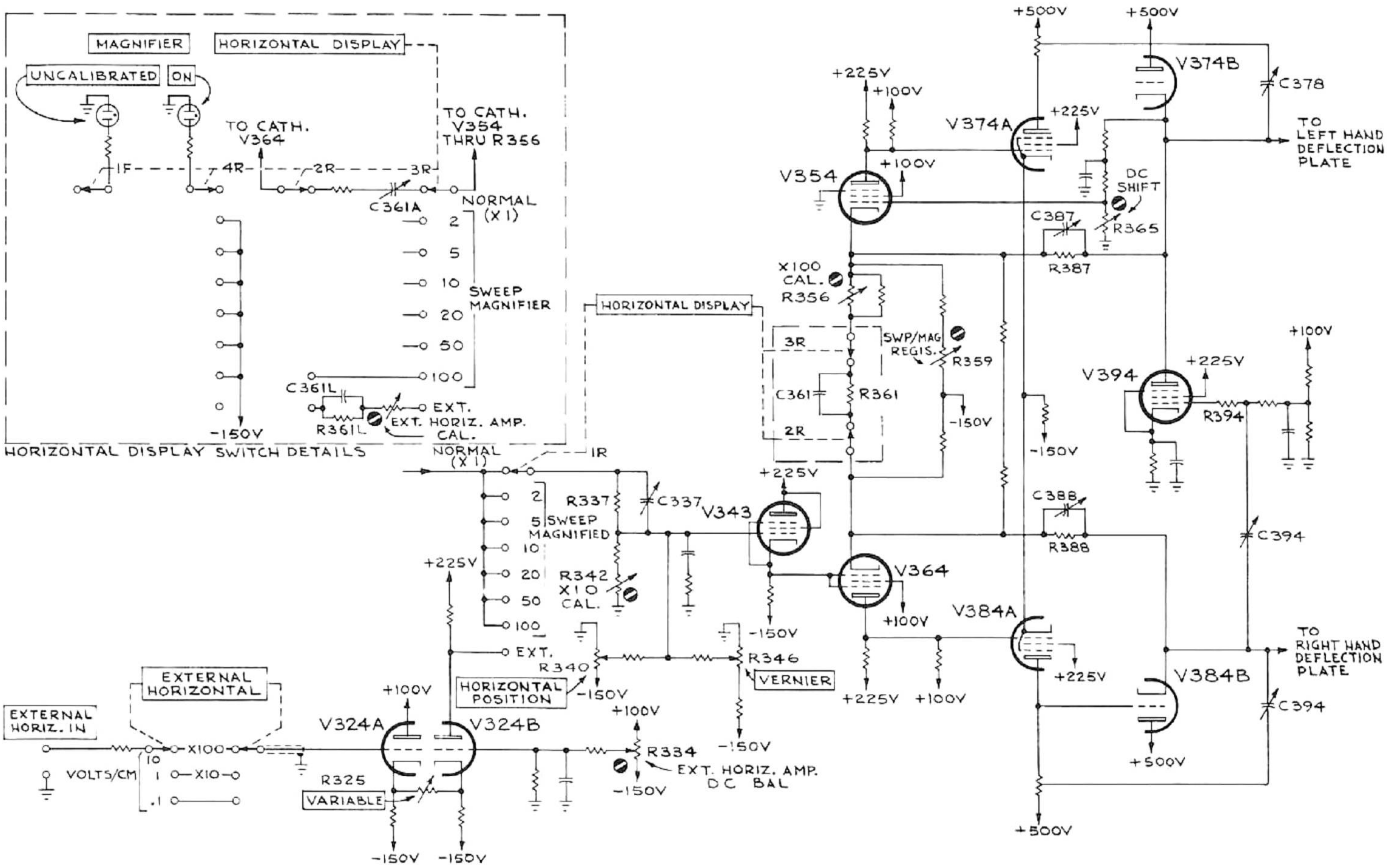


Fig. 4-6. Simplified Type 533/533A Horizontal Amplifier.

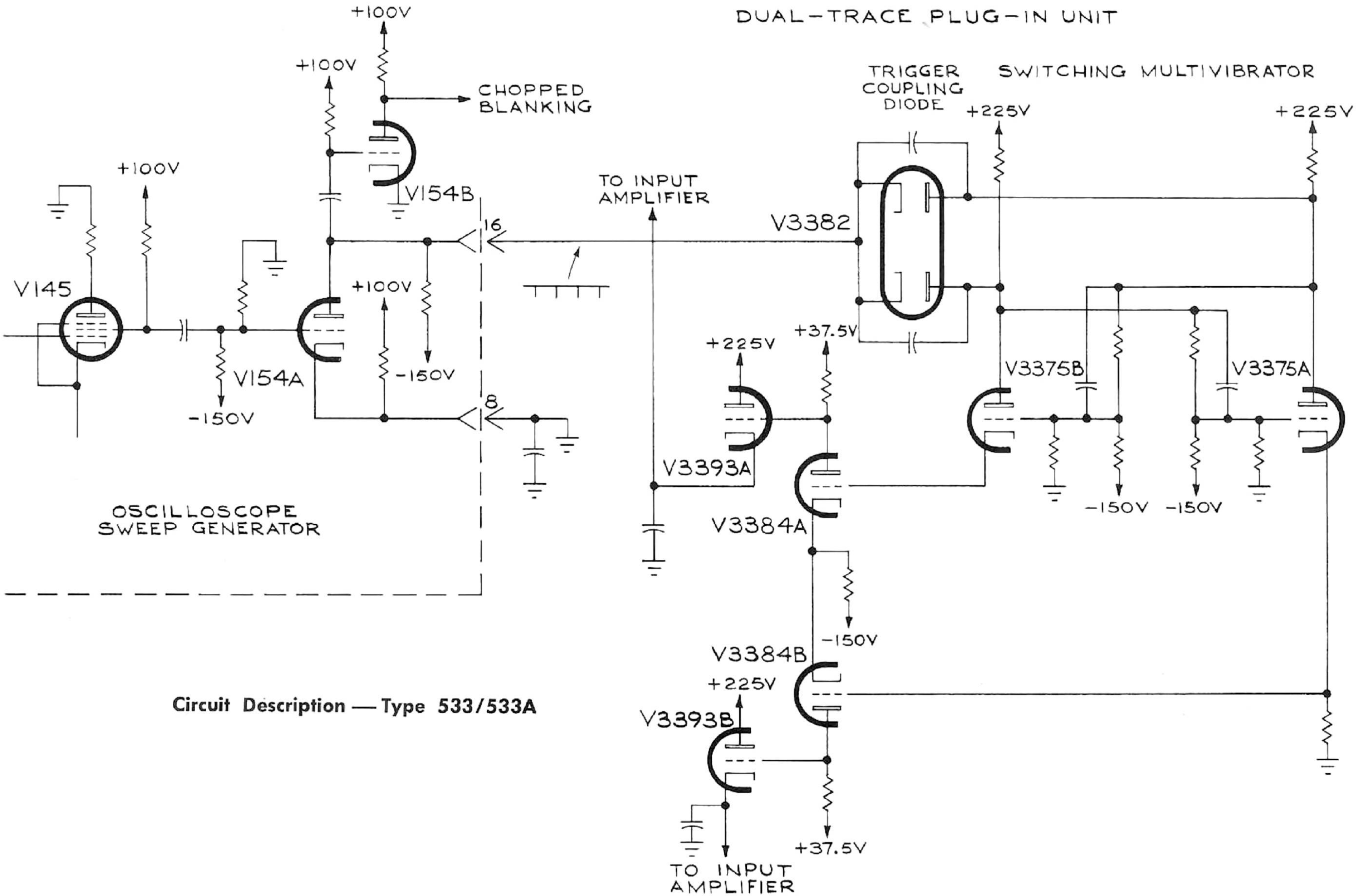


Fig. 4-7. Simplified Dual-Trace Operation.

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

For dc and extremely low frequencies, a small amount of positive feedback is coupled from the cathode of V378B to the grid of V354. The DC SHIFT control R365 is adjusted so that the time constant of the feedback network is equal to the time constant of the slump distortion in the tubes.

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

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

Output Stage

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

Capacitance Driver

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

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

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

External Sweep

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

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

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

LOW-VOLTAGE POWER SUPPLY

General

General circuit design of the low voltage power supply is nearly identical in the Type 533A to that found in the Type 533. However, circuit numbers assigned to individual components are considerably different for the two instruments. Therefore, in the Low-Voltage Power Supply description to follow, descriptions of circuitry for the Type 533 and Type 533A will be given separately for purposes of greater simplicity and ease of understanding. Refer to the section which applies to your type of instrument in each case.

Power Transformer

Plate and filament power for the tubes in the Type 533/533A is furnished by a single power transformer, T700 in Type 533, T601 in Type 533A. The primary has two equal windings which may be connected in parallel for 117-volt operation, or in series for 234-volt operation. The power supply will maintain regulation over line voltage ranges of 105 to 125 volts, or 210 to 250 volts, rms, 50-60 cycles. Bridge rectifiers are employed for the five separate, full-wave power supplies. The five supplies furnish regulated output voltages of —150, +100, +225, +350 and +500 volts.

Type 533 —150 Volt Supply

In Type 533 Instruments, reference voltage for the —150 volt supply is furnished by a gas diode voltage-reference tube V710. This tube, which has a constant voltage drop, establishes a fixed potential of about —87 volts at the grid of V712A, one-half of the difference amplifier. The grid voltage for the other half of the difference amplifier, V712B, is obtained from a divider consisting of R715, R716 and R718. The —150 ADJ. control R716 determines the percentage of total voltage that appears at the grid of V712B and thus determines the total voltage across the divider. This control is adjusted so that the output voltage is exactly —150 volts.

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

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

Type 533A —150 Volt Supply

In the Type 533A, reference voltage for the —150 volt supply is furnished by a gas diode voltage-reference tube V609. This tube, which has a constant voltage drop, establishes a fixed potential of about —87 volts at the grid of V624A, one-half of a difference amplifier. The grid voltage for the other half of the difference amplifier, V624B, is obtained from a divider consisting of R616, R617 and R618. The —150 ADJ. control R616 determines the percentage of total voltage that appears at the grid of V624B and thus determines the total voltage across the divider. This control is adjusted so that the output voltage is exactly —150 volts.

If line-voltage or load fluctuations tend to change the output voltage, an error signal exists between the two grids of the difference amplifier. The error signal is amplified in V624B and V634 and applied to the grids of the series tubes V627, V637 and V647. The resulting changes in voltage at the plates of the series tubes, which will be in a direction to compensate for any change in output voltage, is coupled through the rectifiers to the output to keep this voltage constant. Capacitors C617 and C628 improve the ac gain of the feedback loop to increase the response of the regulator circuit to sudden changes in output voltage.

A small amount of unregulated bus ripple is coupled to to the screen of V634 through R637. The phase of the amplified ripple voltage at the plate of V634 is such as to cancel most of the ripple on the —150 volt bus.

Type 533 +100 Volt Supply

In Type 533, the +100-Volt Supply is regulated by comparing to ground (the cathode of V742) the voltage of a point near ground potential obtained from the divider R750-R751 connected between the +100-volt bus and the regulated —150 volt supply. Any error voltage that exists is amplified and inverted in polarity by V742 and coupled through the cathode follower V748B to the output to prevent the output voltage from changing. Capacitor C750 improves the ac gain of this circuit.

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

Type 533A +100 Volt Supply

In Type 533A, the +100-volt supply is regulated by comparing to ground (the cathode of V664) the voltage of a point near ground potential obtained from the divider R650-R651 connected between the +100-volt bus and the regulated —150 volt supply. Any error voltage that exists is amplified and inverted in polarity by V664 and coupled through the cathode follower V677A to the output to prevent the output voltage from changing. Capacitor C650 improves the ac gain of this circuit.

A small sample of the unregulated bus ripple appears at the screen of V664 through R668. This produces a ripple component at the grid of the cathode follower V677A that is opposite in polarity to the ripple at the plate; this tends to cancel the ripple at the cathode and hence on the

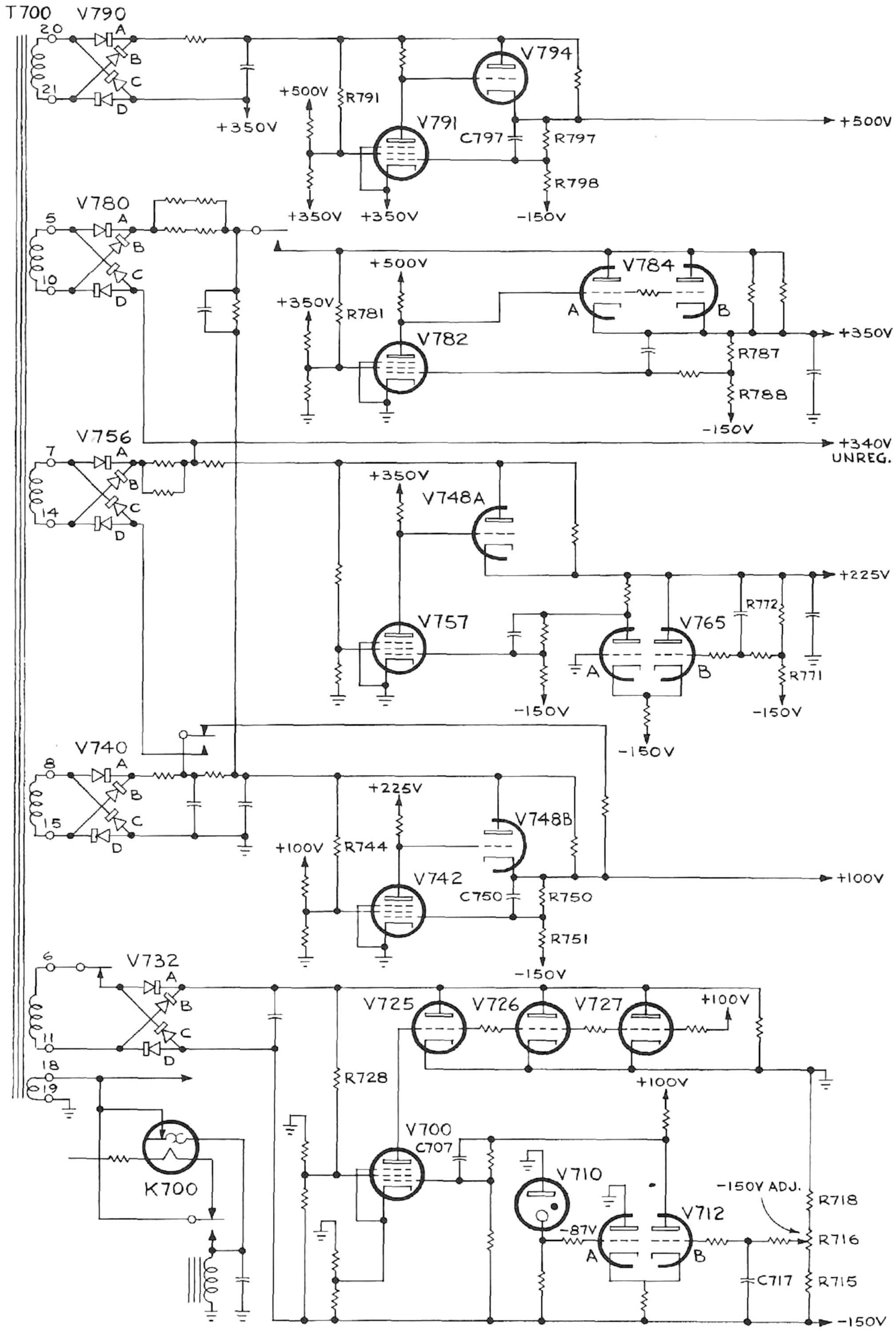


Fig. 4-8. Simplified Type 533 Low-Voltage Power Supply.

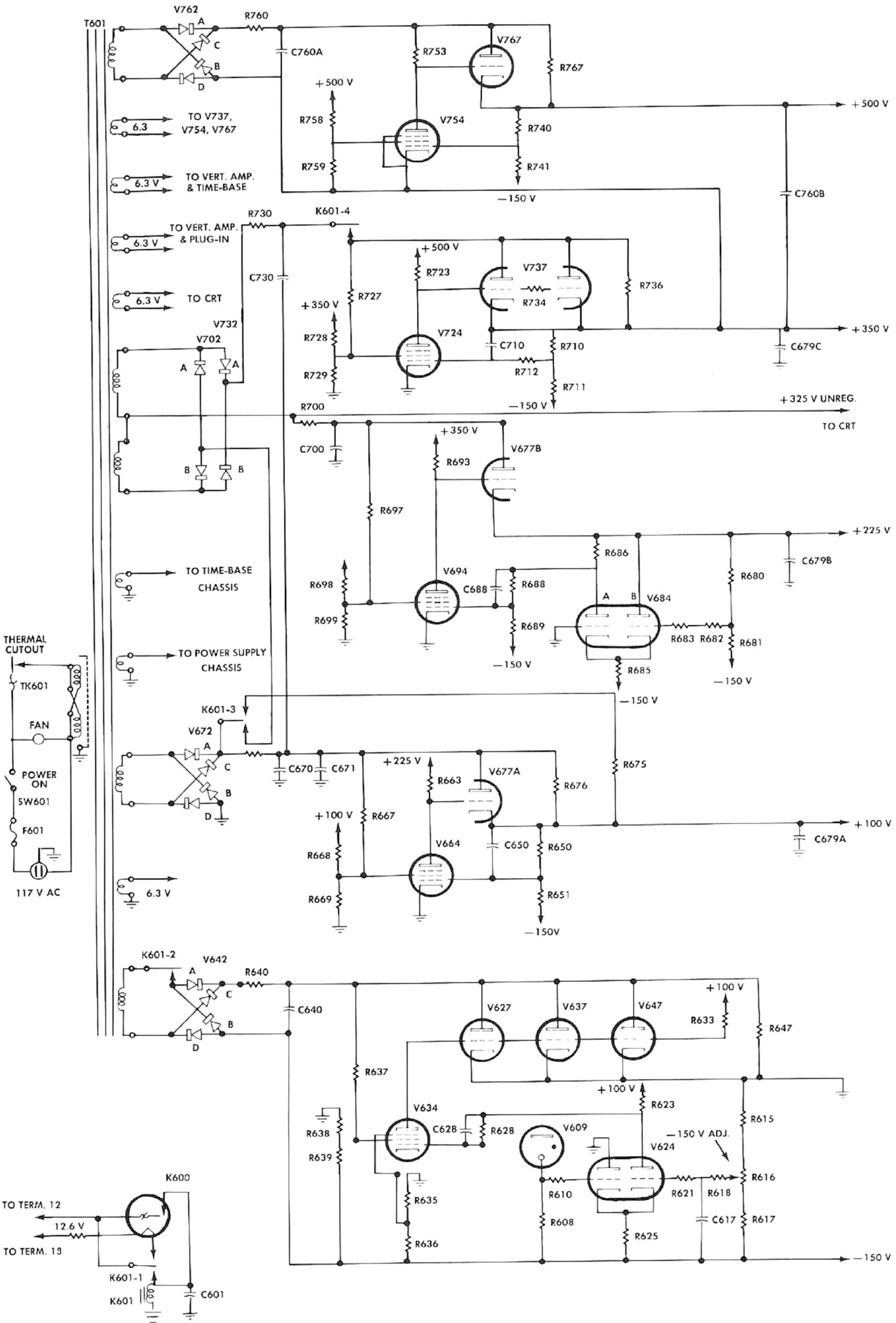


Fig. 4-9. Simplified Type 533A Low-Voltage Power Supply.

+100-volt bus. This same circuit also improves the regulation in the presence of line-voltage variations.

Type 533 +225 Volt Supply

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

Type 533A +225 Volt Supply

In Type 533A, rectified voltage from terminals 10 and 14 of the power transformer is added to the voltage supplying the +100 volt regulator to furnish power for the +225 volt regulator. This supply is regulated by comparing to ground (the grid of V684A) the voltage of a point near ground obtained from the divider R680-R681 connected between the +225 volt bus and the regulated —150 volt supply. Any error voltage that exists between the grids of the difference amplifier (V684) is amplified in both V684 and V694, and coupled through the cathode follower V677B to the +225 volt bus. The change in voltage at the cathode of V677B, due to the regulator action, will be opposite in polarity to the original error signal and will thus tend to keep the output constant. This supply also furnishes an unregulated output of about +325 volts for the oscillator in the crt high-voltage supply. It is unnecessary to regulate this voltage as the crt supply has its own regulator circuits.

Type 533 +350 Volt Supply

In the Type 533, rectified voltage from terminals 5 and 10 of T700 is added to voltage supplying the +225 volt regulator to furnish power for the +350 volt regulator. This supply is regulated by comparing to ground the voltage of a point near ground obtained from the divider R787-R788 connected between the +350 volt bus and the regulated —150 volt supply. The operation of the regulator circuit is the same as that described for the +100 volt supply.

Type 533A +350 Volt Supply

In the Type 533A, rectified voltage from terminals 5 and 14 of T601 is added to voltage supplying the +100 volt regulator to furnish power for the +350 volt regulator. This supply is regulated by comparing to ground the voltage of a point near ground obtained from the divider R710-R711 connected between the +350 volt bus and the regulated —150 volt supply. The operation of the regulated circuit is the same as that described for the +100 volt supply.

Type 533 +500 Volt Supply

In Type 533, rectified voltage from terminals 20 and 21 of T700 is added to the regulated side of the +350 volt supply to furnish power for the +500 volt regulator. This supply is regulated by comparing to the regulated +350 volts the voltage of a point near +350 obtained from the divider R797-R798 connected between the +500 volt bus and the regulated —150 volt supply. The regulator action of this circuit is the same as that described for the +100 volt supply.

Type 533A +500 Volt Supply

In Type 533A, rectified voltage from terminals 20 and 21 of T601 is added to the regulated side of the +350 volt supply to furnish power for the +500 volt regulator. This supply is regulated by comparing to the regulated +350 volts the voltage of a point near +350 obtained from the divider R740-R741 connected between the +500 volt bus and the regulated —150 volt supply. The regulator action of this circuit is the same as that described for the +100 volt supply.

Time-Delay

A Time-Delay relay (K700 in Type 533, K600 in Type 533A) delays the application of dc voltages to the amplifier tubes in the instrument for about 25 seconds. This delay is to allow the tube heaters time to bring the cathodes up to emission temperature before operating potentials are applied.

CRT CIRCUIT

Cathode Ray Tube Control Circuits

The INTENSITY control R826 varies the voltage at the grid of the crt to control the beam current. The FOCUS control R856 varies the voltage at the focusing ring to focus the trace. The ASTIGMATISM control R864 varies the voltage at the astigmatism anode to focus the spot in both dimensions simultaneously. The GEOM. ADJ. R861 varies the field the beam encounters as it emerges from the deflection system to control the linearity at the extremes of deflection.

The CRT CATHODE SELECTOR switch SW848 connects the cathode of the crt through C848 to either a rear panel binding post labeled EXTERNAL CRT CATHODE or to the plate of V154B in the Time-Base Generator circuit. When in the DUAL-TRACE CHOPPED BLANKING position, the cathode of the crt is connected to receive positive pulses from the Time-Base Generator circuit to blank the crt dur-

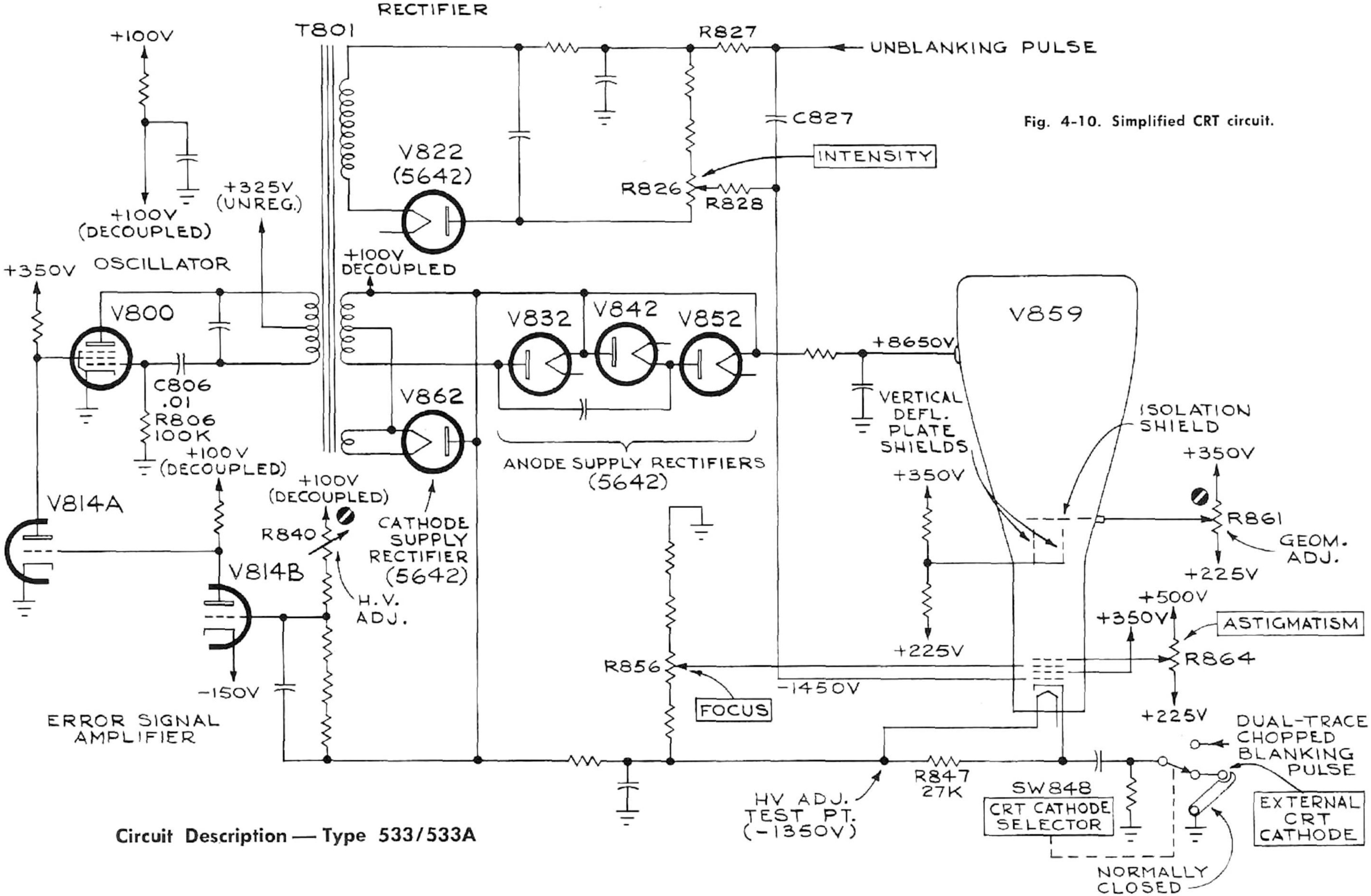


Fig. 4-10. Simplified CRT circuit.

ing switching while operating a dual-trace plug-in unit in the chopped mode.

When SW848 is in the EXTERNAL CRT CATHODE position, the cathode circuit of the crt is connected to the binding post mentioned previously. A bare bus bar normally connects the binding post to ground. When intensity modulation of the beam is desired, the bus bar can be removed so that the modulating signal can be coupled to the crt cathode.

High-Voltage Supply

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

A half-wave rectifier V862 provides —1350 volts for the crt cathode. A half-wave voltage tripler circuit, V832, V842 and V852, provides +8650 volts for the post-anode accelerator. This provides a total accelerating voltage of 10,000 volts. Both supplies are tied to the +100 volt regulated supply through the decoupling filter R800-C800.

A floating half-wave rectifier V822 furnishes bias voltage (about —1450 volts) for the crt grid. This floating grid supply, independent of the cathode supply, is required in order to provide dc-coupled unblanking to the crt grid. All three supplies employ capacitor-input filters.

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

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

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

Unblanking

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

At the faster sweep rates the stray capacitance in the circuit makes it difficult to pull up the floating supply fast enough to unblank the crt in the required time. To overcome this, an isolation network composed of C834, R834, R836, C835, C836 and R835 is employed. By this arrangement the fast leading edge of the unblanking pulse is coupled through C834 to the grid of the crt. For short-duration unblanking pulses, at the faster sweep rates, the power supply itself is not appreciably moved.

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

Calibrator

Type 533

The Type 533 Calibrator is a square-wave generator whose approximately 1 kc output is available at the front panel connector labeled CAL. OUT. It consists of a multivibrator V670 connected so as to switch the cathode follower V246A between two operating stages, cutoff and conduction.

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

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

Type 533A

The Type 533A Calibrator is a square-wave generator producing an output at approximately 1 kc which is available at the front panel CAL. OUT connector. It consists of V875 and V885A comprising a multivibrator, connected so as to switch the cathode follower V885B between two operating stages, cutoff and conduction.

During the negative portion of the multivibrator waveform the grid of V885B is driven well below cutoff and its cathode rests at ground potential. During the positive portion of the waveform V875 is cut off and its plate rests slightly below +100 volts. The voltage at the grid of V885B when this tube is cut off, is determined by the setting of the CAL. ADJ. control R879 part of the divider connected between +100 volts and ground.

Cathode-follower V885B has a precision, tapped divider for its cathode resistor. When the CAL. ADJ. control is properly adjusted, the cathode of V885B is at +100 volts when V875 is cut off. By means of the tapped divider R885 through R893 and a second 100 to 1 divider R896-R897, output voltages from .2 millivolts to 100 volts in steps are available. C885, connected between the cathode of V885B and ground, corrects the output waveform for a slight overshoot.

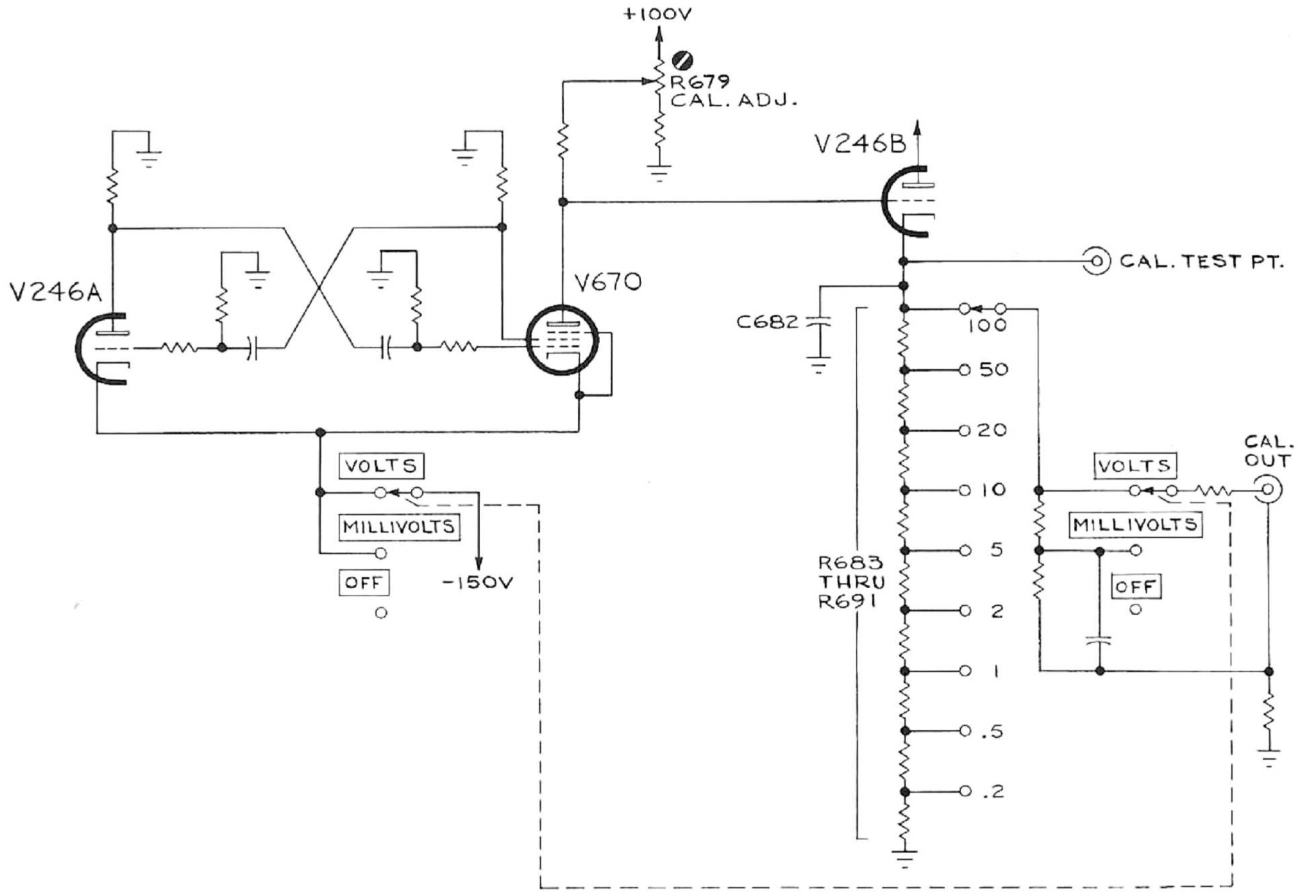


Fig. 4-11. Simplified Type 533 Calibrator.

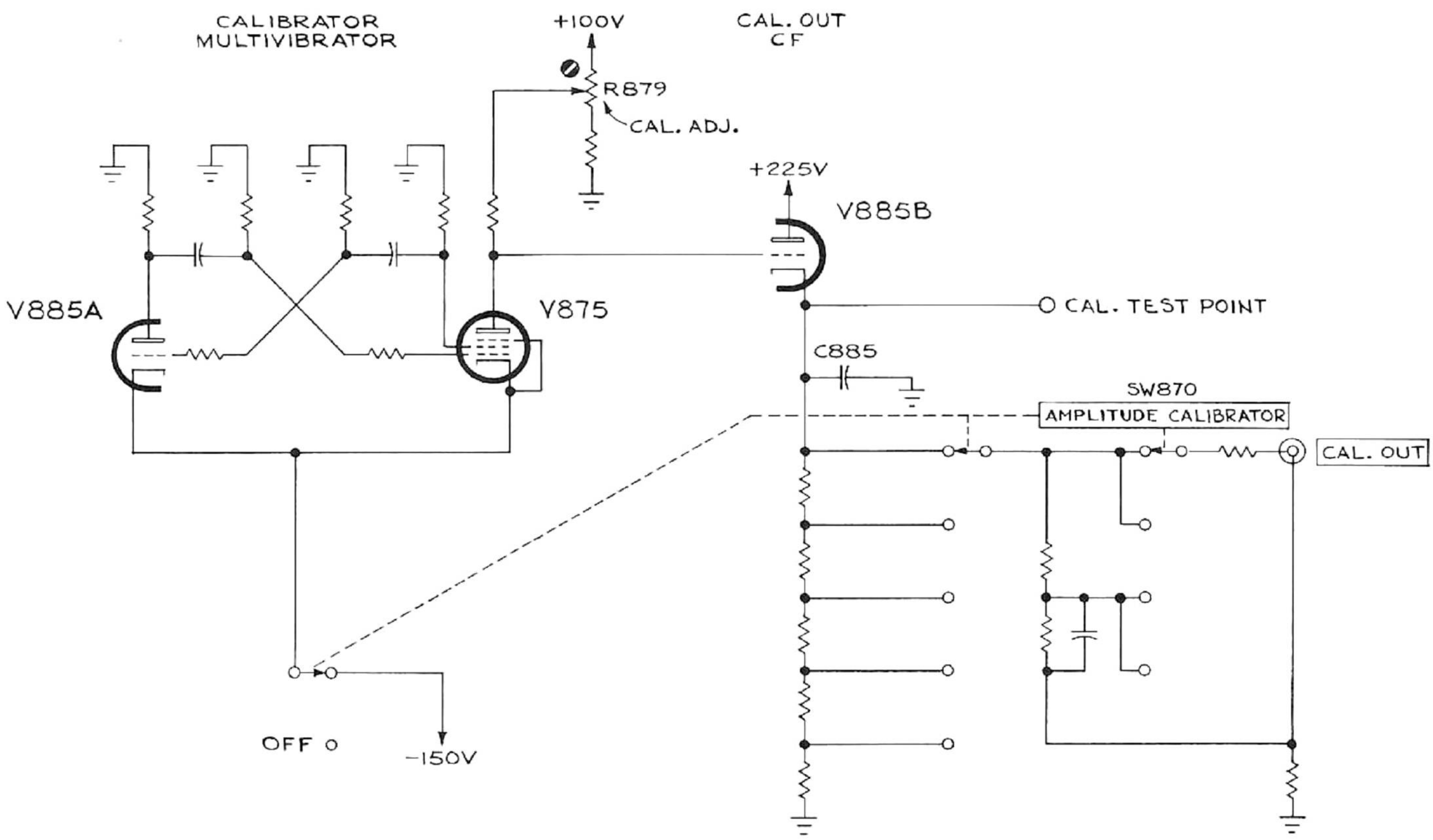
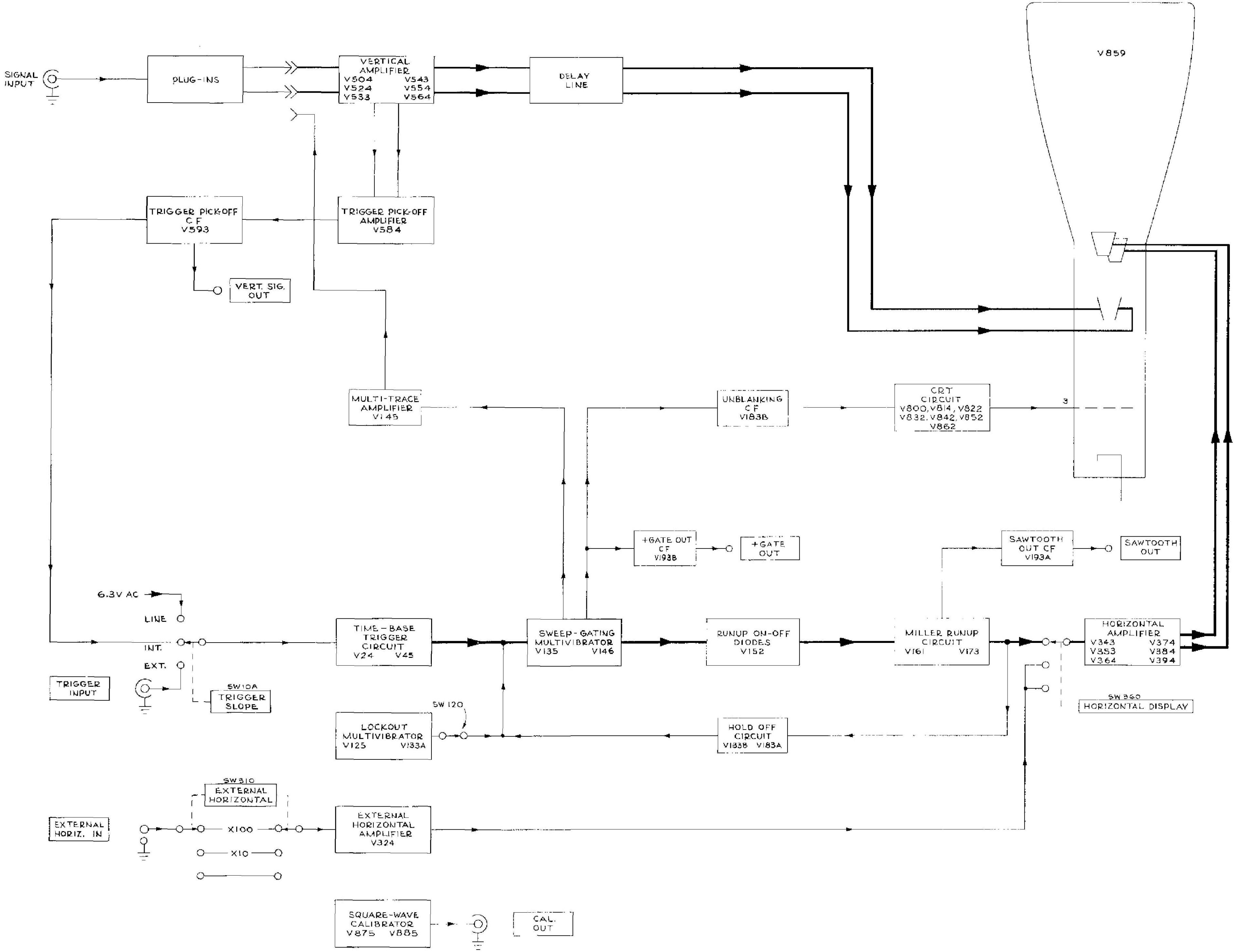


Fig. 4-12. Simplified Type 533A Calibrator.



TYPE 533/533A OSCILLOSCOPE

AA1

IMPORTANT

WAVEFORMS ARE IDEALIZED BUT CLOSELY APPROXIMATE THOSE TO BE FOUND IN THIS INSTRUMENT PROVIDED CONTROLS ARE SET AS INDICATED BELOW AND ON EACH SCHEMATIC. VOLTAGE READINGS, IF TAKEN WITH A VTVM, WILL BE WITHIN ± 10% OF THE INDICATED VALUE. BEFORE STARTING TO CHECK THIS INSTRUMENT THE FOLLOWING CONTROLS SHOULD BE SET AND NOT DISTURBED UNLESS OTHERWISE NOTED ON SCHEMATICS BEING USED. RETURN CONTROLS TO THE POSITIONS LISTED BELOW BEFORE MOVING TO THE NEXT SCHEMATIC.

AMPLITUDE CALIBRATOR	OFF
HORIZONTAL DISPLAY	NORMAL (X1)
VARIABLE (TIME/CM)	CW (CALIBRATED)
TIME/CM	1 mSEC
TRIGGERING MODE	AC SLOW
TRIGGER SLOPE	+LINE
TRIGGERING LEVEL	CENTERED
STABILITY	PRESET

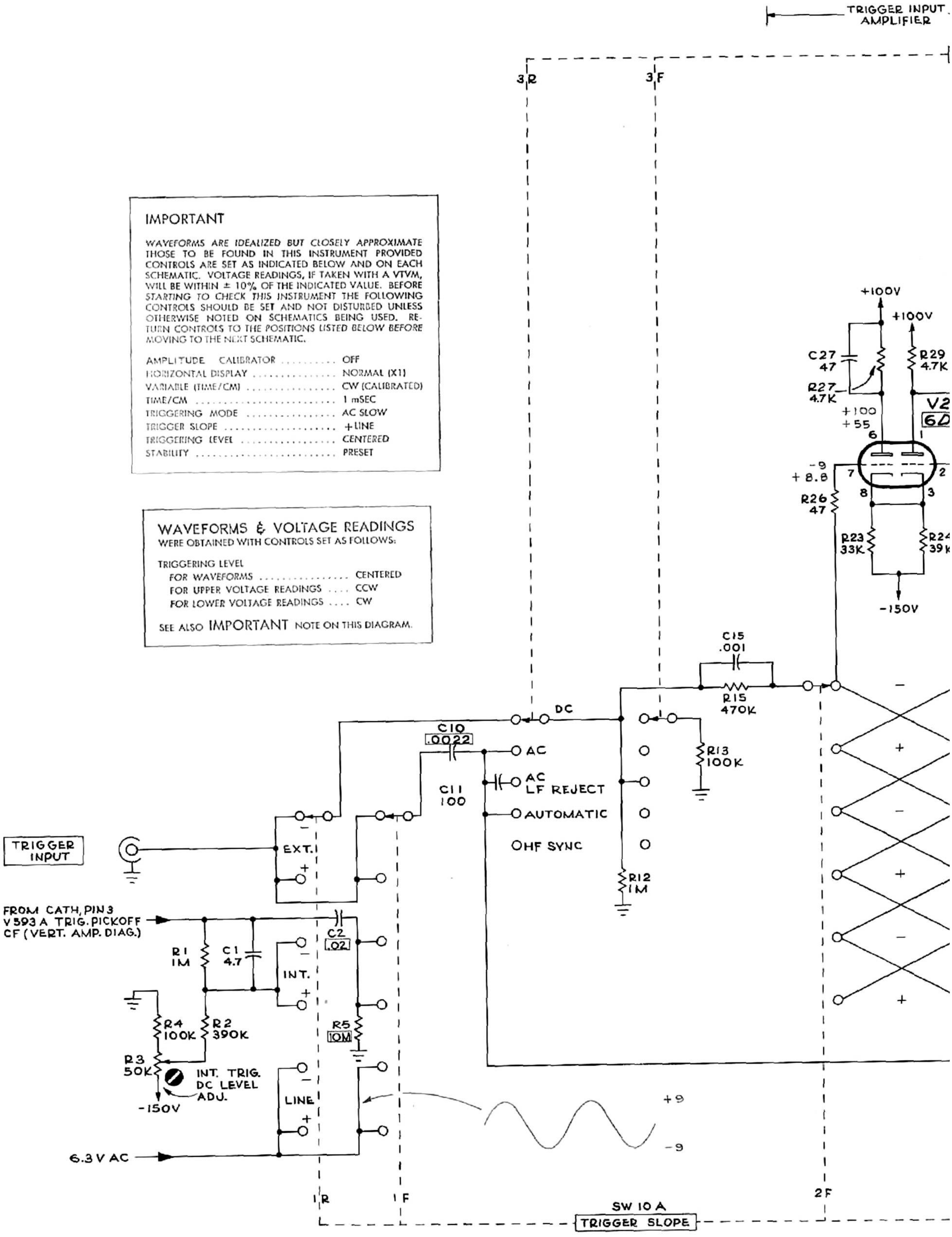
WAVEFORMS & VOLTAGE READINGS

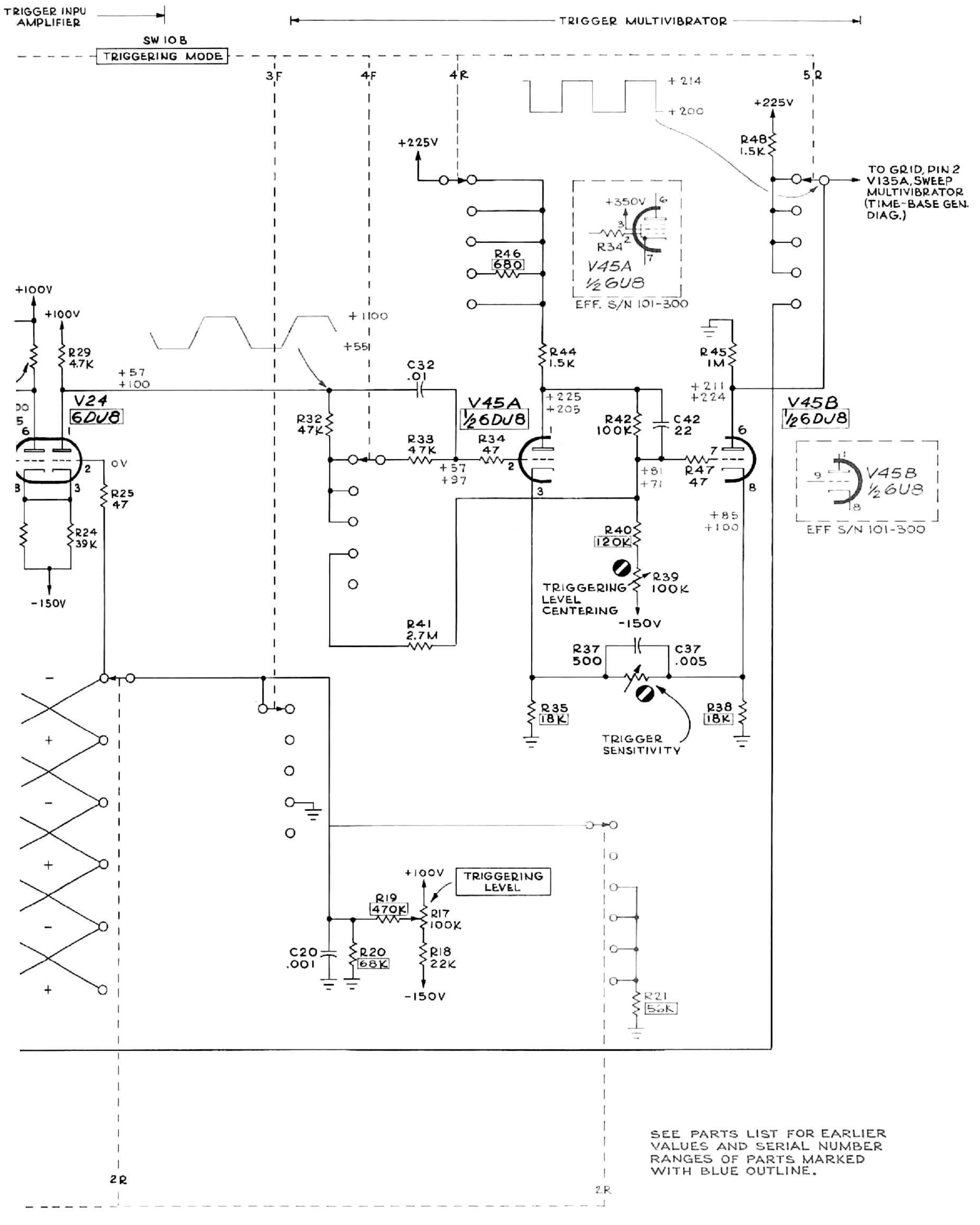
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

TRIGGERING LEVEL

FOR WAVEFORMS	CENTERED
FOR UPPER VOLTAGE READINGS	CCW
FOR LOWER VOLTAGE READINGS	CW

SEE ALSO IMPORTANT NOTE ON THIS DIAGRAM.





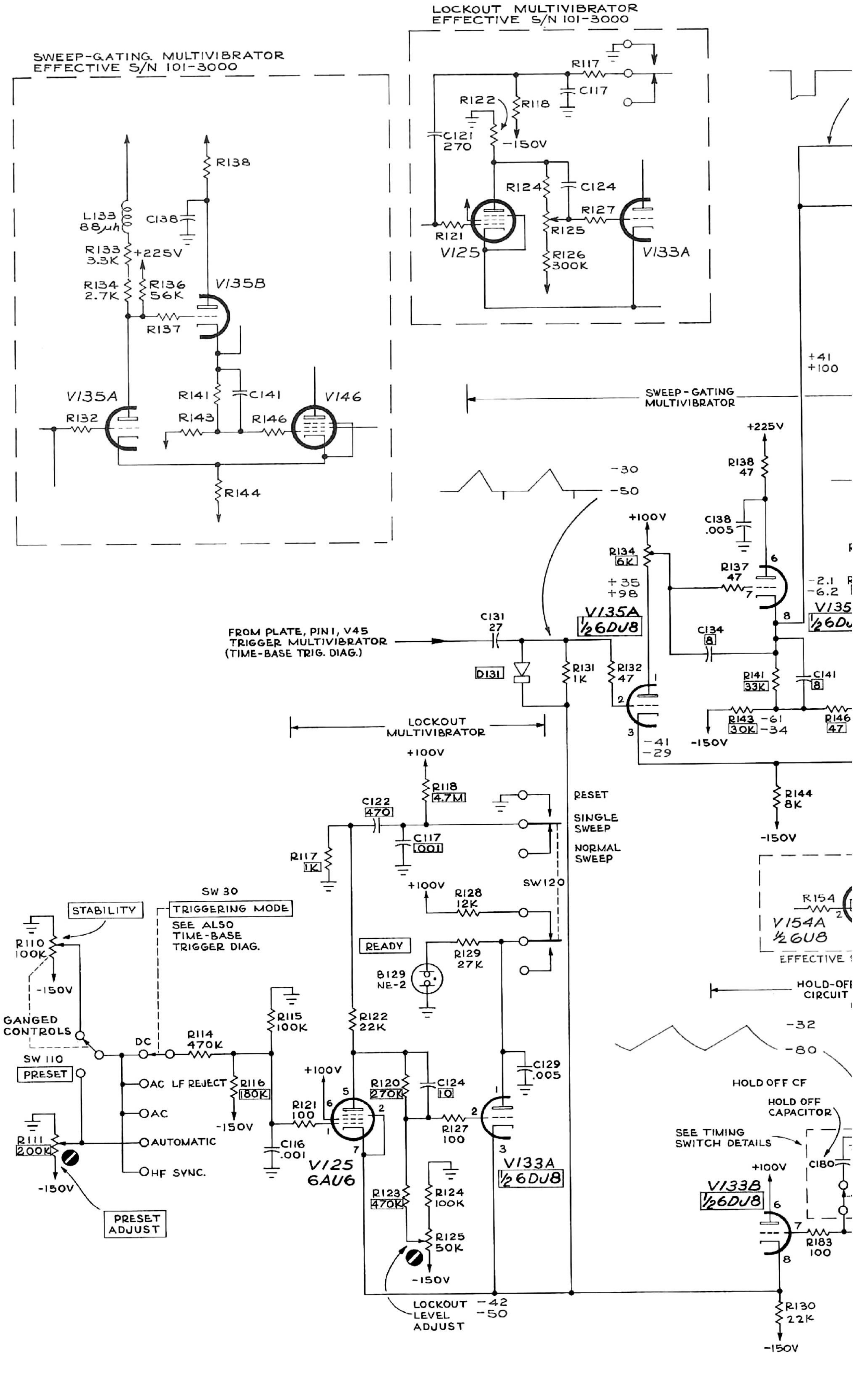
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

CIRCUIT NUMBERS 1 THRU 49

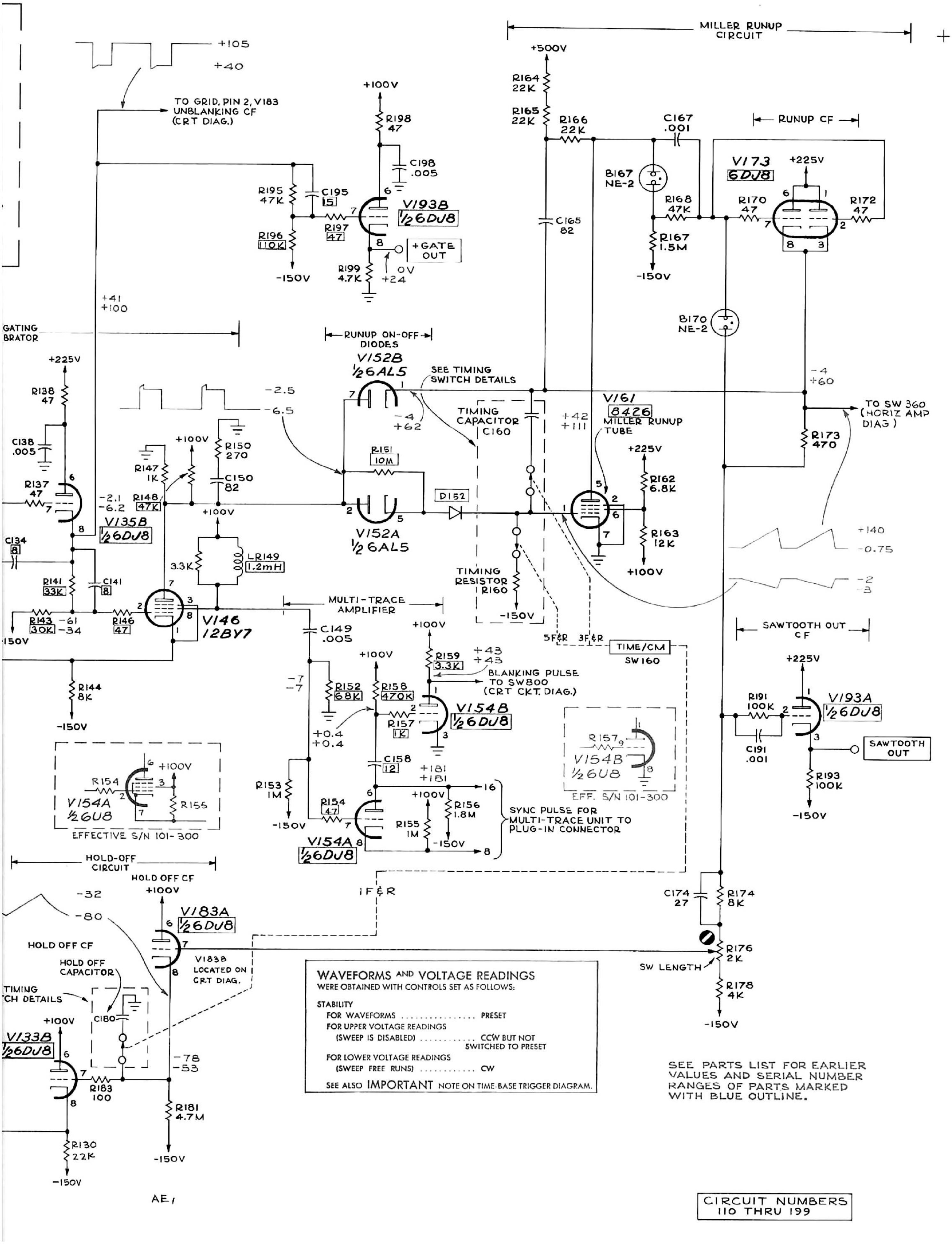
1166
JN

AD

TIME-BASE TRIGGER



LOCKOUT MULTIVIBRATOR
EFFECTIVE S/N 101-3000
SWEEP-GATING MULTIVIBRATOR
EFFECTIVE S/N 101-3000
R117
C117
R122
R118
C121
270
-150V
R124
C124
R127
R121
R125
V125
R126
300K
V133A
R138
L133
88μh
C138
R133
3.3K
+225V
R134
2.7K
R136
56K
V135B
R137
V135A
R141
C141
V146
R132
R143
R146
R144
+41
+100
SWEEP-GATING
MULTIVIBRATOR
+225V
R138
47
-30
-50
+100V
C138
.005
R134
6K
R137
47
+35
+98
-2.1
-6.2
V135A
½6DU8
C131
27
FROM PLATE, PIN 1, V45
TRIGGER MULTIVIBRATOR
(TIME-BASE TRIG. DIAG.)
C134
8
D131
R131
1K
R132
47
R141
33K
C141
8
R143
30K
-61
-34
R146
47
-41
-29
-150V
LOCKOUT
MULTIVIBRATOR
+100V
R118
4.7M
C122
470
C117
.001
R117
1K
RESET
SINGLE
SWEEP
NORMAL
SWEEP
SW120
R144
8K
-150V
+100V
R128
12K
SW 30
STABILITY
TRIGGERING MODE
SEE ALSO
TIME-BASE
TRIGGER DIAG.
READY
R129
27K
B129
NE-2
R154
V154A
½6U8
EFFECTIVE
HOLD-OFF
CIRCUIT
R110
100K
-150V
GANGED
CONTROLS
SW 110
PRESET
DC
R114
470K
R115
100K
R122
22K
-32
-80
+100V
R120
270K
C124
10
C129
.005
AC LF REJECT
R116
180K
AC
-150V
R121
100
R127
100
HOLD OFF CF
HOLD OFF
CAPACITOR
SEE TIMING
SWITCH DETAILS
R111
200K
AUTOMATIC
C116
.001
V125
6AU6
V133A
½6DU8
+100V
C180
HF SYNC.
-150V
R123
470K
R124
100K
V133B
½6DU8
R183
100
PRESET
ADJUST
R125
50K
-150V
LOCKOUT
LEVEL
ADJUST
-42
-50
R130
22K
-150V



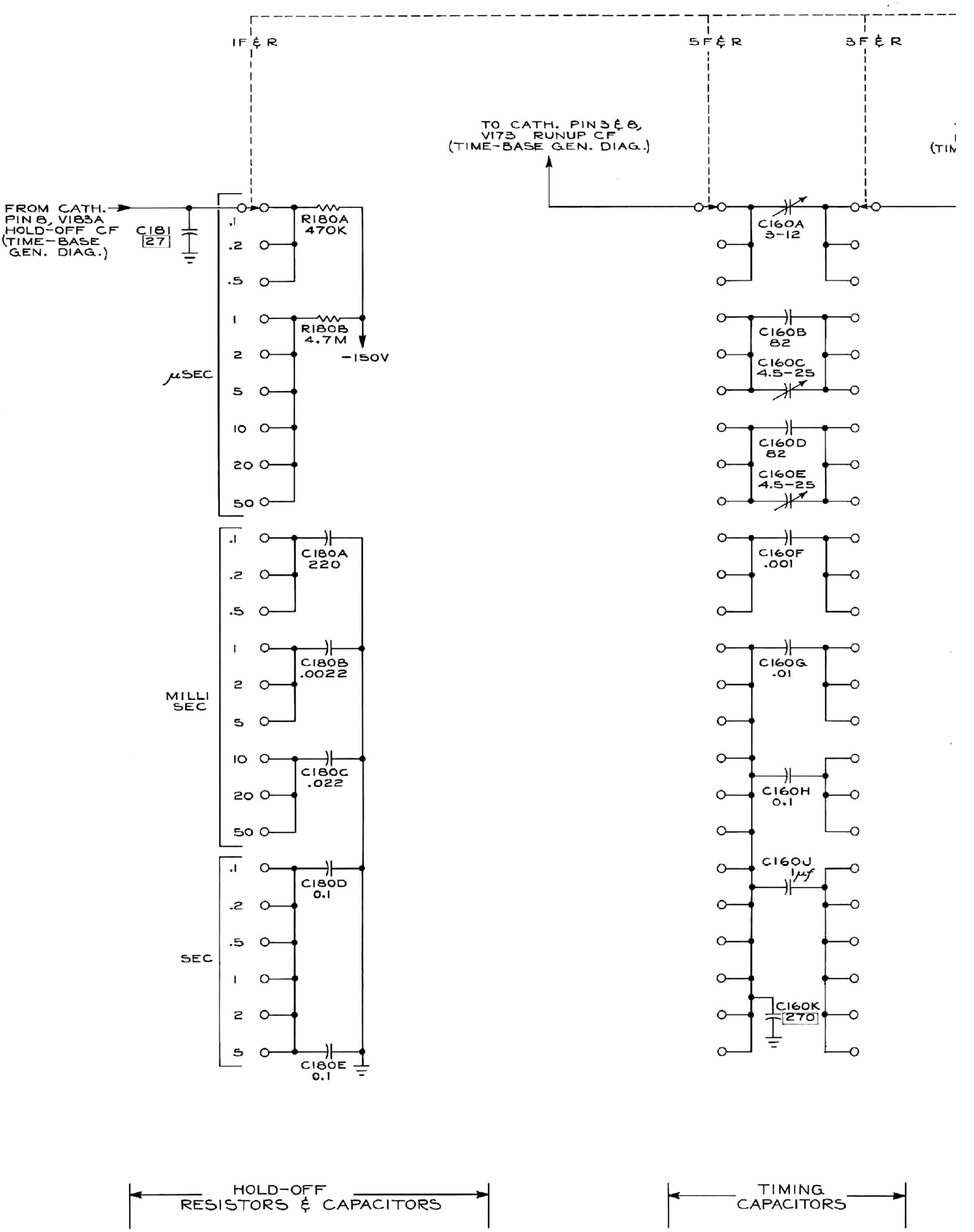
WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

STABILITY
FOR WAVEFORMS .... PRESET
FOR UPPER VOLTAGE READINGS (SWEEP IS DISABLED) .... CCW BUT NOT SWITCHED TO PRESET
FOR LOWER VOLTAGE READINGS (SWEEP FREE RUNS) .... CW

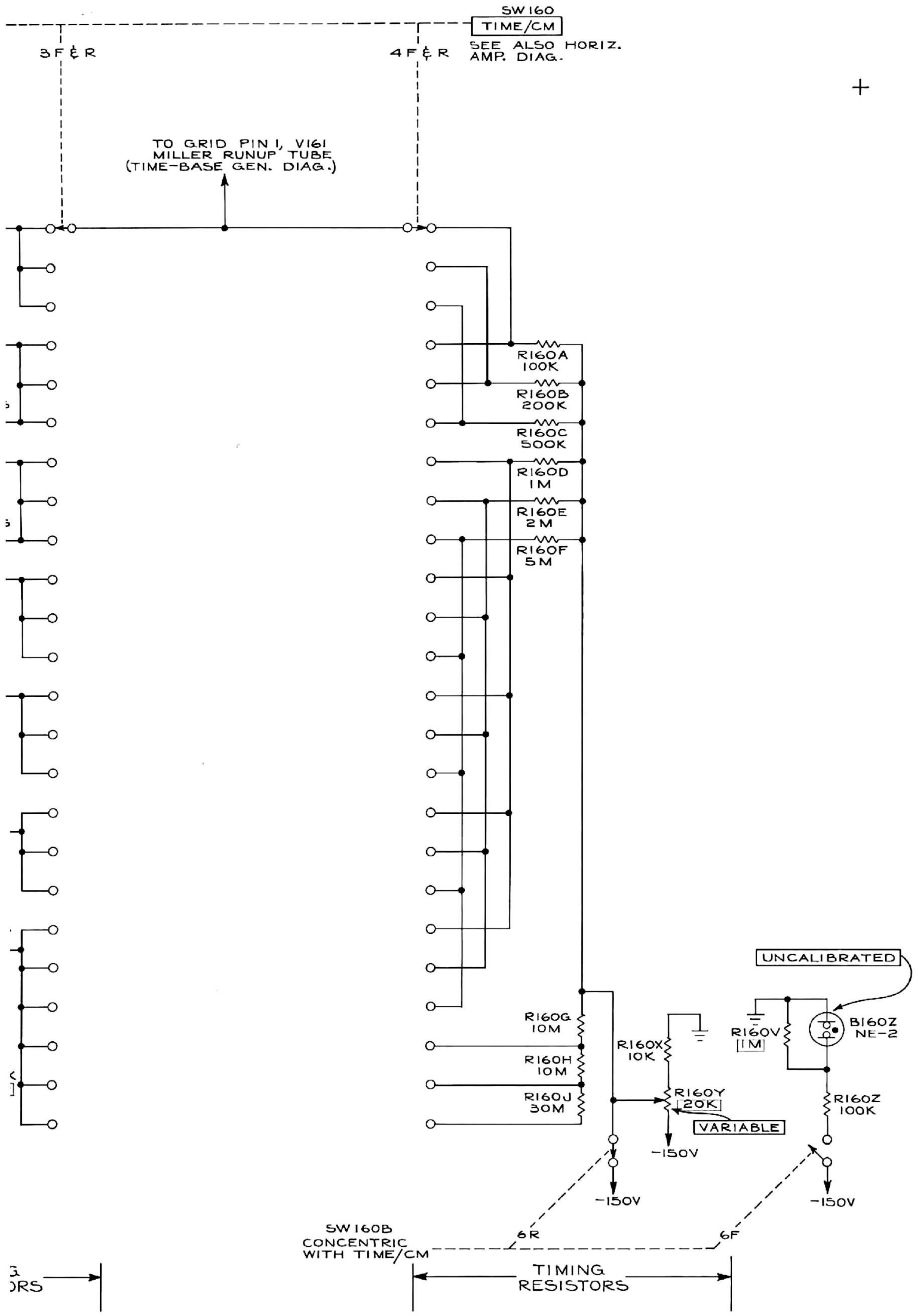
SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

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

CIRCUIT NUMBERS 110 THRU 199



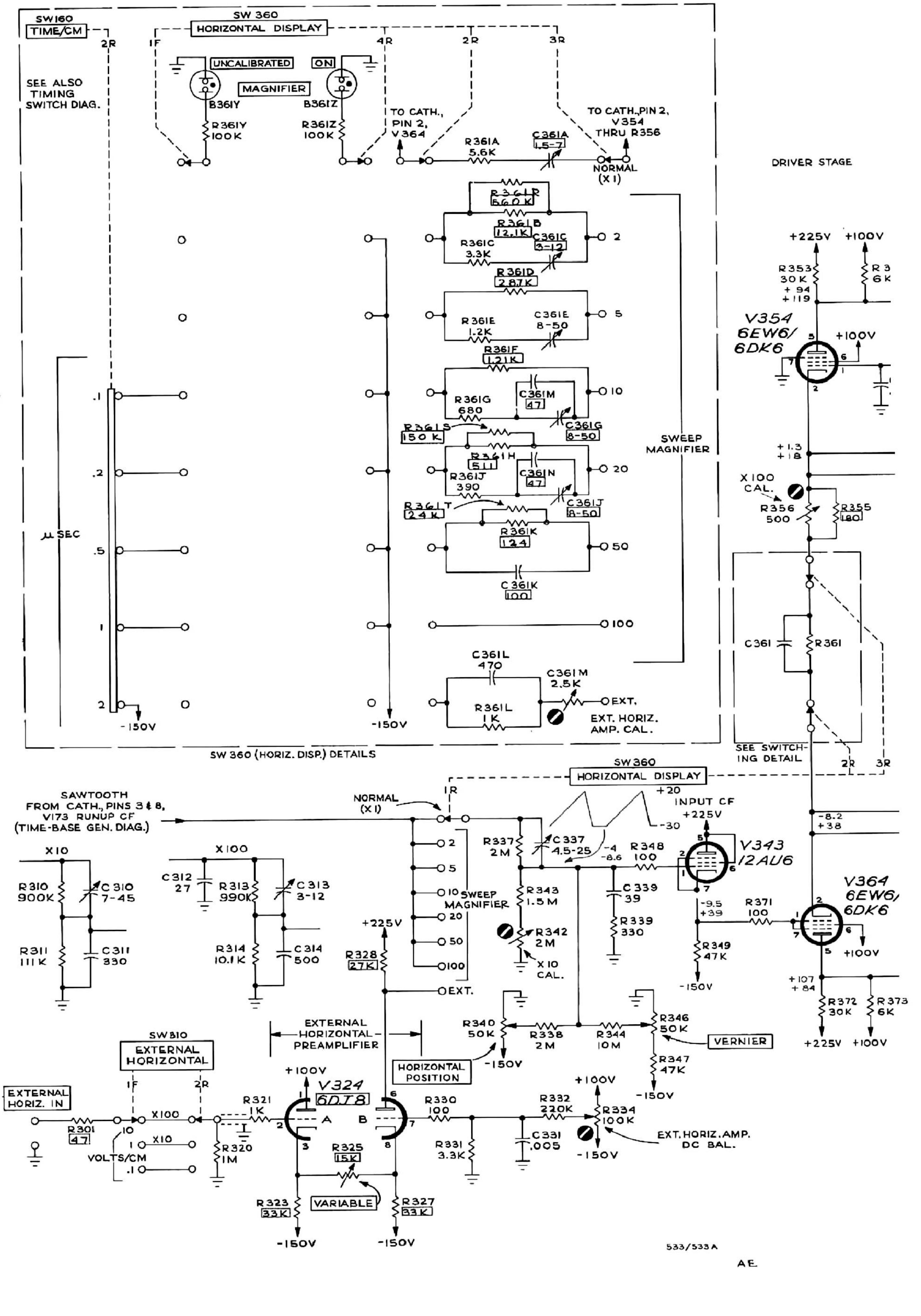
SEE
VAL
RAN
WIT



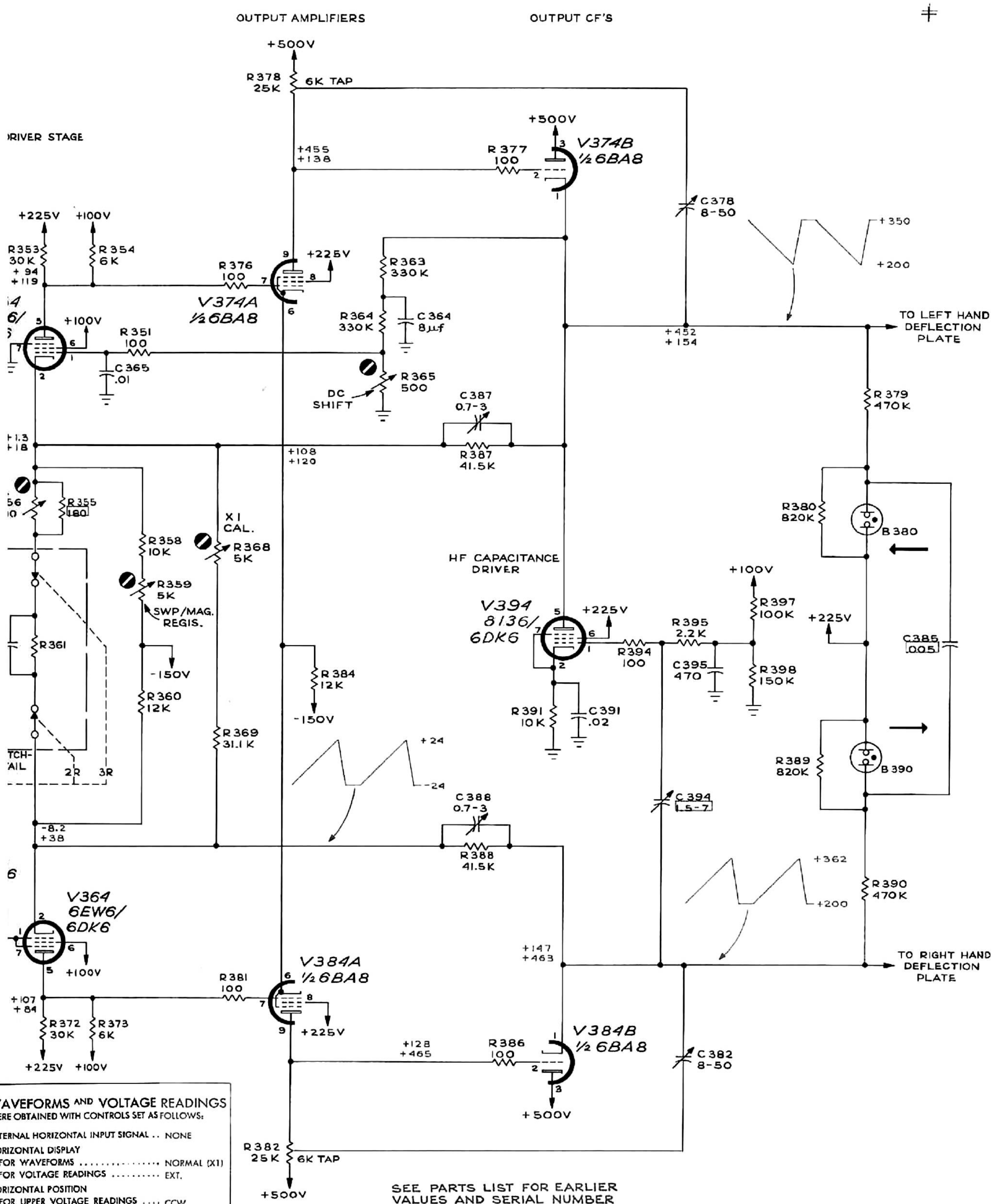
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

PLM 664

AB_2



SW160
TIME/CM
SW 360
HORIZONTAL DISPLAY
SEE ALSO TIMING SWITCH DIAG.
UNCALIBRATED
ON
MAGNIFIER
B361Y
B361Z
R361Y 100K
R361Z 100K
TO CATH., PIN 2, V364
TO CATH., PIN 2, V354 THRU R356
R361A 5.6K
C361A 1.5-7
NORMAL (X1)
DRIVER STAGE
SWEEP MAGNIFIER
µ SEC
-150V
SW 360 (HORIZ. DISP.) DETAILS
EXT.
EXT. HORIZ. AMP. CAL.
V354 6EW6/ 6DK6
V343 12AU6
V364 6EW6/ 6DK6
V324 6DT8
X100 CAL.
SEE SWITCHING DETAIL
SAWTOOTH FROM CATH., PINS 3 & 8, V173 RUNUP CF (TIME-BASE GEN. DIAG.)
INPUT CF
X10 CAL.
EXTERNAL HORIZONTAL PREAMPLIFIER
HORIZONTAL POSITION
VERNIER
SW810
EXTERNAL HORIZONTAL
EXTERNAL HORIZ. IN
VOLTS/CM
VARIABLE
EXT. HORIZ. AMP. DC BAL.
533/533A
AE



WAVEFORMS AND VOLTAGE READINGS
WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

EXTERNAL HORIZONTAL INPUT SIGNAL .. NONE
HORIZONTAL DISPLAY
FOR WAVEFORMS .... NORMAL (X1)
FOR VOLTAGE READINGS .... EXT.
HORIZONTAL POSITION
FOR UPPER VOLTAGE READINGS .... CCW
FOR LOWER VOLTAGE READINGS .... CW
EXTERNAL HORIZONTAL VOLTS/CM 1
EXTERNAL HORIZONTAL VARIABLE ..... CW

ALSO SEE IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

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

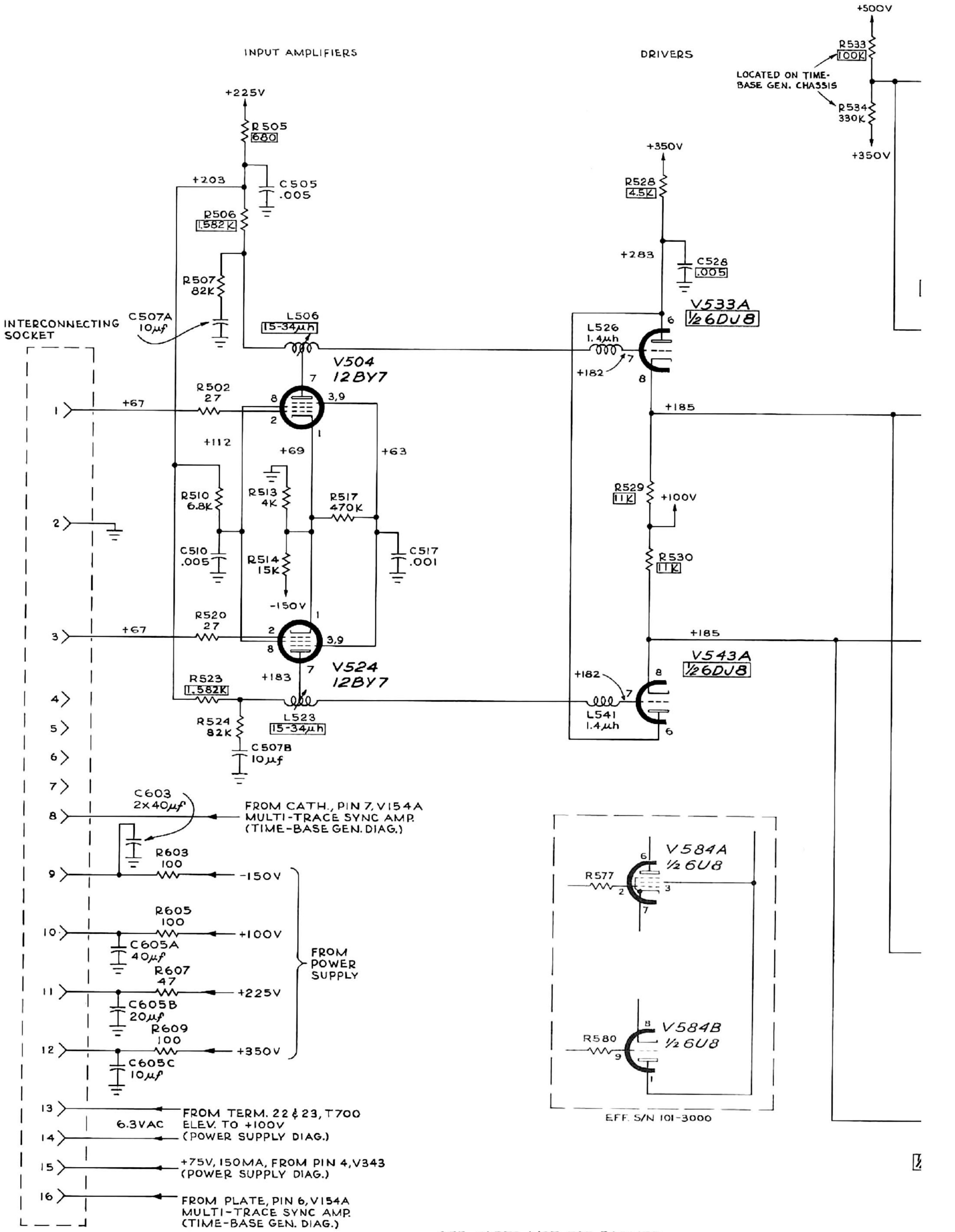
CIRCUIT NUMBERS 300 THRU 399

669

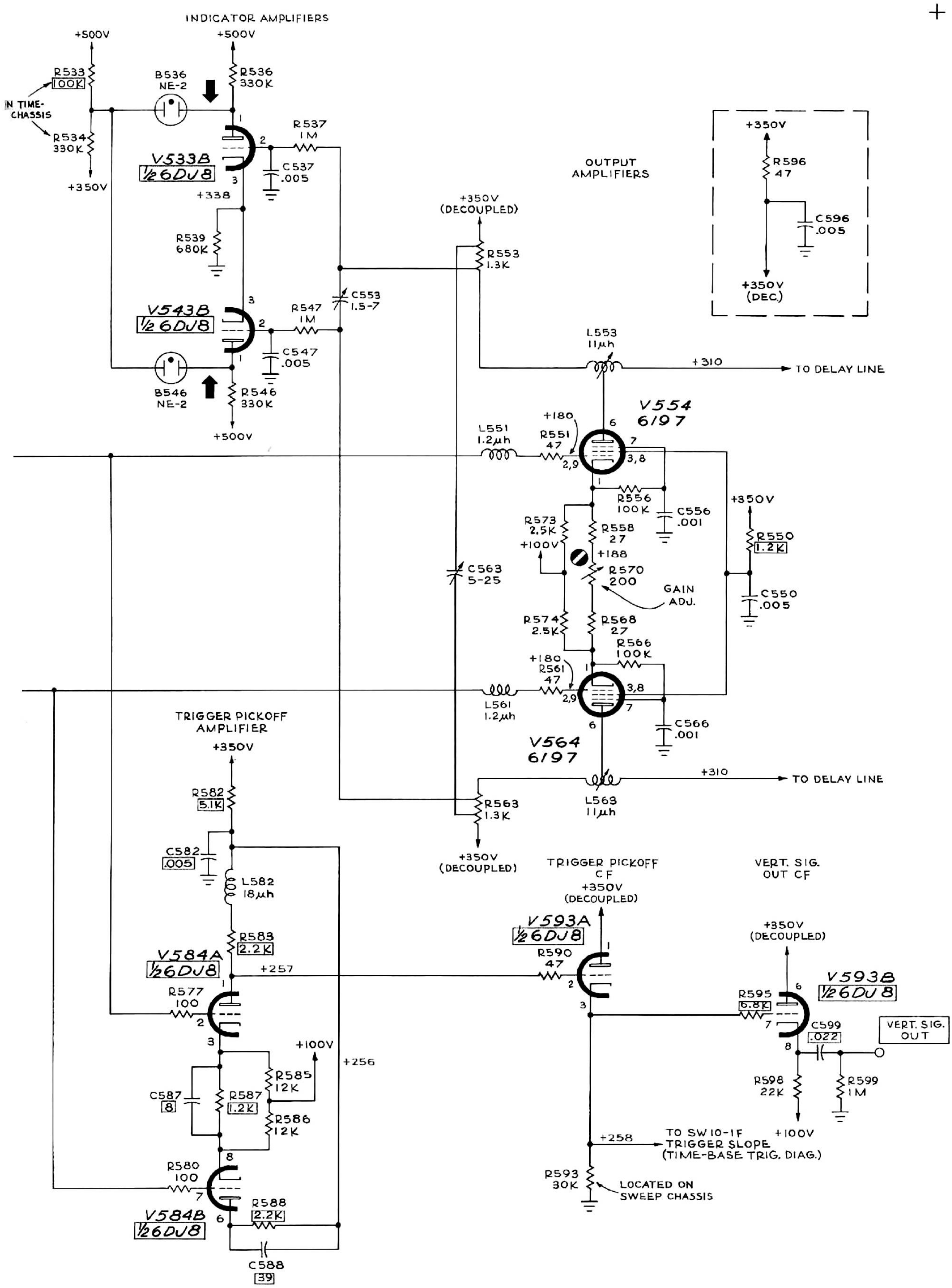
AE

HORIZONTAL AMPLIFIER

IN



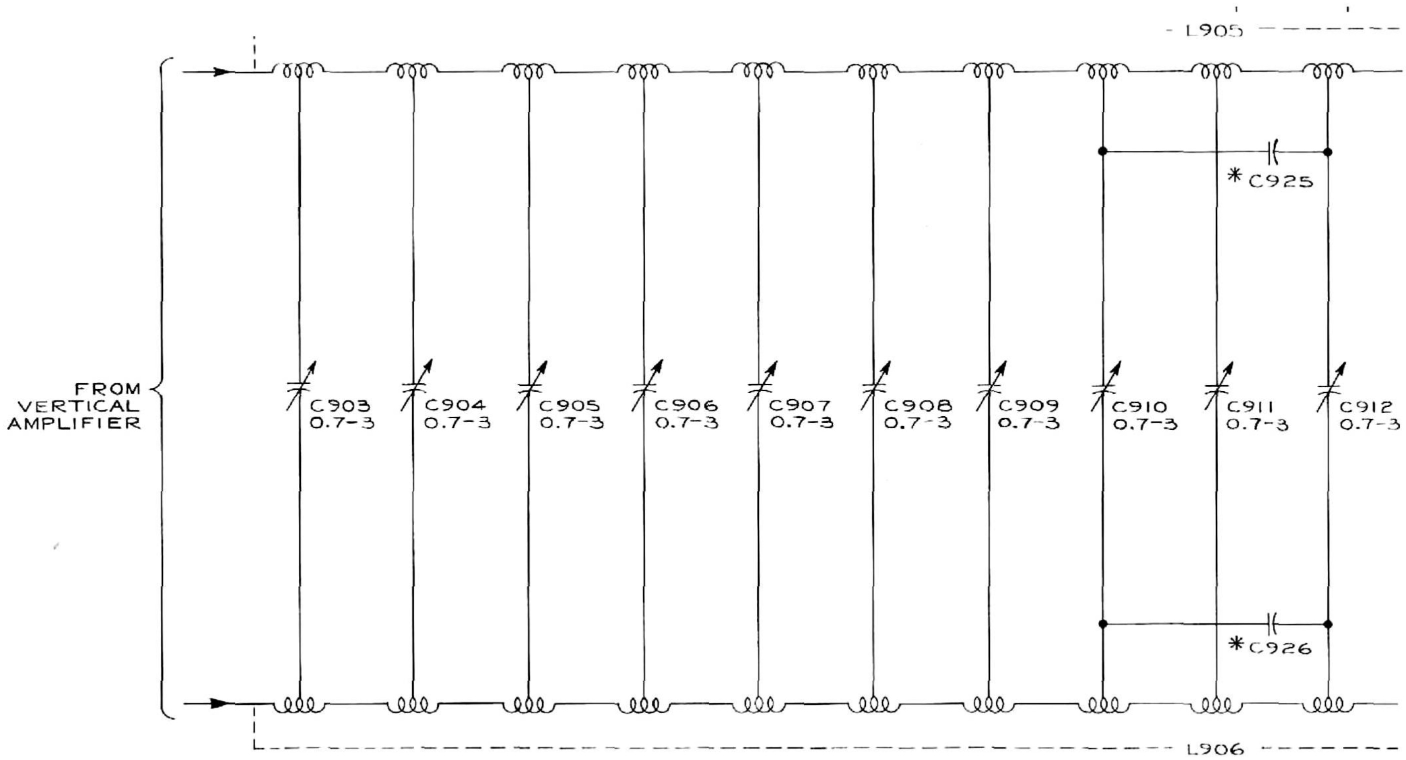
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

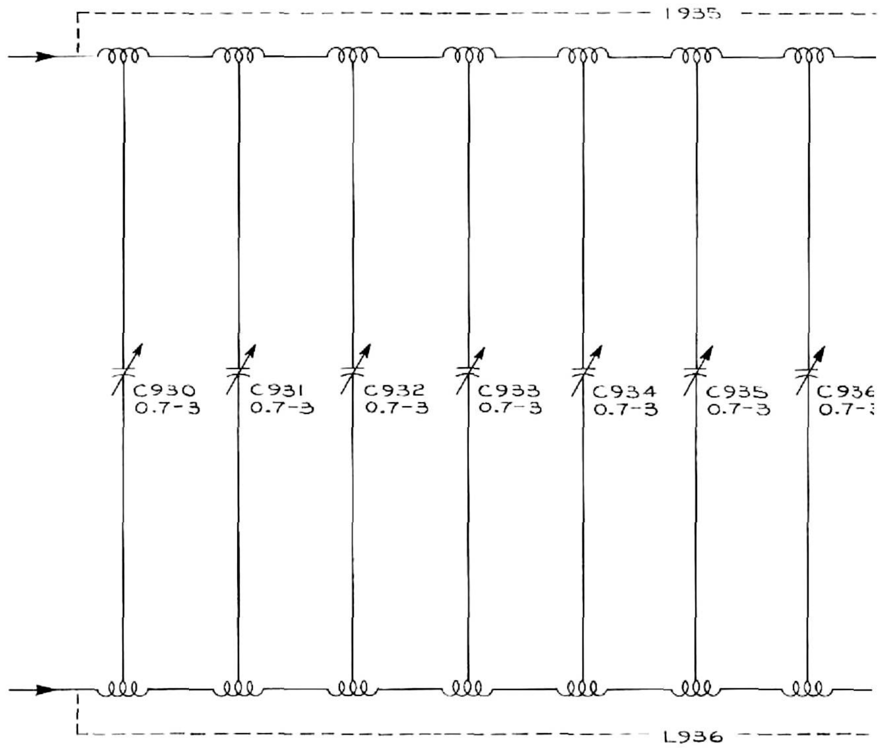


JN
664

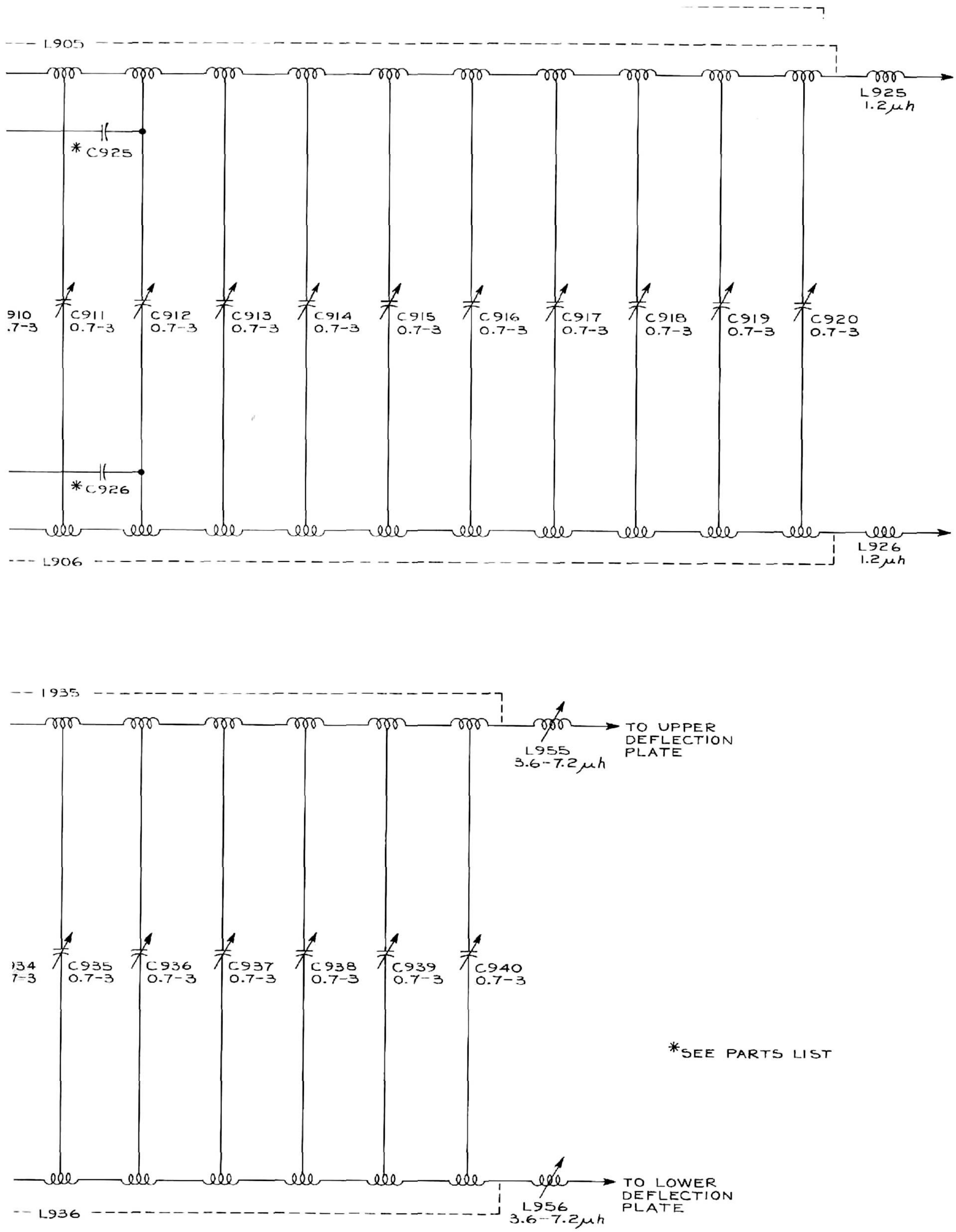
AB2

VERTICAL AMPLIFIER


L905
FROM
VERTICAL
AMPLIFIER
C903
0.7-3
C904
0.7-3
C905
0.7-3
C906
0.7-3
C907
0.7-3
C908
0.7-3
C909
0.7-3
C910
0.7-3
C911
0.7-3
C912
0.7-3
*C925
*C926
L906


L935
C930
0.7-3
C931
0.7-3
C932
0.7-3
C933
0.7-3
C934
0.7-3
C935
0.7-3
L936

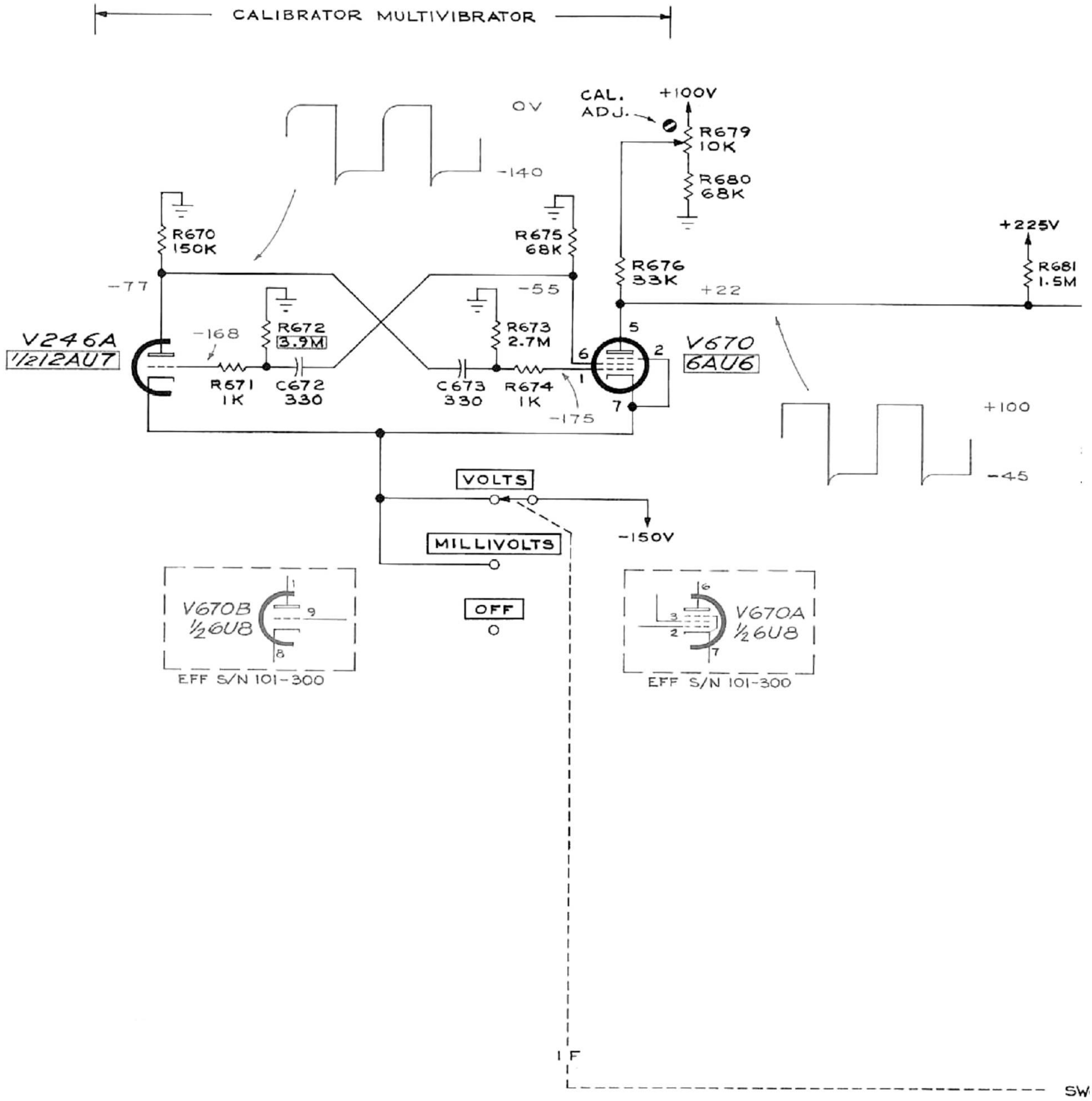
AA_1



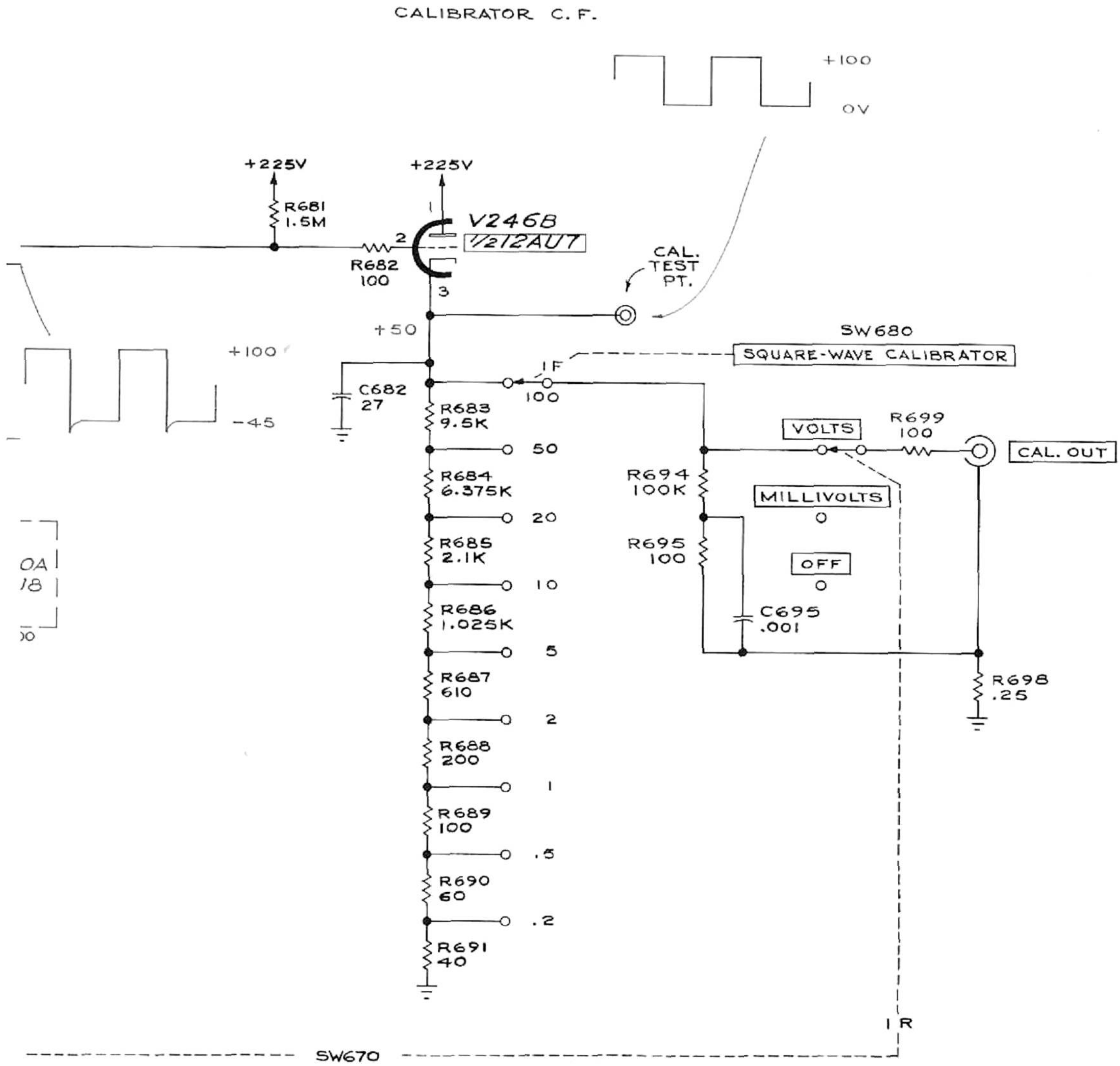
AA$_1$

DELAY LINE

CIRCUIT NUMBERS
900 THRU 959



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



WAVEFORMS AND VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

SQUARE-WAVE CALIBRATOR . . . . . . ON

AA4

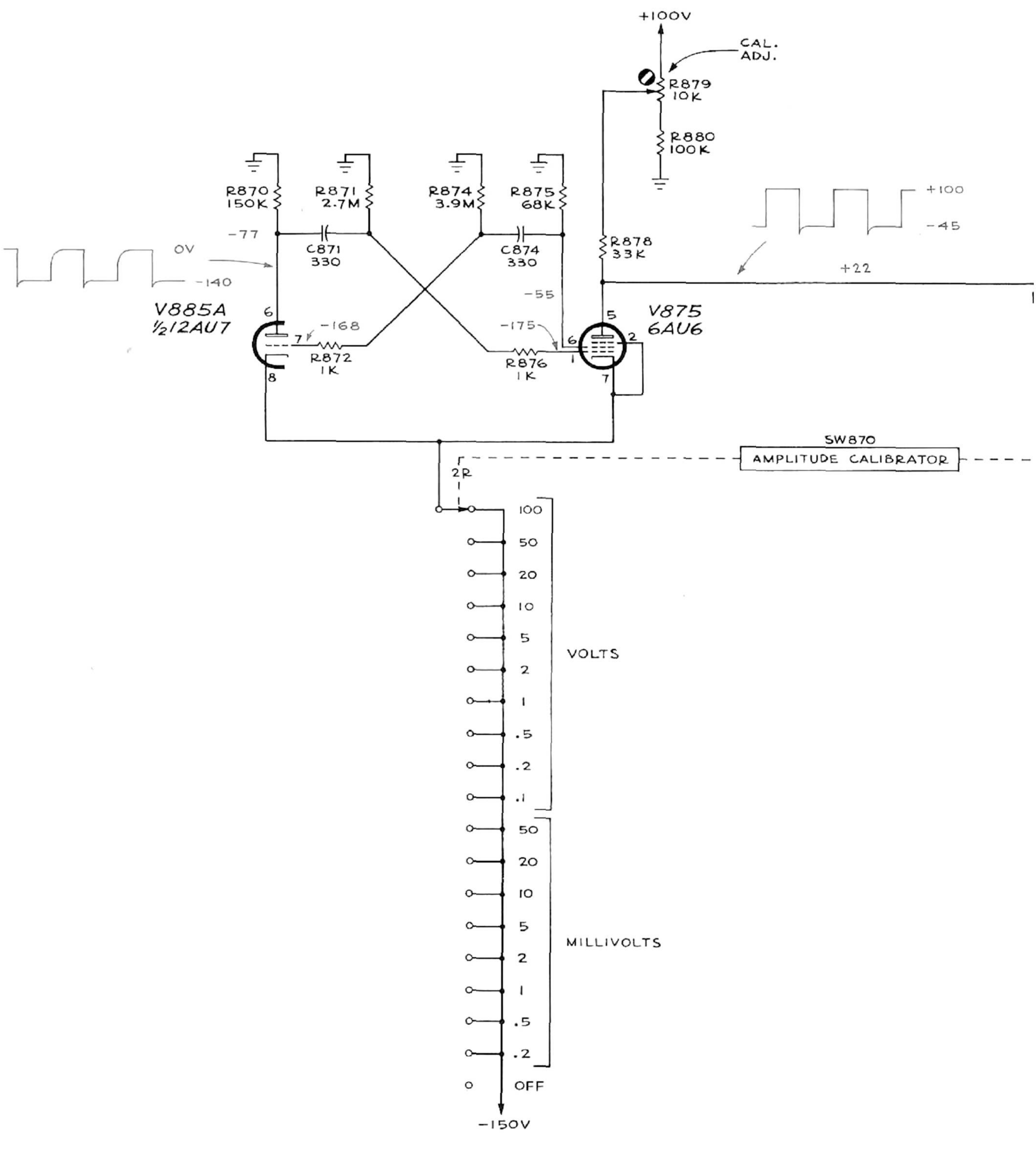
MRH
864

CALIBRATOR

S/N 101 - 3000

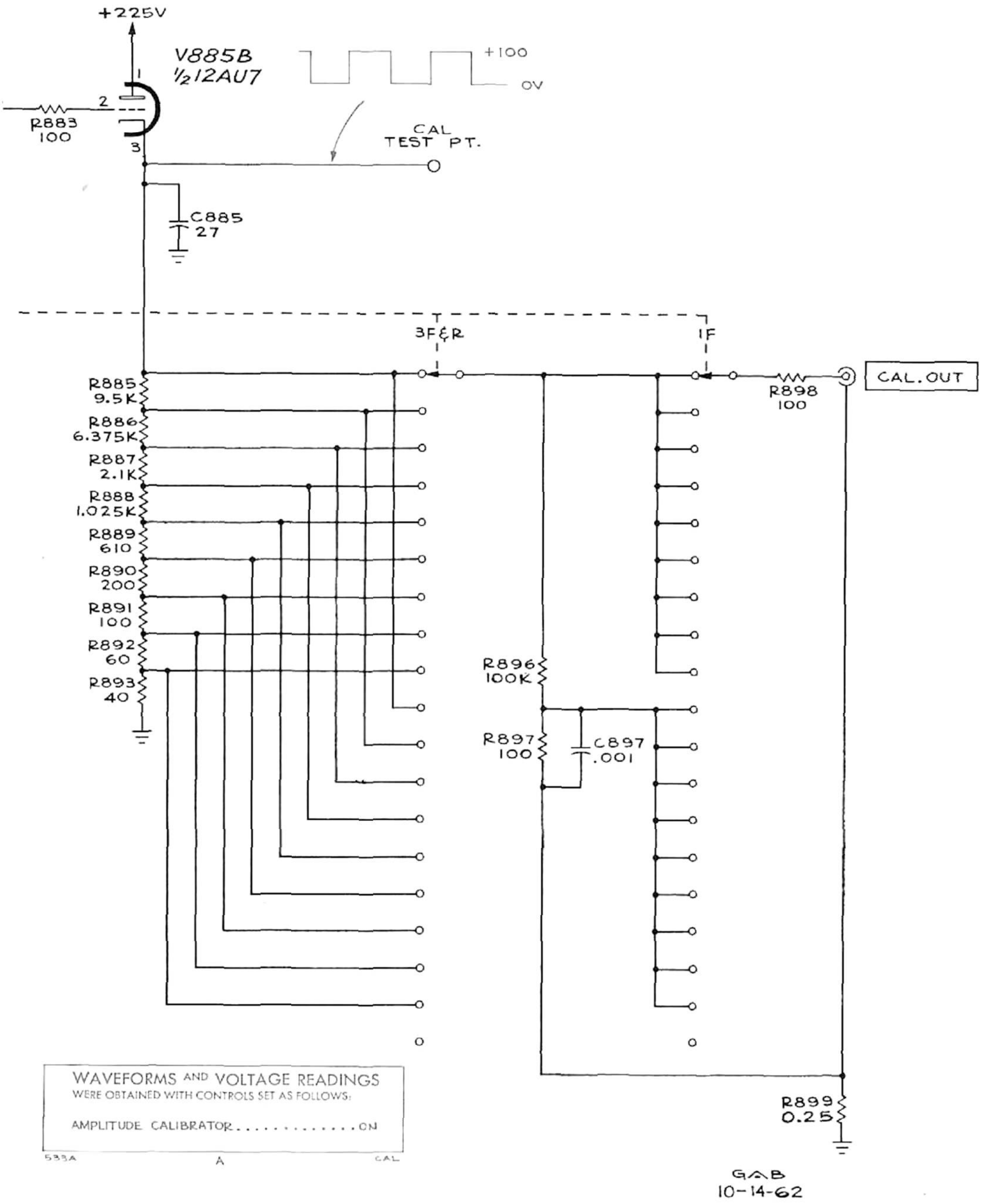
CIRCUIT NUMBERS 670 THRU 699

CALIBRATOR
MULTIVIBRATOR



TYPE 533A OSCILLOSCOPE

AA2



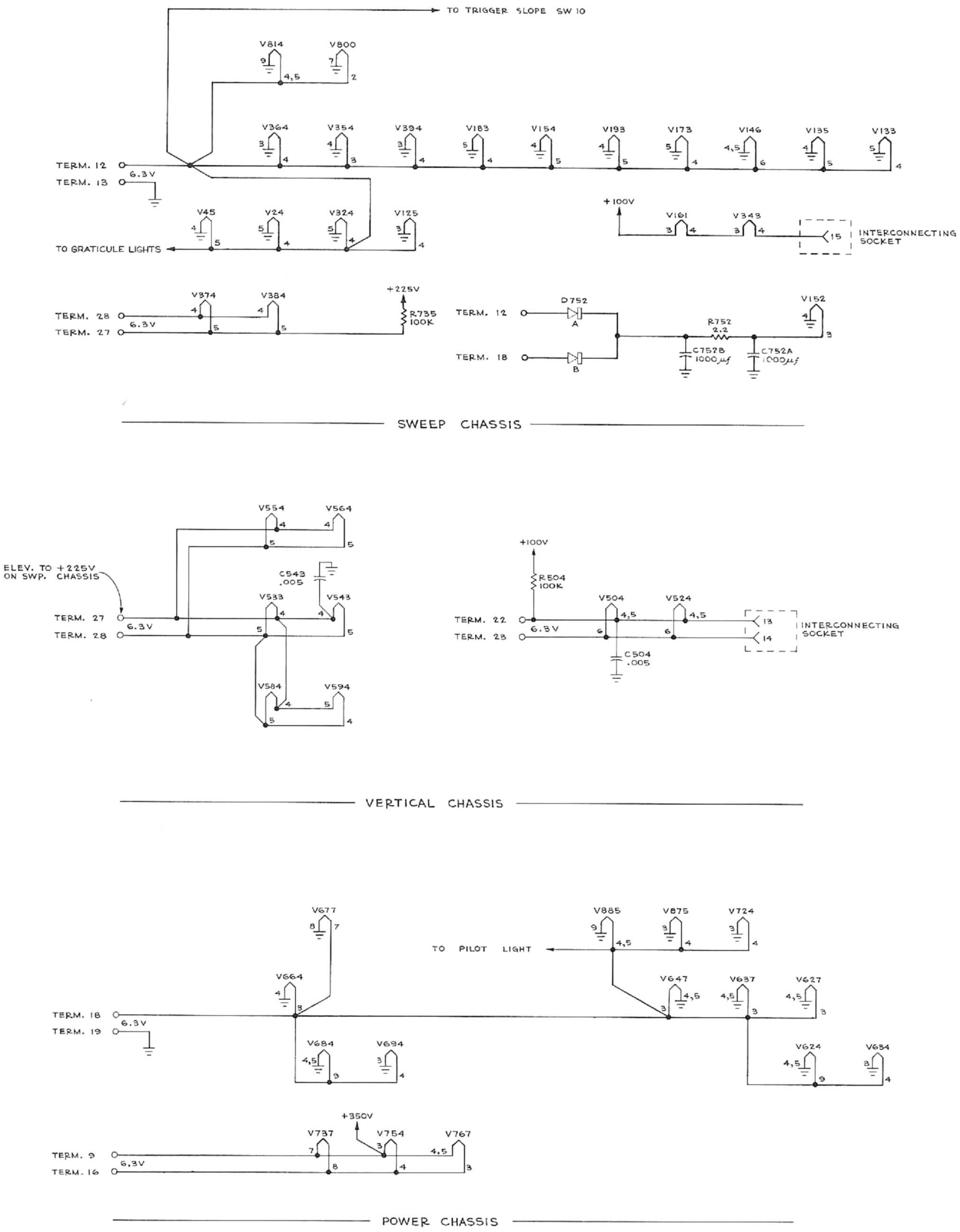
CALIBRATOR

S/N 3001 & UP

CIRCUIT NUMBERS
870 THRU 899

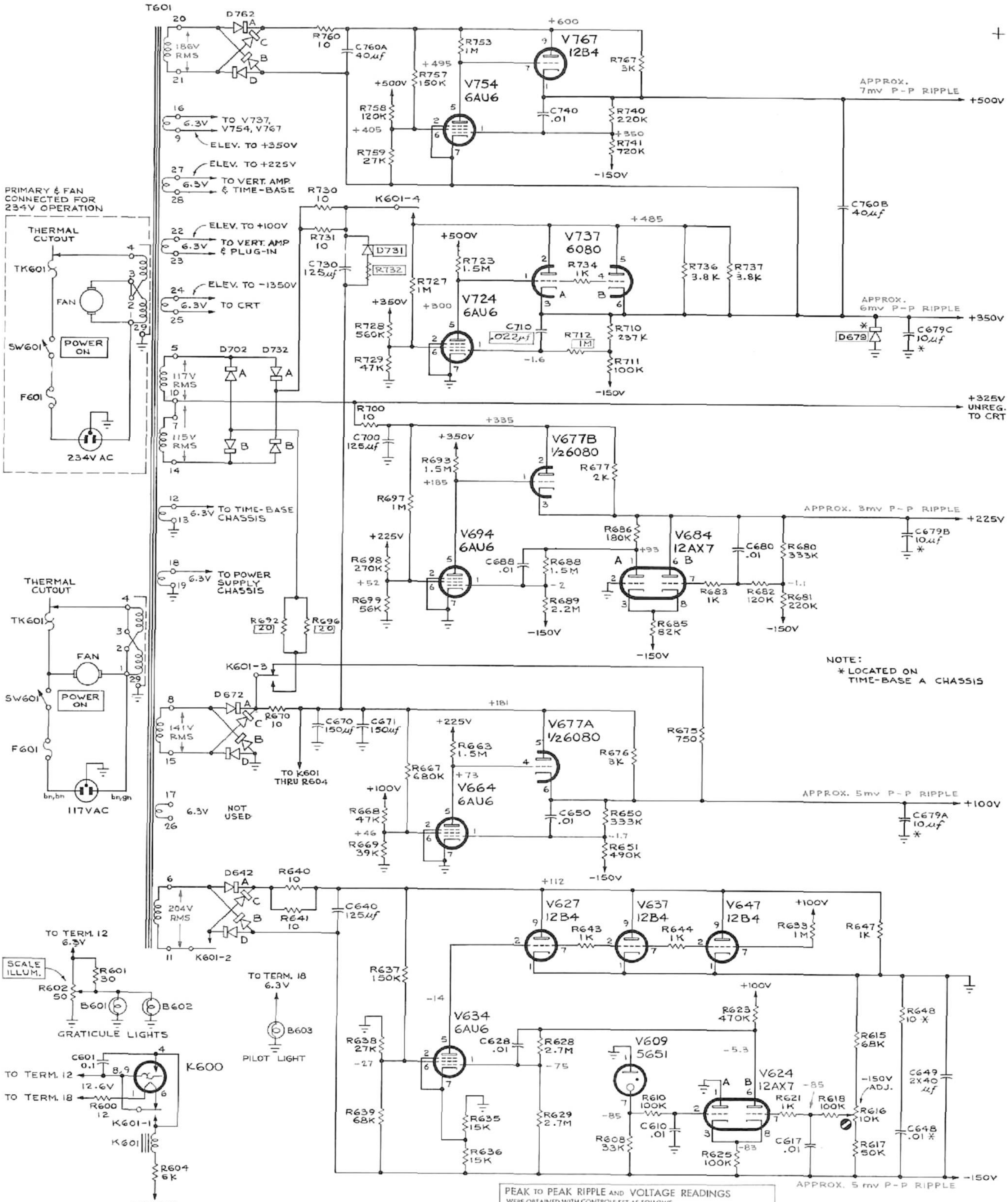
S/N 3001 & UP

CIRCUIT NUMBERS
870 THRU 899



TYPE 533A OSCILLOSCOPE

HEATER WIRING DIAGRAM

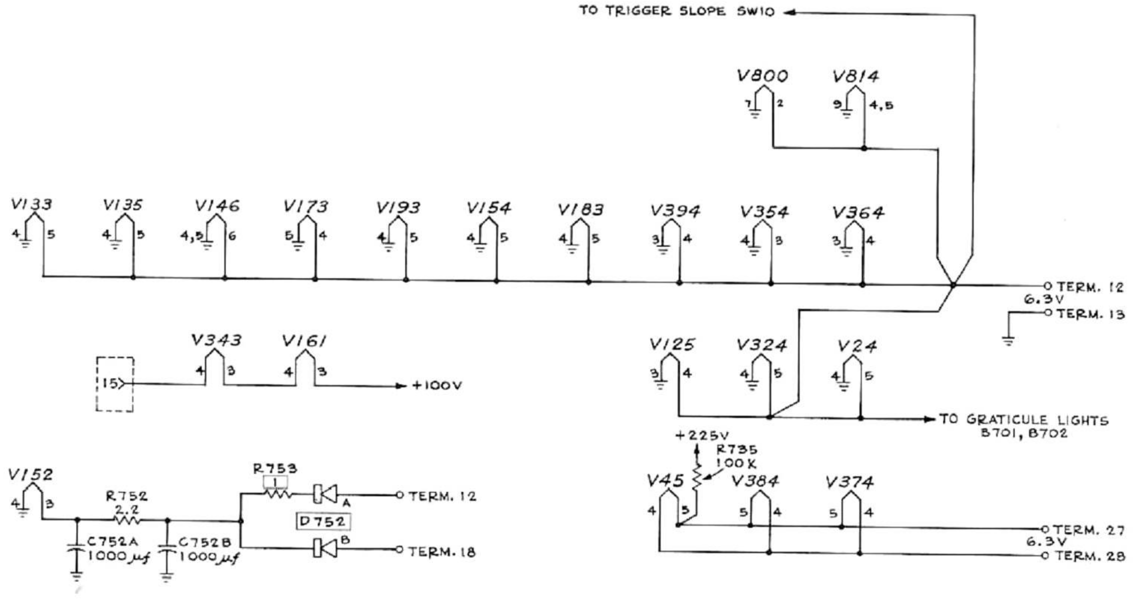


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

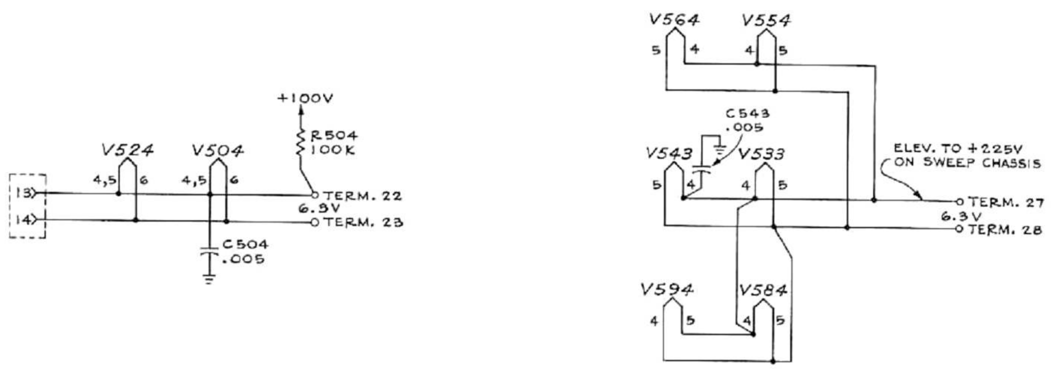
PEAK TO PEAK RIPPLE AND VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117 V AC
STABILITY	CCW, BUT NOT SWITCHED TO PRESET

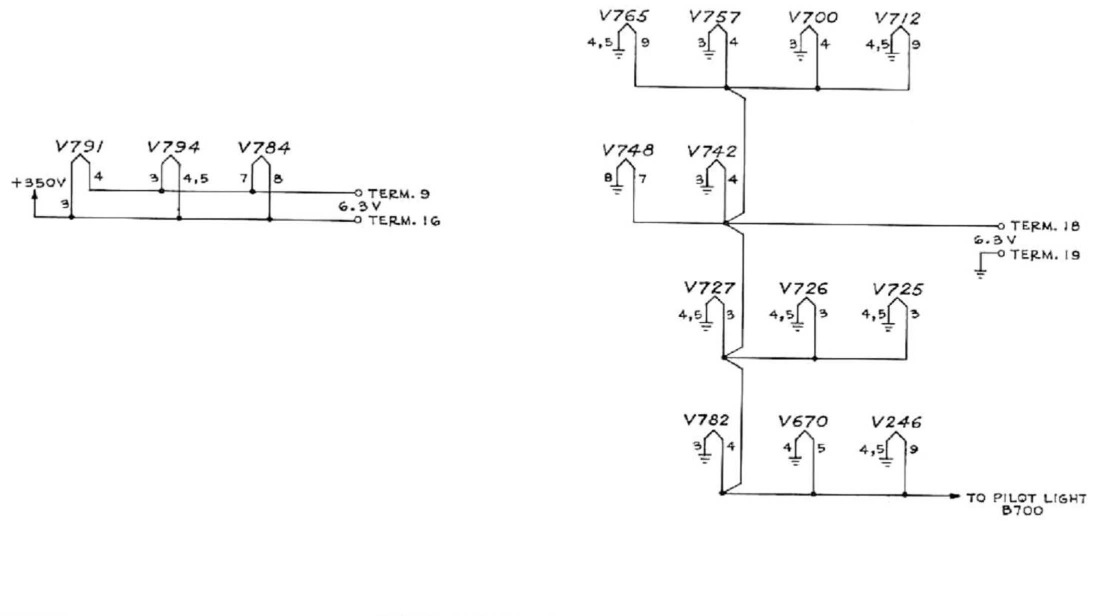
CIRCUIT NUMBERS 600 THRU 769



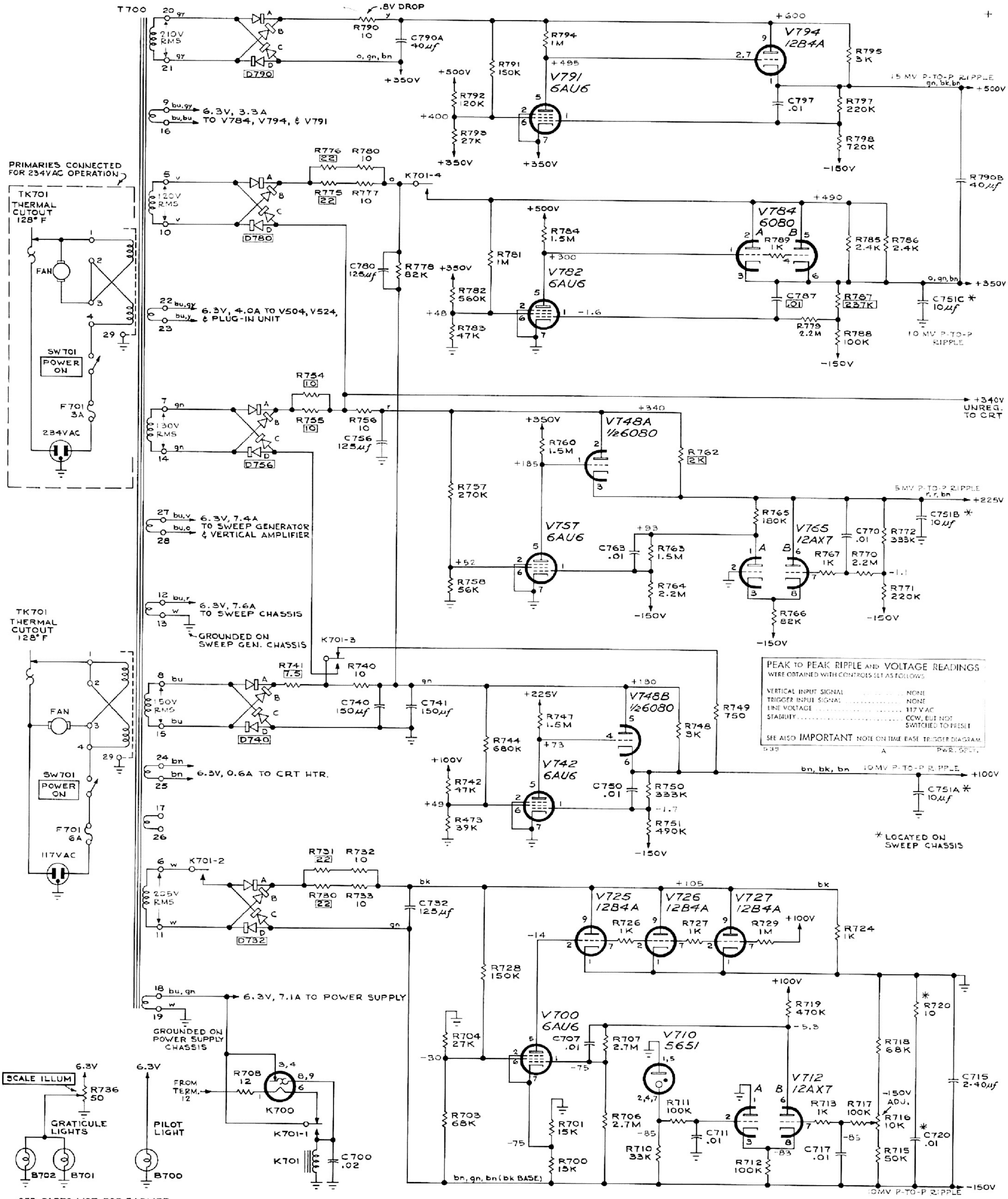
SWEEP CHASSIS



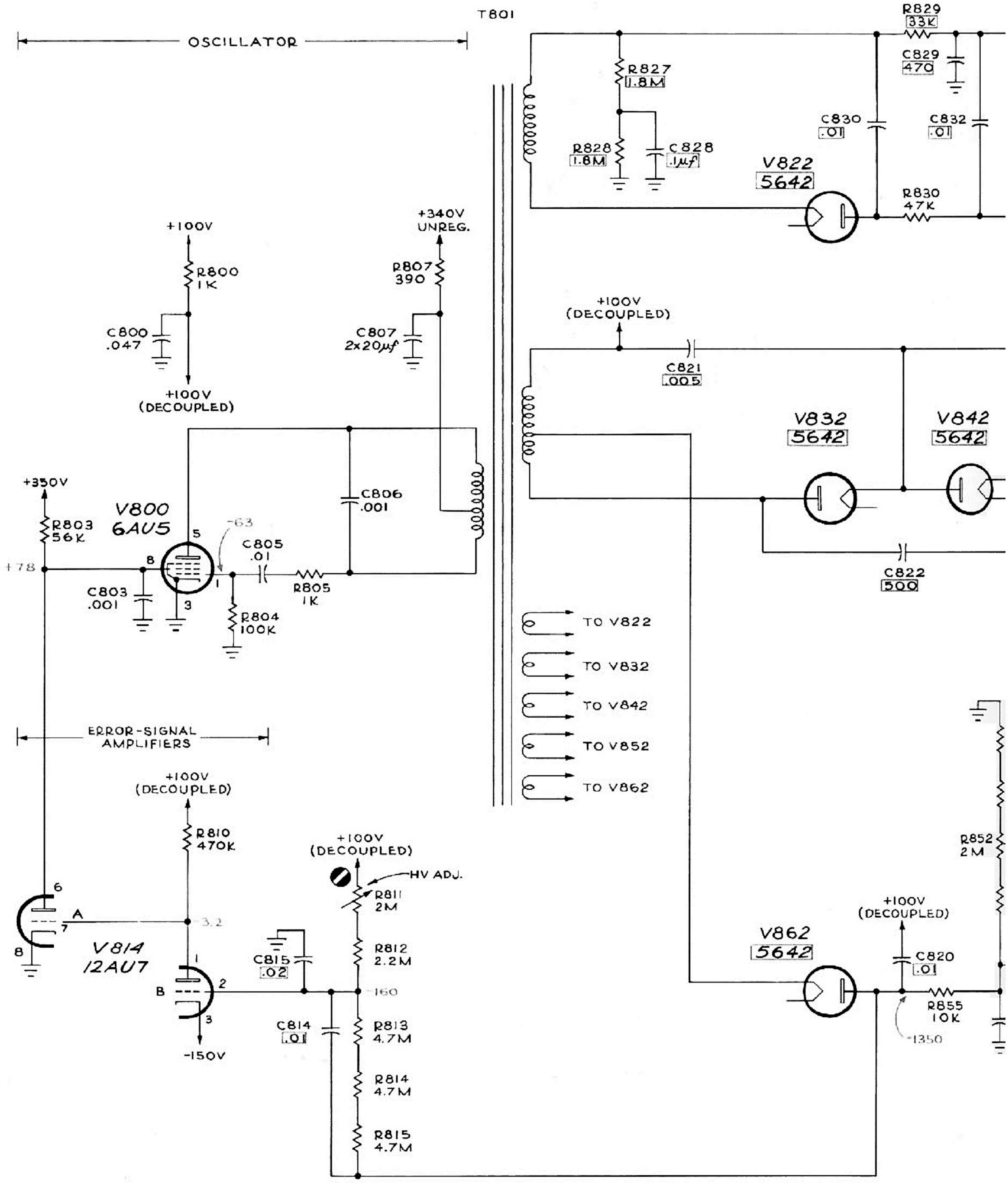
VERTICAL CHASSIS



POWER SUPPLY CHASSIS

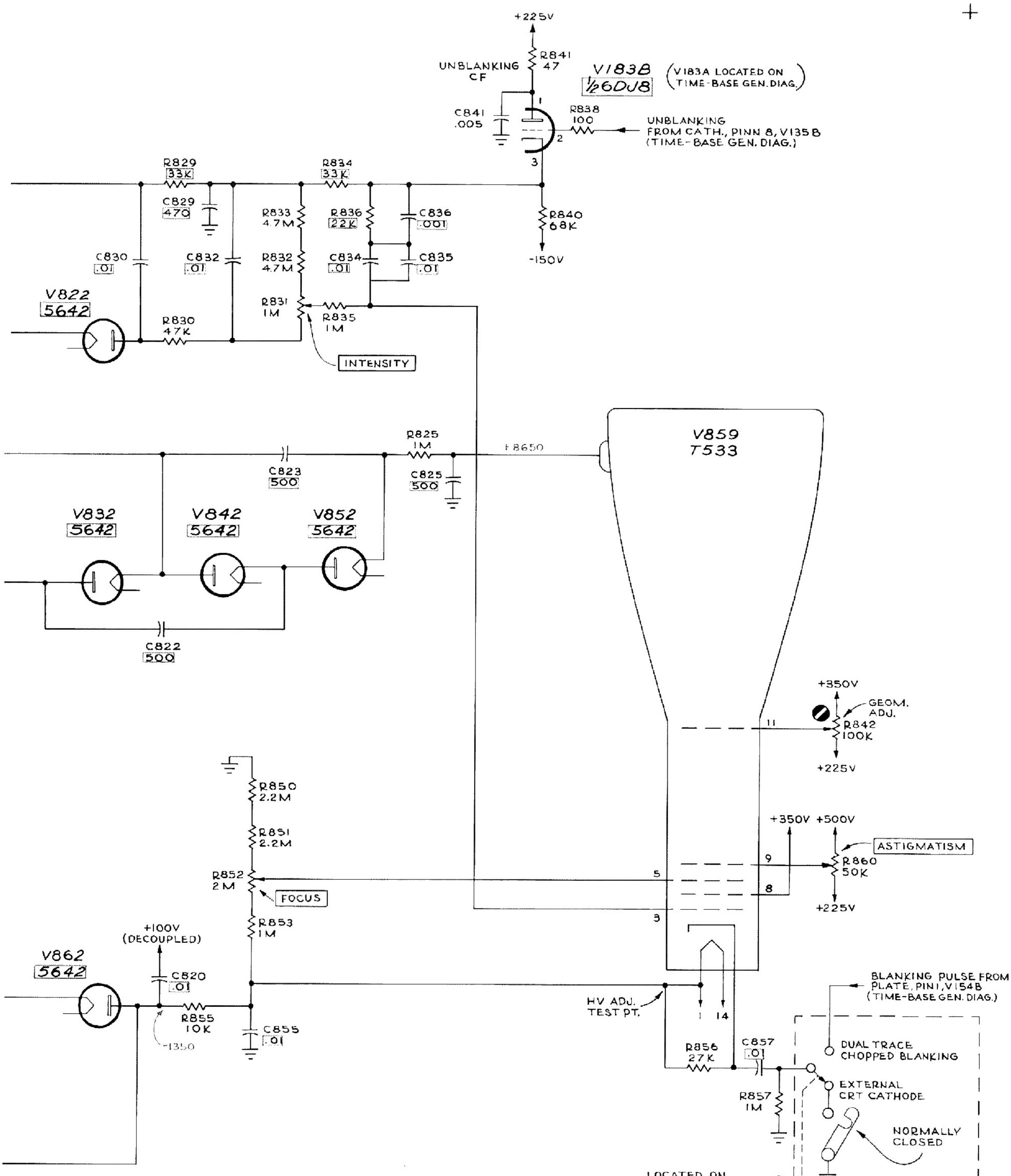


POWER SUPPLY
S/N 101-3000



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

VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

INTENSITY . . . . CCW

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

JN
664

AB3

CRT CIRCUIT

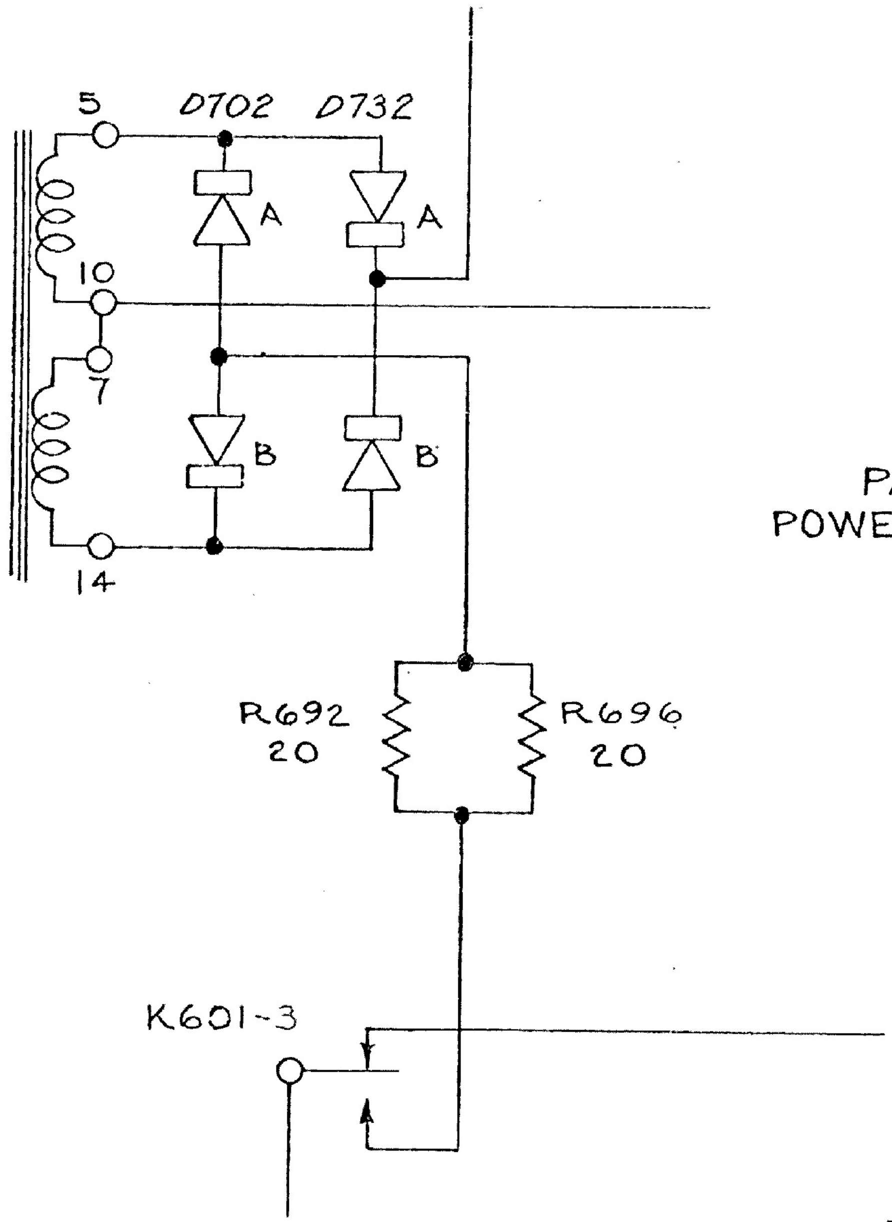
TYPE 533A/RM533A

ELECTRICAL PARTS LIST CORRECTION

ADD:

R692	308-0123-00	20 Ω	5 W	5%
R696	308-0123-00	20 Ω	5 W	5%

SCHEMATIC CORRECTION



PARTIAL-
POWER SUPPLY
⟨1⟩

M14,909/169

EXPORT POWER TRANSFORMER

Transformer Primary

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

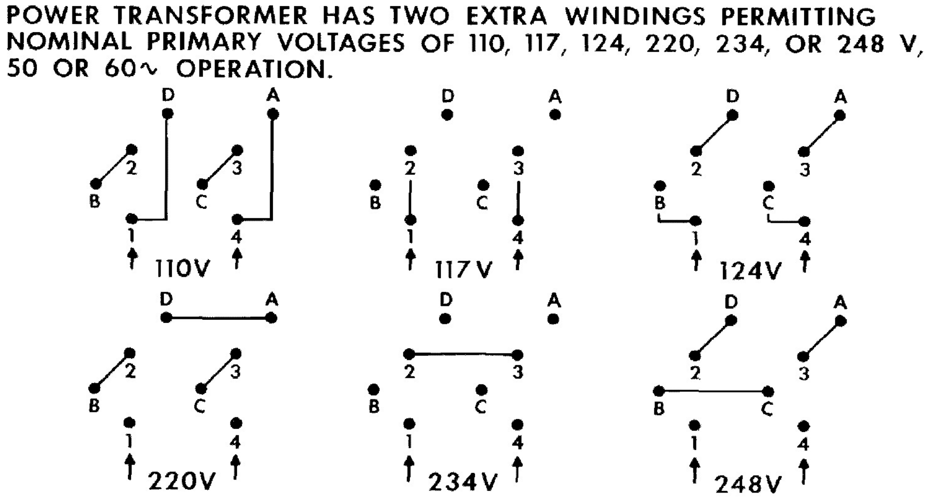


Fig.1. The power transformer has two extra windings permitting nominal primary voltages of 110, 117, 124, 220, 234, 248 volts, 50 or 60 cycle operation.

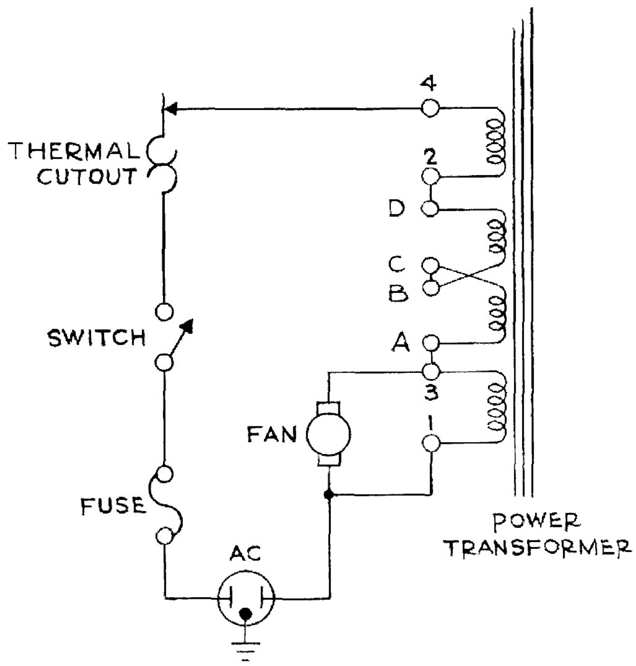


Fig. 2. When connecting the power transformer for operation with a supply voltage of 200 volts or more, be sure that the fan is connected between pins 1 and 3 of the primary. This is to insure that the fan is supplied with no more than 125 volts. Fig. 2 shows a typical high-voltage fan connection, using as an example the wiring for a 248 volt supply.