

INSTRUCTION MANUAL

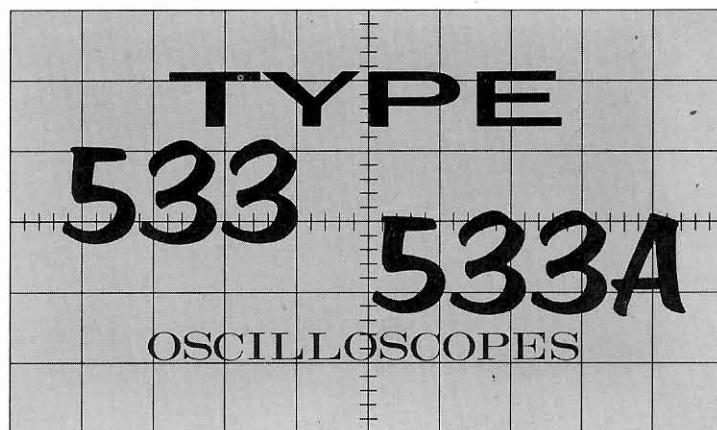
FREE SCAN IN PUBLIC DOMAIN



MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

INSTRUCTION MANUAL

FREE SCAN IN THE PUBLIC DOMAIN



Tektronix, Inc.

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070-258



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

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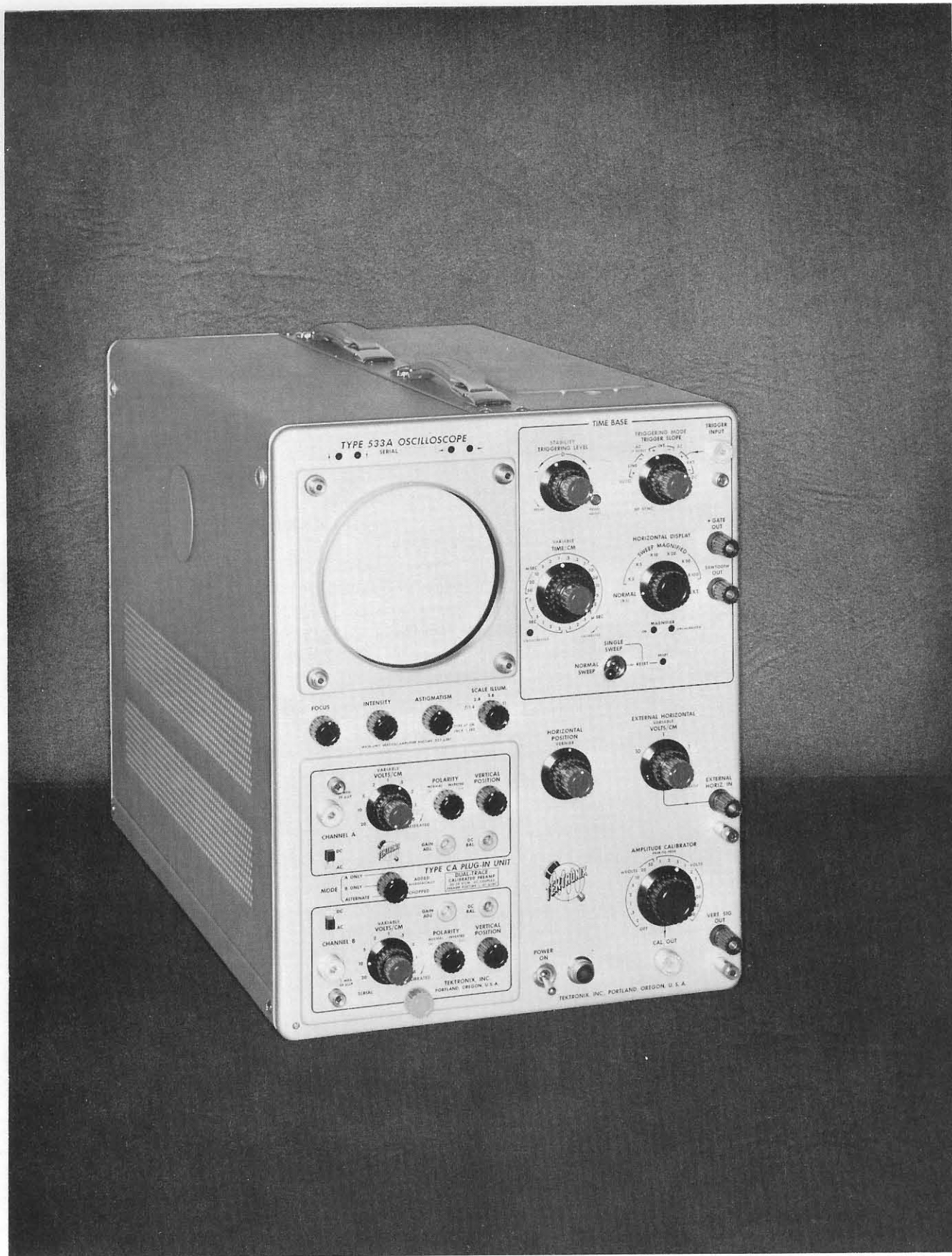
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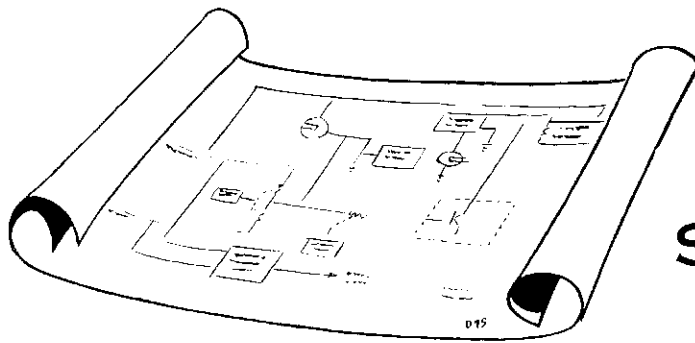
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Type 533/533A

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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 $\pm 1/2$ dB at 15 mc).
Risetime—.024 microseconds.
Delay Line—Balanced network Signal Delay—.02 μ sec.

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 μ sec/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 μ sec/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 μ mf 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, ($\pm 9\%$ on each range) 50 to 60 cycles.

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

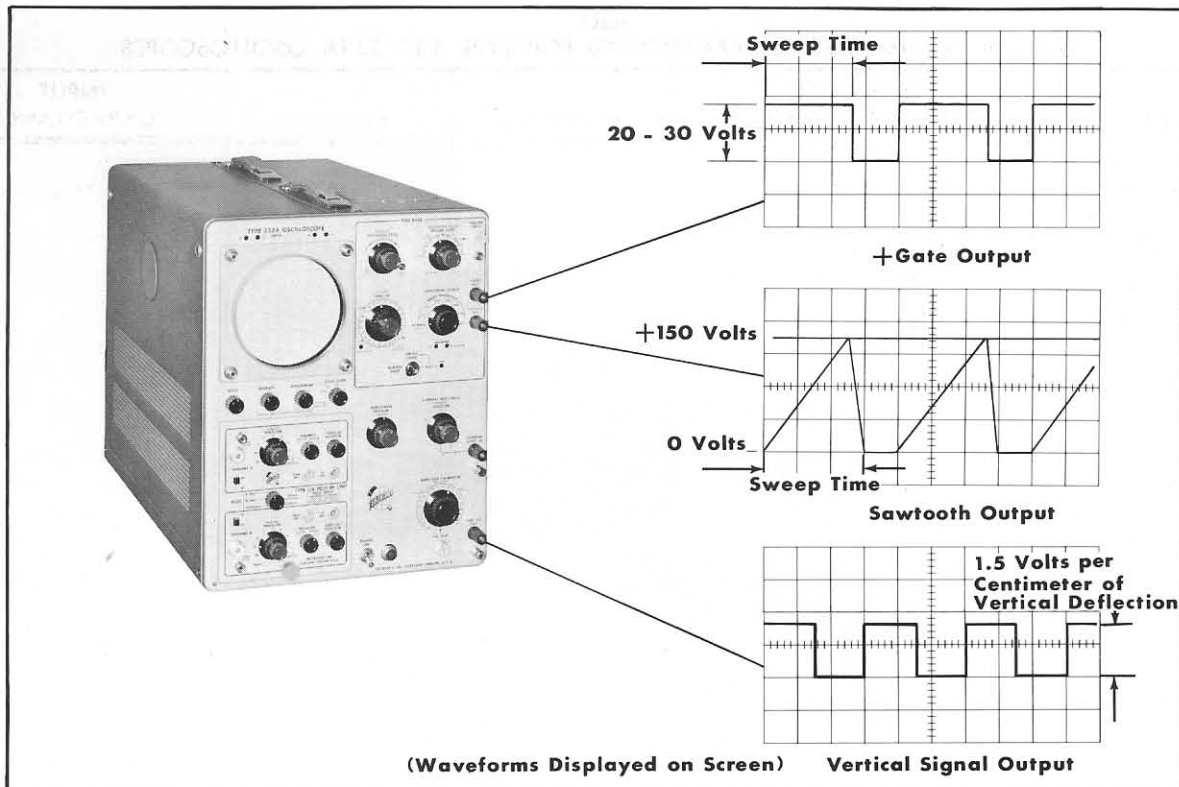


Fig. 1-1. Output waveforms available at the oscilloscope front panel.

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, 16³/₄" high.

Weight—61¹/₂ 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

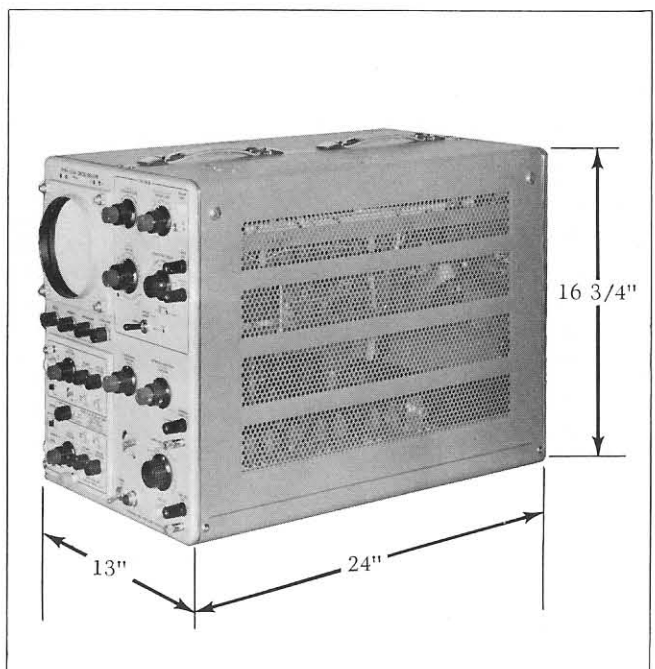


Fig. 1-2. Type 533/533A Oscilloscope dimensions.

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 μ sec	47 pf
TYPE E Low-Level AC Coupled Differential	50 μ v/cm to 10 mv/cm	0.06 cycles to 60 kc	6 μ sec	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 μ strain/div to 10,000 μ strain/div	dc to 6 kc	60 μ sec	Adjustable
TYPE R* Transistor Rise-time	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 μ sec/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

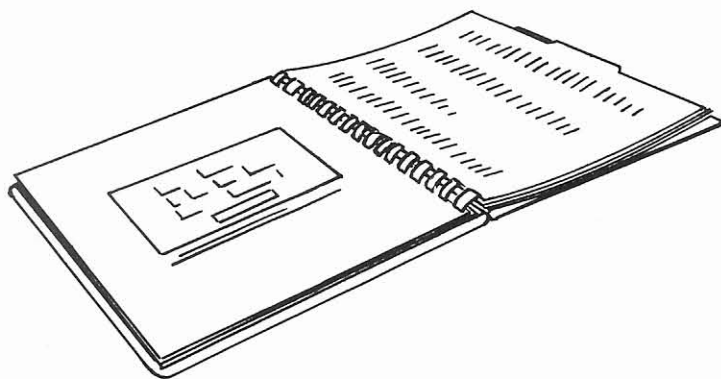
The Type Z Plug-In extends the accuracy of oscilloscope voltage measurements. It can be used in three modes of operation: (1) as a conventional preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator. With sensitivity of 50 mv/cm and insertion voltage range 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.

OPERATING INSTRUCTIONS



General

The Type 533/533A Oscilloscopes are extremely versatile instruments which are adaptable to a great number of applications. However, to make full use of the instruments, it's important that you understand the operation and function of the various controls. This section of the Manual is designated to give you this information.

PRELIMINARY INSTRUCTIONS

Cooling

A fan maintains safe operating temperature in the Type 533/533A by circulating filtered air over the rectifiers and other components. When in operation, the instrument must be placed so that the air intake at the back is clear of any obstruction that might impede the flow of air. Side panels should also be in place for proper air circulation. The air filter should be kept clean, in accordance with cleaning instructions found in the Maintenance Section of the manual.

Under no circumstances should your Type 533/533A oscilloscope be operated without the fan running. Without the fan, inside temperature of the oscilloscope will rise to a dangerous level in five to ten minutes. In this event, the thermal cutout switch will disconnect the power and keep it disconnected until the temperature drops to a safe level.

Power Requirements

Unless tagged otherwise, this instrument is connected at the factory for operation at 105 to 125 volts, 50 to 60 cycles ac (117 volts nominal.) However, provisions are made for easy conversion to operation at 210 to 250 volts, 50 to 60 cycles (234 volts nominal).

The power transformer (T700 in Type 533, T601 in Type 533A) is provided with split input windings, normally connected in parallel for 117-volt operation, but which can be connected in series for 234-volt operation. Each of these split windings terminates in a nest of four terminal lugs (arranged in a square) on the underside of the transformer. The lugs are numbered 1, 2, 3 and 4 in a clockwise rotation.

Terminals 1 and 3 are connected to one winding and terminals 2 and 4 are connected to the second winding. The ac input leads are connected to terminals 1 and 4 for both 117-volt and 234-volt operation, so these connections do not have to be changed when converting from one line voltage to the other.

When wired for 117-volt operation, terminals 1 and 2 are joined by a bare bus wire, and terminals 3 and 4 are similarly joined, as shown in Fig. 2-1a. To convert these terminals, substitute a single connecting wire between terminals 2 and 3, as shown in Fig. 2-1b.

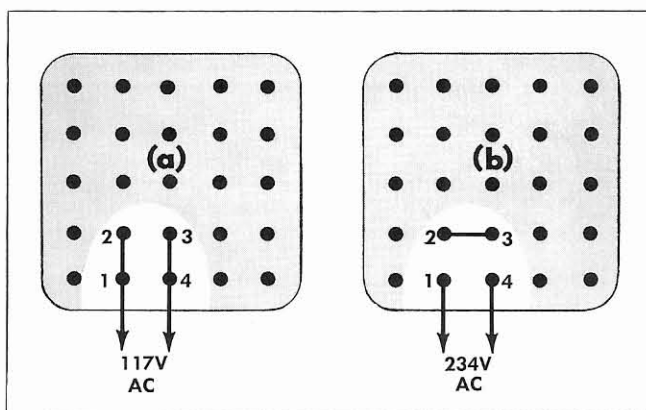


Fig. 2-1. Converting the power transformer from 105-125 volt operation to 210-250 volt operation.

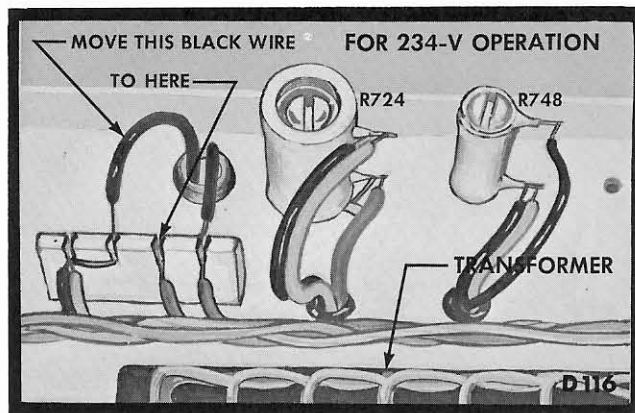


Fig. 2-2. Converting the Type 533 fan motor from 105-125 to 210-250 volt operation.

Fan Connections

The cooling fan is powered by a 117-volt ac motor. If the instrument is converted to operate from a 234-volt line, a change in the fan wiring must be made so that it operates from a 117-volt source.

In Type 533 Oscilloscopes, the leads that connect to the fan motor terminate in a four-terminal ceramic strip adjacent to the power transformer and to R724. The black wire closest to R724 is connected by another wire to terminal 3 of the power transformer for both 117-volt and 234-volt operation. This wire does not have to be changed when converting from one line voltage to the other.

The other black wire should be lifted free of the notch in which it is soldered and moved one notch closer to R724, as shown in Fig. 2-2.

The Type 533A instruments, to make the change from 117-volt to 234-volt operation, refer to the ceramic strip adjacent to one corner of the power transformer, as shown in Fig. 2-3. Unsolder the fan lead in the fifth slot at the ceramic strip, lift it free, and move it to the third slot as illustrated by the dotted line in Fig. 2-3. Use silver-bearing solder to solder the lead into the slot. The other fan lead connected at the second slot is not changed during the conversion from one line voltage to the other.

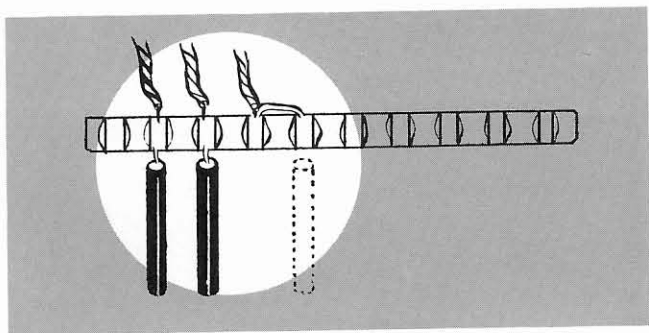
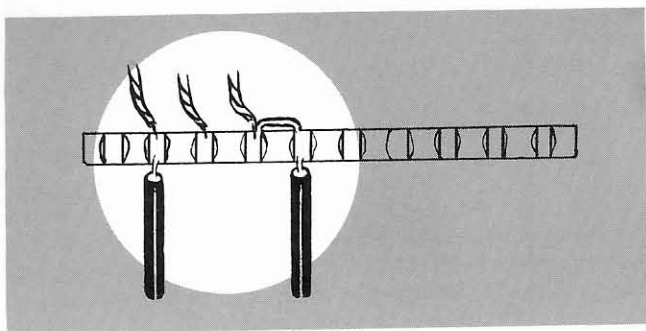


Fig. 2-3. Converting the Type 533A fan motor from 105-125 to 210-250 volt operation.

Fuse Data

Fuse data is silk-screened on the rear panel of the instrument adjacent to the fuse holder. Use only the recommended fuses for maximum over-current protection.

OSCILLOSCOPE OPERATION INFORMATION

Plug-In Units

The Type 533 and 533A Oscilloscopes are designed to operate with any one of the Tektronix letter-series plug-in units. The particular plug-in unit used must be selected by you to satisfy the requirements of your application. In selecting the plug-in unit for any particular application, you must consider the bandpass, sensitivity, and type of input required for that application. Complete information on all available plug-in units will be found in the Specifications Section of this manual.

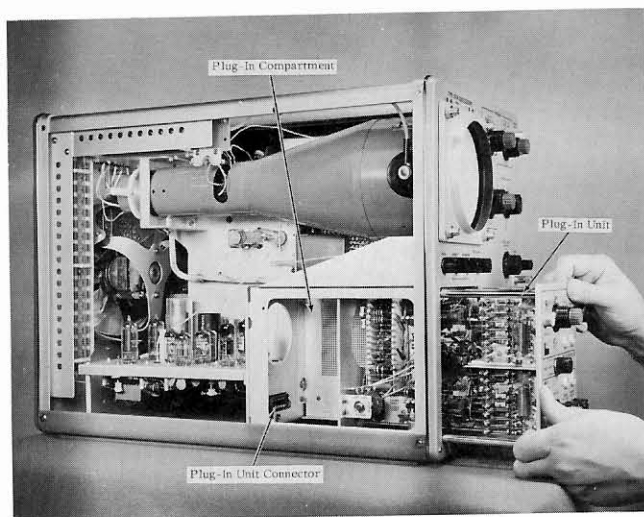


Fig. 2-4. Inserting the selected plug-in unit into the oscilloscope plug-in compartment.

Preparation for use

When the plug-in unit has been selected, insert it into the plug-in compartment of the oscilloscope and press firmly to insure that the connectors make proper contact (see Fig. 2-4). Tighten the plug-in unit locking control to hold the unit securely in place and turn the oscilloscope INTENSITY control fully counterclockwise. Connect the power cord to the rear of the instrument and to the power line and place the POWER switch in the ON position.

Time Delay

Time delay relays used in the Type 533 and 533A Oscilloscopes delay operation of the instrument for approximately 25 seconds after the POWER switch is turned on to allow a brief tube warmup period. The delay allows the tube sufficient time to heat before the dc operating voltages are applied.

If the ac power is off for only an instant, the normal 25-second delay will occur before the instrument returns to full operation. This delay will occur regardless of whether the ac power is off because of a momentary power failure or is turned off with the POWER switch.

Focus and Astigmatism Controls

The FOCUS and ASTIGMATISM controls operate in conjunction with each other to allow you to obtain a sharp, clearly defined spot or trace. The proper setting of the ASTIGMATISM control is obtained by rotating the FOCUS control fully clockwise, setting the HORIZONTAL DISPLAY switch at EXT., the EXTERNAL HORIZONTAL VOLTS/CM at 10, and adjusting the INTENSITY control to obtain a spot on the screen. After positioning the spot to the center of the screen, the ASTIGMATISM control is adjusted for the most nearly circular spot possible. The FOCUS control is then adjusted to reduce the spot diameter as much as possible. You must be certain that all input signals to the oscilloscope are disconnected when you adjust the FOCUS and ASTIGMATISM controls.

Intensity Control

The INTENSITY control is used to adjust the brightness of the oscilloscope display. This permits you to compensate for changes in brightness resulting from changes in the sweep triggering rate. The INTENSITY control is rotated clockwise to increase brightness and counterclockwise to decrease it. Be careful when you use the INTENSITY control that the brightness is not turned up to where it will permanently damage the face of the cathode-ray tube. If brightness is turned up to the point where a halo forms around the spot, it should be turned down immediately.

Graticule Illumination Control

The graticule used with the Type 533/533A Oscilloscope is accurately marked with 10 horizontal and 6 vertical 1-centimeter divisions with 2-millimeter markings on the centerlines. These graticule markings allow you to make time and voltage measurements from the oscilloscope screen.

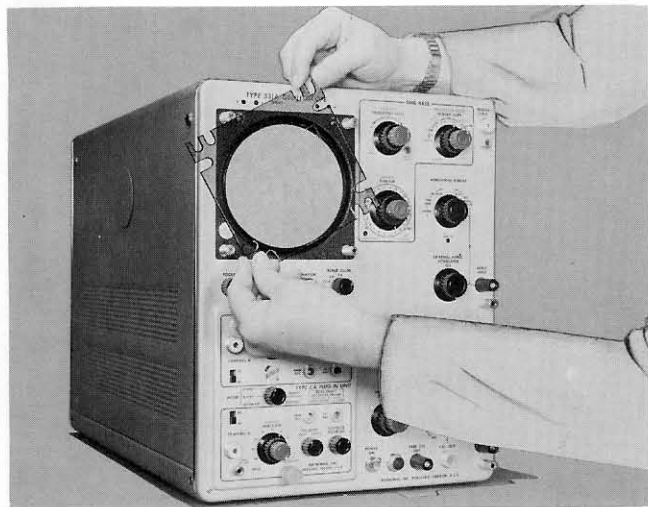


Fig. 2-5. Rotating the graticule to change the color of the graticule markings.

The graticule is illuminated by two lamps located at the top edge of the graticule. The graticule markings can be made either white or red by positioning the graticule so that either the clear bulb slots or those with red plastic inserts are next to the bulbs. Generally, the white graticule markings are better than the red for photographic purposes.

Graticule illumination is adjusted by the SCALE ILLUM. control located just under the oscilloscope screen. Rotating the control clockwise increases the brightness of the graticule markings, and turning it counterclockwise decreases brightness. For convenience in photographing oscilloscope displays, the SCALE ILLUM. control is marked in approximate f-stops. These f-stops can be used with a shutter speed of 1 second when TRI-X film is used, or with a shutter speed of 10 seconds when Polaroid film is used. Regardless of the type of film used, better results can generally be obtained with white graticule markings. For best results, try to match the intensity of the trace with the brightness of the graticule markings.

Positioning Controls

Three controls are used with the Type 533/533A for positioning the trace on the oscilloscope screen. Two controls are used to set horizontal positioning of the trace. These are located on the front panel of the instrument. The third control is used to set vertical positioning, and is located on the front panel of the plug-in unit used with the oscilloscope. The Type 53/54C and Type CA Dual-Trace Plug-In Units have two Vertical Positioning Controls.

The two HORIZONTAL POSITION controls cause the trace to move to the right when they are rotated in the clockwise direction and to the left when rotated counterclockwise. Together, the two controls have a total positioning range of 12 to 1200 centimeters, depending upon the degree of sweep magnification used. The black HORIZONTAL POSITION control has approximately three times the range of the red VERNIER control. The fine range of adjustment of the VERNIER control makes this control particularly useful whenever fine horizontal positioning is required, such as when various positions of sweep magnification are used.

The vertical positioning control has enough range to allow the trace to be positioned completely off the top or bottom of the screen or anywhere in between. The trace moves up when the control is turned clockwise and down when the control is turned counterclockwise.

Beam Position Indicators

Four small indicator lights located just above the oscilloscope screen indicate the position of the spot or trace. When one of these lamps is lit, it indicates that the trace is off-centered in the direction of the arrow. These four lights allow you to position the spot to the center of the screen even though the intensity is so low that the trace is not visible. When the sweep is running, the spot moves from the left side of the screen to the right and may cause both horizontal lamps to light each time the sweep runs.

Input Signal Connections

The electrical waveform to be observed is applied to one of the plug-in unit input connectors. The waveform is then connected through the vertical-deflection system of the plug-in unit and the oscilloscope to cause the spot to be deflected vertically and to trace out the waveform on the screen of the crt. The vertical size of the displayed waveform is adjusted with the plug-in unit VOLTS/CM switch. The VOLTS/CM switch is an accurately calibrated control which, when used with the graticule, allows you to make precise voltage measurements from the displayed waveforms. The operation of other plug-in unit controls varies between plug-in units. For information regarding the operation of these controls, refer to the instruction manual for the plug-in unit you are using.

Certain precautions must be taken when you are connecting the oscilloscope to the input signal source to insure that accurate information is obtained from the oscilloscope display. This is particularly true when you are observing low-level signals or waveforms containing high or extremely low frequency components. For applications where you are observing low-level signals, unshielded input leads are unsatisfactory because they tend to pick up stray signals which produce erroneous oscilloscope displays. Shielded cables should be used whenever pos-

sible, with the shield connected to the chassis of both the oscilloscope and the signal source. Regardless of the type of input lead used, keep them as short as possible.

Distortion of the input waveform may result if very low-frequency input signals are ac coupled into the oscilloscope, if high-frequency waveforms are not properly terminated, or if the input waveform contains high-frequency components which exceed the passband of the oscilloscope and plug-in unit combination. You must be aware of the limitations of the instrument.

In analyzing the displayed waveform, you must consider the loading effect that the oscilloscope has on the input signal source. In most cases this loading effect is negligible, but in some applications, loading caused by the oscilloscope may materially alter the results obtained. In such cases you may want to use a probe to reduce the amount of loading.

Use of Probes

Occasionally, connecting the input of an oscilloscope to a signal source loads the source enough to adversely affect both the operation of the source and the waveform displayed on the oscilloscope. When this occurs, both

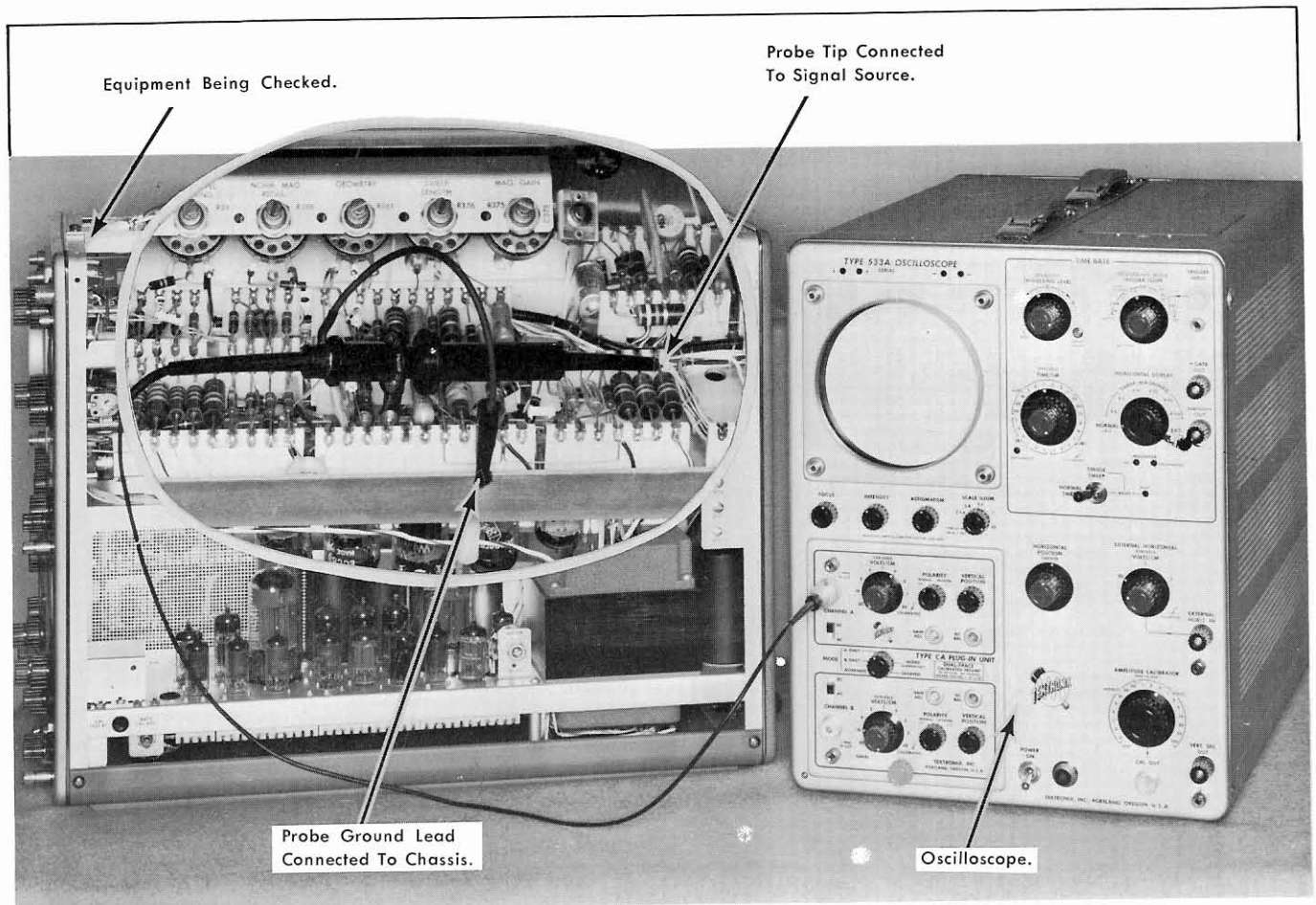


Fig. 2-6. Proper connection of a probe to the input signal source.

capacitive and resistive loading due to the oscilloscope can be reduced to a negligible value by using an attenuator probe.

In addition to providing isolation of the oscilloscope from the signal source, an attenuator probe also decreases the amplitude of the displayed waveform by the attenuation factor of the probe. Use of a probe allows you to increase the vertical deflection factors of the oscilloscope to look at large amplitude signals which are beyond the normal limits of the oscilloscope and plug-in combination. Signal amplitudes, however, must be limited to the maximum allowable value of the probe used.

Before using a probe, you must check (and adjust if necessary) the compensation of the probe to prevent distortion of the applied waveform. To adjust the probe compensation, place the HORIZONTAL DISPLAY switch at NORMAL (X1), the TIME BASE TRIGGERING MODE switch at AUTO, and the TIME BASE TRIGGER SLOPE switch at +INT. Turn up the intensity until the trace is visible and connect the probe tip to the CAL OUT connector. Set the AMPLITUDE CALIBRATOR switch for 2 centimeters of displayed signal. Set the TIME BASE TIME/CM switch to display approximately 3 or 4 cycles of the Calibrator waveform and adjust the probe compensation control to obtain flat tops on the displayed Calibrator square waves as shown in Fig. 2-7(b).

The method of setting the compensation control depends on the probe in use. If your oscilloscope is equipped with a Type P510A probe, compensation is by means of a screwdriver adjustment through the hole near the nose end of the probe body. If a P6000 type probe is used, it is necessary to first unlock the Locking Sleeve by turning it counterclockwise. The probe is then compensated by rotating the probe body while watching the oscilloscope display for the desired waveform. When compensation is

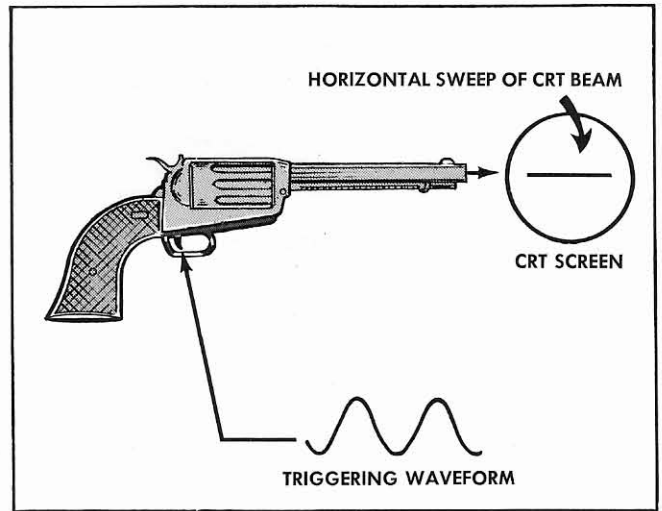


Fig. 2-8. In triggered sweep operation the horizontal sweep is started by the triggering waveforms.

completed, carefully turn the Locking Sleeve clockwise to lock it without disturbing the adjustment of the probe.

HORIZONTAL DEFLECTION SYSTEM

Trigger Operation

For most uses of the oscilloscope a stable display of some waveforms is required. To accomplish this the

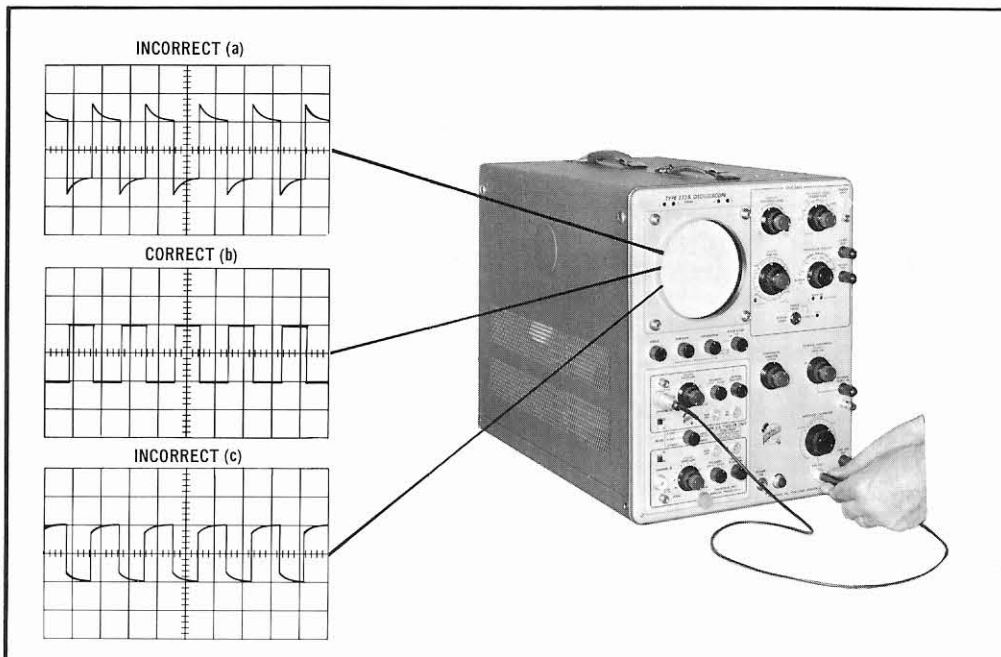


Fig. 2-7. When compensating the probe, it is adjusted to obtain an undistorted presentation of the calibrator square-wave.

oscilloscope can be operated so that the horizontal sweep starts at a given point on the displayed waveform. This is known as "triggered" operation. For the present, we will refer to the starting of the sweep, at the left side of the graticule, as "triggering" the sweep.

Triggered operation is useful for observing a waveform which may occur only once, or which may occur at random intervals. For any of these uses, the oscilloscope can be used in such a way that each horizontal sweep is triggered by some waveform other than the one being observed, but which bears a time relationship to the observed waveform.

The waveform used to start the horizontal sweep is called the "triggering signal", whether it is the waveform being observed, or some other waveform. The instructions that follow tell you how to select this signal. They also contain information on triggering according to various modes, depending on the nature of the triggering signal.

The nomenclature of the various Triggering Mode settings has been changed between the Type 533 and Type 533A Oscilloscopes. However, the switches themselves are the same. In the following descriptive paragraphs, the names of the Triggering Modes will be given for both Type 533 and Type 533A where differences exist. The first name given will be that for the Type 533, the second for the Type 533A.

Selecting the Triggering Signal

1. To trigger the sweep from the waveform being observed, set the black TRIGGER SLOPE knob to INT. (+ or -).

2. To trigger the sweep from the powerline wave (as in the case when observing a waveform which has a time relationship to the power-line wave), set the black TRIGGER SLOPE knob to LINE (+ or -).

3. To trigger the sweep from some external waveform (one having a time relationship to the waveform being observed), connect the source of the triggering signal to the TRIGGER INPUT connector and set the black TRIGGER SLOPE knob to EXT. (+ or -).

Refer to Fig. 2-9 for a complete pictorial presentation of the various triggering source options.

Selecting the Triggering Slope

The horizontal sweep can be triggered on either the rising (+ slope) or falling (- slope) portion of the triggering waveform as determined by the position of the TRIGGER SLOPE switch. When the switch is in one of the + positions, the sweep is triggered on the rising portion of

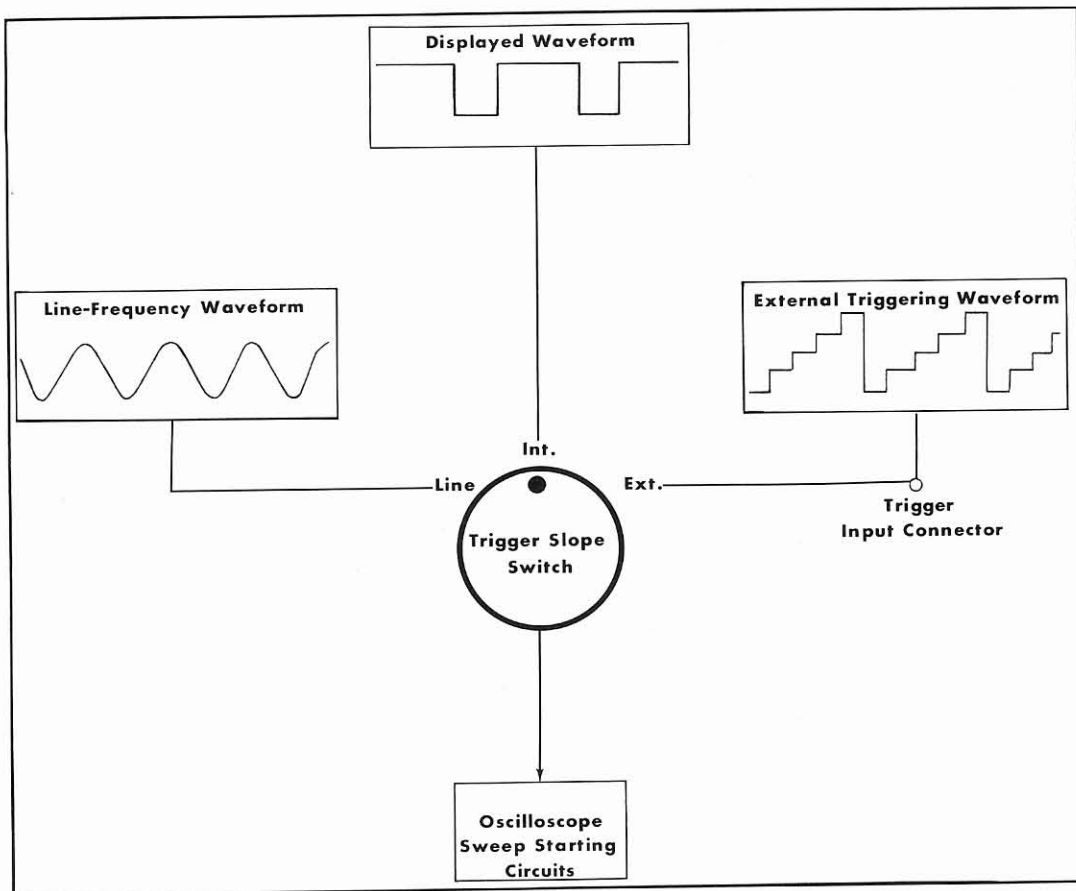


Fig. 2-9. The triggering signal is selected from three possible sources with the TRIGGER SLOPE control.

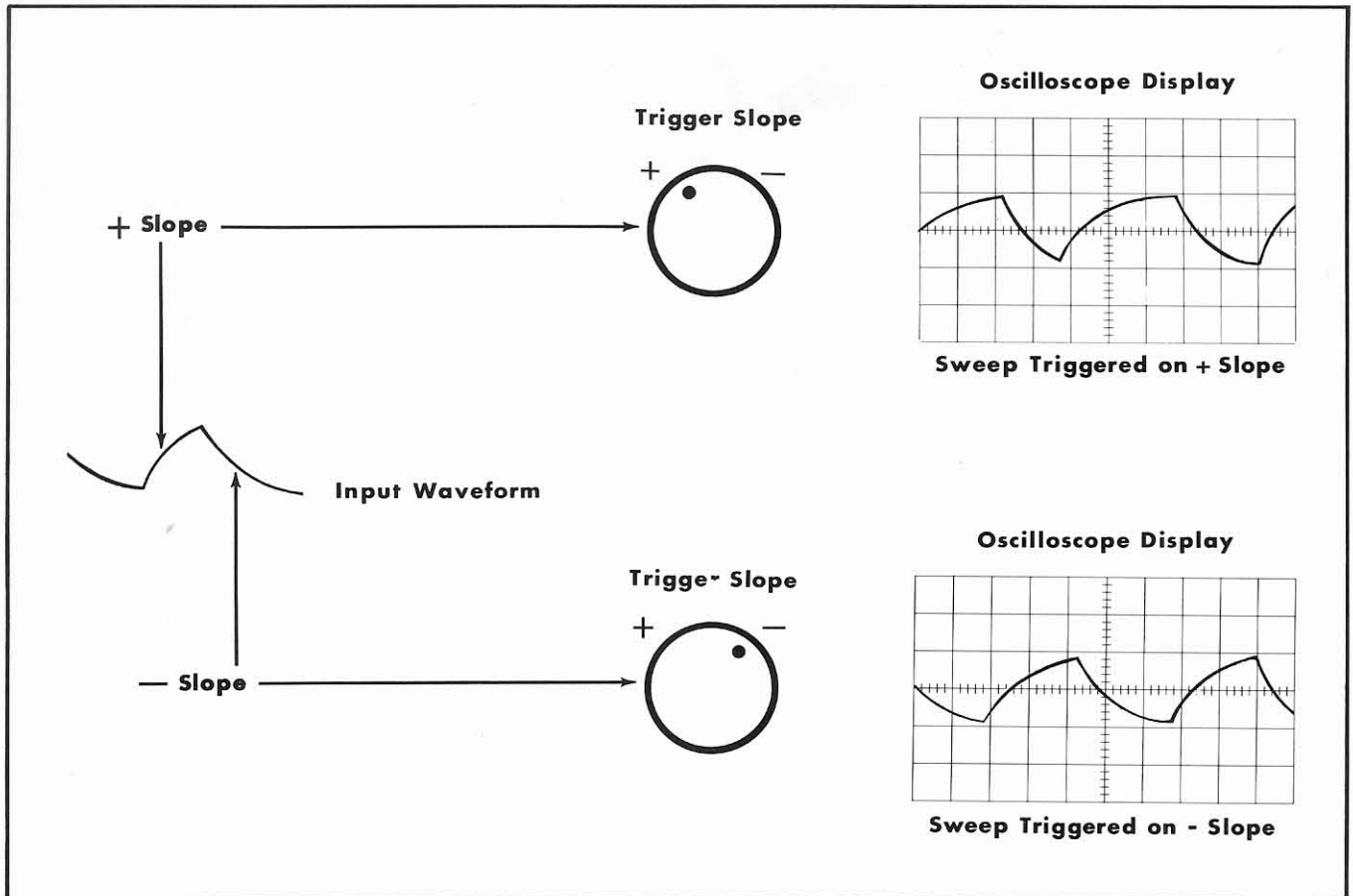


Fig. 2-10. Effects on the oscilloscope display produced by + and - settings of the TRIGGER SLOPE control.

the triggering waveform; when the TRIGGER SLOPE switch is in one of the - positions, the sweep is triggered on the falling portion of the waveform. (See Fig. 2-10).

In many applications the triggering slope is not important, since triggering on either slope will provide a display which is suitable to the application. However, in many other cases such as pulse measurements, the triggering slope is very important. If, while using a fast sweep, you wish to see the rise of a pulse, it will be necessary for you to trigger the sweep on the rising portion of the waveform by placing the TRIGGER SLOPE switch in one of the + positions. To observe the fall of a pulse at a fast sweep speed, it will be necessary to trigger the sweep on the falling portion of the waveform by placing the TRIGGER SLOPE switch in one of the - positions. In either case, selection of the wrong triggering slope will make it impossible for you to see the portion of the waveform you want to check.

Using the STABILITY and TRIGGER LEVEL Controls

Triggered operation in all modes except AUTOMATIC and HF SYNC may require proper setting of the STABILITY and TRIGGER LEVEL controls. The TRIGGER LEVEL

control has no effect in either AUTOMATIC or HF SYNC modes.

The STABILITY control has a PRESET position at the fully counterclockwise setting of the control. This position permits proper triggering in many applications without necessitating additional adjustment of the STABILITY control. If it becomes difficult or impossible for you to obtain proper triggering with the STABILITY control at PRESET, you must then adjust the control. This is done with the TRIGGERING LEVEL control fully counterclockwise. The STABILITY control is rotated clockwise from the PRESET position until a trace appears on the screen. The proper Stability setting for a triggered display is then obtained by turning the knob slowly counterclockwise until the trace just disappears.

The TRIGGERING LEVEL control should then be turned slowly toward the 0 position until a stable display appears on the screen. The TRIGGERING LEVEL control also determines the exact point on the triggering waveform where triggering of the sweep occurs. Turning the control clockwise causes the sweep to trigger at more positive points on the waveform, while turning the control counterclockwise causes the sweep to trigger at more negative points. If the displayed waveform is vertically centered under the graticule, setting the TRIGGERING LEVEL control at 0 will cause the sweep to start at approximately the mid-voltage point of the waveform, except in DC mode.

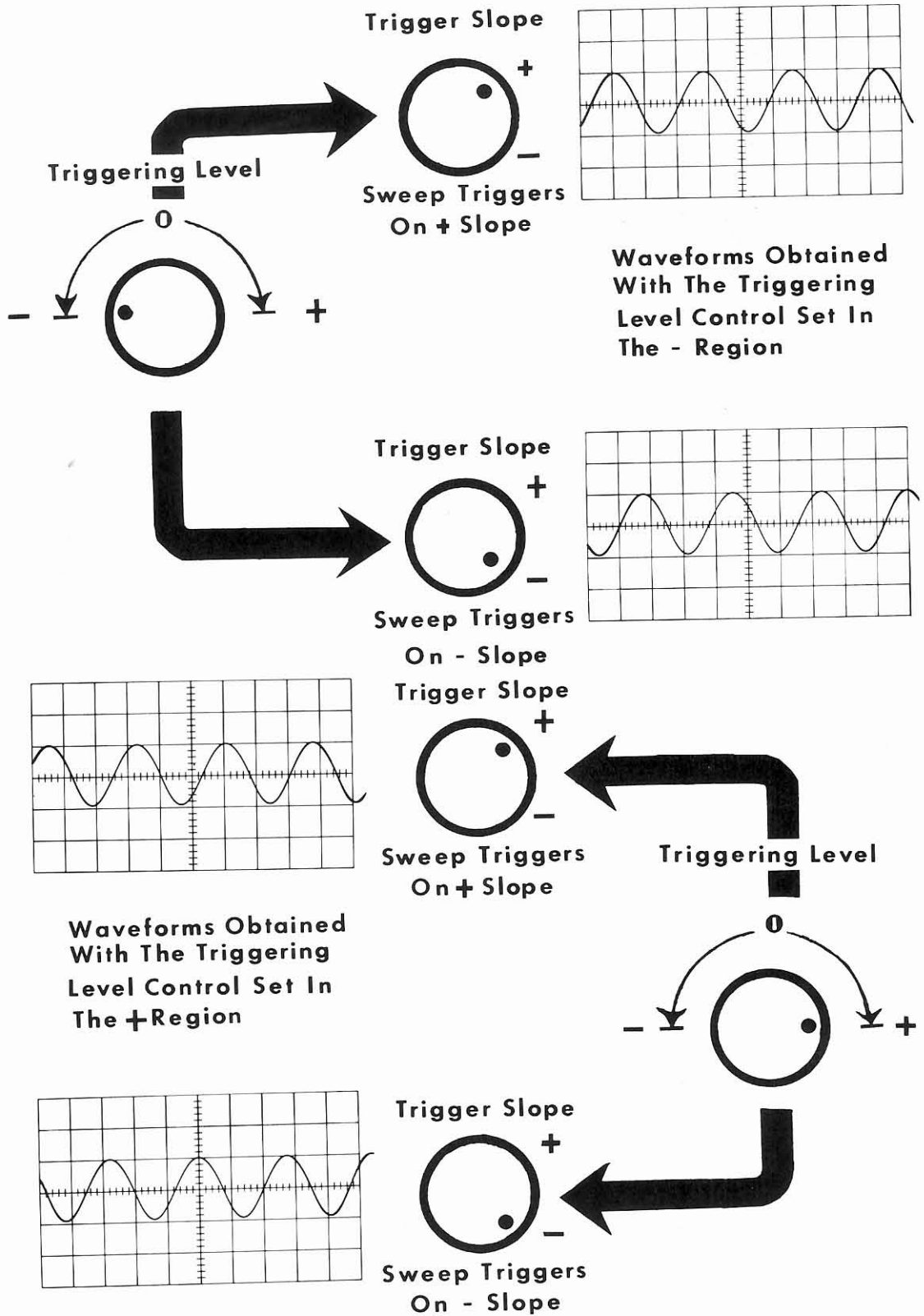


Fig. 2-11. Effects on the oscilloscope display produced by + and - settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the - region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising portion or the falling portion of the input waveform.

Selecting the Triggering Mode

After selecting the triggering source and triggering slope, it is next necessary to select the triggering mode which will allow you to obtain the desired display. Five triggering modes are available. In the Type 533, they are DC, AC SLOW, AC FAST, AUTOMATIC and HIGH FREQUENCY SYNC. In the Type 533A, they are DC, AC, AC LOW FREQUENCY REJECT, AUTOMATIC and HIGH FREQUENCY SYNC.

Each of the triggering modes is designed to provide stable triggering from a certain type of waveform. For most applications however, several of the triggering modes will work equally well. For applications of this type, the triggering mode used is purely a matter of choice. The primary thing to consider in choosing the triggering mode is whether or not it allows you to obtain the display you want.

To determine the best mode of operation for a particular application, it is usually best to try each triggering mode in the application. The Automatic mode should be tried first since this triggering mode provides stable triggering in most applications without the necessity of setting the STABILITY or TRIGGERING LEVEL controls. If the Automatic mode does not provide the desired display, it will then be necessary for you to try one or more of the other triggering modes.

AUTOMATIC Triggering Mode

The AUTOMATIC mode is most frequently used because of its ease of operation. This mode is useful in obtaining stable triggering from waveforms with frequencies of from approximately 60 cycles to 2 megacycles. The principal advantage of this type of operation is that it is not necessary to adjust either the STABILITY or TRIGGERING LEVEL controls to obtain a stable display. This permits you to observe a large number of waveforms with different shapes and amplitudes without adjusting any of the triggering controls. In the absence of a triggering signal, the sweep continues to run to provide a convenient reference trace on the oscilloscope screen.

The AUTOMATIC triggering mode is selected by placing the TRIGGERING MODE switch in the AUTO. position. The triggering source and slope is then selected and the input signal is applied to the oscilloscope. No other control adjustments are required. Since the TRIGGERING LEVEL control has no effect on the display when automatic triggering is used, it is impossible to select the point on the triggering waveform where the sweep is triggered. Each sweep is instead triggered at the average voltage point of the waveform.

DC Triggering Mode

In the DC mode, the sweep can be triggered from periodic signals in the range from dc to 5 mc. This mode is especially useful with trigger signals that change slowly, and is also useful when it is desired to trigger at a certain point (voltage level) on a waveform with respect to ground.

Another application of the DC triggering mode is to attain a stable display of a random-pulse train. The aver-

age voltage of this type of signal is dependent upon the time duration and amplitude of each pulse and the time lapse between successive pulses. Since these are variable quantities in a random-pulse train, the average voltage will also vary. This is likely to cause unstable triggering in the AC modes. In the DC mode, however, the circuits are sensitive to the instantaneous voltage only. Changes in the average voltage do not alter the operation of the circuits. As a result, the TRIGGERING LEVEL control can be adjusted to initiate a sweep whenever a pulse reaches the desired voltage.

AC SLOW (AC) Triggering Mode

Selection of the AC SLOW (AC) triggering mode is made by placing the TRIGGERING MODE switch in the AC SLOW (AC) position. This mode provides useful triggering in the frequency range of approximately 15 cycles to 5 mc. These frequency limits vary slightly depending upon the shapes and amplitude of the triggering waveform. In the AC SLOW or AC mode, triggering is unaffected by the dc components of the triggering signal or by the vertical positioning of the trace. The triggering level can be selected to provide the desired display using the STABILITY and TRIGGERING LEVEL controls. These two controls are set as described for the DC mode.

AC FAST (AC LF REJECT) Mode

The AC FAST (AC Low Frequency Reject) triggering mode is used when the TRIGGERING MODE switch is in the AC FAST (AC LF Reject) position. This mode is similar to the slower AC mode except that low-frequency waveforms are rejected by the triggering circuit. This triggering mode works well with high-frequency waveforms, but it may be difficult to obtain stable triggering with frequencies below approximately 1000 cycles.

Occasionally you may be required to obtain stable triggering from a fairly high-frequency waveform that is mixed with a great deal of low frequency noise or line frequency pickup. In such cases the additional noise and pickup can make it very difficult to obtain a stable display. If this occurs, you can select the AC FAST (AC LF REJECT) triggering mode, thereby eliminating the effects of the low frequency noise and pickup. The low frequencies are blocked from the triggering circuit while the high frequency triggering waveform is passed to produce the stable triggering that you need. In all other respects, the two AC triggering modes are identical.

HF SYNC Triggering Mode

The High Frequency Synchronization Mode permits stable displays of waveforms with frequencies higher than approximately 5 mc. Stability of the display is adjusted with the STABILITY control. The TRIGGERING LEVEL control is not used. To use the High Frequency Synchronization Mode, place the TRIGGERING MODE switch in the HF SYNC position. Turn the STABILITY control clockwise until a trace appears. Continue to adjust the STABILITY control until a stable display is obtained.

Although the synchronization signal source is selected with the TRIGGER SLOPE control, the slope cannot be selected. Also you cannot use the PRESET position of the STABILITY Control in this mode.

Free-Running Sweep Operation

In the usual oscilloscope application, the sweep is triggered or synchronized by the input waveform. However, in some applications it may be more desirable to reverse the process and initiate the input waveform through use of a periodically recurrent waveform from the oscilloscope. In this type of application the sweep is caused to free-run and an output from either the + GATE OUT or SAWTOOTH OUT connectors is used to trigger or synchronize the input waveform. (See Fig. 2-12).

The sweep can be made to free run with any setting of the TRIGGERING MODE switch by turning the STABILITY control fully clockwise. In all positions of the TRIGGERING MODE switch except AUTOMATIC the number of sweeps per second is determined by the setting of the TIME/CM controls. In the AUTOMATIC position, the sweep repetition rate remains at approximately 50 sweeps per second regardless of the setting of the TIME/CM control.

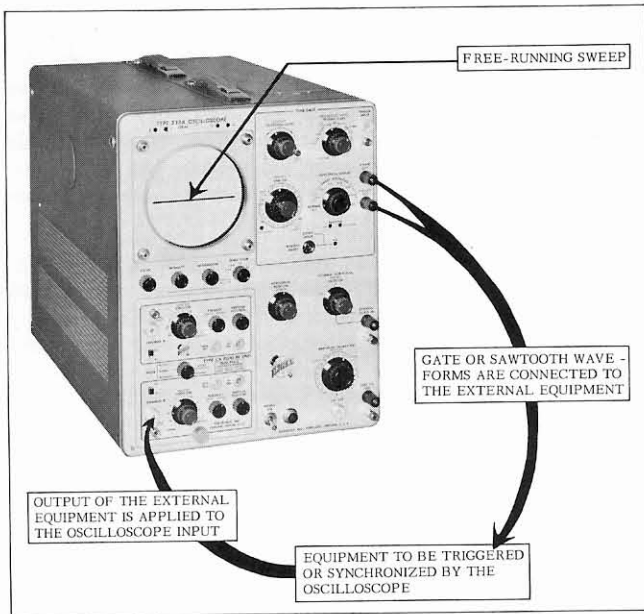


Fig. 2-12. Using the Gate or Sawtooth output waveforms to synchronize or trigger external equipment.

In addition to providing the means of controlling an applied waveform, a free-running sweep also provides a convenient reference trace on the oscilloscope screen without requiring an input signal. This trace can then be used to position the sweep or to establish a voltage reference line.

Sweep Magnification

To magnify a particular part of a display, position that portion of the display with the HORIZONTAL POSITION controls so that it appears near the center of the graticule. Then turn the HORIZONTAL DISPLAY control to the desired SWEEP MAGNIFIED position. That part of the display which formerly occupied the middle section of the graticule will now be expanded horizontally by the selected magnification factor. The apparent time calibration of the X (sweep) axis will now be equal to the setting of the TIME/CM control divided by the magnification factor.

External Horizontal Deflection

In some instances it may be necessary to deflect the beam horizontally by means of an externally derived wave-

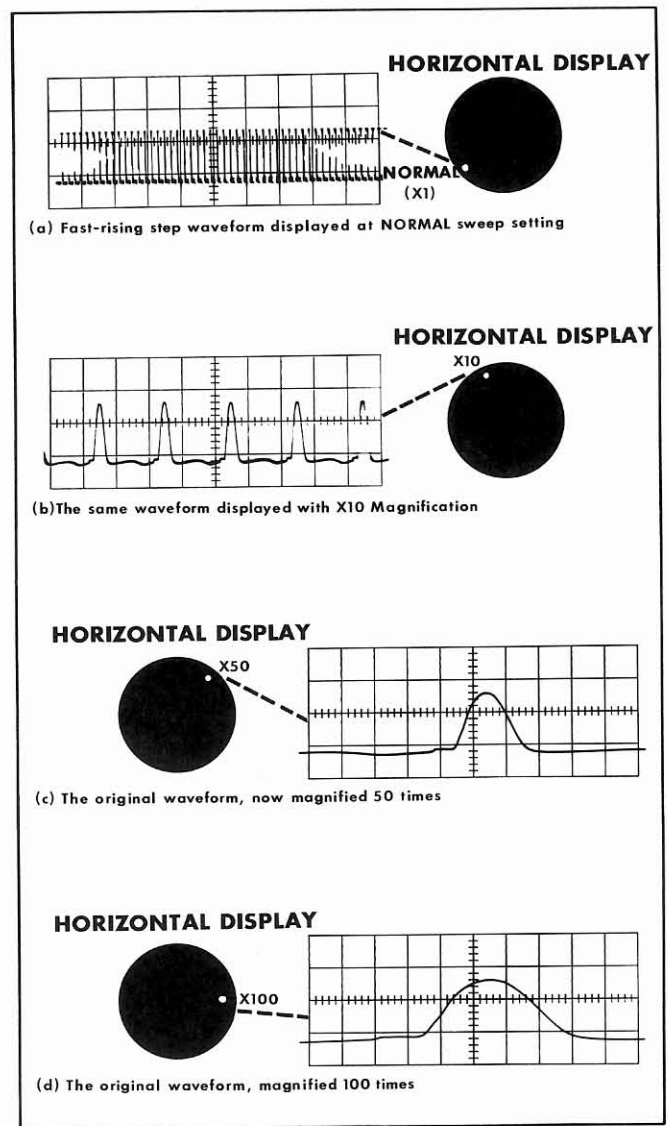


Fig. 2-13. Effects of the sweep magnifier control on the same waveform at various Magnified settings.

form, rather than by means of the internal sweep. To accomplish this, set the HORIZONTAL DISPLAY switch to EXT. and connect the source of the waveform to the EXTERNAL HORIZ. IN connector. Set the EXTERNAL HORIZONTAL controls (VOLTS/CM and VARIABLE) for the desired amount of horizontal deflection. Three ranges of fixed attenuation (of the external sweep signal) are provided, with a variable control to interpolate between ranges.

Output Waveforms

For certain external applications, the sawtooth sweep waveform is available at the SAWTOOTH OUT connector on the front panel. This positive waveform starts at about ground and rises linearly to a peak amplitude of about 150 volts.

The start and duration of the rising part of the sawtooth coincides with the start and duration of the horizontal sweep on the crt. The rate at which the sawtooth rises is determined by the setting of the TIME/CM control.

A positive rectangular waveform is available at the + GATE OUT connector. This waveform starts at ground and rises to about 20 volts. The starting time and duration of each pulse coincides with the starting time and duration of the positive-going part of the sawtooth available at the SAWTOOTH OUT connector.

Single Sweep

The Type 533/533A contains a single-sweep (sweep lock-out) feature which permits a waveform to be displayed for one horizontal sweep only. Subsequent sweeps and waveform displays are locked out until the circuit is rearmed.

This feature is particularly useful for photographing random or nonrepetitive signals.

To use the single-sweep feature, set the instrument for normal manually-triggered operation. Click the spring-loaded NORMAL SWEEP-SINGLE SWEEP switch to the RESET position. Let it return to the SINGLE SWEEP position. The READY lamp will light. The next trigger pulse will produce a single horizontal sweep. Subsequent triggers will have no effect on the circuit until the READY lamp is lighted with the RESET switch.

AUXILIARY FUNCTIONS

Calibrator

The calibrator provides a convenient source of square waves of known amplitude at a frequency of approximately 1 kc. The square-waves are used primarily to adjust probes and to verify the calibration of the vertical deflection system of the oscilloscope and plug-in unit.

Calibrator square-waves are adjustable from .2 millivolts peak to peak, to 100 volts peak to peak, in 18 steps. Calibrator output amplitude is controlled on the Type 533 by two SQUARE-WAVE CALIBRATOR switches on the front panel. The large black knob sets nine ranges of output in increments of from .2 to 100. The smaller concentric red knob, labeled VOLTS, MILLIVOLTS, OFF, determines the proper output in volts or millivolts. On the Type 533A a single AMPLITUDE CALIBRATOR knob controls the full range of 18 outputs, ranging in steps from .2 millivolts to 100 volts.

The peak to peak calibrator voltage is within 3 percent of the CALIBRATOR switch setting when the output is connected to a high impedance load.

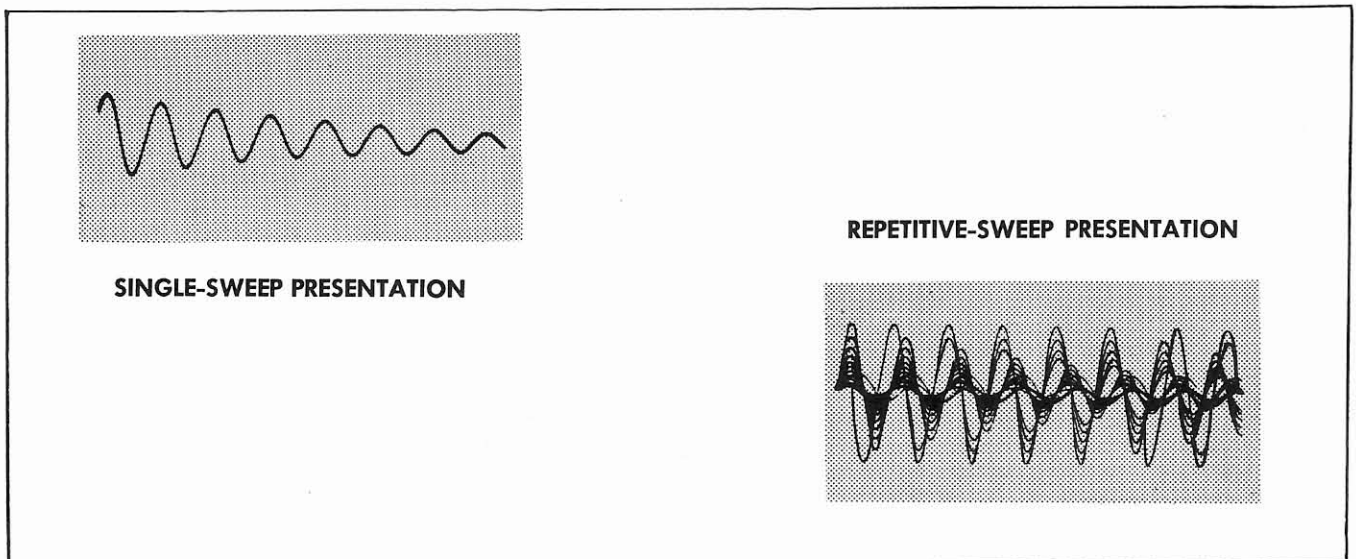


Fig. 2-14. Comparison of single sweep and repetitive sweep presentation of a damped sine wave. In the repetitive sweep presentation, it is difficult to determine what is being presented. However, in the single sweep presentation the damped sine wave can be clearly seen.

Dual Trace Displays

The Type CA Plug-In unit allows you to obtain two separate traces on the face of the crt. This permits you to display two functions simultaneously. Detailed instructions for operating the Type CA Unit in conjunction with the Type 533/533A Oscilloscope are contained in the Instruction Manual for the Type CA Unit.

When you are using the Type CA Unit in the chopped mode to obtain a dual-trace presentation, switching transients will be displayed on the screen. You can eliminate these switching transients by placing the CRT CATHODE SELECTOR switch on the rear of the instrument in the DUAL TRACE CHOPPED BLANKING position.

Intensity Modulation

The crt display of the Type 533/533A Oscilloscope can be intensity modulated by an external signal to display additional information. This is done by disconnecting the grounding bar from the EXTERNAL CRT CATHODE connector at the rear of the instrument and connecting the external signal to this terminal. The CRT CATHODE SELECTOR switch must be in the EXTERNAL CRT CATHODE position.

When you wish to make very accurate time measurements from the crt display, you can intensity modulate the beam with time markers presented on the screen. A positive signal of approximately 25 volts is required to cut off the beam from normal intensity.

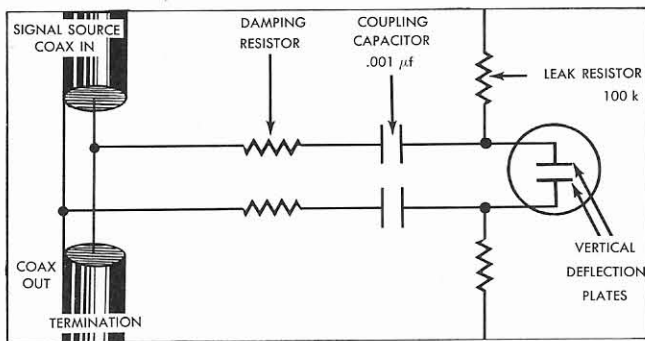


Fig. 2-15. Connecting to the crt deflection plates by AC coupling.

Direct Connection to CRT Deflection Plates

The vertical deflection plate pins are located on the side of the crt neck. The horizontal deflection plate pins are located on the top. In some applications, it is advantageous to connect a signal directly to either one, or both sets of these deflection plate pins — bypassing the internal oscilloscope amplifiers. Maintain the average dc voltage on the deflection plates between +275 and 300 volts. If the voltage is not within this range, the crt display become defocused.

For dc coupling, it is necessary to supply positioning voltages from the signal source. These voltages should fall within the +275 to +300 volt range. When dc coupling the signal to the deflection plates, you should tape the ends of the wires you have removed from the crt pins. This prevents shorting to the chassis and damage to the amplifier. The external signal source is then connected to the crt pins.

In many applications, it is advantageous to use ac coupling. This is necessary for those signals which cannot be made to have the right dc voltage. Positioning is controlled through the vertical amplifier with its normal positioning control.

The usual direct deflection application is to make use of the ultimate rise-time capability of the crt in the oscilloscope. This requires careful connection to the deflection plates from coaxial cables through damping resistors, and physically small coupling capacitors. These leads should be set close to the crt pins, should be short, and should be rigid. Tie down the coax so that a pull on the coax will not break the crt.

Referring to Fig. 2-15, connect one damping resistor to the coax center conductor. Connect the other damping resistor to the coax outer conductor. The size of the damping resistor will depend upon the coaxial line impedance, the lead lengths, and the coupling capacitor type. The best value is found by passing a fast-rise signal through the coax and adjusting the resistance until the display is just short of overshoot. A good starting value is 68Ω for a 52-Ω coaxial cable. No damping resistors are needed for cables with impedance above approximately 200Ω.

In order to realize the desired amount of deflection sensitivity in the Type T533 Cathode Ray Tube, the deflection plates have been placed as close as possible to the path of the electron beam. As a result, a small amount of current will flow in the deflection plate circuits. This current flow varies nonlinearly with the beam position, increasing rapidly in that plate toward which the beam is positioned. In the Type 533/533A oscilloscope, the effects of these currents are negligible. However, if the resistance is increased, these currents can cause objectionable voltage drops. For values of resistance greater than 110 K for the leak resistor, you may experience some difficulty from the current collected on the deflection plates. Some defocusing or distortion may be evident. These effects are most noticeable when the display is positioned close to the limits of the crt graticule.

The low frequency response required will determine the size of the coupling capacitor needed. The formula for the size of the coupling capacitor is $C = 1/(2\pi RF)$, where R is the leak resistor, and F is the desired low-frequency cutoff. For example, to find the coupling capacitor needed when the low frequency cutoff is 1600 cps and the leak resistor is 100 K, take the reciprocal of $2\pi RF$. The coupling capacitor is .001µf.

The coupling capacitor should be spaced about 1/4" to 3/8" from the damping resistors, and should be of the ceramic disc type, or equivalent, to preserve the fast-rise capability of the Type T533 crt.

To simplify making the direct connection to the crt vertical deflection plates, you can order a plastic plate and mounting bracket from Tektronix, Inc. The mounting bracket

is designed to clamp around the neck of the crt shield, adjacent to the deflection plate connections. When mounted correctly, the plate will be accessible through the crt deflection plate access hole in the left side panel. The bracket and plate may be ordered with or without the

necessary parts for vertical positioning voltages. Specify part number 013-008 for the blank unit without parts, or part number 013-007 for the wired unit. Holes can be drilled in the plastic plate for mounting coaxial cable and other connectors.

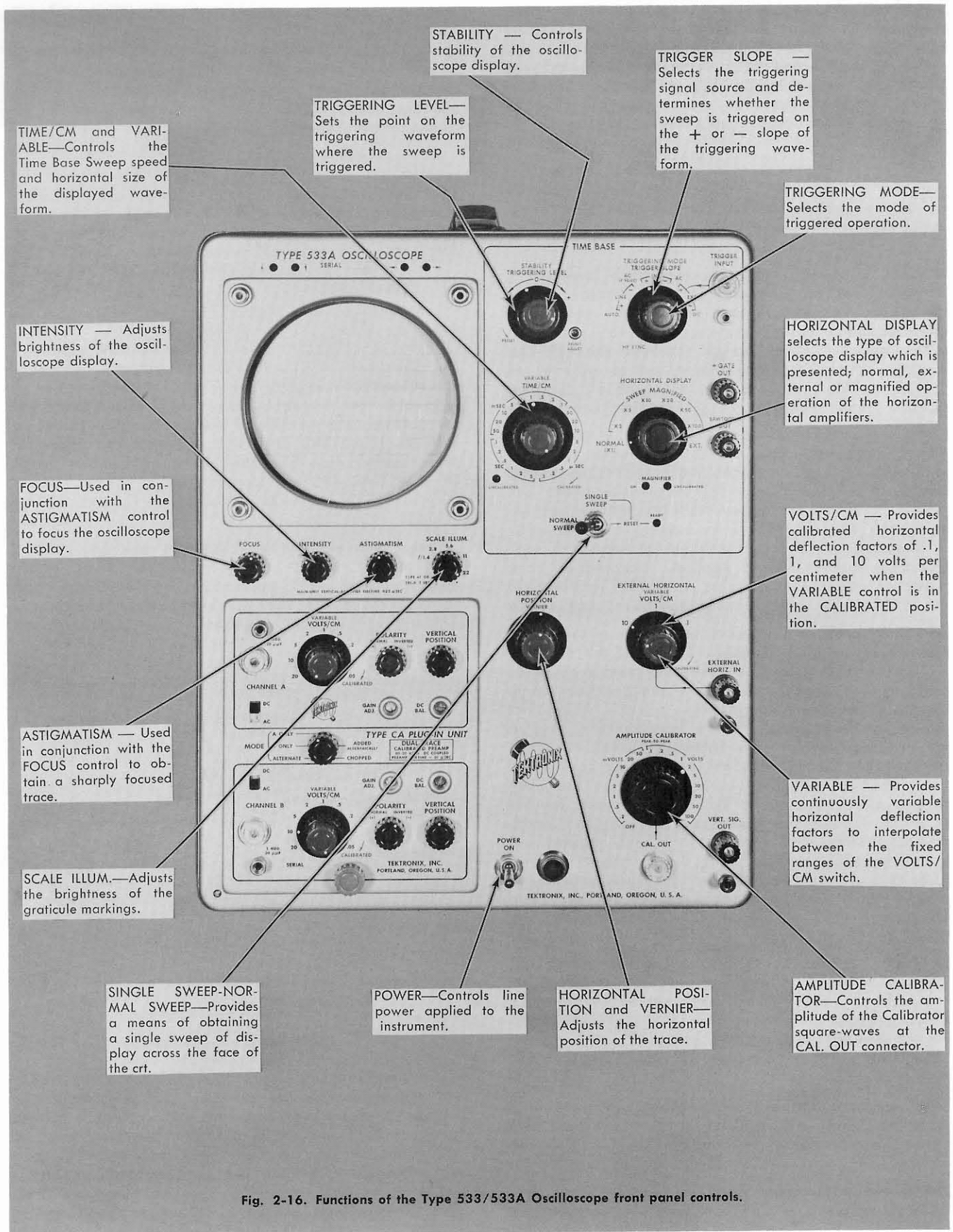
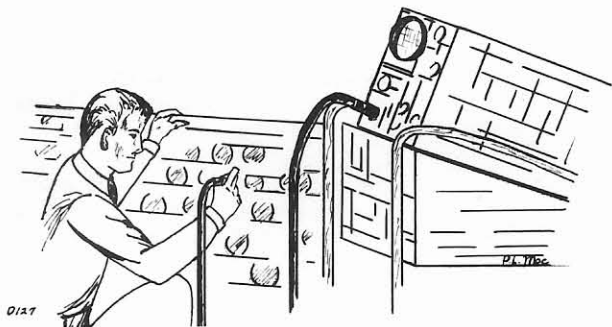


Fig. 2-16. Functions of the Type 533/533A Oscilloscope front panel controls.

APPLICATIONS



Voltage Measurements

The Type 533/533A Oscilloscope can be used to measure the voltage of the input waveform by using the calibrated vertical-deflection factors of the instrument and associated plug-in unit. The method used for all voltage measurements is basically the same although the actual techniques vary somewhat depending on the type of voltage measurements required. Essentially there are two types of voltage measurements: ac-component voltage measurements and instantaneous voltage measurements with respect to some reference potential. Many waveforms contain both ac and dc voltage components. It is often necessary to measure one or both of these components.

When making voltage measurements, you should display the waveform over as large a vertical portion of the screen as possible for maximum accuracy. Also, it is important that you do not include the width of the trace in your measurements. You should consistently make all measurements from one side of the trace. If the bottom side of the trace is used for one reading, it should be used for all succeeding readings. The VARIABLE VOLTS/CM control must be in the CALIBRATED position.

AC Component Voltage Measurements

To measure the ac component of a waveform, the plug-in unit input selector switch should usually be set to one of the AC positions. In these positions only the ac components of the input waveform are displayed on the oscilloscope screen. However, when the ac component of the input waveform is of very low frequency, it is necessary for you to make voltage measurements with the input selector switch in one of the DC positions to prevent errors.

To make a peak-to-peak voltage measurement on the ac component of a waveform, perform the following steps (see Figure 3-1):

1. With the aid of the graticule, measure the vertical distance in centimeters from the positive peak to the negative peak.
2. Multiply the vertical distance measured by the setting of the plug-in unit VOLTS/CM control to obtain the indicated voltage.
3. Multiply the indicated voltage by the attenuation factor of the probe used to obtain the actual peak-to-peak voltage.

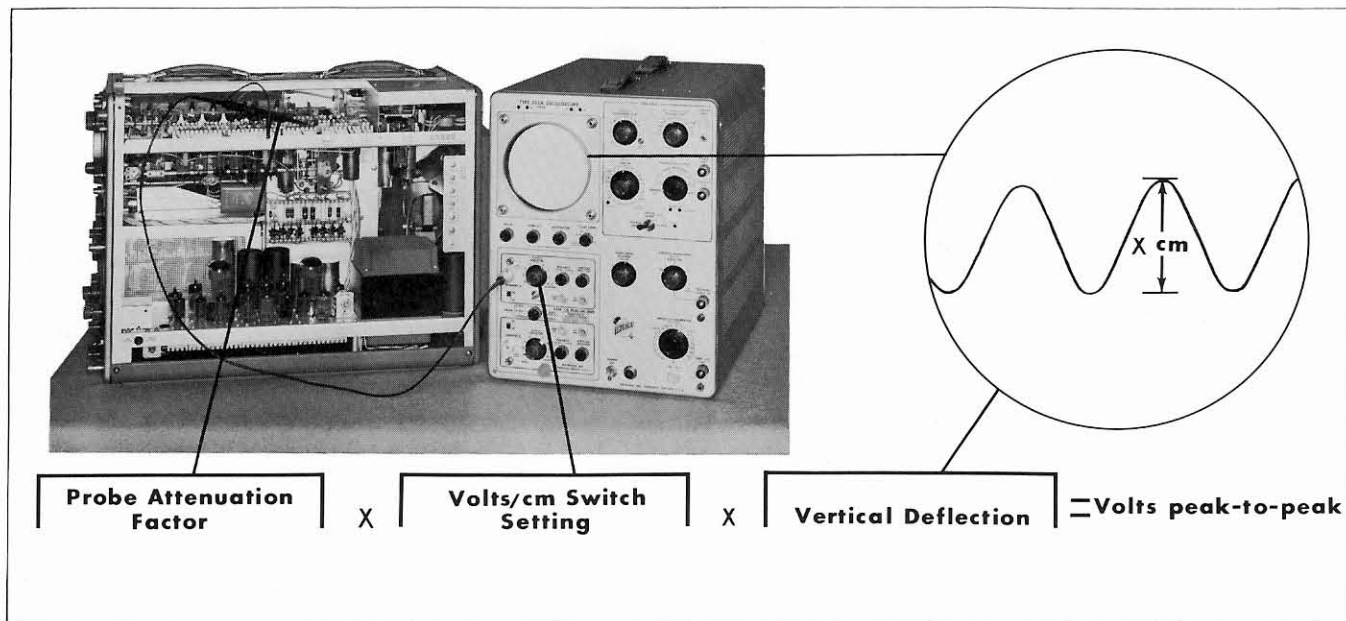


Fig. 3-1. Measuring the peak-to-peak ac component of an applied waveform.

Applications — Type 533/533A

As an example of the method, assume that using a 10X probe and a deflection factor of 1 volt per centimeter, you measure a vertical distance between peaks of 4 centimeters. In this case then, 4 centimeters multiplied by 1 volt per centimeter gives you an indicated voltage of 4 volts peak-to-peak. The indicated voltage multiplied by the probe's attenuation factor of 10 then gives you the true peak-to-peak amplitude of 40 volts.

When sinusoidal waveforms are measured, the peak-to-peak voltage obtained can be converted to peak, rms, or average voltage through use of standard conversion factors.

Instantaneous Voltage Measurements

The method used to measure instantaneous voltage is virtually identical to the method described previously for the measurements of the ac components of a waveform. However, for instantaneous voltage measurements the plug-in unit input selector switch must be placed in one of the DC positions. Also since instantaneous voltages are measured with respect to some potential (usually ground), a reference line must be established on the oscilloscope screen which corresponds to that potential. If, for example, voltage measurements are to be made with respect to +100 volts, the reference line would correspond to +100 volts. In the following procedure the method is given for establishing this reference line as ground since measurements with respect to ground are by far the most common type. The same general method may be used to measure voltage with respect to any other potential, however, so long as that potential is used to establish the reference line.

To obtain an instantaneous voltage measurement with respect to ground, perform the following steps (see Figure 3-2):

1. To establish the voltage reference line, touch the probe tip to an oscilloscope ground terminal (or if the reference line is to represent a voltage other than ground, to a source of that voltage) and adjust the oscilloscope controls to obtain a free-running sweep. Vertically position the trace to a convenient point on the oscilloscope screen. This point will depend on the polarity and amplitude of the input signal, but should always be chosen so that the trace lies along one of the major divisions of the graticule. The graticule division corresponding to the position of the trace is the voltage reference line and all voltage measurements must be made with respect to this line. (Do not adjust the vertical positioning control after the reference line has been established.)
2. Remove the probe tip from ground and connect it to the signal source. Adjust the triggering controls for a stable display.
3. Using the graticule measure the vertical distance in centimeters from the desired point on the waveform to the voltage reference line.
4. Multiply the setting of the VOLTS/CM control by the distance measured to obtain the indicated voltage.
5. Multiply the indicated voltage by the attenuation factor of the probe you are using to obtain the actual voltage with respect to ground (or other reference voltage).

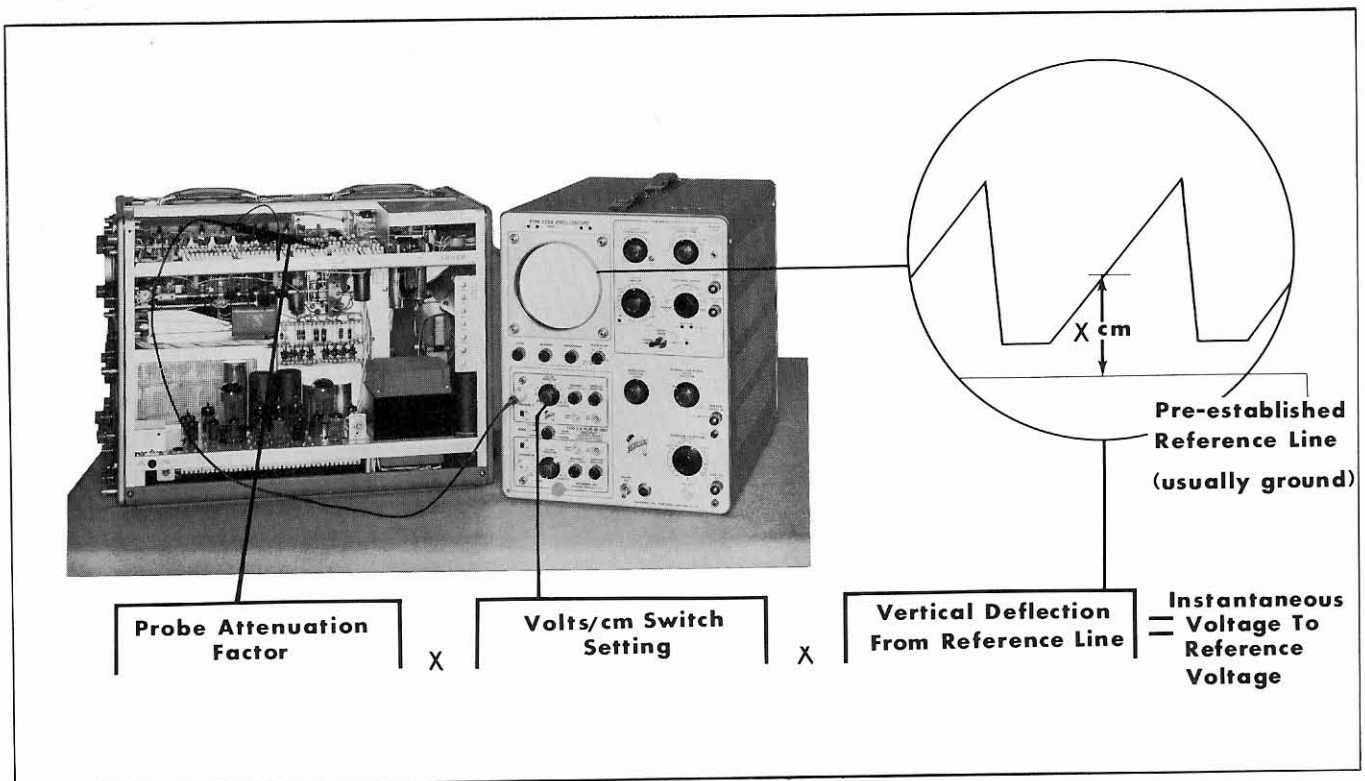


Fig. 3-2. Measuring the instantaneous voltage with respect to ground (or some other reference voltage.)

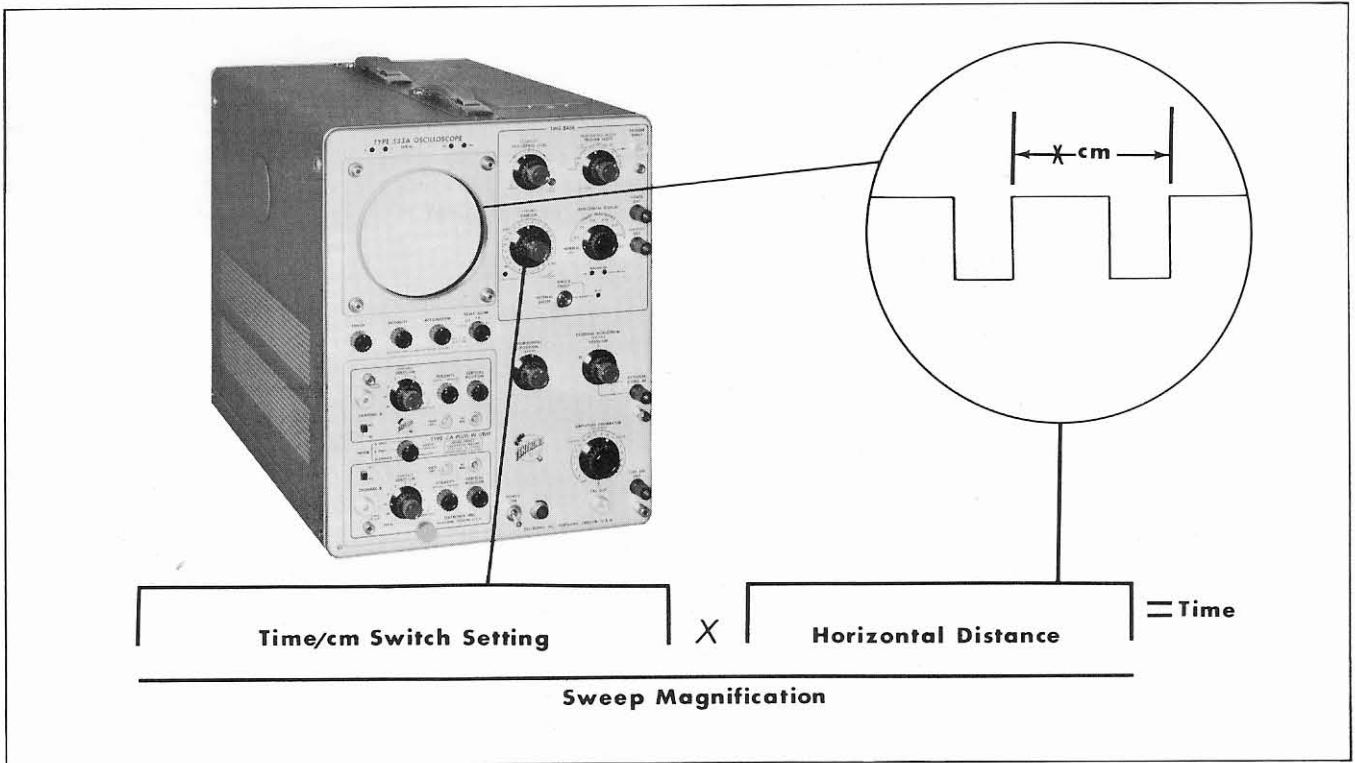


Fig. 3-3. Measuring time interval between events displayed on the oscilloscope screen.

As an example of this method, assume that you are using a 10X probe and deflection factor of .2 volts per centimeter. After setting the voltage reference line at the second from the bottom division of the graticule, you measure a distance of 3 centimeters to a point you wish to check. In this case then, 3 centimeters multiplied by .2 volts per centimeter gives you an indicated .6 volts. Since the voltage point is above the voltage reference line, the polarity is indicated to be positive. The indicated voltage multiplied by the probe's attenuation factor of 10 then gives you the actual voltage of positive 6 volts.

Time Measurements

The calibrated sweeps of the Type 533/533A Oscilloscopes cause any horizontal distance on the screen to represent a definite known interval of time. Using this feature you can accurately measure the time lapse between two events displayed on the oscilloscope screen. This is done by the following method:

1. Using the graticule, measure the horizontal distance between the two displayed events whose time interval you wish to find.
2. Multiply the distance measured by the setting of the TIME/CM control to obtain the apparent time interval. (The VARIABLE TIME/CM control must be in the CALIBRATED position).
3. Divide the apparent time interval by the setting of the MAGNIFIER control if the magnifier is on, and 1 if the magnifier is off, to obtain the actual time interval.

For example, assume that the TIME/CM switch setting is 1 MILLISEC, the magnifier is on, and that you measure a horizontal distance of 5 centimeters multiplied by 1 millisecond per centimeter gives you an apparent time interval of 5 milliseconds. The apparent time divided by 5 then gives you the actual time interval of 1 millisecond.

Frequency Measurements

Using the methods described in the previous section, you can measure the period (time required for one cycle) of a recurrent waveform. The frequency of the waveform can then easily be calculated since frequency is the reciprocal of the period. For example, if the period of a recurrent waveform is accurately measured and found to be 0.2 microseconds, the frequency is the reciprocal of 0.2 microseconds, or 5 mc.

At any given oscilloscope sweep speed, the number of cycles of the input waveform that is displayed on 10 centimeters of the screen is dependent on the frequency of the input waveform. Frequencies can usually be measured faster by the following method than by the one given in the last paragraph.

If you divide the cycles per unit of length by the time required for the input waveform to sweep this unit of length, you get the frequency. The total number of cycles are found for 10 cm for greater accuracy. Since the TIME/CM switch gives time for 1 cm, multiply this setting by 10 to have the time required for 10 cm. (See Fig. 3-4.)

Applications — Type 533/533A

To obtain the frequency of a repetitive input signal, perform the following steps:

1. Adjust the TIME/CM control to display several cycles of the input waveform. Insure that the VARIABLE TIME/CM control is in the CALIBRATED position.
2. Count the number of cycles of the waveform shown on the 10 centimeters of the graticule.

3. Divide this number by 10 times the TIME/CM switch setting. This gives you the frequency of the input waveform.

For example, assume that when you are using a sweep speed of 50 milliseconds per centimeter, you count 7.2 cycles in 10 centimeters. The frequency is 7.2 cycles divided by 50 milliseconds times 10, or 500 milliseconds. 500 milliseconds are $500 \times .001$ seconds, or .5 seconds. 7.2 cycles per $\frac{1}{2}$ second gives you 14.4 per second.

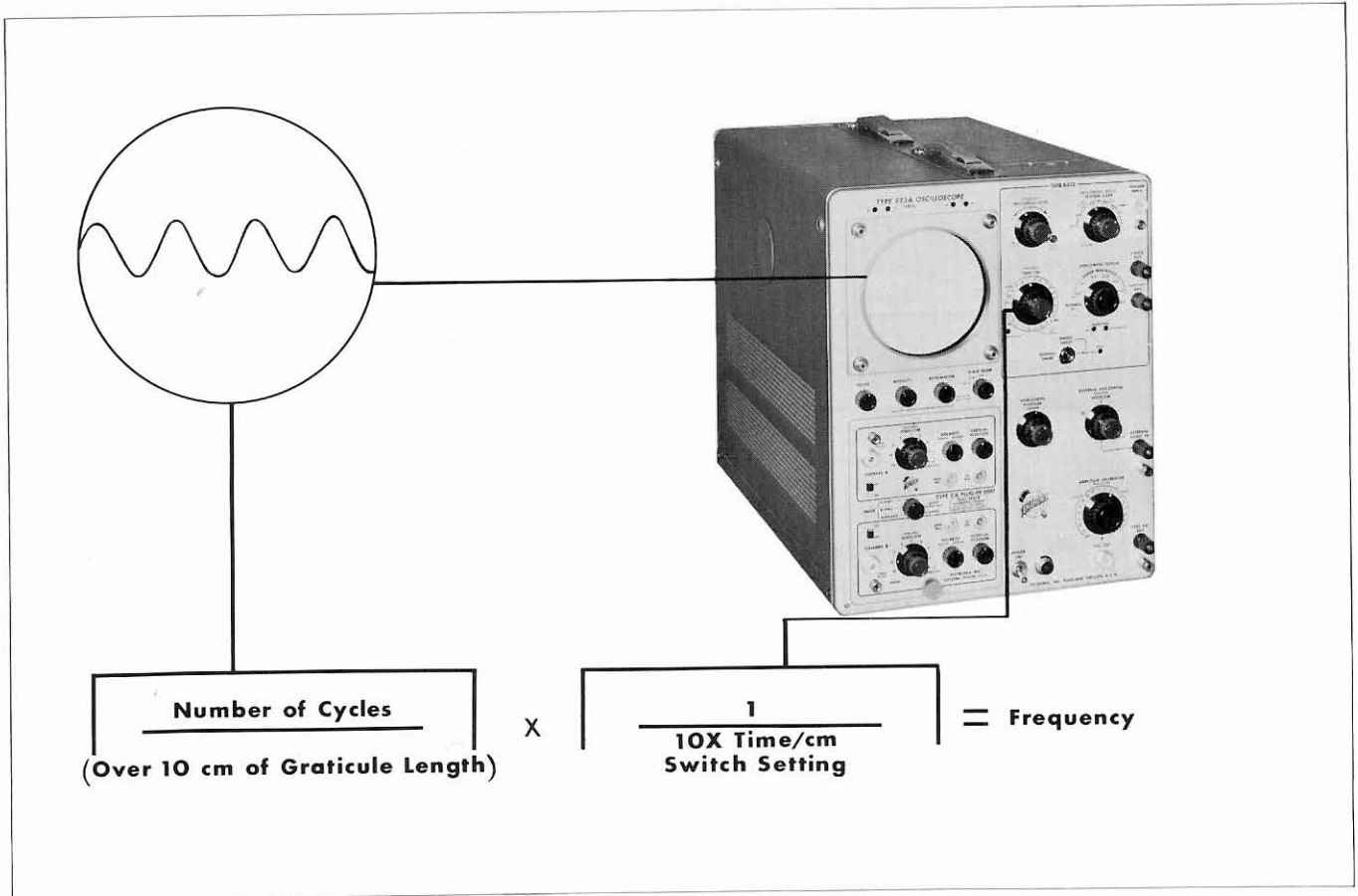
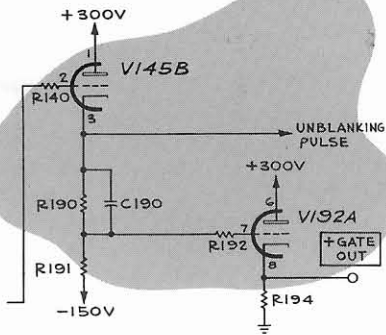


Fig. 3-4. Measuring the frequency of a repetitive input signal.

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 $\frac{1}{4}$ 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.

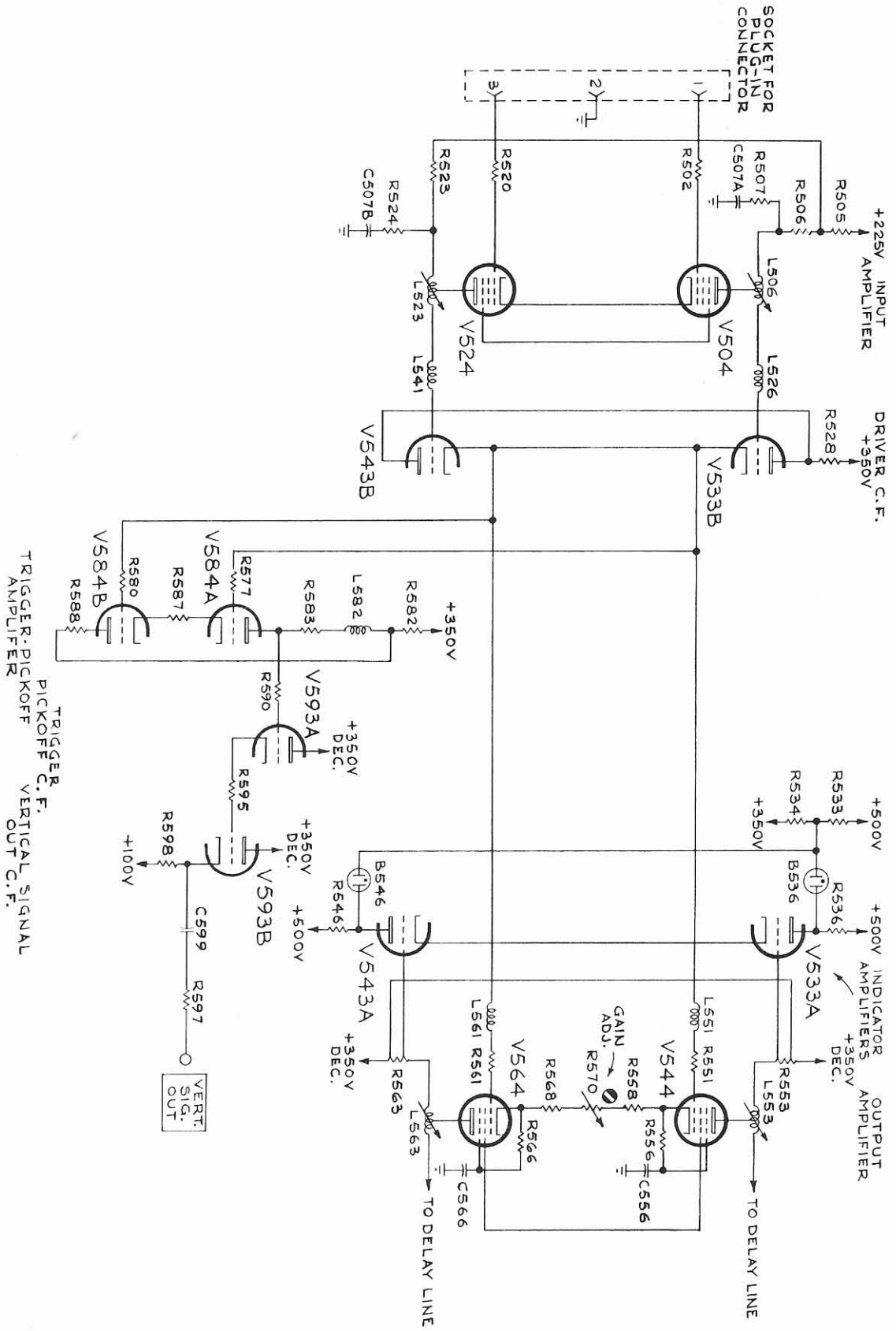


Fig. 4-1. Simplified Type 533/533A Vertical Amplifier.

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 triggering 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 will 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

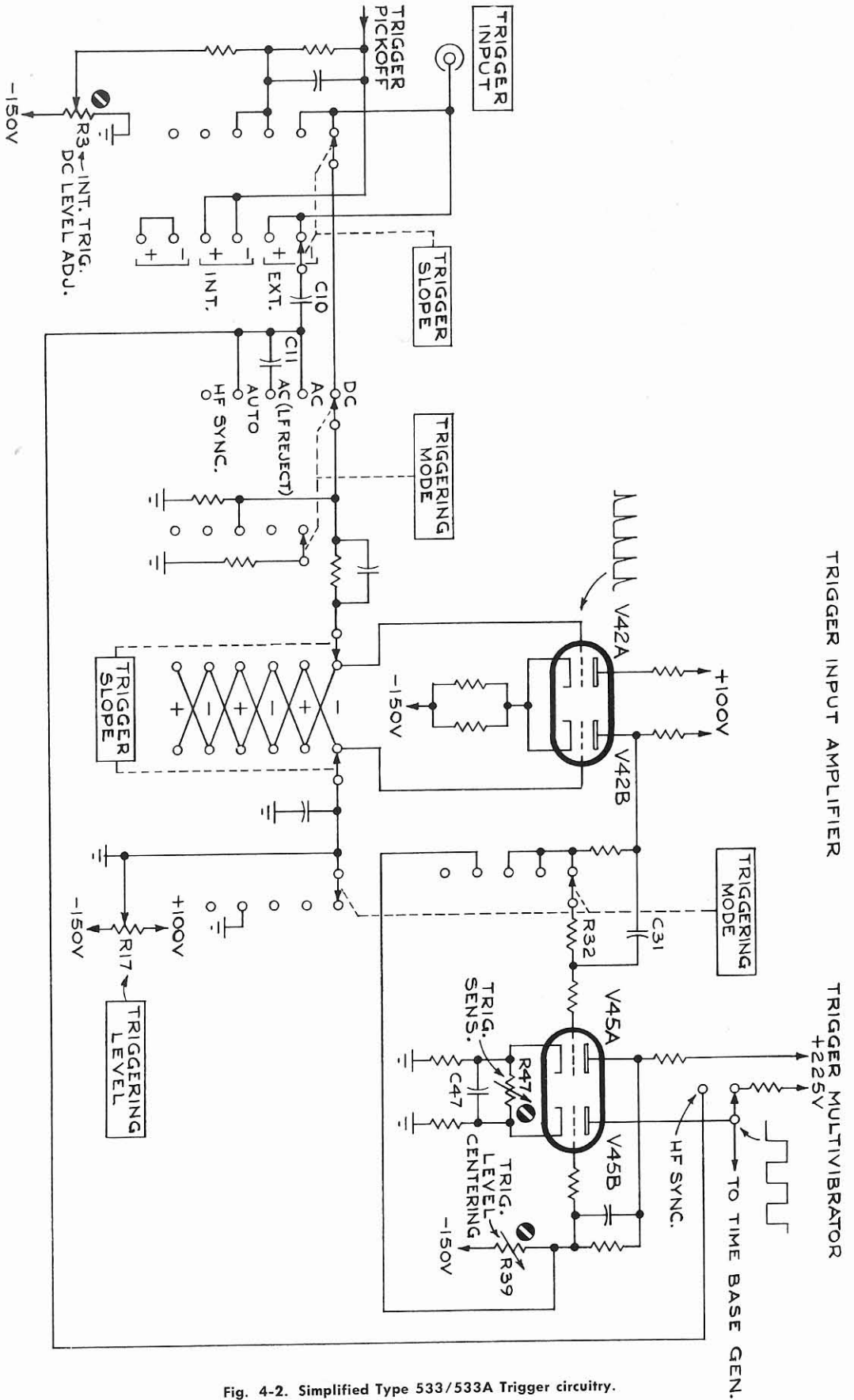


Fig. 4-2. Simplified Type 533/533A Trigger circuitry.

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.

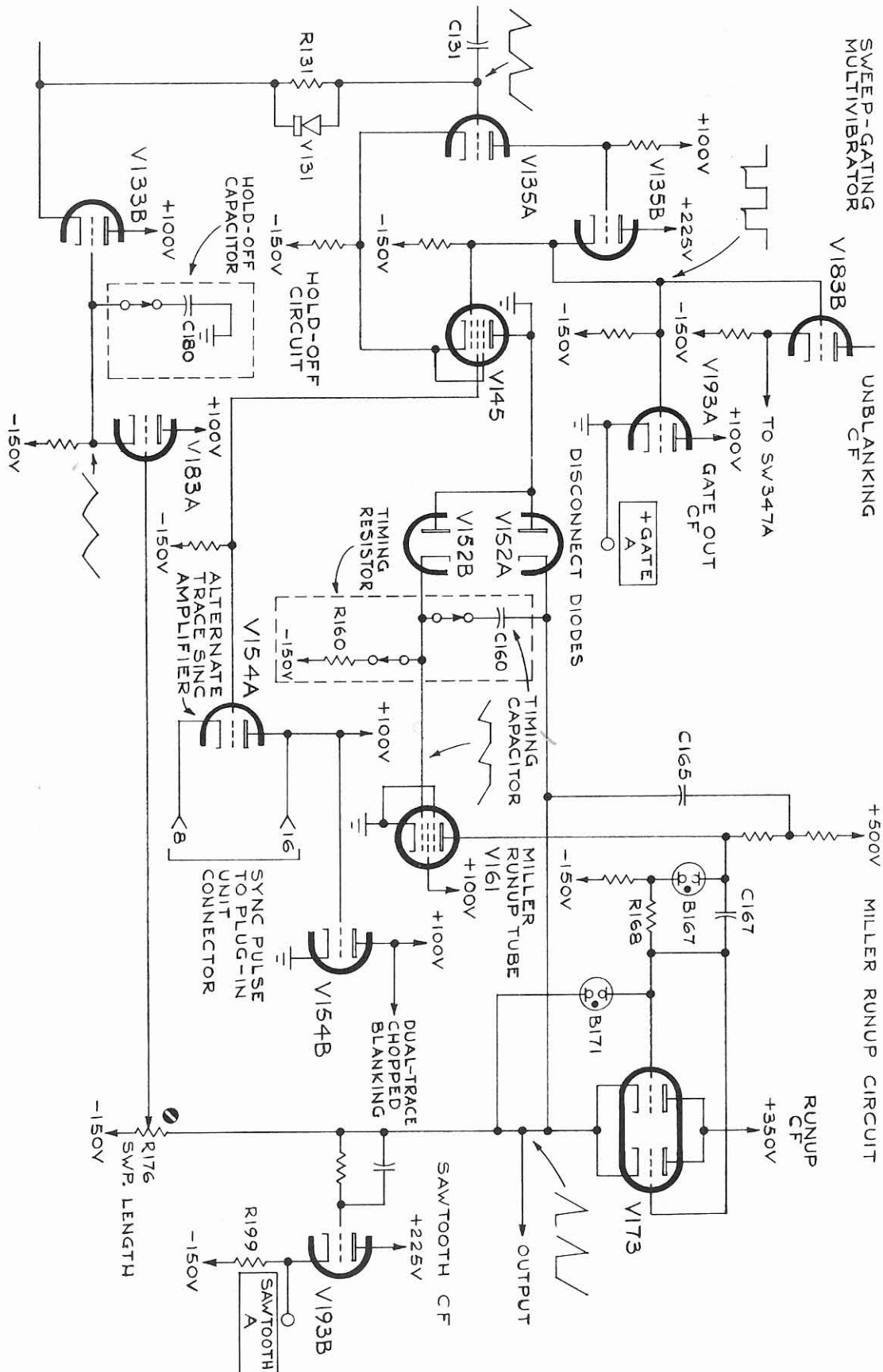


Fig. 4-3. Simplified Type 533/533A Time-Base Generator Circuit.

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 2½ 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.

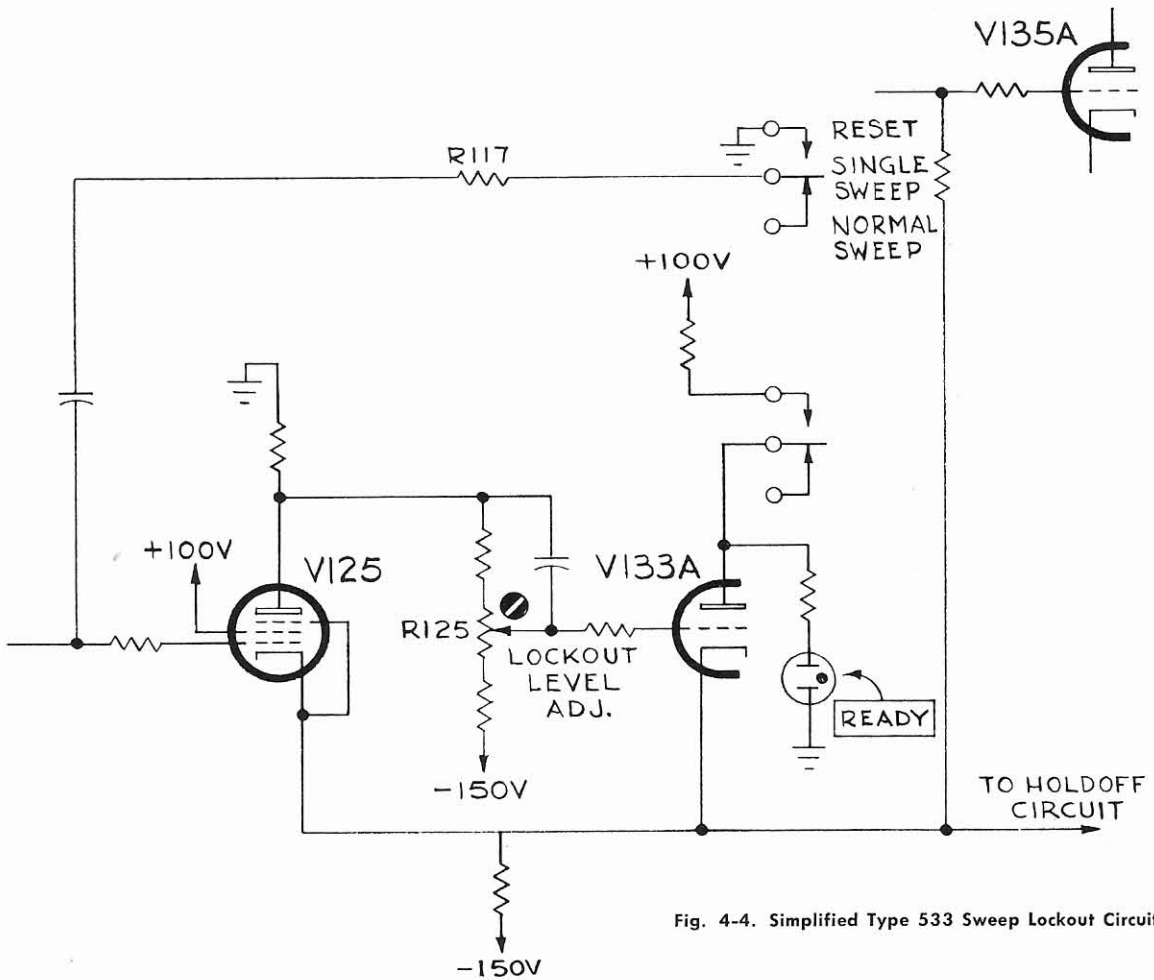
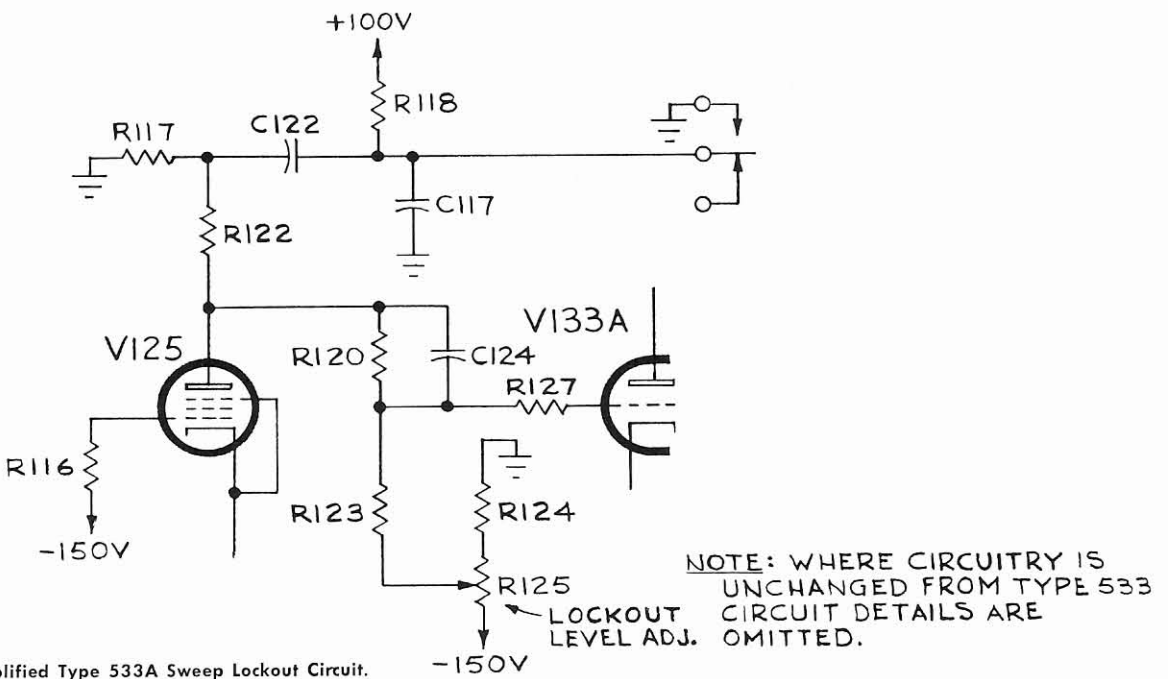


Fig. 4-4. Simplified Type 533 Sweep Lockout Circuit.



NOTE: WHERE CIRCUITRY IS UNCHANGED FROM TYPE 533 CIRCUIT DETAILS ARE OMITTED.

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.

Unblinking

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 unblinks 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 unblinking 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.

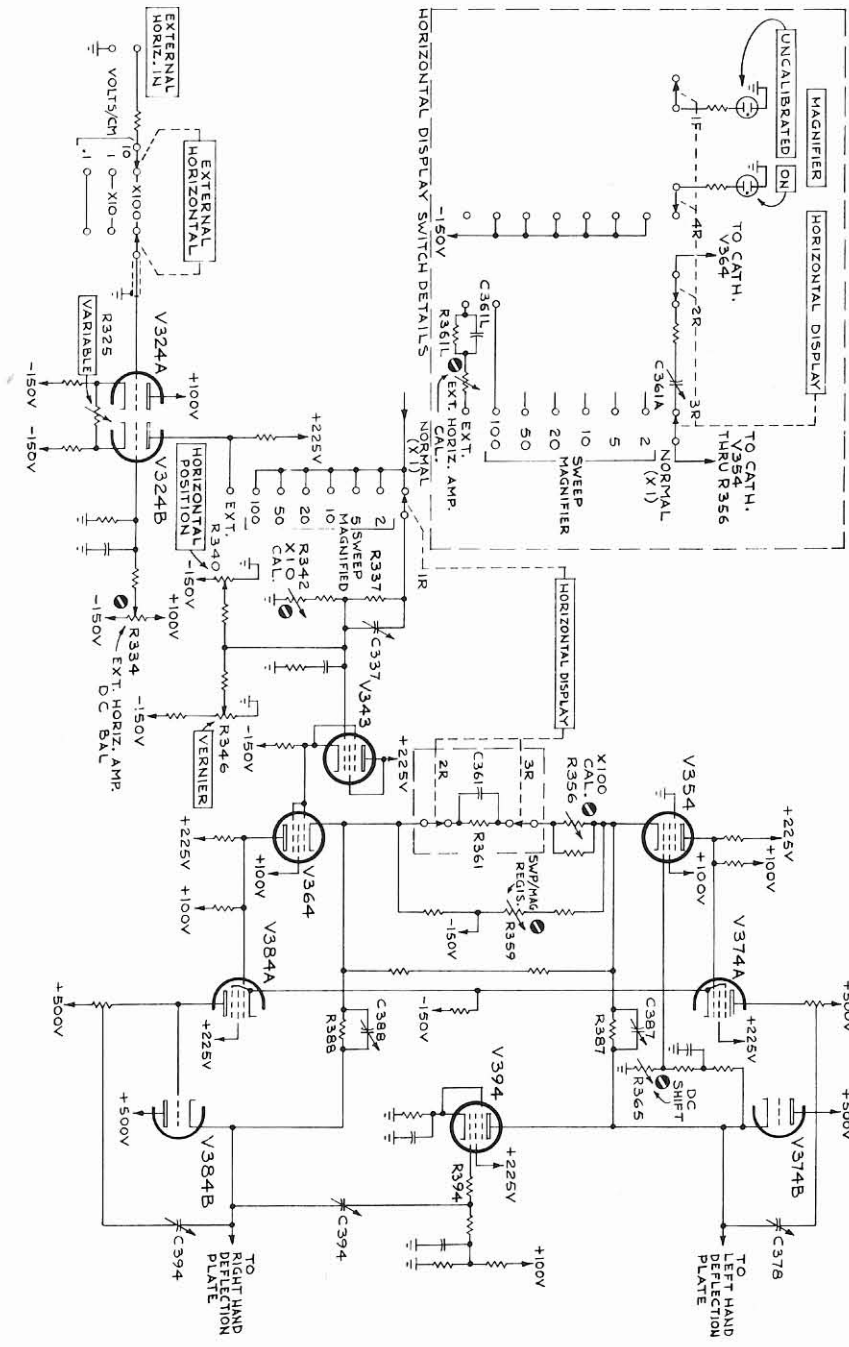


Fig. 4-6. Simplified Type 533/533A Horizontal Amplifier.

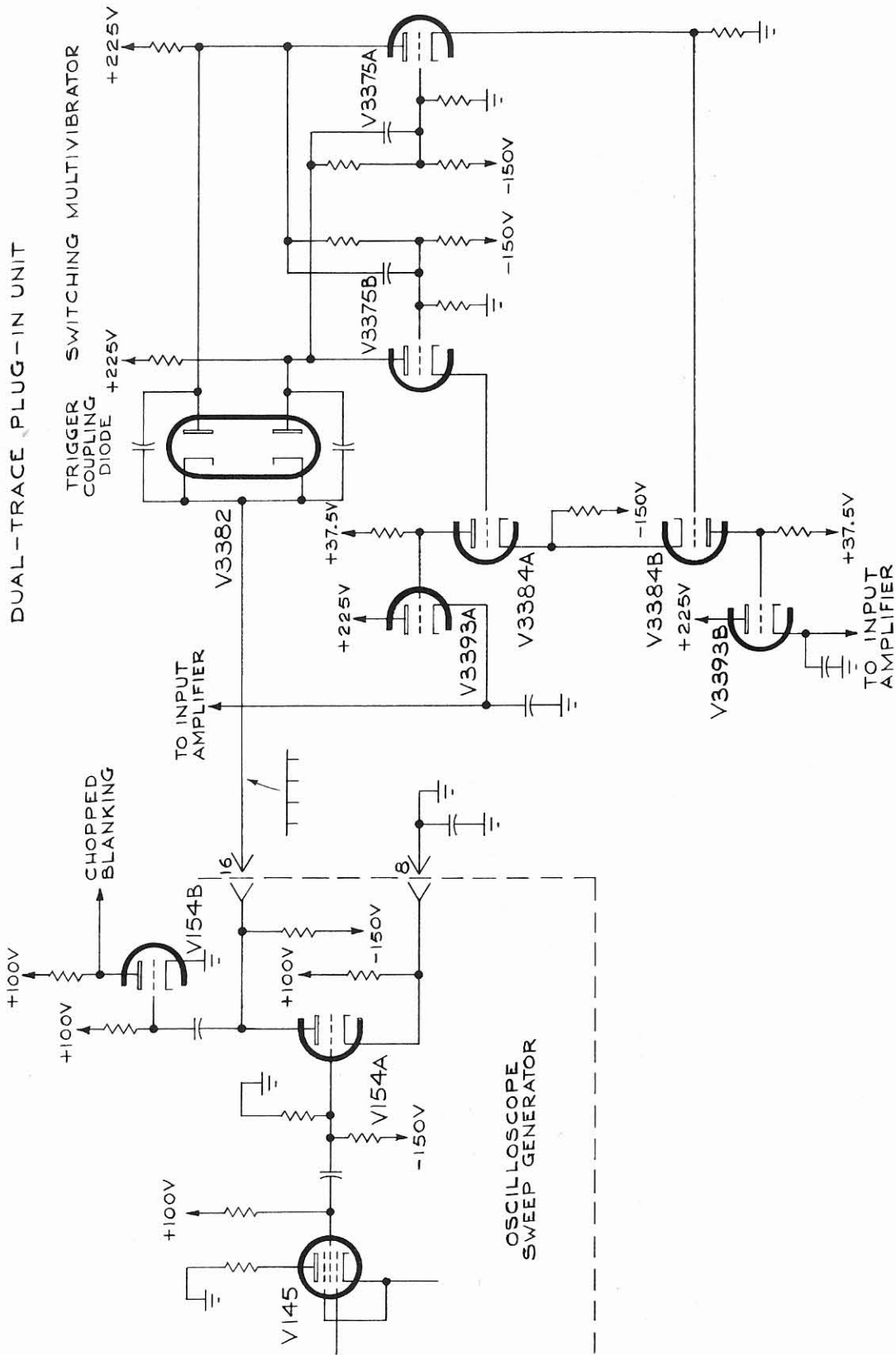


Fig. 4-7. Simplified Dual-Trace Operation.

Circuit Description — Type 533/533A

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 $.02\mu\text{sc/cm}$. This lamp will not glow so long as the setting of the TIME/CM switch, divided by the magnification factor, is not less than $.02\mu\text{sec}$.

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 $45\mu\text{f}$.

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 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

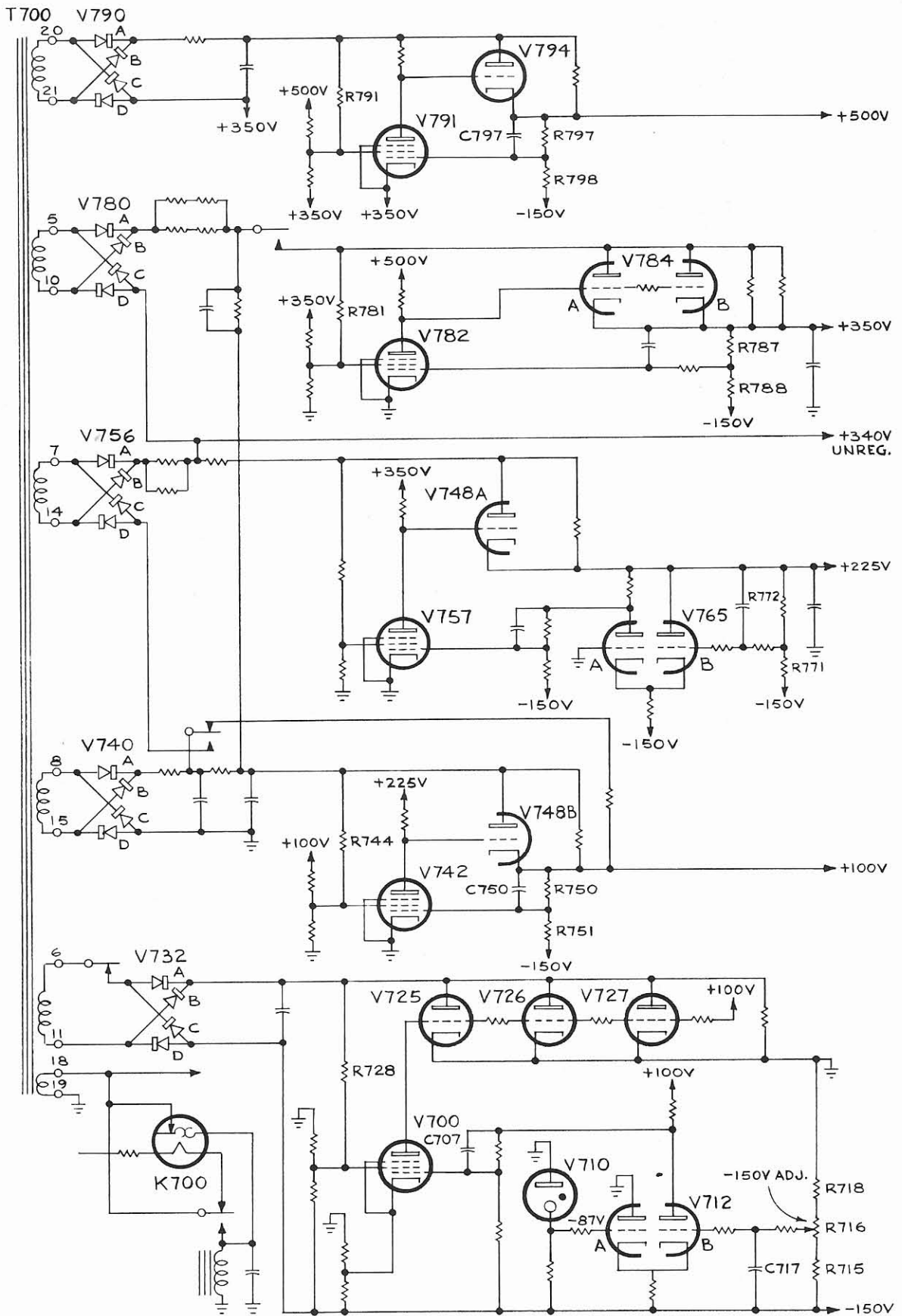


Fig. 4-8. Simplified Type 533 Low-Voltage Power Supply.

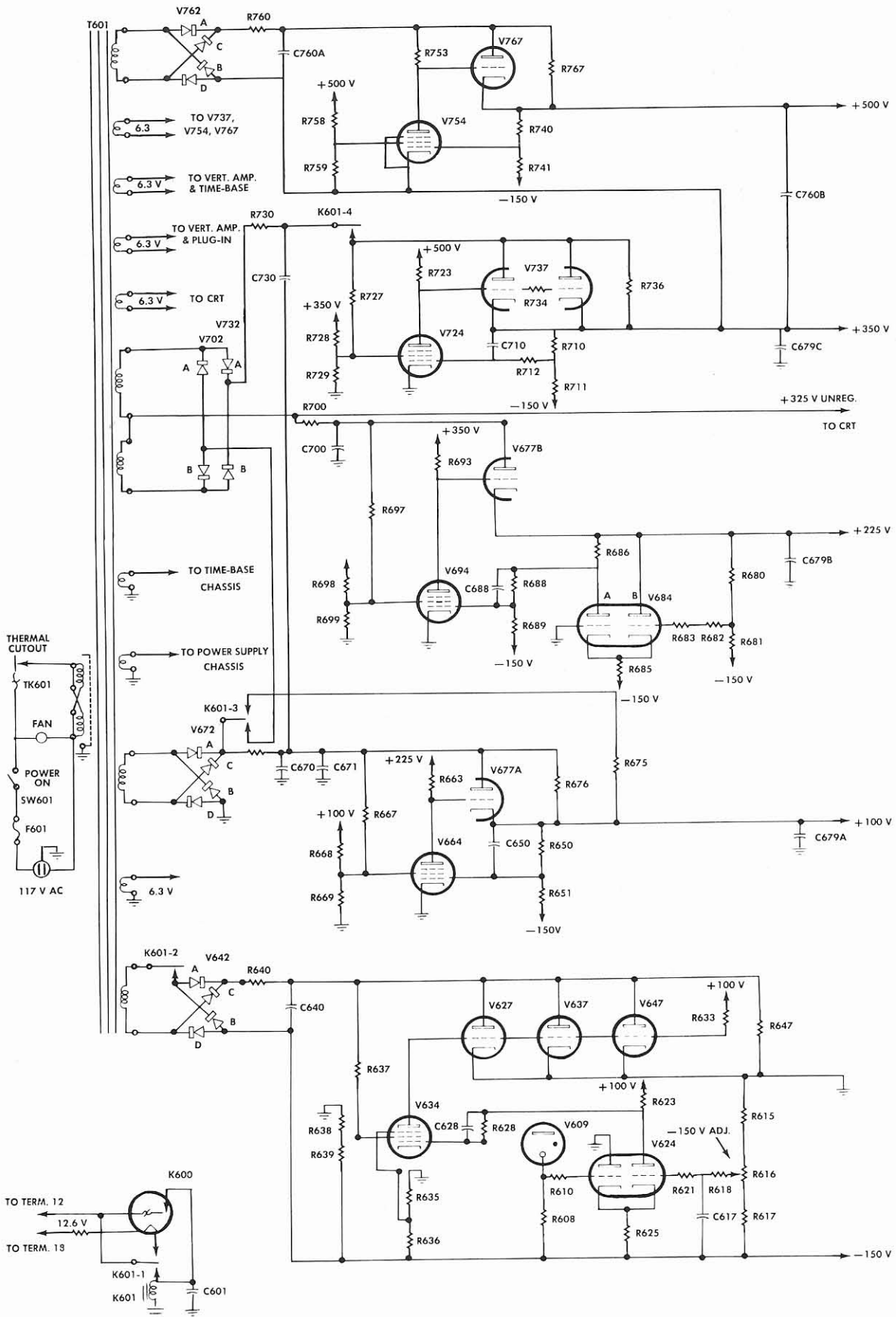


Fig. 4-9. Simplified Type 533A Low-Voltage Power Supply.

Circuit Description — Type 533/533A

+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 volt-

age 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-

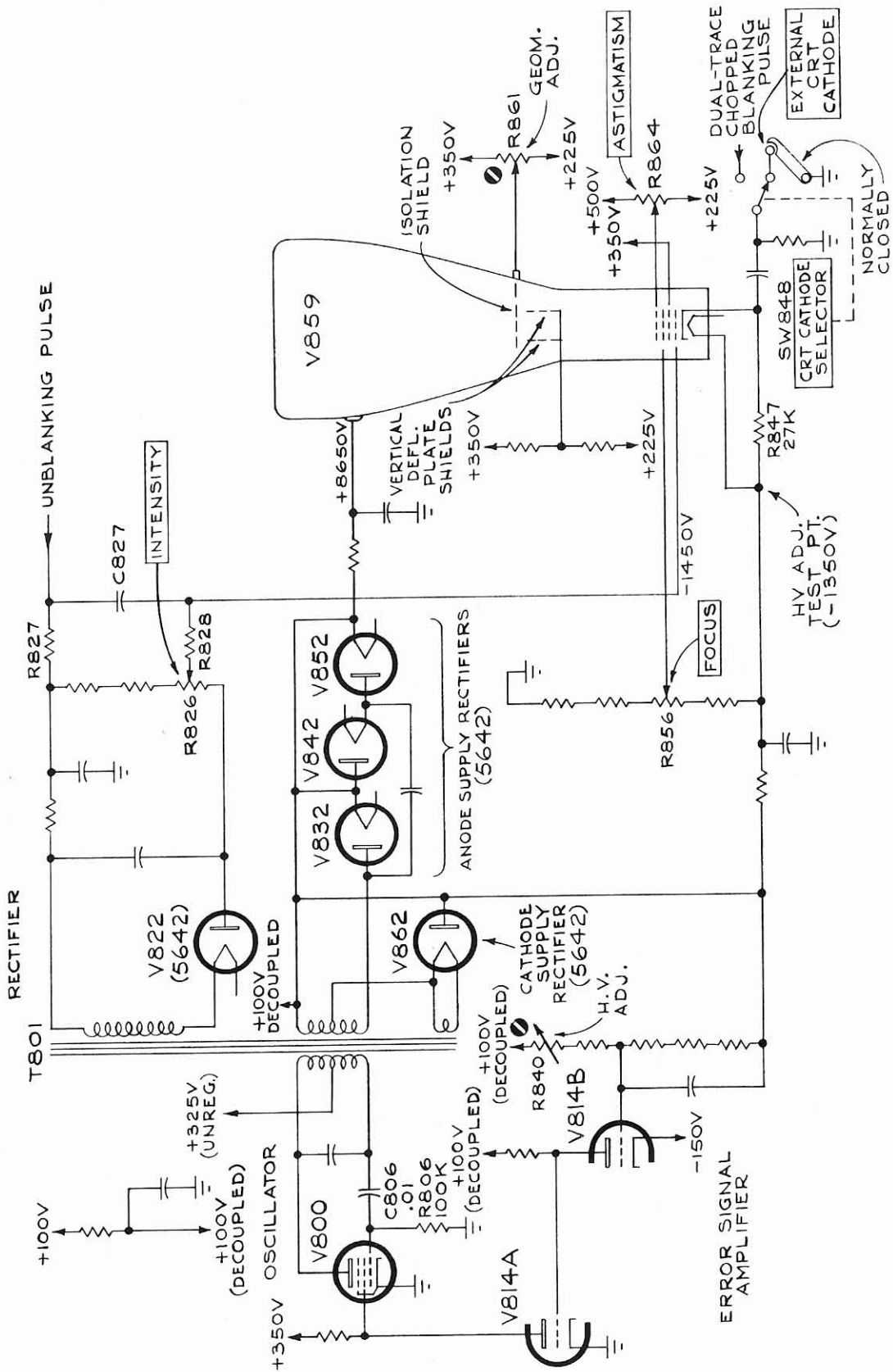


Fig. 4-10. Simplified CRT circuit.

Circuit Description — Type 533/533A

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 arrange-

ment 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.

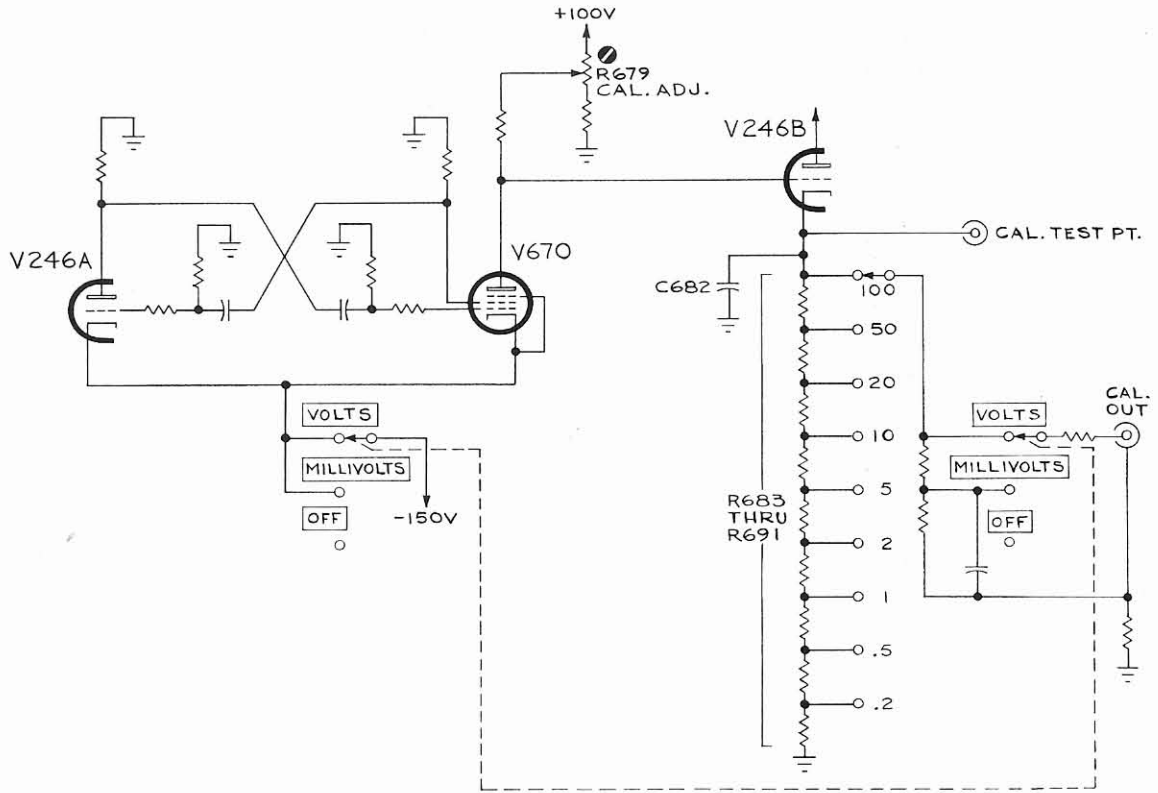


Fig. 4-11. Simplified Type 533 Calibrator.

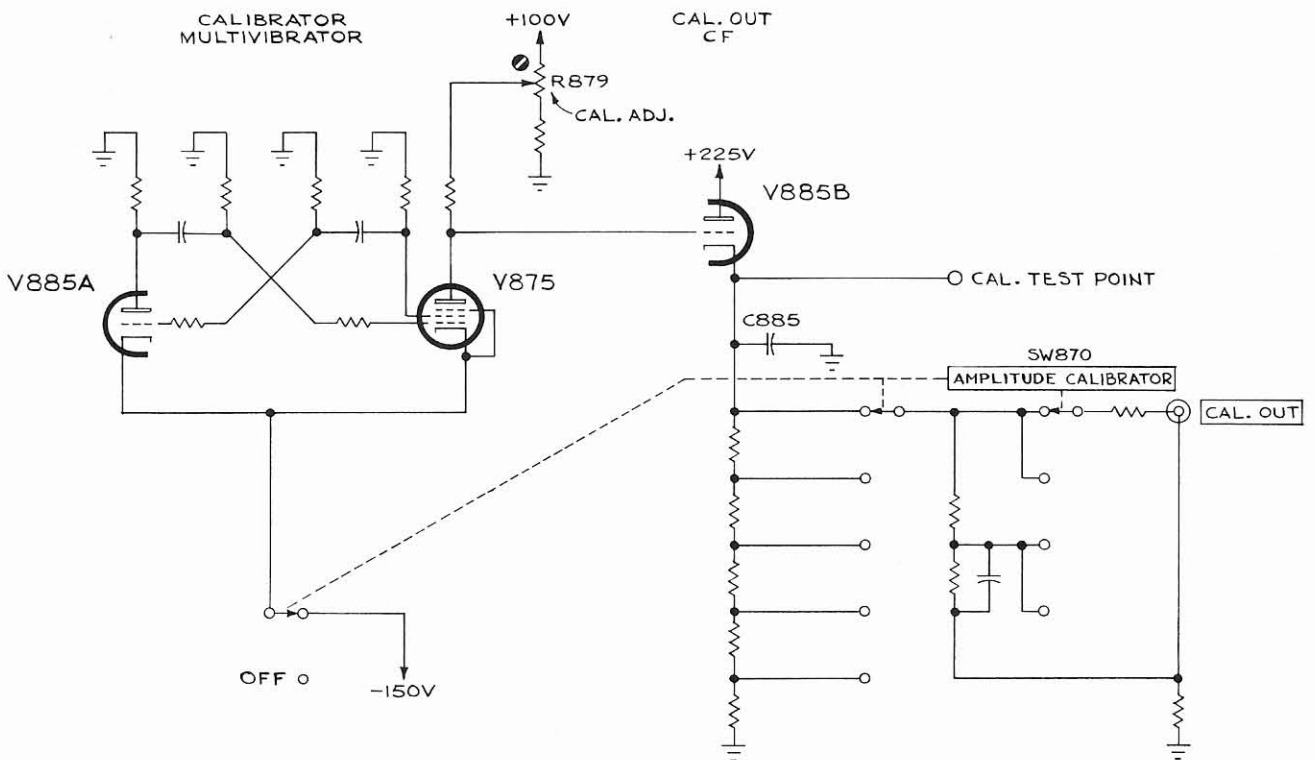
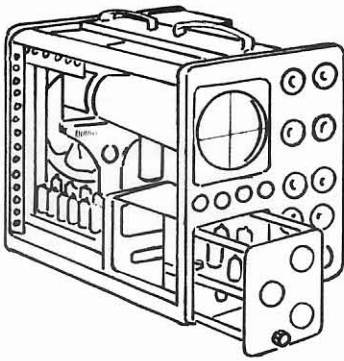


Fig. 4-12. Simplified Type 533A Calibrator.

FREE SCAN IN THE PUBLIC DOMAIN

MAINTENANCE



PREVENTIVE MAINTENANCE

Air Filter

Care must be taken to assure free ventilation of the Type 533/533A inasmuch as some of the components are operated at dissipation levels such that excessive interior temperatures will result without adequate air circulation. To assure free passage of air the instrument must be placed so that the air intake is not blocked and the filter must be kept clean. Moreover, the side panels and bottom cover must be in place for proper air circulation. Do not remove the covers except during maintenance.

A washable EZ KLEEN filter is used at the air intake part of the instrument. Under normal operating conditions the filter should be inspected and cleaned if necessary every three to four months. More frequent inspection is required when the operating conditions are more severe.

The following cleaning instructions are issued by the filter manufacturer:

(1) If grease or dirt load is light, remove filter from installation and rap gently on hard surface to remove loose

dirt. Flush remaining dirt or grease out of filter with a stream of hot water or steam.

(2) If load is too heavy for treatment described in (1), prepare mild soap or detergent solution in pan or sink deep enough to cover filter when laid flat. Agitate filter up and down in solution until grease or dirt is loosened and floated off.

(3) Rinse filter and let dry.

(4) Dip or spray filter with fresh Filter Coat or Handi-Coater. These products are available from the local representative of the Research Products Corporation and from most air conditioner suppliers.

Fan Motor

The fan motor bearings should be lubricated every three or four months with a few drops of light machine oil (see Fig. 5-1). Failure to lubricate the bearings periodically will cause the fan to slow down or stop thereby causing the instrument to overheat. If your oscilloscope is equipped with a dc fan motor—modification number 101—and if it operates throughout the working day, we suggest that you oil the bearings lightly once a month.

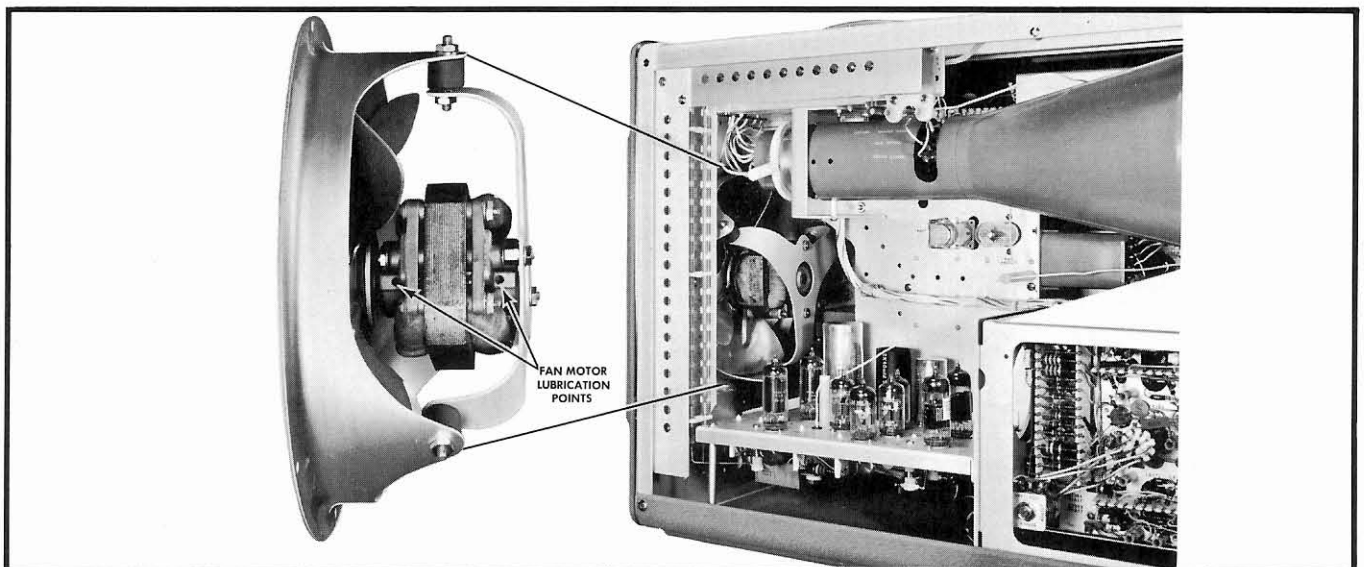


Fig. 5-1. Location of the fan motor lubrication points.

You should check the condition of the brushes of dc fans every other month since their life expectancy is approximately 6 months under conditions of daily use.

Visual Inspection

You should visually inspect the entire oscilloscope every few months for possible circuit defects. These defects may include such things as loose or broken connections, damaged binding posts, improperly seated tubes, scorched wires or resistors, missing tube shields, or broken terminal strips. For most visual troubles the remedy is apparent; however, particular care must be taken when heat-damaged components are detected. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential that you determine the cause of overheating before replacing heat-damaged parts in order to prevent further damage.

Soldering and Ceramic Strips

Many of the components in your Tektronix instruments are mounted on ceramic terminal strips. The notches in these strips are lined with a silver alloy. Repeated use of excessive heat, or use of ordinary tin-lead solder will break down the silver-to-ceramic bond. Occasional use of tin-lead solder will not break the bond if excessive heat is not applied.

If you are responsible for the maintenance of a large number of Tektronix instruments, or if you contemplate frequent parts changes, we recommend that you keep on hand a stock of solder containing about 3% silver. This type of solder is used frequently in printed circuitry and should be readily available from radio-supply houses. If you prefer, you can order the solder directly from Tektronix in one pound rolls. Order by Tektronix part number 251-514.

Because of the shape of the terminals on the ceramic strips it is advisable to use a wedge-shaped tip on your soldering iron when you are installing or removing parts from the strips. Fig 5-2 will show you the correct shape

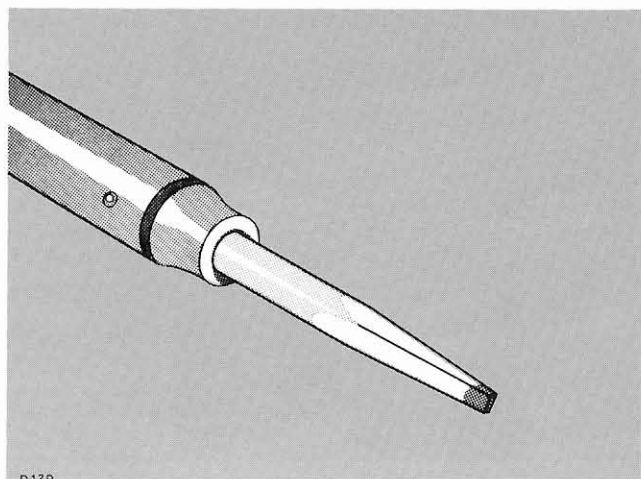


Fig. 5-2. Soldering iron tip properly shaped and tinned.

for the tip of the soldering iron. Be sure to file smooth all surfaces of the iron which will be tinned. This prevents solder from building up on rough spots where it will quickly oxidize.

When removing or replacing components mounted on the ceramic strips you will find that satisfactory results are obtained if you proceed in the manner outlined below.

1. Use a soldering iron of about 75-watt rating.
2. Prepare the tip of the iron as shown in Fig. 5-2.
3. Tin only the first 1/16 to 1/8 inch of the tip. For soldering to ceramic terminal strips tin the iron with solder containing about 3% silver.
4. Apply one corner of the tip to the notch where you wish to solder (see Fig. 5-3).

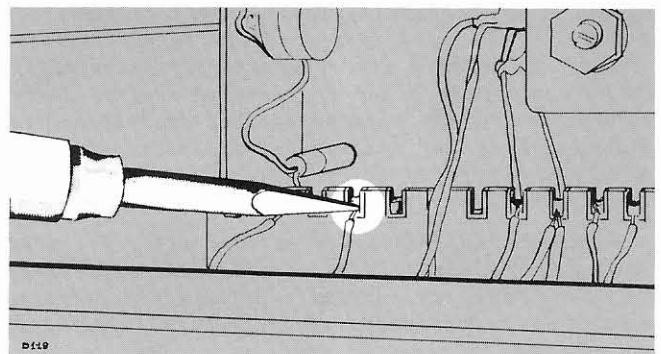


Fig. 5-3. Correct method of applying heat in soldering to a ceramic strip.

5. Apply only enough heat to make the solder flow freely.
6. Do not attempt to fill the notch on the strip with solder; instead, apply only enough solder to cover the wires adequately, and to form a slight fillet on the wire as shown in Fig. 5-4.

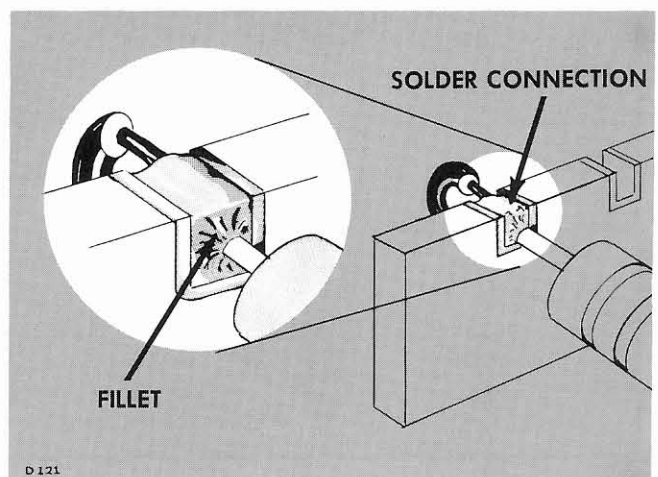


Fig. 5-4. A slight fillet of solder is formed around the wire when heat is applied correctly.

In soldering to metal terminals (for example, pins on a tube socket) a slightly different technique should be employed. Prepare the iron as outlined above, but tin with ordinary tin-lead solder. Apply the iron to the part to be soldered as shown in Fig. 5-5. Use only enough heat to allow the solder to flow freely along the wire so that a slight fillet will be formed as shown in Fig. 5-5.

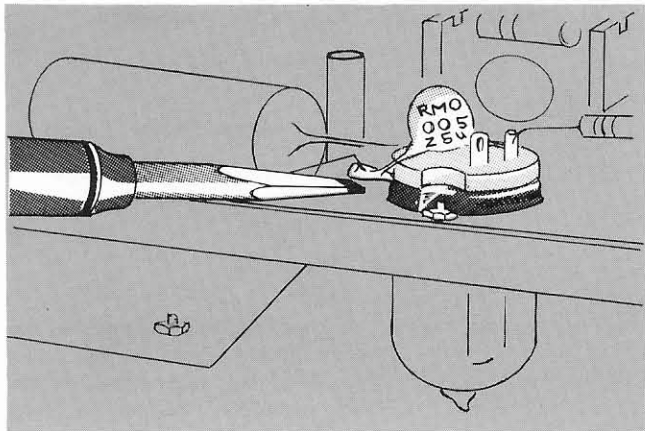


Fig. 5-5. Soldering to a terminal. Note the slight fillet of solder—exaggerated for clarity—formed around the wire.

General Soldering Considerations

When replacing wires in terminal slots clip the ends neatly as close to the solder joint as possible. In clipping the ends of wires take care the end removed does not fly across the room as it is clipped.

Occasionally you will wish to hold a bare wire in place as it is being soldered. A handy device for this purpose is a short length of wooden dowel, with one end shaped as shown in Fig. 5-6. In soldering to terminal pins mounted in plastic rods it is necessary to use some form of "heat sink" to avoid melting the plastic. A pair of long-nosed pliers (see Fig. 5-7) makes a convenient tool for this purpose.

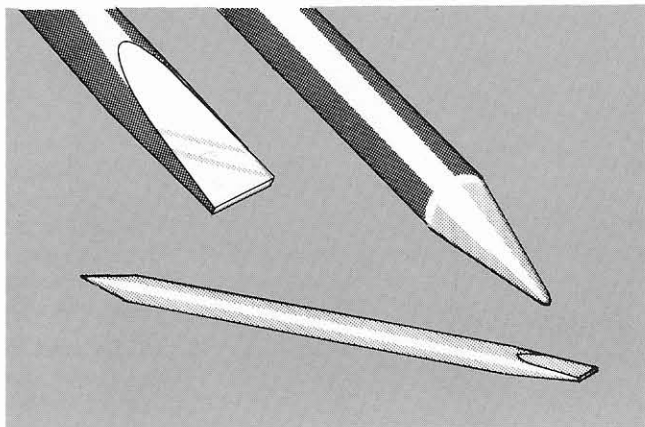


Fig. 5-6. A soldering aid constructed from a 1/4 inch wooden dowel.

Ceramic Strips

Two distinct types of ceramic strips have been used in Tektronix instruments. The earlier type mounted on the chassis by means of #2-56 bolts and nuts. The later type is mounted with snap-in, plastic fittings. Both styles are shown in Fig. 5-8.

To replace ceramic strips which bolt to the chassis, screw a #2-56 nut onto each mounting bolt, positioning the bolt so that the distance between the bottom of the bolt and the

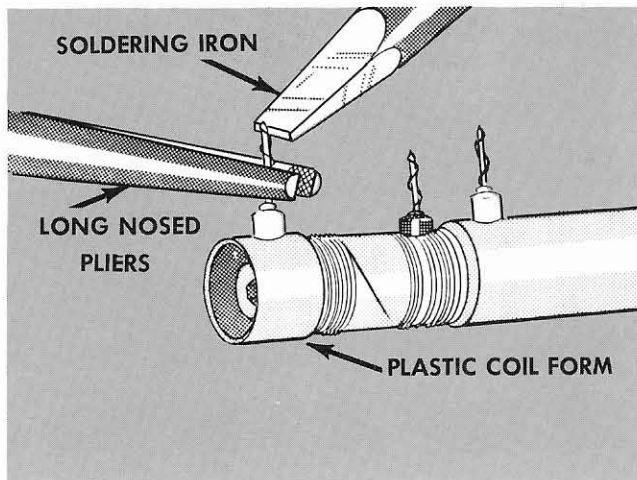


Fig. 5-7. Soldering to a terminal mounted in plastic. Note the use of the long-nosed pliers between the iron and the coil form to absorb the heat.

bottom of the ceramic strip equals the height at which you wish to mount the strip above the chassis. Secure the nuts to the bolts with a drop of red glyptal. Insert the bolts through the holes in the chassis where the original strip

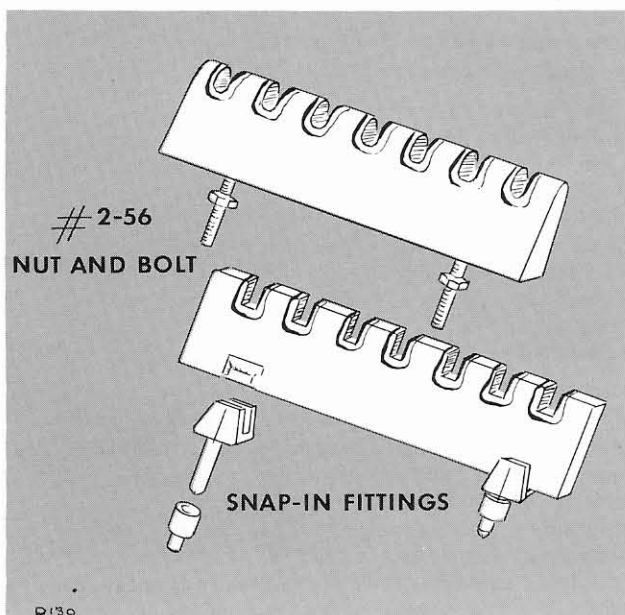


Fig. 5-8. Two types of ceramic strip mountings.

was mounted, placing a #2 starwasher between each nut and the chassis. Place a second set of #2 flat-washers on the protruding ends of the bolts, and fasten them firmly with another set of #2-56 nuts. Place a drop of red glyptal over each of the second set of nuts after fastening.

Mounting Later Ceramic Strips

To replace strips which mount with snap-in plastic fittings, first remove the original fittings from the chassis. Assemble the mounting post on the ceramic strip. Insert the nylon collar into the mounting holes in the chassis. Carefully force the mounting post into the nylon collars. Snip off the portion of the mounting post which protrudes below the nylon collar on the reverse side of the chassis.

NOTE

Considerable force may be necessary to push the mounting rods into the nylon collars. Be sure that you apply this force to that area of the ceramic strip above the mounting rods.

TROUBLESHOOTING PROCEDURE

This section of the manual contains information for troubleshooting your oscilloscope. Before attempting to troubleshoot the instrument, however, make sure that any apparent trouble is actually due to a malfunction within the instrument and not to improper control settings or to a faulty plug-in unit. Instructions for the operation of the oscilloscope and general information concerning plug-in operation, are contained in the Operating Instructions section of this manual. Operating instructions for a specific plug-in unit will be found in the manual for that unit.

To determine that the oscilloscope is at fault, the plug-in unit may be replaced with another known to be in good operating condition. If the trouble is still apparent, it is almost a certainty that the oscilloscope is at fault. However, should the trouble appear to have been corrected by replacing the plug-in unit, the trouble most likely lies within the original plug-in unit and not with the oscilloscope.

Tube failure is the most prevalent cause of circuit failure. For this reason, the first step in troubleshooting any circuit in the instrument is to check for defective tubes, preferably by direct substitution. Do not depend on tube testers to adequately indicate the suitability of a tube for certain positions within the instrument. The criterion for usability of a tube is whether or not it works satisfactorily in the instrument. Be sure to return all good tubes to their sockets; if this procedure is followed less recalibration of the instrument will be required upon completion of the servicing.

When replacing any tube in the instrument, check first to see that components through which the tube draws current have not been damaged. Shorted tubes will sometimes overload and damage plate-load and cathode resistors. These damaged components can generally be located by a visual inspection of the wiring. If no damaged components are apparent, and if tube replacement does not restore operation, it will be necessary to make measurements or other checks within the circuit to locate the trouble.

The component number of each resistor, inductor, capacitor, vacuum tube, control and switch is shown on the circuit diagrams. The following chart lists the component numbers associated with each circuit:

All numbers less than 100	Time-Base Trigger
100 series	Time-Base Generator
300 series	Horizontal Amplifier
500 series	Vertical Amplifier
600 series and 700 series	Low-Voltage Power Supply
800 series	CRT Circuits, High Voltage and Square-Wave Calibrator
900 series	Delay Line

Switch wafers shown on the schematic diagrams are coded to indicate the position of the wafer on the actual switches. The number position of the code refers to the wafer number on the switch assembly. Wafers are numbered from the front of the switch to the rear. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. Photographic details of these switches are shown on the same fold-out page as the corresponding schematic diagram. These photographs are provided as parts location guides.

CIRCUIT TROUBLESHOOTING

Although the Type 533/533A are complex instruments, they can be thought of as consisting of six main circuits, in addition to the Calibrator circuit. These are the:

1. Low-Voltage Power Supply.
2. CRT Circuit and High-Voltage Power Supply.
3. Vertical Amplifier and Delay Line.
4. Time-Base Trigger Circuit.
5. Time-Base Generator.
6. Horizontal Amplifier.

The first circuit to check, for practically any type of trouble, is the Low-Voltage Power Supply. Because of the circuit configuration employed, it is possible for an improper power supply voltage to affect one circuit more than the others. For example, if the gain of the Vertical Amplifier should decrease slightly, while the other circuits appear to be functioning normally, this could be due to an improper supply voltage and not to any condition originating in the Vertical Amplifier. In cases of this type, valuable time can be saved by checking the power supply first.

On the other hand, the crt display can often be used to isolate trouble to one particular circuit when trouble obviously exists in that circuit. If there is no vertical deflection, for example, when the intensity and horizontal deflection appear to be normal, it is apparent that an open condition exists in the Vertical Amplifier and this circuit should be investigated first.

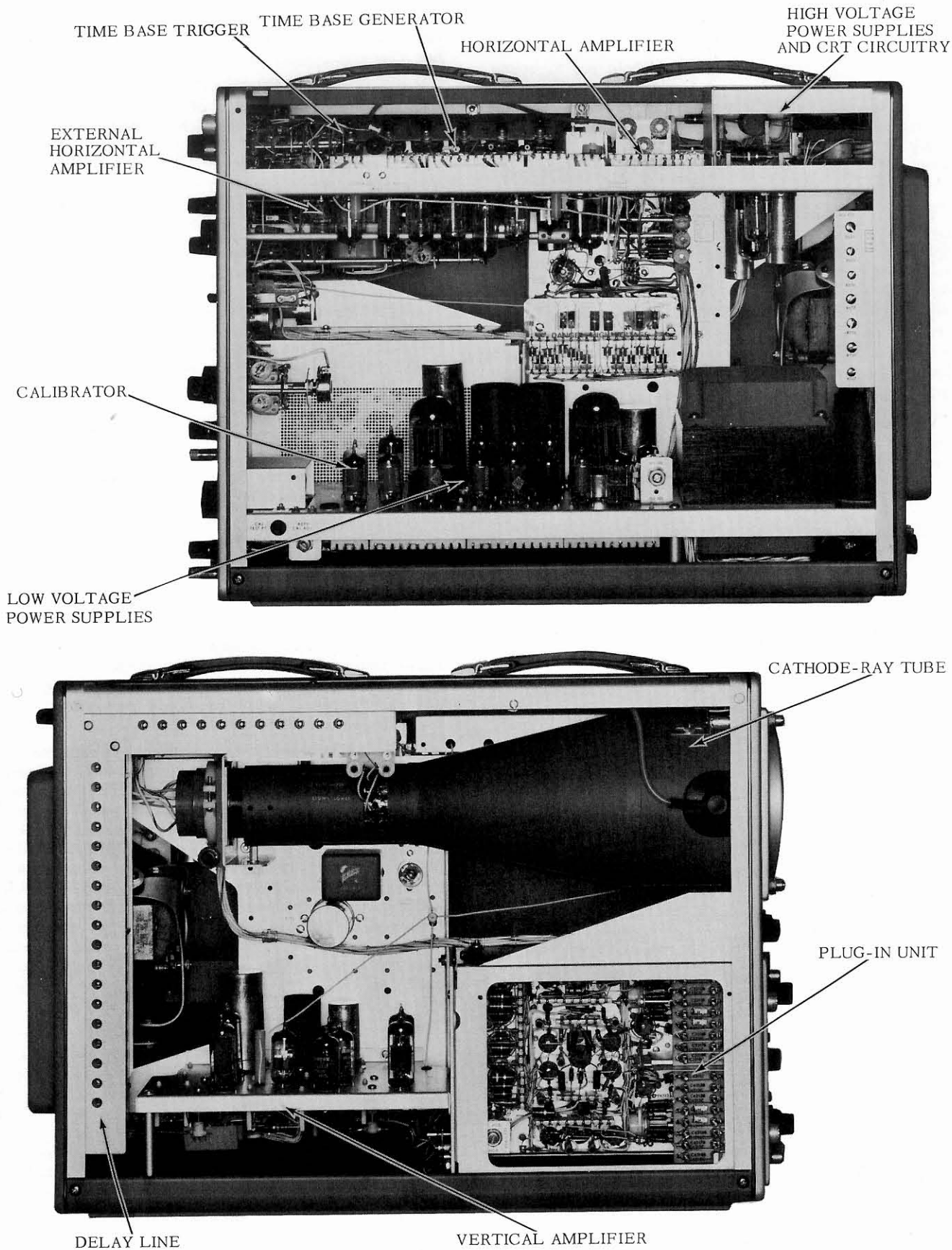


Fig. 5-9. Physical location of the circuits which compose the Type 533/533A Oscilloscope.

Front-Panel Checks

The following front-panel checks will help you to isolate the trouble in an instrument to a given circuit. The interrelation between circuits is such that these checks are not always completely accurate in isolating a trouble to a given circuit. If you are unfamiliar with the instrument these front-panel checks may prove helpful in starting to look for the trouble.

Before attempting any of the following front-panel checks make sure that the plug-in installed in the instrument is operating correctly. If the pilot lamp fails to light when the POWER switch is turned to the ON position, and if the fan fails to operate, turn to the section on troubleshooting the Low-Voltage Power Supply. If the pilot light and fan both operate but the Time-Delay Relay fails to operate with an audible "click" after one minute you should also consult the section on Troubleshooting the Low-Voltage Power Supply.

With an operating plug-in installed, and the pilot light and fan both operating, allow the oscilloscope to run for several minutes.

Set the front-panel controls as follows:

STABILITY	full right (clockwise)
TRIGGERING LEVEL	0
TRIGGERING MODE	AC (AC SLOW)
TRIGGER SLOPE	+INT.
VARIABLE (TIME/CM)	full right
TIME/CM.	5 MILLISEC
HORIZONTAL DISPLAY	NORMAL (X1)
FOCUS	mid-scale
INTENSITY	full-left (counterclockwise)
ASTIGMATISM	mid-scale
SCALE ILLUMINATION	mid-scale
HORIZONTAL POSITION	mid-scale
VERNIER	mid-scale

The settings of other controls are not critical at this time.

If you are using a Type TU1 or TU2 Test-Load Plug-in Unit set the toggle switch to the 1:1 position and the CALIBRATOR switch to the .2 VOLTS position. If using another type of plug-in set the VOLTS/CM switch to 1 volt and the AMPLITUDE CALIBRATOR switch to 2 VOLTS.

Using a patch cord which introduces no attenuation connect the CAL. OUT connector to the INPUT connector of the plug-in preamplifier. Advance the INTENSITY control to the mid-scale position.

Now examine the face of the crt. If no display is evident examine the Beam-Position Indicator lamps. If the display is positioned off the screen vertically turn the VERTICAL POSITION control from one extreme position to the other, watching the face of the crt as you do so. If no display appears, and operation of the VERTICAL POSITION

control has no effect on the Beam-Position Indicator lamps turn to the section on Troubleshooting the Vertical Amplifier.

If the display which appears consists of a horizontal line, you may check the operation of the calibrator by removing the end of the patch cord which is inserted into the CAL. OUT connector and holding it in your hand. A series of sloping vertical lines appearing on the crt indicate that the Vertical Amplifier is operating and that the Amplitude Calibrator is probably inoperative. See the section on Troubleshooting the Amplitude Calibrator for the remedy.

If the operation of the VERTICAL POSITION control causes the vertical Beam-Position Indicator lamps to indicate the display as centered, rotate the HORIZONTAL POSITION control from one extreme position to the other. If the horizontal Beam-Position Indicator lamps still indicate the display is off the screen refer to the section on Troubleshooting the Horizontal Amplifier.

If both sets of Beam Position lamps indicate that the display is centered, but no display is observed, CAUTIOUSLY advance the INTENSITY control. Watch for a display to appear on the screen. If no display is seen or if the display is of low intensity but otherwise normal, refer to the section on Troubleshooting the CRT Circuit.

TROUBLESHOOTING THE VERTICAL AMPLIFIER

No Spot or Trace on CRT

If all power supply voltages are normal, and the crt is known to be good, failure to display a spot or trace on the screen will be due to improper positioning voltages. This condition is caused by dc unbalance in either or both of the deflection amplifier circuits.

To determine which circuit is at fault, adjust the Time-Base controls for a free-running sweep at 1 millisecc/cm (STABILITY control full right). Set the INTENSITY control to midscale. Using a screwdriver with an insulated handle, short the vertical deflection plates together at the neck pins on the crt. These are the pins marked BLUE (UPPER) and BROWN (LOWER). Be careful not to short either pin to the metal shield around the crt, or to the pin marked ORANGE (GEOM). If dc unbalance is being produced in the vertical deflection circuit, the trace will appear at or near the center of the crt. If the trace does not appear, the trouble does not lie in the vertical circuit. The dc balance of the horizontal circuit can be checked in a similar manner, by shorting the horizontal deflection plates together.

If it is determined that the vertical deflection circuit is unbalanced, the next step is to check the Delay Line. For this check, it is convenient to have a short lead (about 8 or 10 inches) with a rubber-covered alligator clip on each end. Connect this lead across the input to the Delay Line. If the trace appears on the crt, the Delay Line is not at fault. If the trace does not appear, check for an open line by turning off the oscilloscope, and checking the continuity of both sides of the line with an ohmmeter.

If the Delay Line is not at fault, connect the shorting strap between the grids (pin 2) of the output amplifiers, V554 and V564. If the trace does not appear, check for an open plate inductor (L553 or L563).

If the trace does appear when the grids of the Output Amplifiers are shorted together, the trouble is occurring in one of the input stages. If tube replacement does not correct the trouble, then look for open peaking coils, defective resistors, and shorted or leaky capacitors.

Insufficient or No Vertical Deflection

Insufficient deflection indicates a change in the gain characteristics of the Vertical Amplifier. If only a slight change in deflection is apparent, the circuit can normally be recalibrated for gain. In this event, refer to the Calibration Procedure section of this Manual.

If the change in deflection is more pronounced, or if there is no deflection at all, the tubes should first be checked. Then check for components which affect the gain of the circuit but not the dc balance. Such components would be the common plate-load resistors R505 and R528, the common cathode resistors R513, R514, R558, R568, and the GAIN ADJ. control R570.

Waveform Distortion

Any waveform distortion that may be produced by the Type 533/533A will generally be of high-frequency nature. There will be no low-frequency distortion since the deflection circuit is dc-coupled from input to output (unless one or more of the tubes enter into heavy grid current, a condition that will produce other types of distortion as well).

A distortion-free positive step function, having a rise-time of 10 millimicroseconds or less, may be used to observe the high-frequency characteristics of the oscilloscope/plug-in combination. This is illustrated in the photographs of Fig. 5-10.

Insufficient high-frequency peaking, which limits the rise-time and consequently the band-width, will produce the "rolloff" or undershoot condition illustrated in Fig. 5-10a. Rolloff is the result of insufficient high-frequency compensation. A small amount of rolloff is normally due to a change, with age, in the characteristics of the circuit components, and can usually be compensated by adjusting the variable peaking coils. If the rolloff is more pronounced the tubes should be checked. If a tube cannot deliver current, instantaneously on demand, the transients in the signal will not be produced.

Shorted or partially shorted peaking coils will result in a rolloff. Be especially careful when soldering around the

peaking circuits as hot solder dropping on a coil may burn through the insulation and short the turns.

Excessive high-frequency peaking will produce the "overshoot" condition illustrated in Fig. 5-10b. This is generally caused by misadjusting the peaking coils. In these cases the distortion can generally be eliminated by readjusting the variable peaking coils L506 and L523 for the Input Amplifiers, and L553 and L563 for the Output Amplifiers.

An overshoot at the leading edge of a fast-rise pulse may also be the result of cathode interface in one of the amplifier tubes. Since the time constant of the interface layer is normally in the range from .1 to 3 μ sec, this effect is most noticeable on waveforms whose period is long compared to the interface time constant. This condition is produced by the tubes themselves, so it is important to first check the tubes when such distortion is evident.

An improperly adjusted Delay Line will produce the "wrinkle" condition illustrated in Fig. 5-10c. These wrinkles are caused by inter-section impedance mismatches. If the Delay Line is badly detuned, the top of the pulse will be uneven instead of smooth and flat. The leading corner may either overshoot or rolloff. If one or two sections of the line are detuned, either due to a shorted coil or defective capacitor, you will notice an aberration in the waveform in the region affected by the defective component. Before adjusting the trimmers in the Delay Line, be sure that all other sources of waveform distortion have been eliminated.

TROUBLESHOOTING THE TIME-BASE TRIGGER CIRCUIT

Unstable Triggering

If the sweep generator is not being properly triggered a stable display of a waveform will not be possible. If the sweep can be turned off and on with the STABILITY control (for any setting of the TRIGGERING MODE switch except AUTOMATIC) the sweep generator is capable of being triggered; this indicates the trigger circuitry is not functioning properly. The first step is to replace the Trigger Pickoff tube V584 in the Vertical Amplifier. The operation of this stage can also be checked by observing the signal available at the VERT. SIG. OUT binding post with

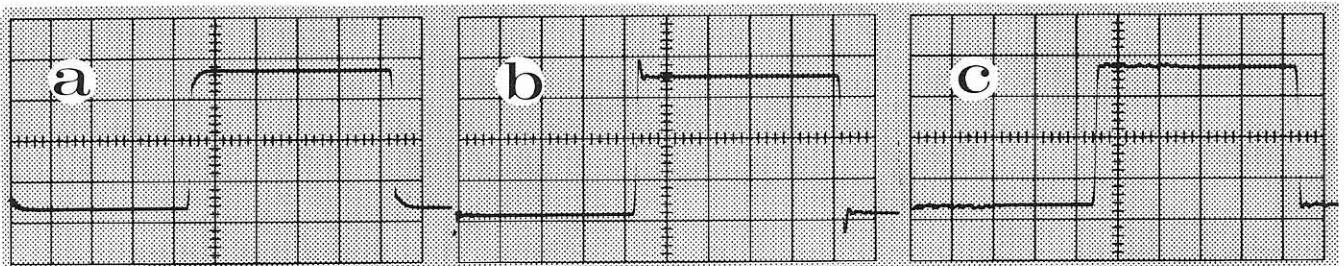


Fig. 5-10. Three types of high-frequency distortion.

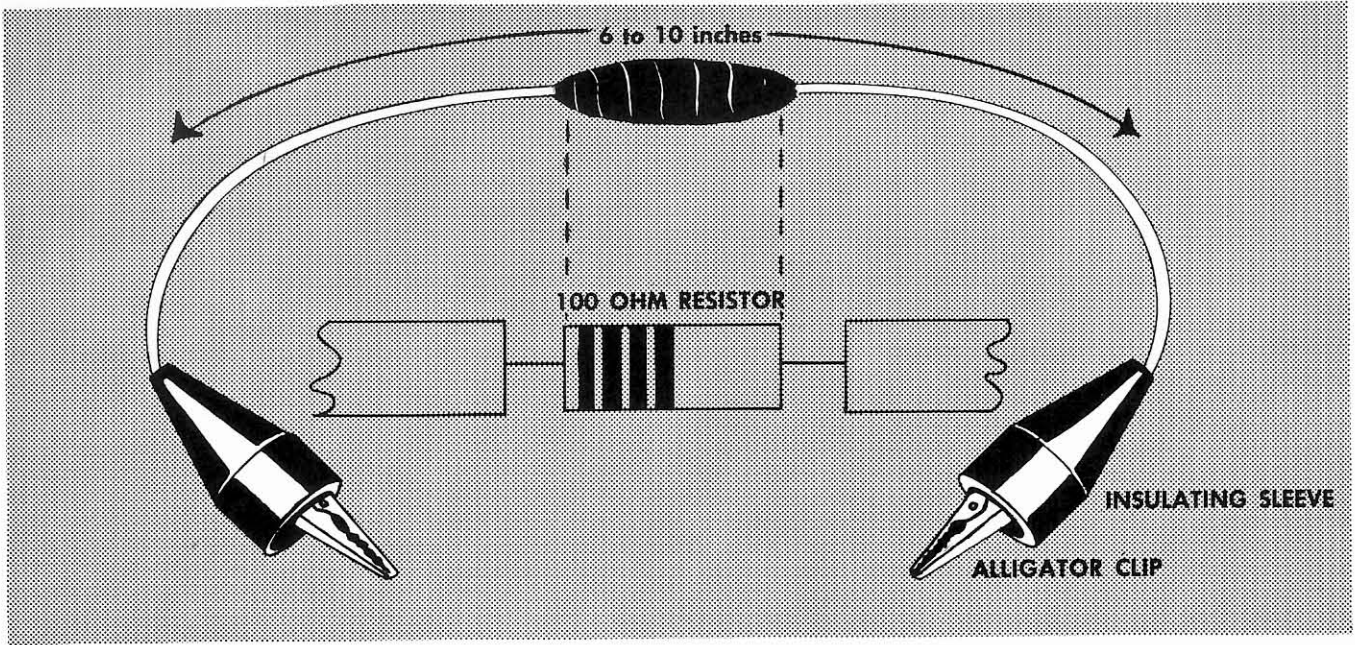


Fig. 5-11. Shorting strap useful in locating an unbalanced stage in a vertical or horizontal amplifier.

another oscilloscope. If no signal is available at this connector the Trigger Pickoff stage is defective; a proper signal at this connector indicates the stage is functioning correctly.

If the Trigger Pickoff stage is operating correctly, trouble exists in the Time-Base Trigger circuit. To check the quiescent stage of the circuit, set the TRIGGERING MODE switch to AC SLOW, the TRIGGER SLOPE switch to —INT. and the TRIGGERING LEVEL control to 0. Next, connect a jumper wire from the junction of R19, R20, and C20 (on the Trigger Switch) to ground. This fixes the voltage at the grid of V24B at ground potential. Then measure the voltage at the plate of V24B; this should be about +85 volts. If this voltage does not measure very close to +85 volts, replace the Trigger Input tube V24. If necessary, check for off-value resistors, broken leads and poor switch contacts.

The next step is to connect the voltmeter between the plate of V24B and the grid of V45B (the junction of R40, R42, C42 and R47 is more convenient than the grid of V45B). The voltage between the plate of V24B and the grid of V45A or the divider side of R47) should not exceed about 2.75 volts. It is the function of the TRIGGERING LEVEL CENTERING control R39 to set the voltage at the grid of V45B approximately equal to the voltage at the grid of V45A. With the grids of V45 at about the same voltage the center of the hysteresis of the Trigger Multivibrator circuit will be at the proper level. It is difficult to measure the voltage directly between the two grids of V45 due to the loading of the voltmeter; for this reason we suggest the voltage be measured between the plate of V24B and the grid circuit of V45B. A voltage of 2.5 to 2.75 volts between these points will indicate proper quiescent operation.

If the voltage at the grid of V45B cannot be adjusted to within 2.5 to 2.75 volts of the voltage at the plate of

V24B, trouble in the Trigger multivibrator is indicated. Replace the tube; then, if necessary, check for off-value resistors, broken leads and poor switch connections.

Conversely, if the voltages are found to be correct, the adjustment of the TRIGGER SENSITIVITY control R37 can be checked. Refer to Step (7) in the Calibration Procedure for the proper method of checking the adjustment of this control.

When triggering in the DC mode from the signal being observed (TRIGGER SLOPE at + or —INT.), the INT. TRIG. DC LEVEL ADJ., R3 and its associated components are connected to the input grid of V24. This control is adjusted so that the input grid (pin 7 at —INT.; pin 2 at +INT.) is at ground potential when the trace is centered vertically on the crt. If the voltage at the input grid cannot be adjusted to zero when the triggering-switch controls are in the indicated positions, this control and its associated components should be checked.

TROUBLESHOOTING THE TIME-BASE GENERATOR

No Horizontal Sweep

If the Time-Base Generator is not producing a sawtooth sweep voltage when the STABILITY control is adjusted for a free-running sweep some defect in the generator is hanging up the Miller circuit. Depending on the on-off characteristics of the diodes V152, the Miller circuit may be hung up at either the high end or the low end of the sawtooth. The manner in which it is hung up may be determined by measuring the voltage at the SAWTOOTH OUT binding

post. If the Miller circuit is hung up at the high end of the sawtooth the voltage at the front-panel binding post will measure about +200 volts; if hung up at the low end, the voltage at this point will measure anywhere between ground and -20 to -30 volts, depending on the cause.

If the Miller circuit is hung up at the high end of the sawtooth a check of the voltage at the grid of the Miller tube will offer a clue to the cause of the trouble. The static voltage at the Miller grid is determined by conduction through the Timing Resistor, R160 (from -150-volt bus), the lower diode V152A, and the divider R147-R148. It will be impossible to measure the exact voltage at the Miller grid because of the loading of the meter. However, if a 20,000- Ω/v meter, or a vacuum-tube voltmeter is used, the voltage reading obtained will be sufficient to indicate the source of the trouble. For example, if a voltage reading more negative than about -15 volts is obtained, there is probably no conduction through the Timing Resistor. This would indicate an open divider, R147-148, assuming the diode V152 to be good.

If the Miller circuit is hung up at the low end of the sawtooth, as indicated by a voltage reading of zero or a few volts negative, a check of the voltage at the plate of the Miller tube will offer a clue to the cause. If this voltage is quite high (about +350 volts), check the neon lamp B167 and the Runup CF tube V173. If the voltage at the plate of the Miller tube is zero or slightly negative, check for an open plate-load resistor R164, R165 or R166.

However, if the voltage at the plate of the Miller tube is near the quiescent level (about +45 volts) the trouble will generally lie ahead of the Miller tube. The result of the trouble is that the On-Off Diodes V152 cannot be gated off; they are conducting heavily and clamping the grid of the Miller tube near ground. If all of the tubes have been checked, then check for open plate and cathode resistors in the Sweep-Gating Multivibrator Circuit, the Hold-Off circuit and the Runup CF circuit. Also check that the STABILITY control can vary the voltage at the grid of V125.

Improper Triggering

If the sweep cannot be triggered properly, the gating pulse from the Multivibrator is not turning the diodes V152 off and on properly. The start of the gating pulse, which turns the diodes off and starts the sweep, is initiated by the triggering pulse at the grid of V135A. The end of the gating pulse, which turns the diodes on and initiates the retrace, is controlled by the hold-off waveform at the grid of V135A. The Sweep-Gating Multivibrator can be eliminated as the cause of the trouble if the sweep can be turned off and on with the STABILITY control. The main component to check, in addition to the tubes, is the differentiating capacitor C131.

Nonlinear Sweep

A nonlinear sweep voltage will be generated if the current charging the Timing Capacitor C160 does not remain constant. If the nonlinearity occurs at all sweep rates a defective Miller tube will be the probable cause. If the nonlinearity occurs only at certain sweep rates a leaky Timing

Capacitor will be the probable cause but the Miller tube should not be overlooked. A defective bootstrap capacitor C165 can cause the sweep to be nonlinear at the faster sweep rates.

Insufficient Horizontal Deflection

If the horizontal trace starts at the left side of the graticule, but does not extend to the right side, the Hold-Off circuit is causing V135A to conduct too soon after the triggering pulse had forced it into cutoff. If the trace cannot be expanded the full length of the graticule with the SWP. LENGTH control R176, check the resistance values in the cathode circuit of V173.

TROUBLESHOOTING THE HORIZONTAL AMPLIFIER

No Spot or Trace Visible on CRT

To determine that the Horizontal Amplifier is in a state of dc unbalance, short the horizontal deflection plates together at the neck pins of the crt in the manner explained for troubleshooting the Vertical Amplifier. The horizontal deflection plates are marked RED (LEFT) and GREEN (RIGHT). The INTENSITY control should be set to midscale. If a spot appears when the horizontal deflection plates are shorted together (it may be necessary to adjust the Vertical POSITIONING control), the trouble lies in the Horizontal Amplifier.

CAUTION

Do not permit the spot to remain on the crt at this setting of the INTENSITY control. Either reduce the intensity until the spot is just visible, or remove the short from the horizontal deflection plates.

The procedure for troubleshooting the Horizontal Amplifier to locate the defective stage, is similar to that explained for troubleshooting the Vertical Amplifier for unbalance. The shorting strap can be moved from the deflection plates back toward the Input Amplifier stage, until a point is reached where the trace does not appear. When the stage at fault is determined, check the defective tubes and components associated with that stage.

Insufficient or No Horizontal Deflection

If the gain of the Horizontal Amplifier decreases, the trace will not extend from the left to the right side of the graticule. In addition, the timing will no longer correspond to the calibrated value indicated by the TIME/CM switch. (This is to distinguish the condition of insufficient sweep produced by a malfunction in the Horizontal Amplifier from the Hold-Off Circuit in the Time-Base Generator, e.g., an improper adjustment of the SWP. LENGTH control. In the latter case the trace will start at the left side of the graticule, for the normal setting of the HORIZONTAL POSITION control, and the timing will not be affected.)

If the change in gain is slight, as indicated by improper timing and a slightly decreased sweep, the amplifier can usually be recalibrated. Since the gain of the Horizontal Amplifier regulates the timing of the sweep, care must be taken to insure that the gain adjustments are accurately made. Be sure to refer to the Recalibration Procedure if it is necessary to adjust the gain of the Horizontal Amplifier.

If the decrease in gain of the Horizontal Amplifier is more pronounced, or if there is no sweep at all (in which case only a spot will be visible on the horizontal axis), check for defective components which can affect the gain but not the dc balance. In addition to the tubes, such components would be the common cathode resistors and controls.

TROUBLESHOOTING THE LOW-VOLTAGE POWER SUPPLY

Proper operation of every circuit in your instrument depends on proper operation of the Power Supply. The regulated dc voltages must remain within their specified tolerances for the instrument to retain its calibration.

CAUTION

Exercise care in checking the power supply. Because of their high-current capabilities and low impedance, the Low-Voltage supplies can produce more harmful shocks than the high-voltage supply in the CRT circuit.

Open Power Circuit (Dead Circuit)

If the pilot lamp and the fan do not come on when the power is turned on, check the source of power and the power cord connections. Check the fuse. If the fuse is blown replace it with one of the proper value and turn the instrument on again. If the new fuse blows immediately, check the power transformer for shorted primary or secondary windings. Also check for shorted rectifiers. If the new fuse does not blow until the time-delay relay has activated (a "click" can be heard), check for a shorted condition in the regulator circuits and the loading on the supply.

If the fuse is good, check for an open primary winding in the power transformer. If your instrument is wired for 234-volt operation, check for an open Thermal Current Switch; the resistance of this switch is about $.1\Omega$. (If your instrument is wired for 117-volt operation, the fan will come on even though the Thermal Cutout Switch may be open).

If both the fan and pilot light come on, the primary circuit of the power transformer is operating normally.

Incorrect Output Voltage

The voltage for each test point is silk-screened on the lip of the chassis adjacent to the ceramic strip on which the test points are located. Refer to Fig 5-12 for a low-voltage check point location.

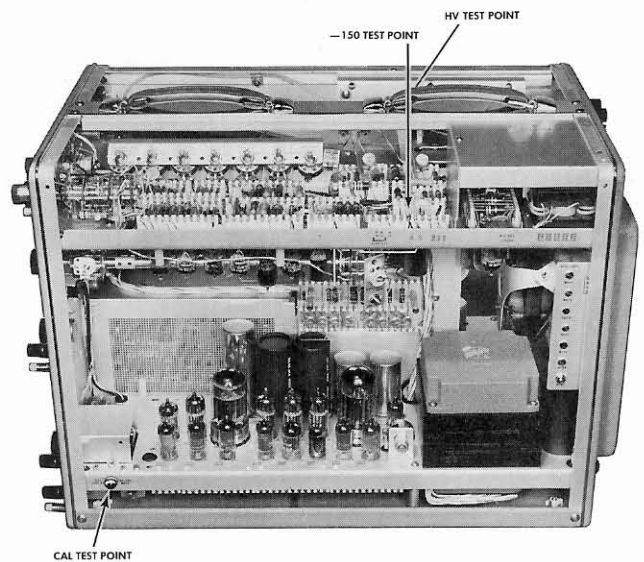


Fig. 5-12. Location of power supply and calibrator test points.

Each regulated bus is identified by a color-coded wire. The -150 -volt bus is coded brown, green and brown on a black wire; the $+100$ -volt bus is coded brown, black and brown on a white wire; the -225 -volt is coded red, red and brown on a white wire; the -350 -volt bus is coded orange, green and brown on a white wire; and the $+500$ volt bus is coded green, black and brown on a white wire.

If any of the supplies fail to regulate the first thing to check is the line voltage. The supplies are designed to regulate between 105 and 125 volts with the design center at 117 volts, or between 210 and 250 volts with the design center at 234 volts, rms, 50-60 cycle single phase ac.

When possible, check the resistance values between the outputs of the Low-Voltage Power supplies and ground.

If the resistance value between the regulated buses and ground check out, check the tubes (if this has not already been done). Then make sure that the line voltage is set near the design center for your instrument (117 or 234v) and check the rms voltage across the secondary winding for each supply; the nominal value of each secondary voltage, when the line is set to the design center, is indicated on the circuit diagram. If the secondary voltages are all correct, check the operation of the bridge rectifiers. This can be done by measuring the rectified voltage at the input to each regulator. These values are also indicated on the circuit diagram. Then check for off-value resistors, especially in the dividers, and for open or leaky capacitors.

The material that follows may be used as a quick index for troubleshooting the regulator circuits.

If the output voltage is high with excessive ripple, check:

- For high line voltage.
- For open voltage-regulator tube.

- c. The amplifier tubes in the regulator circuit.
- d. For insufficient loading.

If the output voltage is high with normal ripple, check:

- a. For proper resistance values in the dividers refer to the schematic for your instrument to determine the location of the resistors involved. Since these are generally precision resistors ($\pm 1\%$ tolerance) the use of a good bridge is recommended in checking the value.

If the output is low with excessive ripple, check:

- a. For low line voltage.
- b. For shorted voltage-regulator tube.
- c. The series tubes in the regulator circuit.
- d. For excessive loading.
- e. Open or leaky filter capacitors.
- f. Defective rectifiers.

If the output is low with normal ripple, check:

- a. The resistance values in the dividers.
- b. The capacitors across the dividers.

NOTE

If any components in the -150 -volt supply are changed, or if the setting of the -150 ADJ. control is changed, it will be necessary to recalibrate the instrument.

TROUBLESHOOTING THE CALIBRATOR

Asymmetrical Output

If the output square wave is not symmetrical (the positive portion has a duration different from that of the negative portion) the two tubes in the Multivibrator circuit are not being held cut off for equal periods. This will normally be caused by a defective tube. If tube replacement does not correct the waveform the circuit components must be checked. In Type 533A the pentode in the Multivibrator is held cutoff for an interval determined by the discharge of C871 and the triode is held cut off for an interval determined by the discharge of C874. A change in value of either capacitor, or in the value of the resistor through which they discharge, could produce an asymmetrical waveform.

In addition, the time needed for these capacitors to discharge a given amount is affected by the potential toward which they discharge; this would be the voltage at the plate of the triode in the case of C871, and the voltage at the screen of the pentode on the case of C874. Since these voltages are affected by the value of R870 and R875, these resistors should be checked. The resistors in the plate circuit of the pentode should also be checked, since they will affect the plate-to-screen ratio of the pentode.

In Type 533 Oscilloscopes, the interval of pentode discharge is determined by C673, and that of triode discharge by C672. With reference to potential toward which the capacitors discharge, C673 discharges toward the triode plate, and C672 toward the pentode screen. These voltages are affected by R670 and R675.

Incorrect Output Voltage

The amplitude of the output square wave is determined almost entirely by the resistance values in the divider in the cathode-follower stage. A quick check of the resistance values can be made by turning off the Calibrator and measuring the voltage at the CAL. TEST PT; if this point does not measure exactly $+100$ volts the output voltages when the Calibrator is turned on will not be correct.

The CAL. ADJ. control R879 in Type 533A, R679 in Type 533 will vary the voltage at the test point over about a 10 -volt range. If this voltage cannot be set to exactly $+100$ volts, and if the tubes have been replaced, then one or more of the precision resistors in the divider have been changed in value.

TROUBLESHOOTING THE CRT CIRCUIT

The intensity, focus, geometry and calibration of the crt display depend on proper operation of the high-voltage supplies in the CRT Circuit.

No Intensity

If the low-voltage power supply is operating normally, but no spot or trace is visible on the crt, the trouble could be a defective crt, a defect in the crt cathode circuit including the supply, or an unbalanced dc condition in either or both of the deflection amplifiers. In the latter case the dc unbalance is producing improper positioning voltages and the beam is being deflected off the screen.

To determine which circuit is at fault, turn the INTENSITY control full right (cw). If a flare is observed on the crt screen (it may be necessary to darken the room), one of the deflection amplifiers is probably at fault; the procedure for troubleshooting these circuits follows a bit later in this section. If no flare is observed with the INTENSITY control turned full right the trouble will either be due to a defective crt or to an inoperative cathode supply circuit. The cathode supply can be checked by measuring the voltage at the HV ADJ. TEST POINT. In the majority of instruments the test point is located at the top left rear of the instrument. Fig. 5-12 shows the location of typical high-voltage test points. Refer to the schematic diagrams for your instrument to determine the correct voltage. If the voltage reading you obtain is in the vicinity of the correct voltage noted on the schematic, turn the instrument off, and measure the value of the $27K$ resistor attached to the test point (see Fig. 4-10). If this resistor is not open a defective crt is indicated.

If the voltage at the HV ADJ. TEST POINT is zero or abnormally low replace the Oscillator tube and the Error-

Signal Amplifier tube. If this does not restore operation the Oscillator circuit should be checked.

A quick check on the operation of the Oscillator circuit can be made by observing the heater glow in the 5642 rectifier tubes, located under the shield at the upper right rear of the instrument. These tubes are visible through the opening in the side of the shield. If no heater glow is visible the Oscillator circuit is inoperative. This could be due to an open high-voltage transformer, or to a defective component in the oscillator or error-signal amplifier circuits.

If heater glow is visible in the rectifier tubes, the Oscillator circuit is operating. If the heater glow appears to be dim, however, the output of the Oscillator may be insufficient for proper operation. A more accurate check on the Oscillator may be made by removing the shield covering the high-voltage transformer and measuring the bias at the grid of the oscillator tube. This can be measured at the junction of the 100 k resistor and the .01- μ fd. capacitor. See the simplified schematic, Fig. 4-10 for the normal circuit configuration in the high-voltage oscillator. The voltage at this point should measure about -65 volts.

CAUTION

Do not let your hand or body touch the chassis when making this check. Secondary reactions to an otherwise harmless shock might result in a painful injury.

If the Oscillator circuit is operating properly, but the voltage at the HV ADJ. TEST POINT does not measure in the vicinity of that indicated on the schematic diagram for the instrument, the 5642 rectifier tube, V822, shown in the simplified schematic of Fig. 4-10 is most likely defective.

Abnormal Intensity

If a trace is visible on the crt, the relative intensity of the trace may be used to identify trouble in either the negative bias supply or the positive anode supply.

If the trace is excessively brilliant, and if the brilliancy does not change as the INTENSITY control is adjusted, check the negative bias supply including the lead to the first grid of the crt. Check for a defective rectifier tube V822, (shown in the simplified schematic diagram of Fig. 4-10, an open supply winding, an open resistor including the INTENSITY control, or a shorted or leaky capacitor. If trouble is not found in any of these components, a defective crt is indicated.

If the intensity of the trace is extremely low, check for an inoperative positive supply. Also check the anode connection to the crt, including R836 and C836.

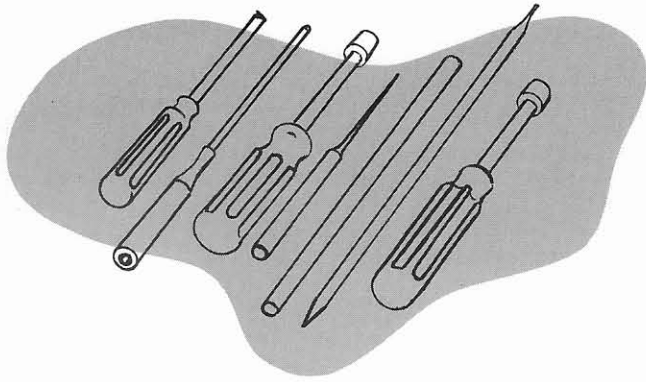
If the accelerating potentials appear to be too high, as evidenced by decreased deflection sensitivity, check the Error-Signal Amplifier circuit.

If a badly distorted trace or spot is visible on the crt, check the GEOM. ADJ. control and its connection to the neck pin on the crt, and the ASTIGMATISM control and its connection to the crt base socket. If the FOCUS control has no effect on the trace, check this control and its connection to the crt base socket.

NOTE

If any components in the Oscillator, Error-Signal Amplifier or cathode supply circuit are changed, or if the setting of the HV. ADJ. control is changed it will be necessary to recalibrate the instrument.

CALIBRATION PROCEDURE



Introduction

The Type 533/533A Oscilloscope is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors, or other components are replaced.

This procedure is a combination performance check and adjustment procedure. The first part of the step title is the name of the check or adjustment and the latter portion is in reference to the pertinent circuit.

The tables list characteristics, performance requirements and front-panel control settings at particular points in the procedure. The latter serves two purposes: To quickly check your own setup and to enable you to start anywhere in the procedure to check or recalibrate a particular section of the instrument. There is no need to go back in the procedure to determine front panel settings. The steps are arranged in the proper order for complete recalibration with the minimum amount of repetition.

EQUIPMENT REQUIRED

The following equipment or its equivalent is necessary for complete calibration of the Type 533/533A Oscilloscope. All equipment must perform within its specifications. If there is doubt it should be calibrated before starting this procedure.

If recommended equipment is not available, equivalent test equipment may be substituted. The user must determine proper settings for the substitute equipment.

If other than recommended accuracy is used the deviation must be added to the tolerances given in this procedure.

Words written in capital or upper case letters refer to front or rear panel control labels of the instrument under calibration.

Unless otherwise stated, all resistances, voltages and waveforms are measured with respect to chassis ground.

DC voltmeter (sensitivity at least 20,000 Ω/v) calibrated for accuracy of at least 1% at 100, 150, 225, 350 and 500 volts, and for an accuracy of 3% at 1350 volts. Be sure the meter is accurate. Few portable meters have comparable accuracy, particularly after a period of use.

Accurate rms-reading ac voltmeter, 0-150 volts (0-250 or 0-300 volts for 234-volt operation).

Variable autotransformer (Powerstat, Variac, etc.) having a rating of at least 6.25 amperes.

Time-Mark Generator, Tektronix Type 180A or equivalent. Time-Mark Generator used must have markers at 1 μsec , 10 μsec , 50 μsec , 100 μsec , 1 msec, 5 msec, 100 msec, 1 sec and 5 sec and sine-wave output of 10 cm and 50 mc, with accuracy of at least 1%.

Constant-Amplitude Signal Generator, Tektronix Type 190B. Signal Generator must provide a 200-millivolt signal variable in frequency from 500 kc to over 30 mc. The signal amplitude must remain constant (200 mv) over the entire frequency range.

Standard Amplitude Calibrator, frequency approximately 1 kc, amplitude accuracy $\pm 0.2\%$. Special.

Type 1M1 (TU-7) Plug-In Test Unit or equivalent units with provisions to test the oscilloscopes low voltage power supplies from minimum to maximum load. Alternate trace and Chopped Mode operation, Common mode rejection ratio and a fast-rise square wave with a risetime of 3 nsec or less.

NOTE

Whenever the TU-7 REPETITION RATE switch is referred to, the following switch positions should be considered equivalent for test purposes:

TU-7	067-0521-01
LOW	4 kHz
MED	80 kHz
HIGH	500 kHz

High gain DC Differential amplifier. Tektronix Type D unit or equivalent.

Test Oscilloscope with 10X attenuator probe. Tektronix Type 530, 540, 550 or equivalent series. Purpose to check low-voltage power supply ripple accuracy of Amplitude Calibrator and Oscilloscope front-panel waveforms.

Three coaxial cables, 50-ohm nominal impedance, 42" long, with BNC plug-connectors on each end. Part No. 012-057.

Two Adapters, single binding post fitted with a BNC plug. Part No. 103-033.

Two Coaxial connector adapter with BNC-jack and UHF-plug connector fittings. Part No. 103-015.

One Jumper clip lead, about 4" long. Equipped with miniature alligator clips on each end.

Calibration Procedure—Type 533/533A

Three interconnecting leads, 18" long, with combination plug-and-jack banana type connectors on each end. Type PC-18R. Part No. 012-031 or 012-039.

One adapter, clip lead to BNC connector. Part No. 013-076.

One BNC T connector. Fits one BNC jack and accepts two BNC plugs. Part No. 103-030.

One UHF male to BNC female adapter. Part No. 103-015.

1 — Screwdriver, $\frac{3}{16}$ " wide bit, shank about 3" long.

1 — Screwdriver, $\frac{3}{32}$ " wide bit, shank about 2" long.

1 — Jaco No. 125 insulated low-capacitance-type screwdriver with a $1\frac{1}{2}$ " long shank and $\frac{1}{8}$ " wide metal tip. Total length is 5". Part No. 003-000.

1 — Low-capacitance alignment tool, consisting of a handle (Part No. 003-307), a gray nylon insert with a metal screwdriver tip (Part No. 003-334), a $\frac{5}{64}$ " hexagonal wrench insert (Part No. 003-310).

1 Hexagonal wrench, $\frac{1}{16}$ ". Purpose: To reposition, if necessary, the TRIGGERING LEVEL control knobs.

1 — Capacitor, approximately 47 pf, 500 v. To couple 50 c to deflection plates of crt.

1 — Type K Plug-In Unit.

PRELIMINARY PROCEDURE

- 1 Remove the cabinet from the oscilloscope.
2. Insert the Type 1M1 (TU-7) in the oscilloscope vertical plug-in compartment.
3. Set the Type 1M1 (TU-7) Test Function switch to the low Load position.
4. Connect the instrument and ac voltmeter to the autotransformer output. Connect the autotransformer to the power line.
5. Turn the INTENSITY control on the instrument fully counterclockwise and turn on the power to all the equipment. Adjust the autotransformer output voltage to 117 volts (or the design-center voltage for which the instrument is wired).

6. Set the front panel controls as follows:

Type 533/533A

INTENSITY	full left (ccw)
TRIGGERING MODE	AUTOMATIC
TRIGGER SLOPE	+INT
TIME/CM	.5 mSEC
VARIABLE	CALIBRATED (full right)
HORIZONTAL DISPLAY	NORMAL (X1)
NORMAL SWEEP/ SINGLE SWEEP	NORMAL SWEEP
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	OFF

7. Set the Type 1M1 (TU-7) front-panel controls to these settings:

Vertical Position	Centered
Test Function	Low Load
Other Controls	As is

8. Allow about five minutes warm-up time. Check that the EXT CRT CATHODE-to-GND shorting strap is in place on the terminals and the CRT CATHODE SELECTOR switch is at EXTERNAL CRT CATHODE position.

9. Set the Test Oscilloscope and the Plug-in unit to the following settings:

Test Oscilloscope

CRT controls	Normal intensity and a well defined trace.
Main Time Base	
Stability and Triggering	Full clockwise
Level controls	
Triggering Mode	AC
Trigger Slope	+ Int.
Time/CM	10 mSec
Horizontal Display	Normal
Horizontal Position controls	Centered

Type D Plug-In Unit

Input Selector	AC (A)
Millivolts/CM	10
MV/CM Multiplier	1
Variable	Calibrated
Vertical Position	Centered

These settings are for a 1X probe. If a 10X attenuator probe is used, the Millivolts/CM switch must be set to 1. This will then calibrate the vertical sensitivity of the test oscilloscope to 10 millivolts/cm.

TABLE 6-1

Power Supply	Tolerance	Maximum Peak-to-Peak Ripple
-150 v	-147 to -153	10 mv
+100 v	+98 to +102	15 mv
+225 v	+220.5 to +229.5	10 mv
+350 v	+343 to +357	20 mv

NOTE

Don't adjust the -150 VOLTS control unless one or more of the supplies is actually out of tolerance. Remember that the calibration of the entire instrument is affected by changes in the power supply voltages. All the positive voltage power supplies depend upon the -150-volt supply measurement accuracy.

CALIBRATION PROCEDURE

1. Check Voltage Accuracy—Power Supply

(If necessary adjust -150 volt ADJ control)

a. Establish the conditions given in the preliminary procedure.

b. Check the voltage accuracy of each power supply output using the VOM according to the information given in Table 6-1. The locations of the test points are marked on the upper chassis on the right side of the instrument.

c. If necessary adjust —150 volt ADJ control (lower chassis, right side next to power transformer) so all power supply voltages are within tolerance.

2. Check Regulation and Output Ripple—Power Supply

NOTE

When checking for proper regulation of the power supplies at the lower line voltage limit, the ac line voltage should contain no more than 3% distortion.

a. Monitor the regulated output of the —150-volt supply with the VOM.

b. Connect the probe from a test oscilloscope to the —150-volt test point and check the output ripple amplitude. The maximum ripple voltage is given in Table 6-1.

NOTE

Ground loops can cause an erroneous ripple measurement. (Ripple due to ground loops is the same frequency as the line; low-voltage power supply ripple is twice the line rate.) One way to avoid ripple due to ground loops is to connect the test scope to the Type 533/533A with an external ground strap.

c. Slowly increase the output of the variable autotransformer to 125 vac (or 250 volts). The dc output voltage should remain essentially constant; typically within 2% of that obtained with design-centerline voltage. The ripple voltage should not exceed the maximum peak-to-peak amplitude given in Table 6-1.

d. Repeat steps 2a through 2c for each supply.

e. Reset the autotransformer for 117 volts output (or 234 volts depending upon the design center voltage for which the instrument is wired).

f. Set the Type 1M1 (TU-7) Test Functions Load switch to High Load.

g. Reduce the line voltage to 105 volts (or 210 volts). The dc output voltage of each supply should remain essentially constant; typically within 2% of that obtained at design-center voltage. Ripple voltage should not exceed the maximum peak-to-peak amplitude given in Table 6-1.

h. Disconnect the VOM and 10X Probe.

i. Reset the autotransformer for 117 volts output (or design-center).

j. Set the Type 1M1 (TU-7) Test Function switch to Low Load.

3. Adjust High Voltage

a. Set the scale of the VOM to measure —1350 volts and connect the VOM between the HV ADJ TEST POINT and ground. (This TEST POINT is accessible through a hole in the

cover for the high voltage circuit.)

b. Adjust the HV ADJ control (located on the upper chassis on the right hand side below the high voltage circuit) for —1350 volts.

4. Check High Voltage Regulation—Crt Circuit

a. With the VOM connected to the high voltage test point, use the meter to monitor the voltage at this point.

b. Set the TRIGGERING MODE switch to AUTO.

c. Rotate the INTENSITY control clockwise until the trace is at normal intensity. Use the Type 1M1 (TU-7) Vertical Position control to vertically center the trace. Defocus the trace with the FOCUS and ASTIGMATISM control. Set the INTENSITY control full clockwise.

d. Use the HORIZONTAL POSITION control to position the trace to start at the left side of the graticule.

e. Slowly increase the output of the variable autotransformer to 125 vac (or 250 volts). The high voltage dc output should remain essentially constant; typically within 2% of that obtained with design-center line voltage. The trace should not show any signs of blooming. (Blooming is when the display changes size as the supply voltage changes.)

f. Reset the autotransformer for 117 volts output (or 234 depending upon the design-center voltage for which the instrument is wired.)

g. Set the Type 1M1 (TU-7) Test Function switch to High Load.

h. Reduce the line voltage to 105 volts (or 210 volts). The high voltage dc output should remain constant; typically within 2% of that obtained with design-center line voltage. The trace should not show any signs of blooming.

i. Reset the autotransformer for 117 volts output (or design-center).

j. Set the Type 1M1 (TU-7) Test Function switch to Low Load.

k. Decrease the trace intensity to normal with the INTENSITY control.

l. Disconnect the VOM.

5. CRT Alignment

Turn up INTENSITY control until trace is visible (it may be necessary to adjust the Vertical Positioning control on the plug-in unit) and adjust FOCUS and ASTIGMATISM for sharpest trace (narrowest trace width). Position trace directly behind center graticule line.

If the trace and graticule line do not coincide over the length of the graticule, loosen the crt base clamp and rotate the tube with the alignment ring. When the trace and graticule line are in coincidence, push the tube forward so that it rests snugly against the graticule. Then tighten the crt base clamp. Recheck the alignment after tightening the clamp to be sure it didn't move while the clamp was being tightened.

On later model instruments if the trace is tipped relative to the graticule line, rotate the crt alignment knob until the trace coincides with the graticule line.

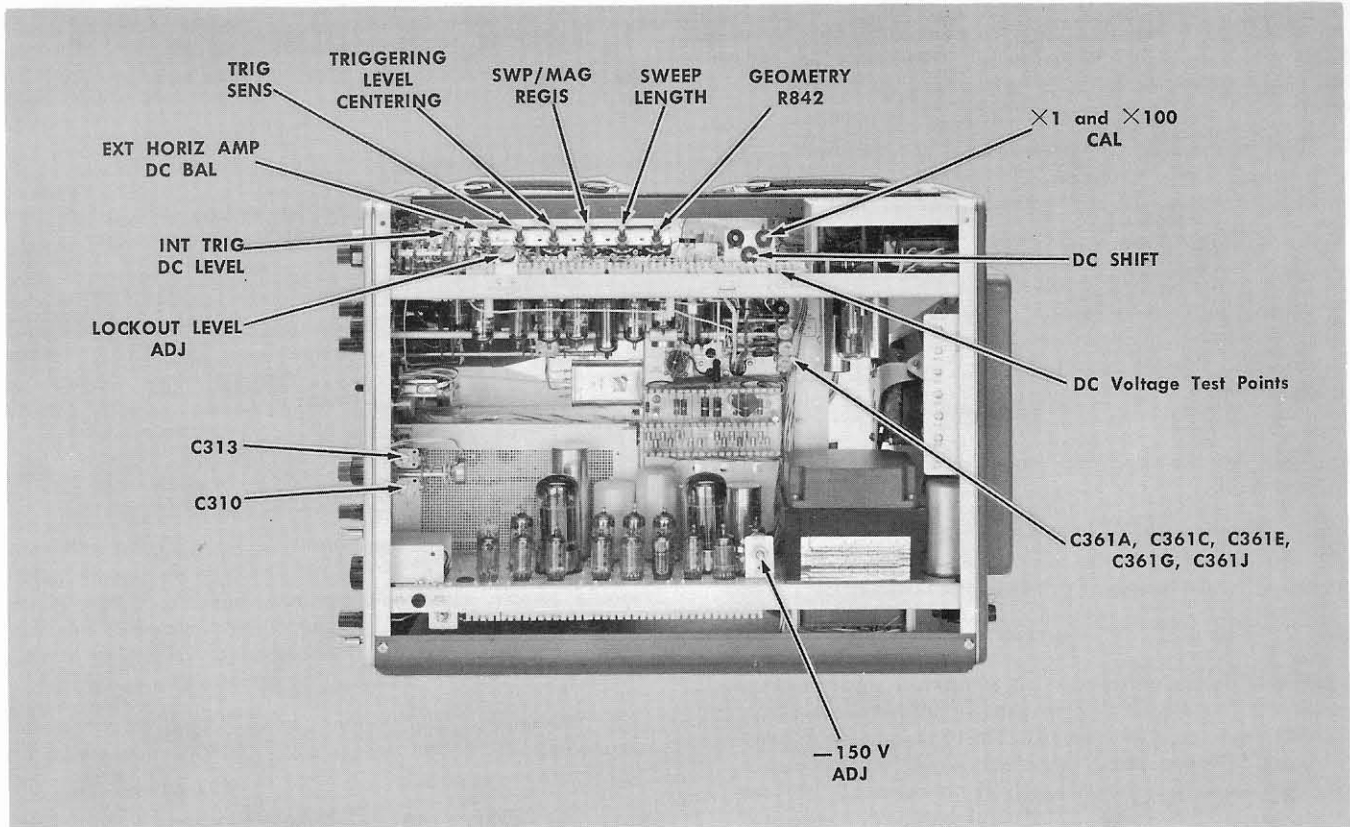


Fig. 6-1. Type 533/533A showing location of test points and adjustments.

6. Adjust GEOMETRY R842—Crt Circuit

- a. Apply 50 μ sec markers from the time-mark generator through a coaxial cable to the Type 1M1 (TU-7) Ext Input connector.
- b. Set the TIME/CM switch to 50 μ SEC.
- c. Advance the INTENSITY control until the display is visible.
- d. Adjust the TRIGGERING LEVEL control to obtain a stable display.
- e. Adjust the 1M1 (TU-7) Variable control so the markers overscan the crt; set the Vertical Position control to position the base line of the markers below the display area.
- f. Use the HORIZONTAL POSITION control to position the markers so they align with the graticule markings.
- g. Adjust the GEOMETRY control R842 (see Fig. 6-1) for the straightest possible vertical marker-lines running parallel to the 0-cm and 10-cm graticule. Note the amount of bowing.
- h. Disconnect the signal from the 1M1 (TU-7) Ext Input connector.
- i. Reduce the trace intensity to normal with the INTENSITY control while positioning the trace onto the crt with the 1M1 (TU-7) Vertical Position control.
- j. Using the 1M1 (TU-7) Vertical Position control, position the trace to the bottom of the graticule. Note the amount of bowing. Then position the trace to the top of the graticule

and note the amount of bowing. Bowing must not be more than 1 mm relative to the graticule line.

- k. Repeat steps 7a through 7j until the trace exhibits minimum bowing in both planes.

1. After completing the previous steps, disconnect the signal from the 1M1 (TU-7) Ext Input connector. Check to see that the trace is positioned in the display area and the INTENSITY control is adjusted to a suitable trace brightness level.

7. Check Position Neons—Vertical and Horizontal Amplifier Circuit

The vertical position neons should indicate when the trace is more than 3 major divisions from the center graticule line and the horizontal neons should indicate when the spot is more than 5 major divisions from the center.

- a. Check the \uparrow position neon and the \downarrow position neon as the trace is moved from top to bottom of the graticule area with the Type 1M1 (TU-7) Vertical Position control.
- b. Return the trace to the center of the graticule.
- c. Defocus the trace and turn the HORIZONTAL DISPLAY switch to EXT position.
- d. Decrease the intensity of the spot to low intensity to avoid burning the phosphor coating of the crt.
- e. Check the \leftarrow position neon and the \rightarrow position neon as the spot is moved from left to right of center with the HORIZONTAL POSITION and VERNIER control.

f. Return the HORIZONTAL DISPLAY switch to NORMAL (X1) position.

g. Center the trace with the position controls and adjust the FOCUS control for a well defined trace.

8. Alternate-Trace Sync Pulse Check—Time-Base Generator

a. Set the Type 1M1 (TU-7) Test Function switch to Alternate. If two traces appear, the Time-Base Generator is producing proper alternate-trace sync pulses for the plug-in unit.

b. Check the dual trace operation for each sweep rate by setting the TIME/CM switch through each setting from 5 mSEC to .1 μSEC. At the slower sweep rates (.1 mSEC to 5 mSEC) the traces will appear as exponential waveforms and at rates slower than 5 mSEC they appear as one exponential line.

9. Check Chopped-Mode Operation—Time-Base Generator

a. Set the Type 1M1 (TU-7) Test Function switch to Chopped.

b. Set the TIME/CM switch to 5 μSEC.

c. Set the STABILITY control to PRESET and adjust the TRIGGERING LEVEL control for a stable display (Fig. 6-2).

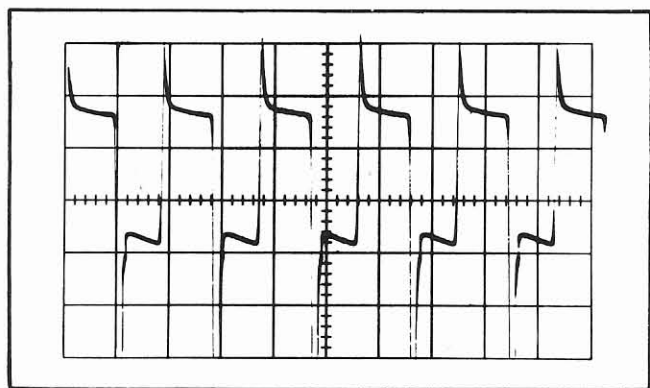


Fig. 6-2. Chopped waveform display.

d. Switch the CRT CATHODE SELECTOR switch (on back panel of oscilloscope) to the CHOPPED BLANKING position and check that the fast rising and falling portions (switching portions) of the display are blanked so that only the "on" segments of each trace are visible (Fig. 6-3).

e. Return the CRT CATHODE SELECTOR switch to the CRT CATHODE position and the Type 1M1 (TU-7) Test Function switch to Low Load position.

10. Adjust Vertical GAIN ADJ (R570)—Vertical Amplifier

a. Turn the Type 1M1 (TU-7) Test Function switch to Gain Set position.

b. Connect a coaxial cable between the Type 1M1 (TU-7) Ext Input connector and the output of the Standard Amplitude Calibrator.

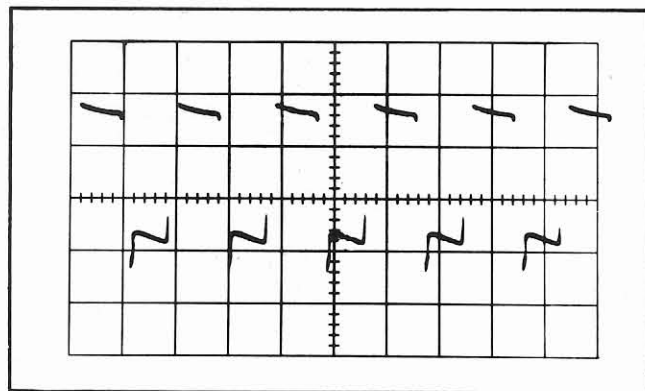


Fig. 6-3. Chopped blanking check with Crt Cathode Selector switch at Chopped. Vertical switching lines are blanked.

c. Set the Standard Amplitude Calibrator for an output of 100 volts.

d. Set the STABILITY and the TRIGGERING LEVEL controls full clockwise.

e. Set the TIME/CM switch to the 10 μSEC position.

f. Adjust the GAIN ADJ R570 so the display vertical deflection amplitude is exactly 4 cm. (Use the center 4 cm of the graticule.)

11. Check Common-Mode Rejection—Vertical Amplifier

a. Set the Standard Amplitude Calibrator for an output of 1 VOLT.

b. Turn the Type 1M1 (TU-7) Test Function switch to Common Mode.

c. Set the TIME/CM switch to .5 mSEC.

d. Note the amplitude of the calibrator waveform. The amplitude of the waveform should not be more than 3 mm.

12. Adjust TRIGGER LEVEL CENTERING R39 and TRIGGER SENS. R37—Time-Base Trigger

Reset front-panel controls as follows:

Type 533/533A

STABILITY	full right (cw)
TRIGGERING LEVEL	0
TRIGGERING MODE	AC SLOW (AC)
TRIGGER SLOPE	+INT
TIME/CM	.5 mSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL
NORMAL SWEEP/SINGLE SWEEP	NORMAL SWEEP

Type 1M1

VARIABLE POSITION	Fully cw
TEST FUNCTION	Centered
	Low Load

Calibration Procedure—Type 533/533A

- a. Set the Standard Amplitude Calibrator for an output of 0.1 VOLT. This should result in a free-running trace with an amplitude of approximately 2 mm (1 minor division).
- b. Center the display and adjust the FOCUS, INTENSITY and ASTIGMATISM controls for best definition.
- c. Connect a jumper strap (clip lead) between ground and the junction of R19, C20 and R20 (Fig. 6-4).

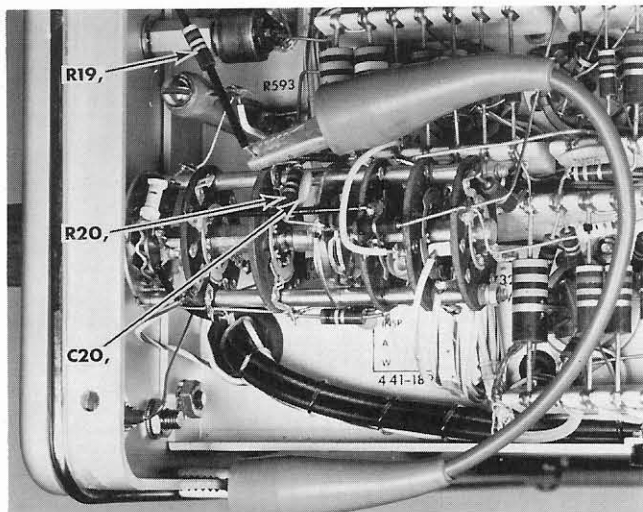


Fig. 6-4. Grounding the junction of R19, R20 and C20 to simplify the adjustment of the triggering controls.

- d. Preset the TRIGGER SENSITIVITY control full left (ccw) and the TRIGGERING LEVEL CENTERING control full right (cw).
- e. Turn the STABILITY control counterclockwise until the trace disappears from the crt screen.
- f. Turn the TRIGGERING LEVEL CENTERING adjustment left (ccw) until the display reappears on the screen. If the display fails to appear, turn the TRIGGER SENSITIVITY adjustment to the right (cw) a few degrees and repeat the adjustment of the TRIGGERING LEVEL CENTERING until a display reappears.
- g. Reduce the amplitude of the signal by turning the Variable gain control on the Type 1M1 (TU-7) to the left (ccw), at the same time continuing to adjust the TRIGGERING LEVEL CENTERING and TRIGGER SENSITIVITY controls to keep the trace on the screen.
- h. With the signal amplitude reduced to a minimum for satisfactory triggering, switch the TRIGGER SLOPE switch to —INT position. Readjust the TRIGGERING LEVEL CENTERING adjustment if necessary to obtain a display.
- i. Set the TRIGGERING LEVEL CENTERING adjustment halfway between the settings at which the waveform is stable in the +INT and —INT positions (the TRIGGER SLOPE switch may be left in either position) and adjust the TRIGGER SENSITIVITY adjustment slowly to obtain a stable display with a minimum 2 mm signal amplitude.
- j. Switch the TRIGGER SLOPE switch between +INT and —INT position and slightly readjust both the TRIGGERING

LEVEL CENTERING and the TRIGGER SENSITIVITY adjustments for stable triggering in both positions.

13. Adjust INT TRIG DC LEVEL ADJ. R3—Time-Base Trigger

- a. Return the Type 1M1 (TU-7) Variable control to the full clockwise position.
- b. Increase the output of the Square-Wave Calibrator to 0.2 VOLT.
- c. Adjust the Type 1M1 (TU-7) Vertical position control so the displayed waveform is equal in amplitude above and below the center graticule line.
- d. Switch the TRIGGERING MODE switch to DC position.
- e. Adjust the INT TRIG DC LEVEL ADJ. (R3) to obtain a stable display.
- f. Check the waveform for proper trigger slope. The sweep trace should start on the positive-going rise of the Calibrator signal when the TRIGGER SLOPE switch is in the +INT position and on the negative going portion when the TRIGGER SLOPE switch is in the —INT position.

14. Check Internal Triggering—Time-Base Trigger

- a. Set the TRIGGERING MODE switch to AC position.
- b. Adjust the Type 1M1 (TU-7) Variable control until the display is 2 mm peak-to-peak in amplitude.
- c. Adjust the TRIGGERING LEVEL control to obtain a stable display.
- d. Check for stable time-base triggering with the TRIGGERING SLOPE switch in both the + and — positions. It may be necessary to readjust the TRIGGERING LEVEL control slightly when checking each switch position.
- e. Check for stable triggering with the TRIGGERING MODE switch in AC LF REJECT and AUTO positions. Must trigger on either +INT or —INT, TRIGGER SLOPE switch positions.
- f. Return the TRIGGERING MODE switch to the AC position.
- g. Remove the jumper lead between R20 and ground.

15. Check TRIGGERING LEVEL Control Zero Set—Time-Base Trigger

- a. Set the TRIGGERING LEVEL control to 0 and the TRIGGER SLOPE switch to +INT.
- b. Connect the VOM between the R20/C20/R19 junction and ground.
- c. Carefully rotate the TRIGGERING LEVEL control to obtain a zero volts reading on the VOM.
- d. Check the TRIGGERING LEVEL control knob. The dot should be directly below the 0 on the front panel. If necessary, loosen the setscrew and position the knob.
- e. Remove the signal cable from the Amplitude Calibrator to the Ext Input of the Type 1M1 (TU-7).

16. PRESET STABILITY Adjustment and Automatic Triggering—Time-Base Generator

- a. Set the TRIGGERING MODE switch to AUTO positions.
- b. Do not change the setting of the STABILITY and TRIGGERING LEVEL controls.
- c. Set the PRESET ADJUST (screwdriver adjustment) to its full ccw position.
- d. Connect a VOM between the center arm of the PRESET ADJUST potentiometer (R111) and ground. Set VOM to read a negative voltage.
- e. Turn the PRESET ADJUST potentiometer shaft clockwise until a trace is just visible. Note the voltmeter reading.
- f. Advance the adjustment further clockwise until the trace brightens. Note the reading.
- g. Set PRESET ADJUST to the midpoint of the two voltage readings.

17. Adjust SWP/MAG REGIS. (Sweep/Magnifier Registration) R359—Horizontal Amplifier

Set up the Type 533/533A controls as follows:

STABILITY	PRESET
TRIGGERING LEVEL	full-right
TRIGGERING MODE	AC SLOW (AC)
TRIGGER SLOPE	+INT
TIME/CM	1 mSEC
*VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL (X1)
NORMAL SWEEP/SINGLE SWEEP	NORMAL SWEEP
CALIBRATOR	OFF

*Make sure the VARIABLE TIME/CM control is locked in the CALIBRATED position for all timing adjustments.

Set up the following oscilloscope and plug-in unit controls for best presentation: FOCUS, INTENSITY, ASTIGMATISM, SCALE ILLUM., HORIZONTAL POSITION, VERTICAL POSITION and VOLTS/CM.

Type 1M1 (TU-7)

Vertical Position	Centered
Variable	≈ 3
Test Function	Low Load

- a. Apply 100 μsec, 1 msec and 5 msec time markers from the time-mark generator through a coaxial cable to the 1M1 Ext Input connector.
- b. Set the 1M1 (TU-7) Variable control so the display is about 4 centimeters in amplitude.
- c. Center the display vertically using the 1M1 Vertical Position control.
- d. Adjust, if necessary, the TRIGGERING LEVEL control to obtain stable triggering on the 5 msec time marks. Fig. 6-5a shows the time markers displayed with respect to the graticule markings. Use the HORIZONTAL POSITION control

to position the center 5 msec time marker to the center of the graticule as shown in the illustration.

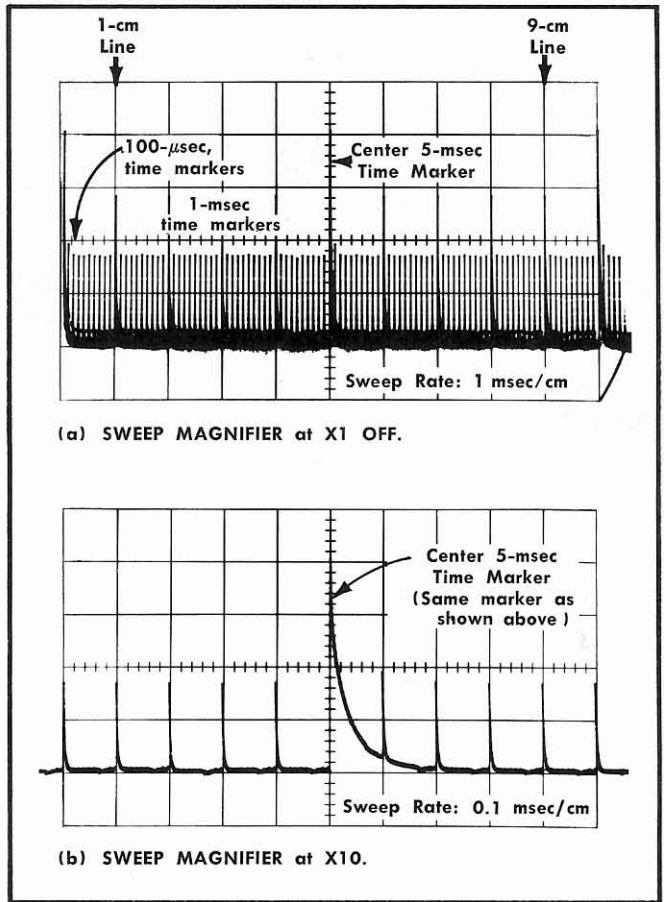


Fig. 6-5. Time marker displays.

- e. Set the SWEEP MAGNIFIER switch to X100. Position the 5 msec time marker to graticule center (see Fig. 6-5b) and then set the SWEEP MAGNIFIER switch to NORMAL (X1).
- f. Adjust the SWP/MAG REGIS R359 control (see Fig. 6-6) to position the center 5 msec time marker to graticule center. If necessary, repeat steps 16e and 16f until there is no movement of the 5 msec time marker as the SWEEP MAGNIFIER switch is changed from X100 to NORMAL (X1) position.

18. Adjust X10 CAL (X10 Magnified Sweep Calibration) R342—Horizontal Amplifier

- a. Set the SWEEP MAGNIFIER switch to X10.
- b. Adjust the X10 CAL R342 control (see Fig. 6-6) so there is 1 marker per cm from the 1-cm to 9-cm graticule lines. For accurate adjustment the X10 CAL control should be adjusted so the markers at the 1- and 9-cm graticule lines coincide exactly with the 1-cm and 9-cm graticule lines.

NOTE

The following hints should help you to obtain the best results in checking and adjusting the time-

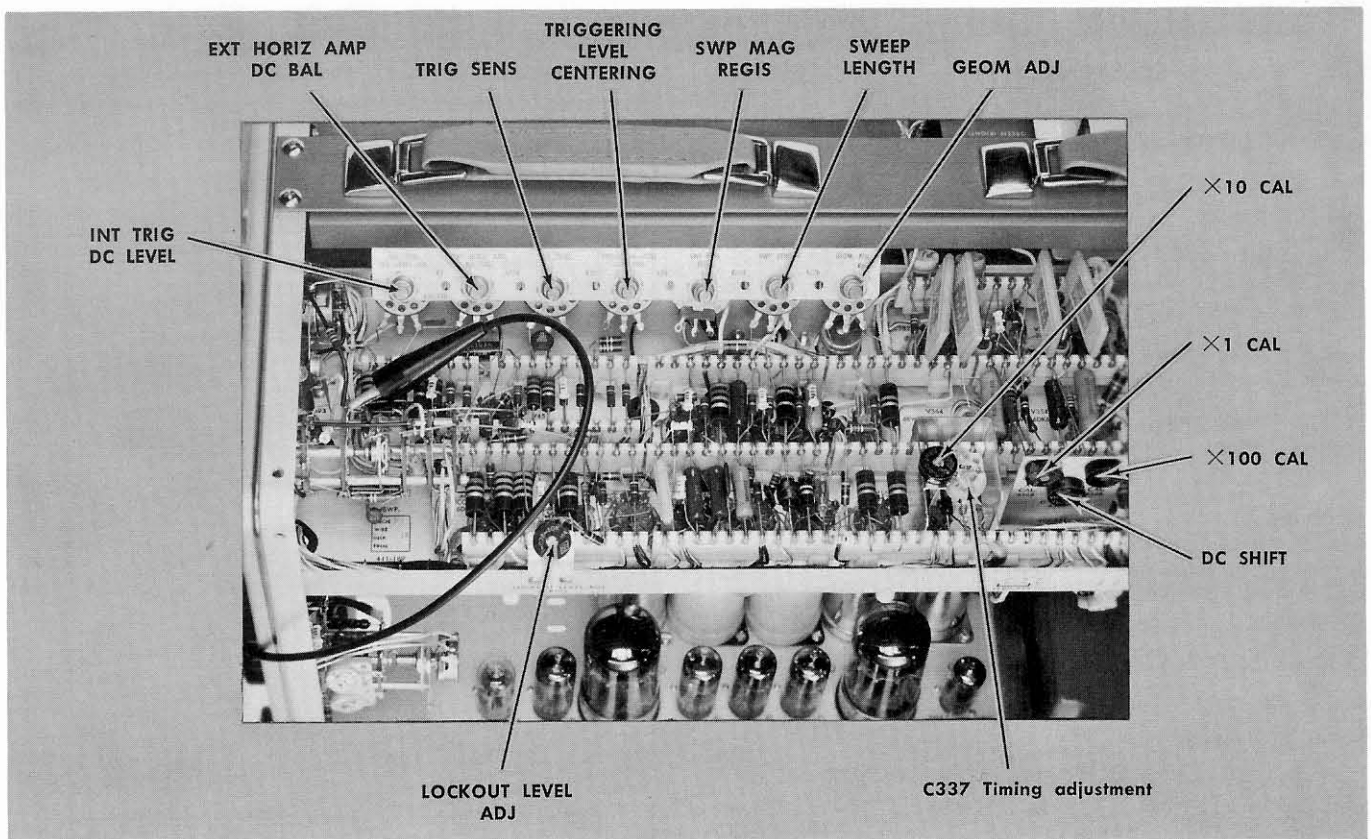


Fig. 6-6. Calibration adjustment locations.

base sweep rates: It is quite difficult to detect small sweep rate errors on the order of 1 or 2% unless measurement is made using most of the graticule width. It is therefore recommended that the sweep rates be checked for correct linearity and timing using the center 8 cm and the middle 80% of the display as shown in Fig. 6-7. With the measurement taken over a distance of 8 cm, the adjustment can be made more accurately. Further on in the procedure when you check the non-adjustable sweep rates a 1.6 mm error would indicate a 2% sweep-rate error as shown in Fig. 6-7. The marker peak provides an excellent reference point, particularly if the amplitude is such that the base line is below the crt viewing area and the tips of the markers are located in the center of the crt. When using the sine waves for markers at the higher sweep rates, set the 1M1 (TU-7) Variable and Vertical Position Controls so the lower half of the display is positioned below the crt and the tips of each cycle are near the center of the display. By increasing the amplitude of the display in this manner each marker or cycle tip appears much narrower.

The adjustable sweep rates should be set for maximum accuracy. When adjusting the timing capacitors, use a screwdriver having a metal tip and a non-metallic shank to minimize capacitance disturbance to the circuit. This will also lessen the

change of accidentally grounding connections elevated above or below ground.

With some time and care spent in making the adjustments described, as accurately as possible, the magnified sweep timing can be adjusted to $\pm 5\%$ or better.

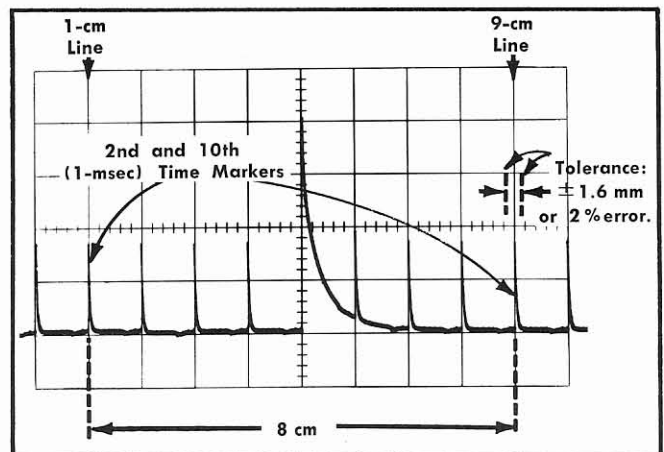


Fig. 6-7. Determining sweep-rate accuracy.

19. Adjust X1 CAL (X1 Sweep Calibration) R368—Horizontal Amplifier

- a. Set the SWEEP MAGNIFIER switch to NORMAL (X1).
- b. Adjust the X1 CAL R368 adjustment so the 1 mSEC markers are spaced 1-cm apart and so the 1-cm markers at the 1-cm and 9-cm points coincide with the graticule lines.

20. Adjust X100 CAL (X100 Sweep Calibration) R356—Horizontal Amplifier

- a. Set the SWEEP MAGNIFIER switch to X100 position.
- b. Remove the 100 μ SEC, 1 mSEC and 5 mSEC markers and apply 10 μ SEC markers to the input of the Type 1M1 (TU-7).
- c. Adjust the X100 CAL R356 adjustments so the 10 μ SEC markers are spaced 1-cm apart and so the 1-cm and 9-cm points coincide with the graticule lines.
- d. Due to some interaction between the CAL controls, repeat steps 18, 19 and 20 until the timing is correct or within tolerance.

21. Check X2, X5, X20 and X50 SWEEP MAGNIFIER positions—Horizontal Amplifier

- a. Apply 100 μ SEC markers from the Time-Mark Generator to the Input of the Type 1M1 (TU-7).
- b. Set the SWEEP MAGNIFIER switch to the X50 position and check for 1 marker per 5 cm.
- c. Set the SWEEP MAGNIFIER switch to X20 position and check for 1 marker per 2 cm.
- d. Remove the 100 μ SEC markers and apply 1 mSEC markers to the Input of the Type 1M1 (TU-7).
- e. Set the SWEEP MAGNIFIER switch to X5 position and check for 1 marker per 5 cm.
- f. Set the SWEEP MAGNIFIER switch to the X2 position and check for 1 marker per 2 cm.

22. Check MAGNIFIER ON Neon—Horizontal Amplifier

- a. Check to see that the MAGNIFIER ON neon is lit when the MAGNIFIER switch is at any of the magnified positions.
- b. Set the SWEEP MAGNIFIER switch to NORMAL (X1) position. Check to see that the Neon light is not on.

23. Adjust DC SHIFT adjustment R365—Horizontal Amplifier

- a. Remove the signal from the Input to the Type 1M1 (TU-7) plug-in unit.
- b. Set the HORIZONTAL DISPLAY switch to X100 SWEEP MAGNIFIED position.
- c. Turn the STABILITY control clockwise until the sweep free runs.
- d. Adjust the HORIZONTAL POSITION control to place the start of the trace on the 1st vertical graticule line.
- e. Slowly turn the trace off and on with the STABILITY control and observe the start of the trace for drift.

- f. Adjust the DC SHIFT adjustment R365 for minimum drift.

24. Adjust SWP LENGTH (Sweep Length) R176—Horizontal Amplifier

- a. Set the HORIZONTAL DISPLAY switch to NORMAL (X1) position.
- b. Turn the STABILITY control clockwise to free run the trace.
- c. Adjust the HORIZONTAL POSITION control to set the start of the trace on the extreme left (0) vertical graticule marker.
- d. Adjust the SWP LENGTH adjustment R176 for a sweep length of 10.4 ± 0.2 centimeters.

25. Check and Adjust Sweep Timing—Timing Switch and Horizontal Amplifier

Accuracy within 3% of full scale on all sweep rates, magnifier within 5% when magnified sweep rate does not exceed the maximum calibrated rate of 0.02 μ SEC/cm.

- a. Set the front-panel controls as follows:

Type 533/533A

STABILITY	PRESET
TRIGGERING LEVEL	full clockwise
TRIGGERING MODE	AC SLOW (AC)
TRIGGER SLOPE	+INT
TIME/CM	1 mSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL (X1)
NORMAL SWEEP/SINGLE SWEEP	NORMAL SWEEP
CALIBRATOR	OFF

Type 1M1 (TU-7) plug-in unit

Variable	5
Test Function	Low Load
Vertical Position	Approximately centered
Variable	So the display is 4 cm in amplitude

- b. Connect the output from the Time-Mark generator to the Ext Input of the Type 1M1 (TU-7) through a coaxial cable.

- c. Check VARIABLE (TIME/CM) and UNCALIBRATED Neon—Sweep Timing Switch

(1) Set the Time-Mark generator for 10 mSEC and 5 mSEC time-mark output.

(2) Adjust the HORIZONTAL POSITION control to position the start of the display on the 0 cm graticule line.

(3) Adjust the Type 1M1 (TU-7) Variable control so the 10 mSEC markers are 4 cm in amplitude.

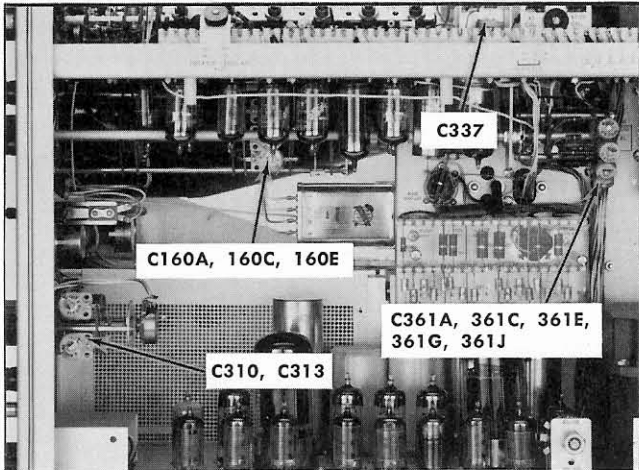
(4) Adjust the TRIGGERING LEVEL control for a stable display.

Calibration Procedure—Type 533/533A

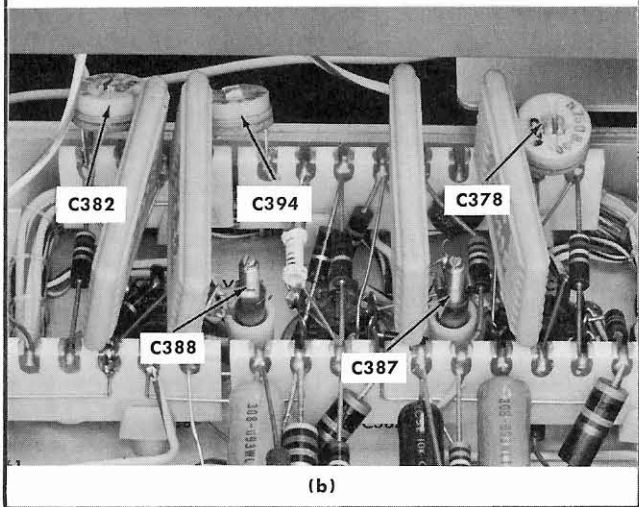
(5) Rotate the VARIABLE (TIME/CM) control slowly counterclockwise. Check to see that the UNCALIBRATED neon ignites when the switch is activated.

(6) Rotate the VARIABLE control full counterclockwise. At least 25 mSEC of time for a distance of 10 cm should be displayed to indicate a ratio of at least 2.5:1. That is, each 5 mSEC marker should be spaced at intervals of 2 cm or less.

(7) Set the VARIABLE control to the CALIBRATED position.



(a)



(b)

Fig. 6-8. Location of major timing adjustment.

d. Adjust C337—Horizontal Amplifier

(1) Set the Time-Mark generator for 50 μ SEC marker output.

(2) Set the TIME/CM switch to 50 μ SEC.

(3) Set the 1M1 (TU-7) Variable control so the markers are 4 cm in amplitude.

(4) Adjust the TRIGGERING LEVEL control for a stable display.

(5) Adjust C337 so the starting position of the trace is the same while switching the TIME/CM switch from 50 μ SEC to .1 mSEC.

e. Adjust C160A, .1 to .5 μ SEC Timing Adjustment—Timing Switch; and C361A for linearity—Horizontal Amplifier

(1) Set the Time-Mark generator for 10 mc output.

(2) Set the TIME/CM switch to .1 μ SEC position.

(3) Adjust the TRIGGERING LEVEL control for a stable display.

(4) Set the Type 1M1 (TU-7) Variable control for a signal amplitude of 4 cm.

(5) Adjust C160A for timing and C361A for linearity. Adjust for 1 cycle/cm from 1 cm to the 9 cm graticule lines.

f. Adjust C160C, 1 to 5 μ SEC Timing Adjustment—Timing Switch

(1) Set the Time-Mark generator for 1 μ SEC marker output.

(2) Set the TIME/CM switch to 1 μ SEC position.

(3) Adjust the TRIGGERING LEVEL control for a stable display.

(4) Adjust the Type 1M1 (TU-7) Variable control for a marker amplitude of 4 cm.

(5) Adjust C160C for 1 marker/cm.

g. Adjust C160E 10 to 50 μ SEC Timing Adjustment—Timing Switch

(1) Set the Time-Mark generator for 10 μ SEC marker output.

(2) Set the TIME/CM switch to 10 μ SEC position.

(3) Adjust C160E for 1 marker/cm.

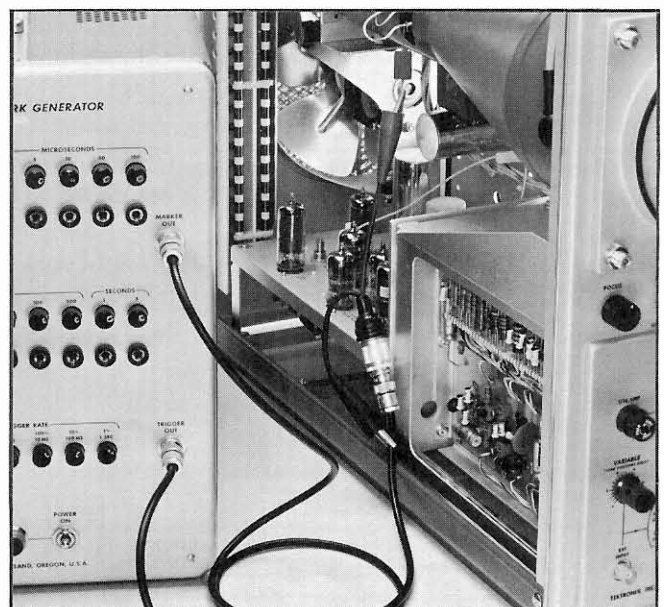


Fig. 6-9. Connecting 50 mc signal to vertical deflection plates.

h. Adjust C387, C388, C378, C382 and C394, Fast Sweep Rate Timing Adjustments—Horizontal Amplifier. (On some instruments C394 is a fixed capacitor).

(1) Connect the output of the Time-Mark generator through a coaxial cable, on adapter (BNC to clip lead, Tektronix No. 013-076) and a small capacitor to the vertical deflection plates (Fig. 6-9).

CAUTION

Deflection plates are elevated approximately 300 volts.

(2) Connect the Trigger Out connector of the Time-Mark generator to the TRIGGER INPUT connector on the Type 533/533A.

(3) Set the TRIGGER SLOPE switch to +EXT position.

(4) Set the Trigger Output of the Time-Mark generator to a 100 kc rate and the Marker Output for a frequency of 50 mc. (This will synchronize the sweep rate so the 50 mc signal may be observed.)

(5) Set the TIME/CM switch to 5 μSEC and the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIED X100 position.

(6) Adjust the TRIGGERING LEVEL control for a stable display.

(7) Preset C387 and C388 so the slugs are protruding about 3/8".

(8) Adjust C394 (current boost) for maximum compression of the center portion of the sweep.

(9) Set TIME/CM switch to 2 μSEC position and adjust C378 and C382 for timing.

(10) Set TIME/CM switch to 1 μSEC and the SWEEP MAGNIFIER to X50 then check timing and linearity. If timing is not within ±5% return the TIME/CM switch to 2 μSEC position and the SWEEP MAGNIFIER switch to X100. Then repeat steps 8 and 9. Final adjustment on these capacitors is a trial and error process, since each adjustment interacts with the other.

(11) Check .5 μSEC X20 (5 cycles every 4 cm), and .2 μSEC X10 (1 cycle/cm) for timing and linearity. Must be within ±5%.

i. Adjust C361C for Timing and Linearity—Horizontal Amplifier

(1) Set the TIME/CM switch to .1 μSEC and the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIED X2.

(2) Adjust C361C for 5 cycles every 2 cm (50 mc still applied from the Time-Mark generator).

j. Adjust C361E for Timing and Linearity—Horizontal Amplifier

(1) Set the TIME/CM switch to .1 μSEC and the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIED X5.

(2) Adjust C361E for 1 cycle/cm.

k. Adjust C361G for Timing and Linearity—Horizontal Amplifier

(1) Set the TIME/CM switch to .2 μSEC and the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIED X10.

(2) Adjust C361G for 1 cycle/cm.

l. Adjust C361J for Timing and Linearity—Horizontal Amplifier

(1) Set TIME/CM switch to 1 μSEC and the HORIZONTAL DISPLAY switch to SWEEP MAGNIFIED X20.

(2) Adjust C361J for 5 cycles/2 cm.

m. Recheck the adjustment of C160A and C361A

(1) Repeat step 26e. If they require adjustment repeat steps 26h through 26l. (Interaction is possible.)

(2) Remove the coupling capacitor to the deflection plates of the crt.

n. Check .1 μSEC/CM through 5 SEC/CM Sweep Rates—Timing Switch and Horizontal Amplifier

(1) Connect the Time-Mark generator output to the Ext Input of the Type 1M1 (TU-7) and the Trigger Out connector of the Time-Mark generator to the TRIGGER INPUT of the Type 533/533A.

(2) Set the front-panel controls of the Type 533/533A and Type 1M1 (TU-7) as follows:

Type 533/533A

STABILITY	PRESET
TRIGGERING LEVEL	0
TRIGGERING MODE	AC
TRIGGER SLOPE	+EXT
TIME/CM	.1 μSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL (X1)
NORMAL SWEEP/SINGLE SWEEP	NORMAL SWEEP

Type 1M1 (TU-7) plug-in unit

Test Function	Low Load
Variable	Approx. 3

(3) Using Table 6-2 as a guide, check each Time Base sweep rate. Tolerance is ±3% for each sweep rate. Refer to Fig. 6-7 to determine % of error.

(4) After checking the sweep rates, remove the Time-Mark generator and interconnecting cables from the oscilloscope/1M1 (TU-7) combination.

26. Adjust LOCKOUT LEVEL ADJ R125 Sweep Lockout Level—Time-Base Generator

Set the front-panel controls as follows:

TABLE 6-2

TIME/CM Setting	Time-Mark Gen. Marker Output	Time-Mark Gen. Trigger Rate	Observe	Tolerance In Millimeters
.1 μSEC	10 mc	100 kc	1 cycle/cm	2.4
.2 μSEC	5 mc	100 kc	1 cycle/cm	2.4
.5 μSEC	1 μSEC	100 kc	1 marker/2 cm	2.4
1 μSEC	1 μSEC	100 kc	1 marker/cm	2.4
2 μSEC	1 μSEC	100 kc	2 markers/cm	2.4
5 μSEC	5 μSEC	100 kc	1 marker/cm	2.4
10 μSEC	10 μSEC	100 kc	1 marker/cm	2.4
20 μSEC	10 μSEC	10 kc	2 markers/cm	2.4
50 μSEC	50 μSEC	10 kc	1 marker/cm	2.4
.1 mSEC	100 μSEC	10 kc	1 marker/cm	2.4
.2 mSEC	100 μSEC	10 kc	2 markers/cm	2.4
.5 mSEC	500 μSEC	1 kc	1 marker/cm	2.4
1 mSEC	1 mSEC	1 kc	1 marker/cm	2.4
2 mSEC	1 mSEC	1 kc	2 markers/cm	2.4
5 mSEC	5 mSEC	100 cycles	1 marker/cm	2.4
10 mSEC	10 mSEC	100 cycles	1 marker/cm	2.4
20 mSEC	10 mSEC	100 cycles	2 markers/cm	2.4
50 mSEC	50 mSEC	10 cycles	1 marker/cm	2.4
.1 SEC	100 mSEC	10 cycles	1 marker/cm	2.4
.2 SEC	100 mSEC	10 cycles	2 markers/cm	2.4
.5 SEC	500 mSEC	1 cycle	1 marker/cm	2.4
1 SEC	1 SEC	1 cycle	1 marker/cm	2.4
2 SEC	1 SEC	1 cycle	2 markers/cm	2.4
5 SEC	5 SEC	1 cycle	1 marker/cm	2.4

Type 533/533A

STABILITY	Counterclockwise but not to PRESET
TRIGGERING LEVEL	0
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
TIME/CM	.5 mSEC
HORIZONTAL DISPLAY	NORMAL (X1)

Type 1M1 (TU-7) plug-in unit

Test Function	Low Load
Variable	Full clockwise

- a. Connect the VOM to pin 3 of V133.
- b. Turn the STABILITY control clockwise to a point just before the sweep free runs.
- c. Check VOM reading at this point.
- d. Set the NORMAL SWEEP/SINGLE SWEEP switch in the SINGLE SWEEP position. The neon READY light should come on.
- e. Trigger the sweep by turning the STABILITY control full clockwise. The READY light should extinguish, indicating the sweep is locked out.
- f. Adjust the LOCKOUT LEVEL ADJ R125 for a VOM reading 11 volts less negative than the previous reading.

g. Return the NORMAL SWEEP/SINGLE SWEEP switch to the NORMAL position.

h. Connect the output of the Standard Amplitude Calibrator to the Ext Input of the Type 1M1 (TU-7) and set the output to .5 volts.

i. Adjust the STABILITY and TRIGGERING LEVEL controls for a stable display.

j. Remove the cable to the Type 1M1 (TU-7) Ext Input and depress the NORMAL SWEEP/SINGLE SWEEP switch to the RESET position then release to the SINGLE SWEEP position.

k. The READY light should ignite indicating the sweep circuit is armed.

l. Connect the coaxial lead from the Standard Amplitude Calibrator to the Ext Input connector of the Type 1M1 (TU-7) and check to see that the sweep circuit triggers and the READY light goes out at the completion of the sweep.

m. Turn the STABILITY control left (ccw) but not to PRESET. The READY light should ignite but the sweep should not retrigger.

n. Set the NORMAL SWEEP/SINGLE SWEEP switch in the NORMAL position.

27. Adjust EXT HORIZ AMP DC BAL R334 (External Horizontal Preamp Balance)—Horizontal Amplifier

a. Connect a patch cord between Type 1M1 (TU-7) Ext Input connector and the SAWTOOTH OUT connector by the use of BNC to binding post adapter and 18" patchcord with banana plugs.

CAUTION

Do not ground the SAWTOOTH OUT signal. This voltage can be harmful, therefore exercise extreme caution when connecting the patchcord.

b. Set the STABILITY control full clockwise so the trace is free running.

c. Set the HORIZONTAL DISPLAY switch to the EXT position.

d. Center the vertical trace on the crt with the HORIZONTAL POSITION controls.

e. Set the EXTERNAL HORIZONTAL VOLTS/CM switch to 10.

f. Adjust EXT HORIZ AMP DC BAL adjustment R334 (located on the 7 pot mounting bracket) for no horizontal trace shift as the EXTERNAL HORIZONTAL VARIABLE control is rotated through its range. Trace shift must be 0.5 cm or less.

g. Remove the patchcord and adapter from the Type 1M1 (TU-7) Input and the SAWTOOTH OUT connector.

28. Adjust External Horizontal Preamp Gain R361M—Horizontal Amplifier

Set the front-panel controls as follows:

STABILITY	Full clockwise
HORIZONTAL DISPLAY	EXT
EXTERNAL HORIZONTAL VOLTS/CM	.1
VARIABLE (EXTERNAL HORIZONTAL)	CALIBRATED

a. Apply a 0.5 volt signal from the Standard Amplitude Calibrator to the EXTERNAL HORIZ IN connector.

b. Adjust the EXT HORIZ AMP CAL control R361M (located on top of the HORIZONTAL DISPLAY switch) for 5 cm of horizontal deflection.

c. Turn the EXTERNAL HORIZONTAL VOLTS/CM switch to 1 and apply 5 volt signal from the Standard Amplitude Calibrator. Check for 5 cm $\pm 3\%$ of horizontal deflection.

d. Set the EXTERNAL HORIZONTAL VOLTS/CM switch to 10 and check the deflection with a 50 v signal applied to the EXTERNAL HORIZ IN connector. Deflection should be 5 cm $\pm 3\%$.

29. Adjust C310 and C313 External Horizontal Attenuator Compensation—Horizontal Amplifier

Set the front-panel controls as follows:

STABILITY	PRESET
TRIGGERING MODE	AC
TRIGGER SLOPE	+EXT
TIME/CM	.5 mSEC
HORIZONTAL DISPLAY	EXT

EXTERNAL HORIZONTAL 1
VOLTS/CM

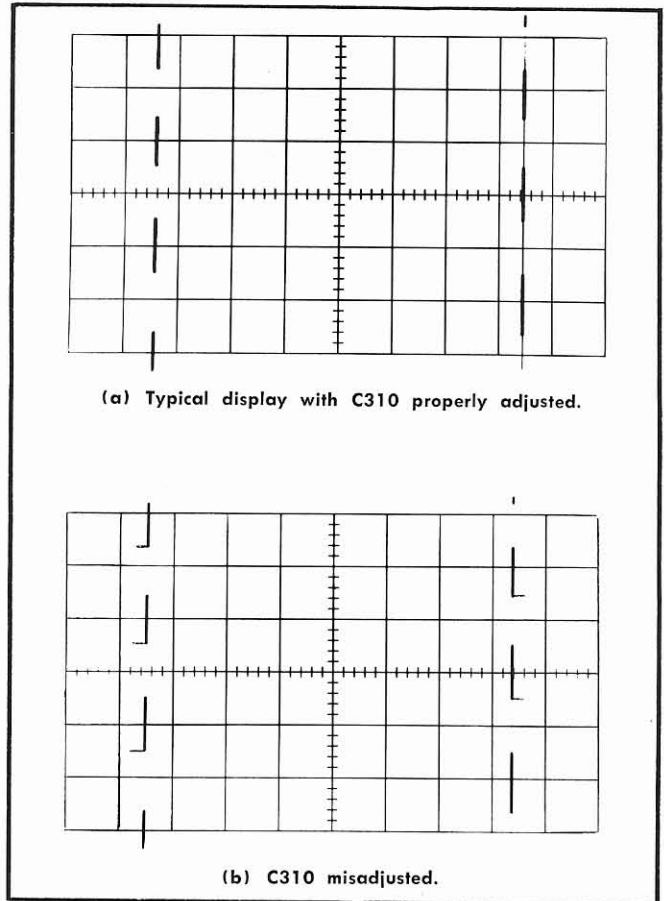
VARIABLE CALIBRATED

a. Apply a 5 volt signal from the Standard Amplitude Calibrator to the EXTERNAL HORIZ IN connector.

b. Connect a patchcord between the EXTERNAL HORIZ IN connector and the TRIGGER INPUT connector.

c. Connect a patchcord between the SAWTOOTH OUT connector and the Ext Input of the Type 1M1 (TU-7).

d. Adjust the TRIGGERING LEVEL control for a stable display and the Type 1M1 (TU-7) Variable control so several cycles of the Calibrator waveform are displayed (Fig. 6-10).



(a) Typical display with C310 properly adjusted.

(b) C310 misadjusted.

Fig. 6-10. Typical waveform displays with C310 and C313 properly adjusted and misadjusted.

e. Adjust C310 for optimum waveform (see Fig. 6-10). Should not have more than 5% aberration or tilt.

f. Set the EXTERNAL HORIZONTAL VOLTS/CM switch to 10 and increase the Standard Amplitude Calibrator signal to 50 volts.

g. Adjust C313 for optimum square wave presentation.

30. Check External Horizontal Amplifier VARIABLE control—Horizontal Amplifier

a. Rotate the VARIABLE control to the full counterclockwise position. Change the EXTERNAL HORIZONTAL VOLTS/CM switch to 1 and check for 5 cm or less deflection am-

Calibration Procedure—Type 533/533A

plitude. (This assures the VARIABLE control has an attenuation ratio of 10:1 or better.)

b. Return the VARIABLE control to the full clockwise position.

c. Remove the cable between the Standard Amplitude Calibrator and the EXTERNAL HORIZONTAL IN connector.

31. Check the External Horizontal Amplifier Bandpass—Horizontal Amplifier

a. Remove the patchcord between the TRIGGER INPUT connector and the EXTERNAL HORIZONTAL IN connector. There should still be a patchcord between the SAWTOOTH OUT connector and the Type 1M1 (TU-7) Ext Input.

b. Connect the output of the Constant-Amplitude signal generator to the EXTERNAL HORIZONTAL IN connector. (This may be accomplished by plugging the UHF type connector of the Attenuator box directly into the EXTERNAL HORIZONTAL IN connector.)

c. Turn the STABILITY control and the TRIGGERING LEVEL control full clockwise.

d. Set the EXTERNAL HORIZONTAL VOLTS/CM switch to .1 and the VARIABLE control to the CALIBRATED position. (.1 volt/cm.)

e. Set the frequency of the Constant-Amplitude signal generator to 50 kc and adjust its output for 4 cm of horizontal deflection.

f. Adjust the Variable control on the Type 1M1 (TU-7) for a vertical deflection of approximately 6 cm.

g. Increase the frequency of the Constant-Amplitude signal generator until the horizontal amplitude of the display decreases to 2.8 cm.

h. Check the frequency of the generator at this setting. Must be 500 kc or more.

i. Remove the output cable of the Constant-Amplitude signal generator and the patchcord from the front-panel connectors.

32. Adjust and Check the Amplitude Calibrator

Provides approximately 1 kc square wave with a peak-to-peak amplitude accuracy of $\pm 3\%$ of indicated value.

Set the Test Oscilloscope and Type D controls as follows:

Test Oscilloscope

HORIZONTAL DISPLAY	Main Time Base
MAGNIFIER	OFF or X1 position
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
TIME/CM	10 μ SEC
VARIABLE	CALIBRATED
STABILITY and TRIGGERING LEVEL	Full clockwise position

Differential Amplifier (Type D plug-in unit)

MILLIVOLTS/CM	1000
MV/CM MULTIPLIER	1
VARIABLE	CALIBRATED
Input Selector	A-B DC
Vertical Position	Centered

With no signal input, adjust the Fine and Preamp Balance controls for minimum vertical trace movement when the Variable MV/CM Multiplier control is varied. Allow 15 minutes warm-up time to stabilize the amplifier before proceeding with this check.

a. Connect the Standard Amplitude Calibrator to Input B of the Differential Amplifier through a 50 Ω coaxial cable.

b. Connect the Type 533/533A CAL OUT connector to Input A of the Differential Amplifier.

c. Set the Standard Amplitude Calibrator and the Type 533/533A AMPLITUDE CALIBRATOR switch to 2 volts. There should now be 3 or 4 parallel traces on the Test oscilloscope. The center trace or traces show the difference in amplitude of the two signals which are applied to inputs A and B of the Differential Amplifier (Fig. 6-11).

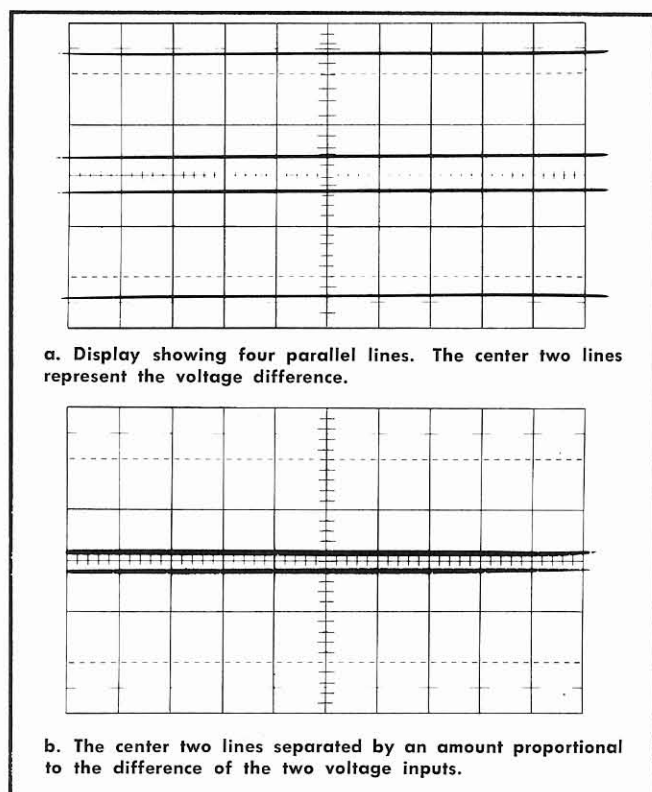


Fig. 6-11. Display of differential voltage measurement on test oscilloscope.

d. Increase the setting of both the Standard Amplitude Calibrator and the Type 533/533A AMPLITUDE CALIBRATOR to 100 volts. The center pair of lines will be the only

traces not displayed on the Test oscilloscope. The amount of separation of the two traces is proportional to the difference in voltage of the two calibrators.

e. Adjust CAL ADJ (R879) so the difference displayed on the Test oscilloscope is minimum or zero.

f. Set the Standard Amplitude Calibrator as per the following table and check the tolerance of the Type 533/533A AMPLITUDE CALIBRATOR.

TABLE 6-3

Standard Calibrator and TYPE 533/533A CALIBRATOR	Differential Amp. MILLI-VOLTS/CM	Allowable Error in CM
100 VOLTS	1000	3
50 V	1000	1.5
20 V	1000	.6
10 V	100	3
5 V	100	1.5
2 V	100	.6
1 V	10	3
.5 V	10	1.5
.2 V	10	.6
.1 V	1	3
50 mV	1	1.5

g. Check Symmetry and Risetime

(1) Set the Differential Amplifier MILLIVOLTS/CM switch to 1000 and the Input Selector switch to A DC.

(2) Set the Type 533/533A AMPLITUDE CALIBRATOR switch to 2 volts.

(3) Set the Test oscilloscope Time/cm switch to .1 mSEC.

(4) Set the Test oscilloscope Stability control to Preset and adjust the Triggering Level control for a stable display.

(5) Adjust the Test oscilloscope Variable Time/cm control to place one complete cycle of the square wave within the center 8 centimeters of the graticule area.

(6) Check for symmetry. The 1st half cycle of the square wave must be within $\pm 10\%$ of the time of the 2nd half cycle.

(7) Return the Test oscilloscope Time/cm Variable to the Calibrated position.

(8) Set the Test Oscilloscope Time/cm switch to 1 μ SEC and adjust the Triggering Level so the leading edge of the pulse is displayed.

(9) Adjust the Horizontal Position control so the leading edge of the waveform is on the center vertical graticule line.

(10) Measure the risetime (10 to 90% amplitude points) (Fig. 6-12). Risetime is typically 2 μ SEC or less. This is not a specification, but an indication of operating performance.

(11) Remove the cables from the Type 533/533A to the Differential Amplifier and turn the AMPLITUDE CALIBRATOR to OFF.

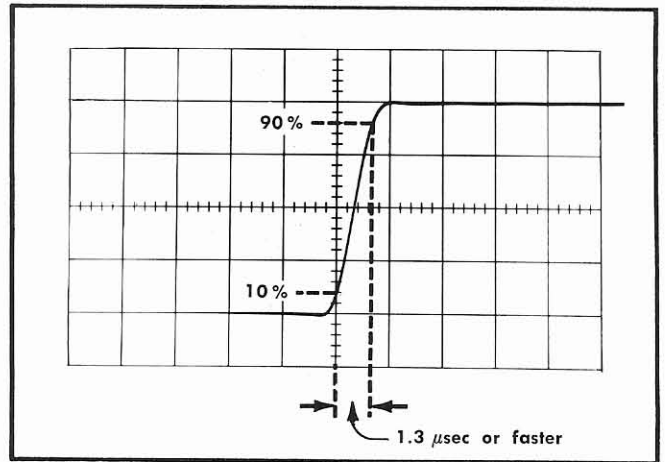


Fig. 6-12. Measuring the risetime of a normal waveform. Sweep rate is 2 μ Sec/cm.

33. Check CRT Cathode Input—CRT Circuit

A 20 volt signal on the cathode of the crt should intensity modulate the crt.

a. Set the STABILITY and TRIGGERING LEVEL controls full clockwise.

b. Set the HORIZONTAL DISPLAY switch to NORMAL (X1) position.

c. Set the TIME/CM switch to 1 mSEC position.

d. Remove the ground strap from the CRT CATHODE jack on the rear of the Type 533/533A and connect patchcords between the CAL OUT jack and the EXTERNAL CRT CATHODE connector.

e. Set the TRIGGER SLOPE switch to +INT position.

f. Set the AMPLITUDE CALIBRATOR switch to 20 volts.

g. Display should appear as a series of dots or dashes. The INTENSITY control may need adjustment counterclockwise to show this modulation.

h. Remove the patchcords and reconnect the ground strap to the EXTERNAL CRT CATHODE post.

34. Check and Adjust GAIN ADJ R570 (Vertical Amplifier Gain)—Vertical Amplifier

This step is a preliminary to checking the high-frequency compensation in step 38.

a. Turn the Type 1M1 (TU-7) Test Function switch to Gain Set position.

b. Apply the output of the Standard Square-Wave Amplitude Calibrator to the Ext Input of the Type 1M1 (TU-7) and adjust for an output of 100 volts.

c. Turn the STABILITY and TRIGGERING LEVEL controls full clockwise.

d. Set the TIME/CM switch to the 10 μ SEC position.

e. Check the display amplitude for exactly 4 cm, and if necessary adjust the GAIN ADJ. R570 (on the vertical am-

Calibration Procedure—Type 533/533A

plier chassis). When making this adjustment use the center 4 cm of the graticule.

f. Remove the output cable of the Standard Amplitude Calibrator from the Type 1M1 (TU-7) Input.

35. Check Vertical Amplifier Balance

a. Turn the Test Function switch of the Type 1M1 (TU-7) to Common Mode position. Note the trace position on the graticule.

b. Short the vertical deflection plates with a screwdriver or shorting strap. Plates are marked BLUE (UPPER) and BROWN (LOWER).

CAUTION

Deflection plates are elevated approximately 300 volts. Avoid electrical shock or grounding the plates to the crt shield.

c. Note the change in trace position. Trace shift should not be more than 2 cm.

36. Check and Adjust Graticule Alignment

a. Apply the output cable from the Constant-Amplitude signal generator to the Ext Input of the Type 1M1 (TU-7).

b. Set the Test Function switch of the Type 1M1 (TU-7) to Low Load position and the Variable control to full clockwise position.

c. Set the Constant-Amplitude signal generator to a frequency of 50 kc and adjust its output so the crt screen is flooded with a display. (This is utilizing the useable area of the crt.)

d. Remove the graticule cover and loosen the set-screw in the nylon cam at the lower right corner of the graticule.

e. Position the center line of the graticule in the center of the flooded display.

f. Tighten the set-screw and replace the graticule cover.

37. Check Compression and Expansion of crt and Vertical Circuit

a. Adjust the output of the Constant-Amplitude signal generator and the Variable control on the Type 1M1 (TU-7) for a 2 cm display amplitude.

b. Position the display to the top of the graticule (upper 2 cm markers on the graticule) and note the amplitude of the display.

c. Position the display to the bottom (lower 2 cm markers on the graticule) and check the amplitude of the display.

d. The increase or decrease in waveform vertical amplitude as the display is positioned to the top or bottom of the graticule area is the amount of expansion or compression.

With a 2 cm display the maximum allowable expansion or compression of this display is 1 mm at the top or bottom of the graticule area with a total of 2 mm overall.

e. Remove the output cable from the Constant-Amplitude signal generator from the Ext Input of the Type 1M1 (TU-7).

38. Check and/or Adjust High Frequency Compensation—Vertical Amplifier and Delay Line

Before proceeding with this step check steps 34 to 37.

Set the front-panel controls as follows:

Type 533/533A

STABILITY	full right
TRIGGERING LEVEL	full right
TRIGGERING MODE	AC FAST (AC LF REJECT)
TRIGGER SLOPE	+INT
TIME/CM	.2 μ SEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL (X1)
NORMAL SWEEP/SINGLE SWEEP	NORMAL SWEEP

Type 1M1 (TU-7)

Vertical Position	Centered
Test Function	+Pulse
Amplitude	\approx 7.5
Repetition Rate	Med

a. Using the oscilloscope HORIZONTAL POSITION control, position the display to start near the graticule center.

b. Set the 1M1 (TU-7) Amplitude and Vertical Position controls so the display is vertically centered on the crt and the amplitude of the step-waveform is exactly 4 cm.

c. Using the 1M1 (TU-7) Vertical Position control, position the waveform downward about 2 mm for easier visibility away from the graticule lines.

d. Adjust the INTENSITY control to increase the brightness of the display to normal viewing level.

e. Adjust the FOCUS and ASTIGMATISM controls to produce a well-defined leading top corner on the step waveform.

f. Examine the waveform for clean transient response. Typical waveform should appear similar to Fig. 6-13a.

g. Set the SWEEP MAGNIFIER switch to X10.

h. Measure the risetime of the rising portion of the waveform from the 10% point to the 90% point (see Fig. 6-13b). The risetime should not be any slower than 23 nsec based on a 3 nsec risetime pulse from the 1M1 (TU-7). (Take into consideration sweep-rate timing error, if any, and/or geometry in the area where the measurement is made.)

i. Turn SWEEP MAGNIFIER switch to (X1) position.

j. Fig. 6-13c shows the same waveform except for a small aberration in the top about 2 centimeters to the right of the leading corner. This aberration is known as the "termination bump", and was obtained by detuning the Delay Line termination network (C533-C563) slightly. The oscilloscope was adjusted for a sweep rate of .2 μ sec/cm for this

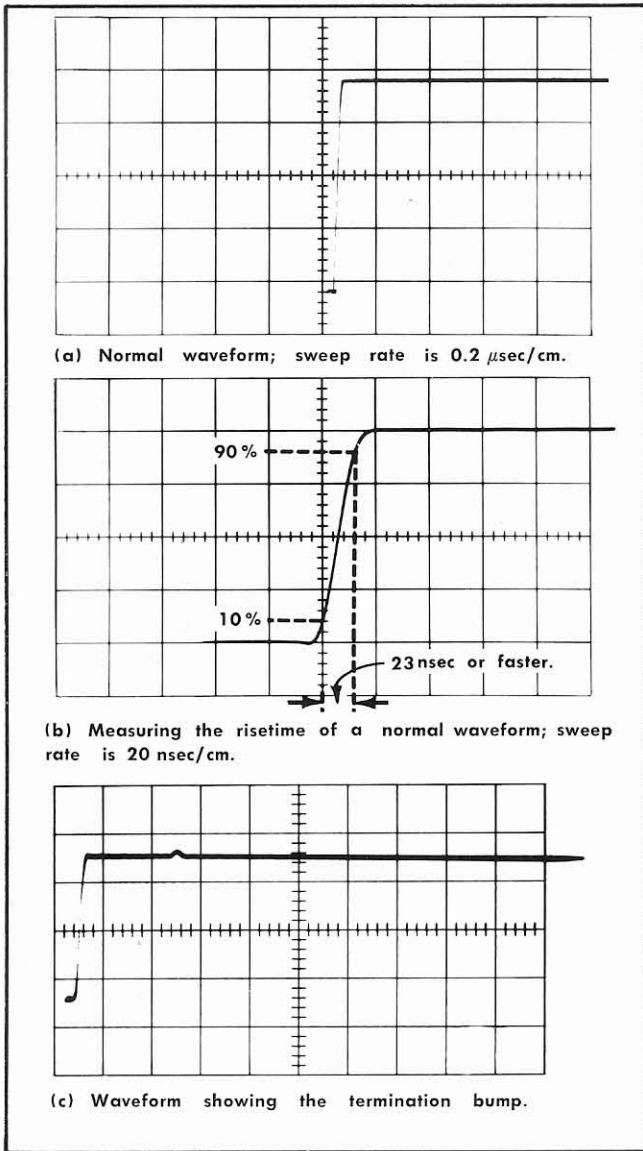


Fig. 6-13. The Type 1M1 (TU-7) waveform displayed on the Type 533/533A.

photograph; the termination bump therefore occurs .4 microseconds after the leading corner. Since the Delay Line is reverse terminated, this corresponds to twice the .2-microseconds delay of the circuit.

k. If the Type 1M1 (TU-7) waveform, when displayed on the Type 533/533A, does not appear as shown in Fig. 6-3a the Delay Line and/or peaking circuits are in need of adjustment.* The following facts should be remembered when adjusting the circuit:

(1) The Delay Line is reverse-terminated[†] (R533-R563).

The Delay-Line capacitors nearest the crt will affect the start of the pulse, i.e., the leading corner. The Delay-Line capacitors nearest the Vertical Amplifier will affect the pulse in the region of the termination bump.

*See also "Waveform Distortion" in the Maintenance section of this manual.

(2) The delay time of the line is 0.2 μ seconds; but since the line is reverse-terminated, the termination bump will appear 0.4 μ seconds after the corner.

(3) The termination bump is affected by the adjustment of the termination network (C553-C563), however the termination network also affects the corner of the pulse.

(4) The peaking adjustment ahead of the termination network and those at the crt deflection plates affect the leading corner of the waveform.

Adjustment Procedure

Minor Adjustment Required

A minor adjustment of the Delay Line and/or peaking circuits will be required when only the leading corner is rounded off or has a slight overshoot, when aberrations appear both at the leading corner and in the vicinity of the termination bump, or when there are slight aberrations in the top of the pulse (similar to those shown in Fig. 5-10c). By analyzing the type of distortion according to the information presented in the preceding paragraph and that presented in the Troubleshooting Procedure (under Waveform Distortion), it is generally an easy matter to locate the components that have been misadjusted and correct their adjustment.

Major Adjustment Required

A major adjustment of the Delay Line and peaking circuits may be required:

- If the Delay Line and/or Vertical Amplifier have been replaced;
- If the instrument has been subjected to severe vibration;
- If the adjustments have been tampered with.

There are four steps involved in making a major adjustment of the Delay Line and the Vertical Amplifier—presetting the adjustments, establishing a level display, removing the "wrinkles" in the top of the pulse, and compensating the amplifier.

Presetting the Adjustments

If the displayed pulse on the crt indicates that the Delay Line and peaking circuits are considerably out of adjustment, presetting the controls before starting the adjustment procedure will generally render the best results.

The variable inductors L506 and L523, located in the plate circuit of the Input Amplifier, should be preset so that the cores are positioned deeper into the coil forms than the windings of the coils extend. L553 and L563, located in the plate circuit of the Output Amplifier, each has two cores...an inner core and an outer core. The inner core can be reached by using the small end of alignment tool 003-301. The inner cores should be positioned deeper into the coil forms than the windings of the coils extend; the outer cores should be positioned just out of the windings. The two variable inductors at the crt end of the line (L955 and L956) should be preset so that the cores are also just out of the windings. By presetting the inductors in this manner their effect in the circuit is reduced and the adjustment of the Delay Line is simplified.

Calibration Procedure—Type 533/533A

The variable capacitors in the delay line should be preset so that the top of the adjusting screw extends about one-quarter of an inch above the top of the contact springs, or if preferred about three-eighths of an inch above the body of the capacitor. The important characteristic is that the tops of all adjusting screws should be at about the same height, both after the preset procedure and after the final adjustment.

The capacitors in the termination network (C553-C563) are the first to be adjusted in the adjustment procedure; for this reason it is unnecessary to preset these adjustments.

Establishing a Level Display

The reference level for the displayed waveform is established by that portion of the pulse following the termination bump. The first step, therefore is the adjustment of the termination network. Observe the pulse closely about two centimeters to the right of the leading corner, and adjust C553 and C563 for the minimum termination bump.

The level of that portion of the pulse preceding the termination bump is determined by the collective effect of L553 and L563, and all the Delay-Line capacitors. The top of the pulse should be level (not necessarily wrinkle-free at this time); that is, there should be neither an upward nor downward slant to the top of the pulse between the termination bump and the corner. The level can best be checked by reducing the sweep rate to about $20 \mu\text{SEC}/\text{CM}$; this reduces the width of the top of the pulse and "crowds" the wrinkles into a smoother display. The reduction in pulse width makes any departure from a level display more easily observed.

To improve the level of the display, adjust L553 and L563 (both cores) until the top of the waveform adjacent to the termination bump is level. Then, starting with the Vertical Amplifier end of the Delay Line, adjust each capacitor a small amount, carefully observing the top of the waveform for the result. Be sure to retain a level top when progressing toward the crt end of the line.

After making the preceding adjustments and establishing an average level for the display, advance the sweep rate to $2 \mu\text{SEC}/\text{CM}$ and repeat the procedure. This time, try to adjust the inductors and capacitors for a smooth transition from bump to bump, at the same time maintaining the level. Do not try to obtain a wrinkle-free display at this time; just try to reduce the amplitude of all the bumps the same amount. The important consideration is to retain the level of the display.

Removing the Bumps and Wrinkles

After making the preceding adjustments and reducing the amplitude of the bumps a bit, you can start removing the wrinkles and bumps to a greater degree. Again start with the Vertical Amplifier end and work through the line to the crt.

Advance the sweep rate to $.5 \mu\text{SEC}/\text{CM}$ and adjust C553, C563, L553 and L563 again to reduce the wrinkles in the vicinity of the termination bump. Do not try to achieve a perfectly straight line across the top of the display at this time; just reduce the amplitude of the bumps by about one-half. Then advance to the first group of capacitors in the

Delay Line (about four or five) and adjust them for a reasonably smooth line over that portion of the display they affect. Keep in mind that each capacitor will require only a slight adjustment, and that it is the combined effect of a group of capacitors with which you must be concerned. As you advance along the line, from one group of capacitors to the next, reduce the sweep rate from time to time to check the level. It is just as important to maintain the level of the display as it is to obtain a wrinkle-free display.

After traversing the entire length of the line, advance the sweep rate to $.2 \mu\text{SEC}/\text{CM}$ and repeat the process. Be extremely careful in your adjustments at this time. Any capacitors that require adjustment will need only a slight touch... any over-adjustment might nullify all of your efforts up to this point. From time to time switch back to a sweep rate of $20 \mu\text{SEC}/\text{CM}$ to check the level.

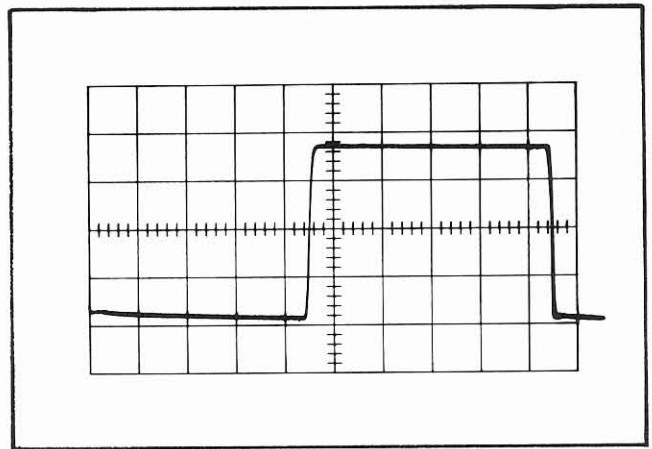


Fig. 6-14. The level, wrinkle-free display indicates proper adjustment of the Delay Line; the rounded corner is due to the fact that the variable inductors in the Vertical Amplifier and at the crt end of the line have not as yet been adjusted from their preset position.

Final Compensation

Upon completing this portion of the adjustment, the display should appear similar to Fig. 6-14. That is, the display should be level and free from aberrations, with a pronounced rolloff at the leading corner. Then adjust L506 and L523 in the Vertical Amplifier and L955 and L956 at the crt end of the line, being careful to adjust any two that make up one pair the same amount. Continue adjusting each pair of inductors, maintaining balance, until the corner begins to square up. This process will introduce some new wrinkles in the display, but these can easily be removed by adjusting the first few capacitors of the Delay Line at the crt end of the line. When the Delay Line and Vertical Amplifier are in proper adjustment, the display should appear similar to Fig. 6-13a.

39. Check External Triggering—Time-Base Trigger

a. Connect a BNC 'T' connector to the TRIGGER INPUT connector.

b. Connect coaxial cables between the CAL OUT connector and one side of the BNC 'T' connector on the TRIGGER INPUT, also a cable between the other side of the 'T' connector and the Ext Input of the Type 1M1 (TU-7).

c. Set the AMPLITUDE CALIBRATOR switch to .2 volts.

d. Set the TIME/CM switch to .5mSEC position and the HORIZONTAL DISPLAY switch to NORMAL (X1) position.

e. Set the TRIGGERING MODE switch to DC and the TRIGGER SLOPE switch to EXT — (minus) position.

f. Check for proper triggering with the TRIGGERING MODE switch in DC, AC, AC LF REJECT and AUTO positions and the TRIGGER SLOPE switch in both + and — EXT position. (It may be necessary to readjust the TRIGGERING LEVEL control for each position of the TRIGGERING MODE and SLOPE switches.)

g. Set the AMPLITUDE CALIBRATOR switch to 10 volts and adjust the Type 1M1 (TU-7) Variable control to reduce the waveform amplitude to 2 cm.

h. Set the TRIGGERING MODE switch to the AC position.

i. Vary the TRIGGERING LEVEL control from extreme clockwise to counterclockwise position. The display should disappear at both extremes.

j. Remove the cable between the CAL OUT connector and the BNC 'T' connector.

40. Check HF Sync.—Time-Base Generator

a. Connect the output cable from the Constant-Amplitude signal generator to the BNC 'T' connector on the TRIGGER INPUT.

b. Set the front-panel controls as follows:

Type 533/533A

STABILITY	Full clockwise
TRIGGERING LEVEL	0
TIME/CM	.1 μSEC
HORIZONTAL DISPLAY	NORMAL (X1)
TRIGGERING MODE	HF SYNC
TRIGGERING SLOPE	EXT +

Type 1M1 (TU-7)

VARIABLE	Full clockwise
Test Function	High Load

c. Set the frequency of the Constant-Amplitude signal generator to 30 mc and adjust its Attenuator and Output Amplitude control for a 2 cm display amplitude.

d. Adjust the STABILITY control for a stable display.

e. Check for stable triggering with the TRIGGER SLOPE switch in —EXT, and +INT positions.

41. Check Vertical Bandpass—Vertical Amplifier

a. Remove all interconnecting cables on the Type 533/533A and 1M1 (TU-7); remove the 1M1 (TU-7) from the Type 533/533A.

b. Install a properly calibrated Type K Unit in the Type 533/533A.

c. Connect the output cable from the Constant-Amplitude signal generator to the INPUT connector of the Type K Unit.

d. Set the front-panel controls as follows:

Type 533/533A

STABILITY	full right
TRIGGERING LEVEL	any position
TRIGGER SLOPE	INT (+ or —)
TRIGGER MODE	AC LF REJECT, AC or DC
TIME/CM	1 MILLISEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	NORMAL

Type K Unit

AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED

e. Set the frequency of the Constant-Amplitude signal generator to 500 kc and adjust the output for a 4-cm vertical display amplitude.

f. Increase the Constant-Amplitude signal generator frequency until the display amplitude decreases to 2.8 cm.

g. Check the frequency of the Constant-Amplitude signal generator. Must be 15 mc or higher.

h. Remove the output cable from the Type K Unit INPUT connector; remove the Type K Unit from the Type 533/533A.

i. Install the Type 1M1 (TU-7) in the Type 533/533A.

42. Check Line Triggering—Time-Base Trigger

a. Connect a 10X probe to the input of the Type 1M1 (TU-7).

b. Set the TIME/CM switch to the 5 mSEC position.

c. Set the TRIGGER SLOPE switch to +LINE and the TRIGGERING MODE switch to AC.

d. Connect the probe tip to the high side of the same AC power line to which the Type 533/533A is connected.

e. Adjust the TRIGGERING LEVEL control for a stable display.

f. Check the triggering polarity against the setting of the TRIGGER SLOPE switch. (Must trigger on the positive portion of the signal.)

g. Check for proper triggering with the TRIGGER SLOPE switch in —LINE position.

h. Remove the 10X probe from the AC power source.

43. Check Front-Panel Waveforms

a. SAWTOOTH OUT

Calibration Procedure—Type 533/533A

(1) Set the front-panel controls of the Type 533/533A as follows:

STABILITY and TRIGGERING LEVEL	Full clockwise
TIME/CM	.1 mSEC
TRIGGERING MODE	AC
TRIGGERING SLOPE	+INT

(2) Connect a 10X probe between Input A of the Differential Amplifier in the Test oscilloscope and the SAWTOOTH OUT connector of the Type 533/533A.

(3) Set the Test oscilloscope and the Differential Amplifier controls as follows:

Test oscilloscope

Time/cm	1 mSEC
Stability	Preset
Triggering Mode	AC
Trigger Slope	+Int
Horizontal Display	Main Time Base

Differential Amplifier

Input Selector	A DC
Millivolts/cm	1000
MV/CM Multiplier	10

b. Connect coaxial cables between the CAL OUT connector and one side of the BNC 'T' connector on the TRIGGER INPUT, also a cable between the other side of the 'T'

c. VERT SIG OUT.

(1) Connect coaxial cable between CAL OUT connector and the Ext Input of the Type 1M1 (TU-7).

(2) Set the AMPLITUDE CALIBRATOR switch to 1 volt and adjust the Type 1M1 (TU-7) Variable for a display amplitude of 2 cm.

(3) Set the Differential Amplifier Millivolts/cm switch to 100.

(4) Connect the 10X probe to the VERT SIG OUT connector on the Type 533/533A.

(5) Check for a minimum display amplitude of 3 cm on the Test oscilloscope. (1.5 volts/cm min.)

(4) Adjust Triggering Level control of the Test oscilloscope for a stable display. Amplitude of the sawtooth should be 130 to 170 volts with the exception of the faster sweep rates in which case the amplitude may increase to 200 volts.

b. +GATE OUT

(1) Remove the probe from the SAWTOOTH OUT connector and reconnect to the +GATE OUT connector.

(2) Set the TIME/CM switch to .5 μ SEC.

(3) Set the TIME/CM switch on the Test oscilloscope to 1 μ SEC and the MV/CM Multiplier on the Differential Amplifier to 1.

(4) Adjust the Triggering Level control on the Test oscilloscope for a stable display then check the amplitude

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PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

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PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

- | | |
|-----------------|---|
| ×000 | Part first added at this serial number |
| 00× | Part removed after this serial number |
| *000-0000-00 | Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components. |
| Use 000-0000-00 | Part number indicated is direct replacement. |

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PARTS LIST

Values are fixed unless marked Variable.

Bulbs

Ckt. No.	S/N Range	Description		Tektronix Part Number
B129	101-5259	Neon, Type NE-23	READY	Use 150-027
B129	5260-up	Neon, Type NE-2V	READY	150-0030-00
B160Z	101-5259	Neon, Type NE-23	UNCALIBRATED	Use 150-027
B160Z	5260-up	Neon, Type NE-2V		150-0030-00
B167		Neon, Type NE-23		Use 150-027
B170		Neon, Type NE-23		Use 150-027
B361Y	101-5259	Neon, Type NE-23	UNCALIBRATED	Use 150-027
B361Y	5260-up	Neon, Type NE-2V	UNCALIBRATED	150-0030-00
B361Z	101-5259	Neon, Type NE-23	ON	Use 150-027
B361Z	5260-up	Neon, Type NE-2V	ON	150-0030-00
B380	101-5259	Neon, Type NE-23		Use 150-027
B380	5260-up	Neon, Type NE-2V		150-0030-00
B390	101-5259	Neon, Type NE-23		Use 150-027
B390	5260-up	Neon, Type NE-2V		150-0030-00
B536	101-5259	Neon, Type NE-23		Use 150-027
B536	5260-up	Neon, Type NE-2V		150-0030-00
B546	101-5259	Neon, Type NE-23		Use 150-027
B546	5260-up	Neon, Type NE-2V		150-0030-00
B601	X3001-up	Graticule Light, Type 47		150-001
B602	X3001-up	Graticule Light, Type 47		150-001
B603	X3001-up	Pilot Light, Type 47		150-001
B700	101-3000X	Pilot Light, Type 47		150-001
B701	101-3000X	Graticule Light, Type 47		150-001
B702	101-3000X	Graticule Light, Type 47		150-001

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C1		4.7 μmf	Cer.	500 v	$\pm 1 \mu\text{mf}$	281-501
C2	X4650-up	.02 μf	Discap	600 v		283-006
C10	101-1909	.0047 μf	PTM	400 v		Use 285-543
	1910-up	.0022 μf	PTM	400 v		285-543
C11		100 μmf	Cer.	350 v		281-523
C15		.001 μf	Discap	500 v		283-000
C20		.001 μf	Discap	500 v		283-000
C27		47 μmf	Cer.	500 v		281-518
C32		.01 μf	PTM	400 v		285-510
C37		.005 μf	Discap	500 v		283-001
C42		22 μmf	Cer.	500 v		281-510
C116		.001 μf	Discap	500 v		283-000
C117	101-3000	.005 μf	Discap	500 v		283-001
	3001-up	.001 μf	Discap	500 v		283-000
C121	101-3000X	270 μmf	Cer.	500 v	$\pm 10\%$	281-543
C122	X3001-up	470 μmf	Cer.	500 v		281-525
C124	101-3000	8 μmf	Cer.	500 v	$\pm 0.5 \mu\text{mf}$	281-503
	3001-up	10 μmf	Cer.	500 v	$\pm 10\%$	281-504
C129		.005 μf	Discap	500 v		283-001
C131		27 μmf	Cer.	500 v		281-513
C134	X3001-up	8 μmf	Cer.	500 v	$\pm 0.5 \mu\text{mf}$	281-503
C138		.005 μf	Discap	500 v		283-001
C141	101-3000	12 μmf	Cer.	500 v	$\pm 10\%$	281-506
	3001-up	8 μmf	Cer.	500 v	$\pm 0.5 \mu\text{mf}$	281-503
C149		.005 μf	Discap	500 v		283-001
C150		82 μmf	Cer.	500 v	$\pm 10\%$	281-528

Capacitors (continued)

							Tektronix Part Number
C158	101-300	27 $\mu\mu\text{f}$	Cer.		500 v		281-513
	301-up	12 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-506
C160A		3-12 $\mu\mu\text{f}$	Cer.	Var.			281-007
C160B		82 $\mu\mu\text{f}$	Mica		500 v	$\pm 5\%$	283-534
C160C		4.5-25 $\mu\mu\text{f}$	Cer.	Var.			281-010
C160D		82 $\mu\mu\text{f}$	Mica		500 v	$\pm 5\%$	283-534
C160E		4.5-25 $\mu\mu\text{f}$	Cer.	Var.			281-010
C160F	101-5389	.001 μf	Mylar			$\pm 1/2\%$	*291-008
C160G	101-5389	.01 μf		Mylar Timing Series		$\pm 1/2\%$	*291-007
C160H		.1 μf					
C160J		1 μf					
C160F	5390-up	0.001 μf		Timing Capacitor Assembly			*295-0095-00
C160G		0.01 μf					
C160H		0.1 μf					
C160J		1 μf					
C160K	X3580-up	270 $\mu\mu\text{f}$	Cer.		500 v		281-543
C165		82 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-528
C167		.001 μf	Discap		500 v		283-000
C174		27 $\mu\mu\text{f}$	Cer.		500 v		281-513
C180A		220 $\mu\mu\text{f}$	Mica		500 v	$\pm 10\%$	283-536
C180B		.0022 μf	PTM		400 v		285-543
C180C		.022 μf	PTM		400 v		285-515
C180D		.1 μf	PTM		400 v		285-526
C180E		.1 μf	PTM		400 v		285-526
C181	101-3000	39 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-517
	3001-up	27 $\mu\mu\text{f}$	Cer.		500 v	$\pm 1.35 \mu\mu\text{f}$	281-515
C191		.001 $\mu\mu\text{f}$	Discap		500 v		283-000
C195	101-3000	12 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-506
	3001-up	15 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-509
C198		.005 μf	Discap		500 v		283-001
C310		7-45 $\mu\mu\text{f}$	Cer.	Var.			281-012
C311		330 $\mu\mu\text{f}$	Mica		500 v	$\pm 10\%$	283-518
C312		27 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-512
C313		3-12 $\mu\mu\text{f}$	Cer.	Var.			281-007
C314		500 $\mu\mu\text{f}$	Mica		500 v	$\pm 5\%$	283-523
C331		.005 μf	Discap		500 v		283-001
C337		4.5-25 $\mu\mu\text{f}$	Cer.	Var.			281-010
C339		39 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-516
C361A	101-1022	3-12 $\mu\mu\text{f}$	Cer.	Var.			281-036
	1023-up	1.5-7 $\mu\mu\text{f}$	Cer.	Var.			281-034
C361C	101-1022	5-25 $\mu\mu\text{f}$	Cer.	Var.			281-011
	1023-up	3-12 $\mu\mu\text{f}$	Cer.	Var.		Use	281-036
C361E		8-50 $\mu\mu\text{f}$	Cer.	Var.			281-022
C361G	101-1022	68 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-549
	1023-up	8-50 $\mu\mu\text{f}$	Cer.	Var.			281-022
C361J	101-1022	120 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-550
	1023-up	8-50 $\mu\mu\text{f}$	Cer.	Var.			281-022
C361K	101-1022	390 $\mu\mu\text{f}$	Cer.		500 v		281-551
	1023-up	100 $\mu\mu\text{f}$	Cer.		350 v		281-523
C361L		470 $\mu\mu\text{f}$	Cer.		500 v		281-525
C361M	X3001-up	47 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-519
C361N	X3001-up	47 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$	281-519
C364		8 μf	EMT		450 v	-10% + 50%	290-094
C365		.01 μf	Discap		150 v		283-003
C378		8-50 $\mu\mu\text{f}$	Cer.	Var.			281-022
C382		8-50 $\mu\mu\text{f}$	Cer.	Var.			281-022
C385	X458-up	.005 μf	Discap		500 v		283-001

Capacitors (continued)

						Tektronix Part Number
C387		.7-3 $\mu\mu\text{f}$	Tub.	Var.		281-027
C388		.7-3 $\mu\mu\text{f}$	Tub.	Var.		281-027
C391		.02 μf	Discap		150 v	283-004
C394	101-1022	1.5 $\mu\mu\text{f}$	Cer.		500 v	281-526
	1023-up	1.5-7 $\mu\mu\text{f}$	Cer.	Var.		281-034
						$\pm 0.5 \mu\mu\text{f}$
C395		470 $\mu\mu\text{f}$	Cer.		500 v	281-525
C504		.005 μf	Discap		500 v	283-001
C505		.005 μf	Discap		500 v	283-001
C507A,B		2 x 10 μf	EMC		250 v	-10%+100% Use 290-0075-00
C510		.005 μf	Discap		500 v	283-001
C517		.001 μf	Discap		500 v	283-000
C528	X301-up	.005 μf	Discap		500 v	283-001
C537		.005 μf	Discap		500 v	283-001
C543		.005 μf	Discap		500 v	283-001
C547		.005 μf	Discap		500 v	283-001
C550		.005 μf	Discap		500 v	283-001
C553		1.5-7 $\mu\mu\text{f}$	Cer.	Var.		281-034
C556		.001 μf	Discap		500 v	283-000
C563		5-25 $\mu\mu\text{f}$	Cer.			281-011
C566		.001 μf	Discap		500 v	283-000
C582	101-300	.005 μf	Discap		500 v	283-001
	301-3000	.01 μf	Discap		500 v	283-002
	3001-up	.005 μf	Discap		500 v	283-001
C587	101-300	6.8 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$ 281-541
	301-up	8 $\mu\mu\text{f}$	Cer.		500 v	$\pm 0.5 \mu\mu\text{f}$ 281-503
C588	X301-up	39 $\mu\mu\text{f}$	Cer.		500 v	$\pm 10\%$ 281-516
C596		.005 μf	Discap		500 v	283-001
C599	101-3000	.022 μf	PTM		600 v	$\pm 10\%$ 285-516
	3001-up	.022 μf	PTM		600 v	285-517
C601	X3001-up	.1 μf	Discap		500 v	283-008
C603		2 x 40 μf	EMC		250 v	-10%+100% Use 290-0012-00
C605A		40 μf	EMC		475 v	Use 290-0062-00
C605B		20 μf				
C605C		10 μf				
C610	X3001-up	.01 μf	PTM		400 v	285-510
C617	X3001-up	.01 μf	PTM		400 v	285-510
C628	X3001-up	.01 μf	PTM		400 v	285-510
C640	X3001-up	125 μf	EMC		350 v	-10%+100% Use 290-0016-00
C648	X3001-up	.01 μf	Discap		500 v	GMV 283-002
C649	X3001-up	2 x 40 μf	EMC		250 v	-10%+100% Use 290-0012-00
C650	X3001-up	.01 μf	PTM		400 v	285-510
C670	X3001-up	150 μf	EMC		250 v	-10%+100% Use 290-0019-00
C671	X3001-up	150 μf	EMC		250 v	-10%+100% Use 290-0019-00
C672	101-3000X	330 $\mu\mu\text{f}$	Mica		500 v	$\pm 10\%$ 283-518
C673	101-3000X	330 $\mu\mu\text{f}$	Mica		500 v	$\pm 10\%$ 283-518
C679A,B,C,	X3001-up	3 x 10 μf	EMC		450 v	-10%+50% Use 290-0005-00
C680	X3001-up	.01 μf	PTM		400 v	285-510
C682	101-3000X	27 $\mu\mu\text{f}$	Cer.		500 v	281-513
C688	X3001-up	.01 μf	PTM		400 v	285-510
C695	101-3000X	.001 μf	Discap		500 v	283-000
C700	101-3000	.02 μf	Discap		150 v	283-004
	3001-up	125 μf	EMC		450 v	-10%+50% Use 290-0017-00
C707	101-3000X	.01 μf	PTM		400 v	285-510
C710	X3001-5739	.01 μf	PTM		600 v	285-511
C710	5740-up	.022 μf	PTM		600 v	285-0517-00

Capacitors (continued)

						Tektronix Part Number
C711	101-3000X	.01 μ f	PTM	400 v		285-510
C715	101-3000X	2 x 40 μ f	EMC	250 v	-20% +50%	290-040
C717	101-3000X	.01 μ f	PTM	400 v		285-510
C720	101-3000X	.01 μ f	Discap	500 v	GMV	283-002
C730	X3001-up	125 μ f	EMC	350 v	-20% +50%	Use 290-016
C732	101-3000X	125 μ f	EMC	350 v	-20% +50%	290-044
C740	101-3000	150 μ f	EMC	250 v	-20% +50%	290-048
	3001-up	.01 μ f	PTM	400 v		285-510
C741	101-3000X	150 μ f	EMC	250 v	-20% +50%	290-048
C750	101-3000X	.01 μ f	PTM	400 v		285-510
C751A,B,C,	101-3000X	3 x 10 μ f	EMC	450 v		290-033
C752A,B		2 x 1000 μ f	EMC	15 v		Use 290-022
C756	101-3000X	125 μ f	EMC	450 v	-10% +50%	290-045
C760A,B	X3001-up	2 x 40 μ f	EMC	450 v	-10% +50%	Use 290-013
C763	101-3000X	.01 μ f	PTM	400 v		285-510
C770	101-3000X	.01 μ f	PTM	400 v		285-510
C780	101-3000X	125 μ f	EMC	350 v	-10% +100%	290-044
C787	101-1409	.01 μ f	PTM	400 v		Use 285-511
	1410-3000X	.01 μ f	PTM	600 v		285-511
C790A,B	101-3000X	2 x 40 μ f	EMC	450 v	-10% +50%	290-042
C797	101-3000X	.01 μ f	PTM	400 v		285-510
C800		.047 μ f	PTM	400 v		285-519
C803		.001 μ f	PTM	600 v		285-501
C805		.01 μ f	PTM	400 v		285-510
C806		.001 μ f	PTM	600 v		285-501
C807		2 x 20 μ f	EMC	450 v	-10% +50%	Use 290-010
C814	101-1907	.0068 μ f	PTM	3000 v		285-508
	1908-up	.01 μ f	Discap	2000 v		283-011
C815		.02 μ f	Discap	600 v		Use 283-006
C820	101-1907	.0068 μ f	PTM	3000 v		285-508
	1908-up	.01 μ f	Discap	2000 v		283-011
C821	101-1759	.0068 μ f	PTM	5000 v		Use 283-034
	1760-up	.005 μ f	Discap	4000 v		283-034
C822	101-1628	470 μ μ f	PTM	10,000 v		Use 281-556
	1629-up	500 μ μ f	Cer.	10,000 v		281-556
C823		500 μ μ f	Cer.	10,000 v		Use 281-556
C825		500 μ μ f	Cer.	10,000 v		Use 281-556
C828	X3001-up	.1 μ f	Discap	200 v		Use 283-057
C829	X3001-up	470 μ μ f	PTM	500 v		281-525
C830	101-1907	.0068 μ f	PTM	3000 v		285-508
	1908-up	.01 μ f	Discap	2000 v		283-011
C832	101-1659	.015 μ f	PTM	3000 v		285-513
	1660-up	.01 μ f	Discap	2000 v		283-011
C834	101-1659	.015 μ f	PTM	3000 v		285-513
	1660-up	.01 μ f	Discap	2000 v		283-011
C835	X1660-up	.01 μ f	Discap	2000 v		283-011
C836	X3001-up	.001 μ f	Discap	500 v		283-000
C841		.005 μ f	Discap	500 v		283-001
C855	101-1659	.015 μ f	PTM	3000 v		285-513
	1660-up	.01 μ f	Discap	2000 v		283-011
C857	101-1659	.015 μ f	PTM	3000 v		285-513
	1660-up	.01 μ f	Discap	2000 v		283-011
C871	X3001-up	330 μ μ f	Mica	500 v	\pm 10%	283-518
C874	X3001-up	330 μ μ f	Mica	500 v	\pm 10%	283-518

Capacitors (continued)

							Tektronix Part Number	
C885	X3001-up	27 μmf	Cer.		500 v			281-513
C897	X3001-up	.001 μf	Discap		500 v			283-000
C903-920		.7-3 μmf	Tub.	Var.				(18) 281-037
C925 †		10 meg	1/2 w	Fixed	Comp.	10%		302-106
C926 †		10 meg	1/2 w	Fixed	Comp.	10%		302-106
C930-940		.7-3 μmf	Tub.	Var.				(11) 281-037

Diodes

Even though the diodes may be different in physical size, they are direct electrical replacements for the diodes in your instrument.

D131	X3001-up	Germanium Diode						152-008
D152	X5400-up	Silicon Low Leakage 0.25 W, 40 V						152-0246-00
D642A,B,C,D	X3001-5319	Silicon Diode						152-047
D642A,B,C,D	5320-up	Silicon Diode	1N3194					152-0066-00
D672A,B,C,D	X3001-5319	Silicon Diode						152-047
D672A,B,C,D	5320-up	Silicon Diode	1N3194					152-0066-00
D679	X3060-5319	Silicon Diode						152-047
D679	5320-up	Silicon Diode	1N3194					152-0066-00
D702A,B	X3001-5319	Silicon Diode						152-047
D702A,B	5320-up	Silicon Diode	1N3194					152-0066-00
D731	X5740-up	Silicon Diode	1N3194					150-0066-00
D732A,B,C,D	X1191-3000	Silicon Diode						Use 152-047
D732A,B	3001-5319	Silicon Diode						152-047
D732A,B	5320-up	Silicon Diode	1N3194					152-0066-00
D740A,B,C,D	X1191-3000X	Silicon Diode						Use 152-047
D752A,B	X1191-5319	Silicon Diode						Use 152-047
D752A,B	5320-up	Silicon Diode	1N3194					152-0066-00
D756A,B,C,D	X1191-3000X	Silicon Diode						Use 152-047
D762A,B,C,D	X3001-5319	Silicon Diode						152-047
D762A,B,C,D	5320-up	Silicon Diode	1N3194					152-0066-00
D780A,B,C,D	X1191-3000X	Silicon Diode						Use 152-047
D790A,B,C,D	X1191-3000X	Silicon Diode						Use 152-047

Fuses

F601	X3001-up	6 Amp 3 AG Fast-Blo 117 V operation 60 cycle		159-013
		6.25 Amp 3 AG Slo-Blo 117 V operation 50 cycle		159-011
		3 Amp 3 AG Fast-Blo 234 V operation 60 cycle		159-015
		3 Amp 3 AG Slo-Blo 234 V operation 50 cycle		159-005
F701	101-3000X	6 Amp 3 AG Fast-Blo 117 V operation 60 cycle		159-013
		6.25 Amp 3 AG Slo-Blo 117 V operation 50 cycle		159-011
		3 Amp 3 AG Fast-Blo 234 V operation 60 cycle		159-015
		3 Amp 3 AG Slo-Blo 234 V operation 50 cycle		159-005

Inductors

L133	101-3000X	88 μh			*108-022
LR149	101-5609	850 μh			*108-058
LR149	5610-up	1.2 mh			*108-0164-00
L506	101-2179	10-21 μh	Var.	core 276-511	*114-100
		15-34 μh	Var.	core 276-511	*114-121
		10-21 μh	Var.	core 276-511	*114-100
		15-34 μh	Var.	core 276-511	*114-121
L523	101-2179	10-21 μh	Var.	core 276-511	*114-100
		15-34 μh	Var.	core 276-511	*114-121
		10-21 μh	Var.	core 276-511	*114-100
		15-34 μh	Var.	core 276-511	*114-121
L526		1.4 μh			*108-095
L541		1.4 μh			*108-095
L551		1.2 μh			*108-056
L553		11-28 μh	Var.	core 276-511	*114-102
L561		1.2 μh			*108-056

† C925 and C926 used in delay line for their capacitive properties.

Inductor (continued)

				Tektronix Part Number
L563		11-28 μ h	Var. core 276-511	*114-102
L582		18 μ h		*108-129
L905	101-1409	18-section Delay Line		Use *108-178
	1410-up	18-section Delay Line		*108-178
L906	101-1409	18-section Delay Line		Use *108-178
	1410-up	18-section Delay Line		*108-178
L925		1.2 μ h		*108-056
L926		1.2 μ h		*108-056
L935	101-1409	11-section Delay Line		Use *108-179
	1410-up	11-section Delay Line		*108-179
L936	101-1409	11-section Delay Line		Use *108-179
	1410-up	11-section Delay Line		*108-179
L955		3.6-7.2 μ h	Var. core 276-506	*114-105
L956		3.6-7.2 μ h	Var. core 276-506	*114-105

Rectifiers †

SR732	101-1190X	5 plates/leg		*106-012
SR740	101-1190X	5 plates/leg		*106-013
SR752	101-1190X	1 plate/leg		*106-038
SR756	101-1190X	4 plates/leg		*106-019
SR780	101-1190X	4 plates/leg		*106-014
SR790	101-1190X	5 plates/leg		*106-015

† S/N 1191 & up see V732, V740, V752, V756, V780, V790.

Relays

K600	X3001-up	45-sec. Thermal time delay tube		148-002
K601	X3001-up	D.C. Relay		148-016
K700	101-3000X	45-sec. Thermal time delay tube		148-002
K701	101-3000X	6 v 4 pole 2 throw		148-004

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R1		1 meg	$\frac{1}{2}$ w		5%	301-105
R2		390 k	$\frac{1}{2}$ w		5%	301-394
R3		50 k	2 w	Var.	Int. Trig. DC Level Adj.	311-023
R4		100 k	$\frac{1}{2}$ w			302-104
R5	X4650-up	10 meg	$\frac{1}{2}$ w			302-106
R12		1 meg	$\frac{1}{2}$ w			302-105
R13		100 k	$\frac{1}{2}$ w			302-104
R15		470 k	$\frac{1}{2}$ w			302-474
R17†		100 k	$\frac{1}{2}$ w	Var.	TRIGGERING LEVEL	311-096
R18		22 k	$\frac{1}{2}$ w			302-222
R19	101-5359	470 k	$\frac{1}{2}$ w			302-474
R19	5360-up	470 k	$\frac{1}{2}$ w		5%	301-0474-00
R20	101-300	470 k	$\frac{1}{2}$ w			302-474
	301-5359	56 k	$\frac{1}{2}$ w			302-563
R20	5360-up	68 k	$\frac{1}{2}$ w		5%	301-0683-00
R21	101-300X	56 k	$\frac{1}{2}$ w			302-563
R23		33 k	2 w			306-333
R24		39 k	2 w			306-393
R25		47 Ω	$\frac{1}{2}$ w			302-470
R26		47 Ω	$\frac{1}{2}$ w			302-470
R27		4.7 k	1 w			304-472
R29		4.7 k	1 w			304-472
R32		47 k	$\frac{1}{2}$ w			302-473

†R17 concentric with SW110 and R110. Furnished as a unit.

Resistors (continued)

							Tektronix Part Number
R33		47 k	1/2 w				302-473
R34		47 Ω	1/2 w				302-470
R35	101-300	22 k	2 w				306-223
	301-up	18 k	1 w				304-183
R37		500 Ω	2 w	Var.		Trigger Sens.	311-005
R38	101-300	22 k	2 w				306-223
	301-up	18 k	1 w				304-183
R39		100 k	2 w	Var.		Trig Level Centering	311-026
R40	101-300	100 k	1/2 w				302-104
	301-up	120 k	1/2 w				302-124
R41		2.7 meg	1/2 w				302-275
R42		100 k	1/2 w				302-104
R44	101-300	2.7 k	1/2 w				302-272
	301-up	1.5 k	1/2 w				302-152
R45		1 meg	1/2 w				302-105
R46	101-300	1 k	1/2 w				302-102
	301-up	680 Ω	1/2 w				302-681
R47		47 Ω	1/2 w				302-470
R48		1.5 k	1/2 w				302-152
R110†		100 k	1/2 w	Var.		STABILITY	311-096
R111	101-2039	100 k	.2 w	Var.		Preset Adj.	Use 311-219
	2040-up	200 k	.2 w	Var.		Preset Adj.	311-219
R114		470 k	1/2 w			5%	301-474
R115		100 k	1/2 w			5%	301-104
R116	101-3000	200 k	1/2 w			5%	301-204
	3001-up	180 k	1/2 w			5%	301-184
R117	X621-3000	47 Ω	1/2 w				302-470
	3001-up	1 k	1/2 w				302-102
R118	101-3000	10 meg	1/2 w				302-106
	3001-up	4.7 meg	1/2 w				302-475
R120	X3001-up	270 k	1/2 w			5%	301-274
R121		100 Ω	1/2 w				302-101
R122		22 k	1/2 w				302-223
R123	X3001-up	470 k	1/2 w			5%	301-474
R124		100 k	1/2 w			5%	301-104
R125		50 k	.1 w	Var.		Lockout Level Adj.	311-078
R126	101-3000X	300 k	1/2 w			5%	301-304
R127		100 Ω	1/2 w				302-101
R128		12 k	1/2 w				302-123
R129		27 k	1/2 w				302-273
R130		22 k	2 w				306-223
R131		1 k	1/2 w				302-102
R132		47 Ω	1/2 w				302-470
R133	101-3000	3.3 k	1 w	Checked to 6 k 2 w 2-1/2%			*312-569
R134	101-3000	2.7 k	1 w				
R133	3001-up	Deleted					
R134	3001-up	6 k	3 w	Mica Plate			*310-555
R136	101-3000X	56 k	1 w			5%	303-563
R137		47 Ω	1/2 w				302-470
R138		47 Ω	1/2 w				302-470
R141	101-3000	39 k	1 w	Checked to ratio of 5% each other			*312-570
R143	101-3000	33 k	1 w				
R141	3001-up	33 k	1 w		Prec.	1%	310-070
R143	3001-up	30 k	1 w		Prec.	1%	310-072
R144		8 k	5 w		WW	5%	308-053
R146	101-3000	100 Ω	1/2 w				302-101
	3001-up	47 Ω	1/2 w				302-470

† R110 concentric with R17 and ganged with SW110. Furnished as a unit.

Resistors (continued)

							Tektronix Part Number
R147		1 k	1/2 w				302-102
R148	101-3000	39 k	1/2 w				302-393
	3001-up	47 k	1/2 w				302-473
R150		270 Ω	1/2 w				302-271
R151	X5400-up	10 meg	1/4 w				316-0106-00
R152	101-300	36 k	1/2 w			5%	301-363
	301-up	68 k	1/2 w				302-683
R153		1 meg	1/2 w				302-105
R154	101-5439	10 k	1/2 w				302-103
R154	5440-up	47 Ω	1/2 w				302-0470-00
R155		1 meg	1/2 w				302-105
R156		1.8 meg	1/2 w				302-185
R157	X301-up	1 k	1/2 w				302-102
R158	101-300	220 k	1/2 w				302-224
	301-up	470 k	1/2 w				302-474
R159	101-300	1.2 k	1/2 w				302-122
	301-up	3.3 k	2 w				306-332
R160A		100 k	1/2 w			Prec.	1% 309-045
R160B		200 k	1/2 w			Prec.	1% 309-051
R160C		500 k	1/2 w			Prec.	1% 309-003
R160D		1 meg	1/2 w			Prec.	1% 309-014
R160E		2 meg	1/2 w			Prec.	1% 309-023
R160F		5 meg	1/2 w			Prec.	1% 309-087
R160G		10 meg	1 w			Prec.	1% 310-107
R160H		10 meg	1 w			Prec.	1% 310-107
R160J		30 meg	2 w			Prec.	1% 310-505
R160V	X1790-up	1 meg	1/2 w	Var.			302-105
R160X		10 k	1/2 w	Var.	WW		302-103
R160Y†	101-320	20 k	2 w			VARIABLE	311-083
	321-up	20 k	2 w			VARIABLE	311-108
R160Z		100 k	1/2 w				302-104
R162		6.8 k	1 w				304-682
R163		12 k	1 w				304-123
R164		22 k	2 w				306-223
R165		22 k	2 w				306-223
R166		22 k	2 w				306-223
R167		1.5 meg	1/2 w				302-155
R168		47 k	1/2 w				302-473
R170		47 Ω	1/2 w				302-470
R172		47 Ω	1/2 w				302-470
R173		470 Ω	1/2 w				302-471
R174		8 k	5 w			WW	308-053
R176		2 k	2 w	Var.		Swp. Length	311-008
R178		4 k	5 w			WW	308-051
R180A		470 k	1/2 w				302-474
R180B		4.7 meg	1/2 w				302-475
R181		4.7 meg	1/2 w				302-475
R183		100 Ω	1/2 w				302-101
R191		100 k	1/2 w				302-104
R193		100 k	1 w				304-104

†Concentric with SW160 and SW160Y.

Resistors (continued)

						Tektronix Part Number
R195		47 k	1/2 w			302-473
R196	101-3000	100 k	1/2 w			302-104
	3001-up	110 k	1/2 w		5%	301-114
R197	101-3000	100 Ω	1/2 w			302-101
	3001-up	47 Ω	1/2 w			302-470
R198		47 Ω	1/2 w			302-470
R199		4.7 k	1 w			304-472
R301	X558-up	47 Ω	1/2 w			302-470
R310		900 k	1/2 w		Prec. 1%	309-111
R311		111 k	1/2 w		Prec. 1%	309-046
R313		990 k	1/2 w		Prec. 1%	309-013
R314		10.1 k	1/2 w		Prec. 1%	309-034
R320		1 meg	1/2 w		Prec. 1%	309-014
R321		1 k	1/2 w			302-102
R323	101-1439	47 k	1 w			304-473
	1440-up	33 k	2 w			306-333
R325		15 k	2 w	Var.	VARIABLE	Use 311-0571-00
R327	101-1439	47 k	1 w			304-473
	1440-up	33 k	2 w			306-333
R328	101-1439	33 k	2 w			306-333
	1440-up	27 k	2 w			306-273
R330		100 Ω	1/2 w			302-101
R331		3.3 k	1/2 w			302-332
R332		220 k	1/2 w			302-224
R334		100 k	2 w	Var.	Ext. Horiz. Amp DC Bal.	311-026
R337		2 meg	1/2 w		Prec. 1%	309-023
R338		2 meg	1/2 w		Prec. 1%	309-023
R339		330 Ω	1/2 w			302-331
R340†		50 k	1/2 w	Var.	HORIZ. POS.	311-109
R342		2 meg	.1 w	Var.	X10 Cal.	311-082
R343		1.5 meg	1/2 w		Prec. 1%	309-017
R344		10 meg	1/2 w		Prec. 1%	309-095
R346†		50 k	1/2 w	Var.	VERNIER	311-109
R347		47 k	1/2 w			302-473
R348		100 Ω	1/2 w			302-101
R349		47 k	1 w			304-473
R351		100 Ω	1/2 w			302-101
R353		30 k	1 w		5%	303-303
R354		6 k	1/2 w		Prec. 1%	309-099
R355	101-2349	136 Ω	1/2 w		Prec. 1%	Use 309-072
	2350-up	180 Ω	1/2 w		Prec. 1%	309-072
R356		500 Ω	.1 w	Var.	X100 Cal.	311-056
R358		10 k	5 w		WW 5%	308-054
R359		5 k	2 w	Var.	Swp./Mag. Regis.	311-011
R360		12 k	8 w		WW 5%	308-093
R361A		5.6 k	1/2 w			302-562
R361B	101-5709	11.76 k	1/2 w		Prec. 1/4%	309-200
R361B	5710-up	12.1 k	1/2 w		Prec. 1%	323-0297-00

† R346 and R340 concentric. Furnished as a unit.

Resistors (continued)

						Tektronix	
						Part	Number
R361C		3.3 k	1/2 w				302-332
R361D	101-5649	2.85 k	1/2 w		Prec.	1/4 %	309-201
R361D	5650-up	2.87 k	1/2 w		Prec.	1 %	323-0237-00
R361E		1.2 k	1/2 w				302-122
R361F	101-5709	1.2 k	1/2 w		Prec.	1/4 %	309-202
R361F	5710-up	1.21 k	1/2 w		Prec.	1 %	323-0201-00
R361G		680 Ω	1/2 w				302-681
R361H	101-5709	505.4 Ω	1/2 w		Prec.	1/4 %	309-203
R361H	5710-up	511 Ω	1/2 w		Prec.	1 %	323-0165-00
R361J		390 Ω	1/2 w				302-391
R361K	101-5709	122.5 Ω	1/2 w		Prec.	1/4 %	309-204
R361K	5710-up	124 Ω	1/2 w		Prec.	1 %	323-0106-00
R361L		1 k	1/2 w				302-102
R361M		2.5 k	.1 w	Var.		Ext. Horiz. Amp. Cal.	311-010
R361R	X5710-up	560 k	1/4 w			5 %	315-0564-00
R361S	X5710-up	150 k	1/4 w			5 %	315-0154-00
R361T	X5710-up	24 k	1/4 w			5 %	315-0243-00
R361Y		100 k	1/2 w				302-104
R361Z		100 k	1/2 w				302-104
R363		330 k	1/2 w				302-334
R364		330 k	1/2 w				302-334
R365		500 Ω	.1 w	Var.		DC Shift	311-056
R368		5 k	.1 w	Var.		X1 Cal.	311-074
R369		31.1 k	1/2 w		Prec.	1 %	309-037
R371		100 Ω	1/2 w				302-101
R372		30 k	1 w			5 %	303-303
R373		6 k	1/2 w		Prec.	1 %	309-099
R376		100 Ω	1/2 w				302-101
R377		100 Ω	1/2 w				302-101
R378		6—25 k	7 w	Mica Plate		1 %	*310-506
R379		470 k	1/2 w				302-474
R380		820 k	1/2 w				302-824
R381		100 Ω	1/2 w				302-101
R382		6—25 k	7 w	Mica Plate		1 %	*310-506
R384		12 k	8 w		WW	5 %	308-093
R386		100 Ω	1/2 w				302-101
R387		41.5 k	8 w		WW	1/2 %	Use *310-614
R388		41.5 k	8 w		WW	1/2 %	Use *310-614
R389		820 k	1/2 w				302-824
R390		470 k	1/2 w				302-474
R391		10 k	1/2 w				302-103
R394		100 Ω	1/2 w				302-101
R395		2.2 k	1/2 w				302-222
R397		100 k	1/2 w				302-104
R398		150 k	1/2 w				302-154
R502		27 Ω	1/2 w				302-270
R504		100 k	1/2 w				302-104
R505	101-300	620 Ω	2 w			5 %	305-621
	301-up	680 Ω	2 w			5 %	305-681
R506	101-2179	1.6 k	1/2 w	Mica Plate		1 %	*310-550
	2180-up	1.582 k	1/2 w		Prec.	1 %	309-029
R507		82 k	1/4 w				316-823
R510		6.8 k	1 w				304-682
R513		4 k	5 w		WW	5 %	308-051

Resistors (continued)

							Tektronix Part Number
R514		15 k	5 w		WW	5%	308-108
R517		470 k	1/2 w				302-474
R520		27 Ω	1/2 w				302-270
R523	101-2179	1.6 k	1/2 w		Mica Plate	1%	*310-550
	2180-up	1.582 k	1/2 w		Prec.	1%	309-029
R524		82 k	1/4 w				316-823
R528	X301-up	4.5 k	5 w		WW	5%	308-092
R529	101-300	8.2 k	2 w			5%	305-822
	301-up	11 k	2 w			5%	305-113
R530	101-300	8.2 k	2 w			5%	305-822
	301-up	11 k	2 w			5%	305-113
R533	101-3029	150 k	1/2 w				302-154
R533	3030-up	100 k	1/2 w				302-104
R534		330 k	1/2 w				302-334
R536		330 k	1/2 w				302-334
R537		1 meg	1/2 w				302-105
R539		680 k	1/2 w				302-684
R546		330 k	1/2 w				302-334
R547		1 meg	1/2 w				302-105
R550	101-300	750 Ω	5 w		WW	5%	308-067
	301-up	1.2 k	1 w				304-122
R551		47 Ω	1/2 w				302-470
R553		1.3 k	6 w		Mica Plate	1%	*310-549
R556		100 k	1/2 w				302-104
R558		27 Ω	1/2 w				302-270
R561		47 Ω	1/2 w				302-470
R563		1.3 k	6 w		Mica Plate	1%	*310-549
R566		100 k	1/2 w				302-104
R568		27 Ω	1/2 w				302-270
R570		200 Ω	2 w	Var.		GAIN ADJ.	311-004
R573		2.5 k	5 w		WW	1%	308-103
R574		2.5 k	5 w		WW	1%	308-103
R577		100 Ω	1/2 w				302-101
R580		100 Ω	1/2 w				302-101
R582	101-300	3 k	2 w			5%	305-302
	301-up	5.1 k	2 w			5%	305-512
R583	101-300	3.6 k	1 w			5%	303-362
	301-up	2.2 k	1/2 w			5%	301-222
R585		12 k	2 w			5%	305-123
R586		12 k	2 w			5%	305-123
R587	101-300	1.5 k	1/2 w			5%	301-152
	301-up	1.2 k	1/2 w			5%	301-122
R588	X301-up	2.2 k	1/2 w			5%	301-222
R590		47 Ω	1/2 w				302-470
R593		30 k	10 w		WW	5%	308-027
R595	101-300	47 Ω	1/2 w				302-470
	301-up	6.8 k	1/2 w				302-682
R596		47 Ω	1/2 w				302-470
R598		22 k	2 w				306-223
R599		1 meg	1/2 w				302-105
R600	X3001-up	12 Ω	1 w				304-120
R601	X3001-up	30 Ω	3 w		WW	5%	308-142
R602	X3001-up	50 Ω	2 w	Var.	WW	SCALE ILLUM.	311-055

Resistors (continued)

							Tektronix Part Number
R603		100 Ω	1 w				304-101
R604	X3001-up	6 k	5 w		WW	5%	308-052
R605		100 Ω	$\frac{1}{2}$ w				302-101
R607		47 Ω	$\frac{1}{2}$ w				302-470
R608	X3001-up	33 k	$\frac{1}{2}$ w				302-333
R609		100 Ω	$\frac{1}{2}$ w				302-101
R610	X3001-up	100 k	$\frac{1}{2}$ w				302-104
R615	X3001-up	68 k	1 w		Prec.	1%	310-054
R616	X3001-up	10 k	2 w	Var.	WW	-150 V Adj.	311-015
R617	X3001-up	50 k	1 w		Prec.	1%	310-086
R618	X3001-up	100 k	$\frac{1}{2}$ w				302-104
R621	X3001-up	1 k	$\frac{1}{2}$ w				302-102
R623	X3001-up	470 k	$\frac{1}{2}$ w				302-474
R625	X3001-up	100 k	$\frac{1}{2}$ w				302-104
R628	X3001-up	2.7 meg	$\frac{1}{2}$ w				302-275
R629	X3001-up	2.7 meg	$\frac{1}{2}$ w				302-275
R633	X3001-up	1 meg	$\frac{1}{2}$ w				302-105
R635	X3001-up	15 k	1 w				304-153
R636	X3001-up	15 k	1 w				304-153
R637	X3001-up	150 k	$\frac{1}{2}$ w				302-154
R638	X3001-up	27 k	$\frac{1}{2}$ w				302-273
R639	X3001-up	68 k	$\frac{1}{2}$ w				302-683
R640	X3001-up	10 Ω	1 w				304-100
R641	X3001-up	10 Ω	1 w				304-100
R643	X3001-up	1 k	$\frac{1}{2}$ w				302-102
R644	X3001-up	1 k	$\frac{1}{2}$ w				302-102
R647	X3001-up	1 k	25 w		WW	5%	308-037
R648	X3001-up	10 Ω	$\frac{1}{2}$ w				302-100
R650	X3001-up	333 k	1 w		Prec.	1%	310-056
R651	X3001-up	490 k	1 w		Prec.	1%	310-057
R663	X3001-up	1.5 meg	$\frac{1}{2}$ w				302-155
R667	X3001-up	680 k	$\frac{1}{2}$ w				302-684
R668	X3001-up	47 k	$\frac{1}{2}$ w				302-473
R669	X3001-up	39 k	$\frac{1}{2}$ w				302-393
R670	101-3000	150 k	$\frac{1}{2}$ w				302-154
	3001-up	10 Ω	2 w				306-100
R671	101-3000X	1 k	$\frac{1}{2}$ w				302-102
R672	101-300	3.3 meg	$\frac{1}{2}$ w				302-335
	301-3000X	3.9 meg	$\frac{1}{2}$ w				302-395
R673	101-3000X	2.7 meg	$\frac{1}{2}$ w				302-275
R674	101-3000X	1 k	$\frac{1}{2}$ w				302-102
R675	101-3000	68 k	$\frac{1}{2}$ w				302-683
	3001-up	750 Ω	10 w		WW	5%	308-016
R676	101-3000	33 k	1 w				304-333
	3001-up	3 k	10 w		WW	5%	308-020
R677	X3001-up	2 k	25 w		WW	5%	308-065
R679	101-3000X	10 k	2 w	Var.		CAL. ADJ.	311-016
R680	101-3000	68 k	$\frac{1}{2}$ w				Use 302-683
	3001-up	333 k	1 w		Prec.	1%	310-056
R681	101-3000	1.5 meg	$\frac{1}{2}$ w				302-155
	3001-up	220 k	1 w		Prec.	1%	310-055

Resistors (continued)

						Tektronix Part Number
R682	101-3000	100 Ω	$\frac{1}{2}$ w			302-101
	3001-up	120 k	$\frac{1}{2}$ w			302-124
R683	101-3000	9.5 k	$\frac{1}{2}$ w	Prec.	1%	309-121
	3001-up	1 k	$\frac{1}{2}$ w			302-102
R684	101-3000X	6.375 k	$\frac{1}{2}$ w	Prec.	1%	309-119
R685	101-3000	2.1 k	$\frac{1}{2}$ w	Prec.	1%	309-117
	3001-up	82 k	1 w			304-823
R686	101-3000	1.025 k	$\frac{1}{2}$ w	Prec.	1%	309-116
	3001-up	180 k	$\frac{1}{2}$ w			302-184
R687	101-3000X	610 Ω	$\frac{1}{2}$ w	Prec.	1%	309-113
R688	101-3000	200 Ω	$\frac{1}{2}$ w	Prec.	1%	309-073
	3001-up	1.5 meg	$\frac{1}{2}$ w			302-155
R689	101-3000	100 Ω	$\frac{1}{2}$ w	Prec.	1%	309-112
	3001-up	2.2 meg	$\frac{1}{2}$ w			302-225
R690	101-3000X	60 Ω	$\frac{1}{2}$ w	Prec.	1%	309-067
R691	101-3000X	40 Ω	$\frac{1}{2}$ w	Prec.	1%	309-066
R693	X3001-up	1.5 meg	$\frac{1}{2}$ w			302-155
R694	101-3000X	100 k	$\frac{1}{2}$ w	Prec.	1%	309-045
R695	101-3000X	100 Ω	$\frac{1}{2}$ w	Prec.	1%	309-112
R697	X3001-up	1 meg	$\frac{1}{2}$ w			302-105
R698	101-3000	.25 Ω	1 w	Special	WW	*308-090
	3001-up	270 k	$\frac{1}{2}$ w			302-274
R699	101-3000	100 Ω	$\frac{1}{2}$ w			302-101
	3001-up	56 k	$\frac{1}{2}$ w			302-563
R700	101-3000	15 k	1 w			304-153
	3001-up	10 Ω	2 w			306-100
R701	101-3000X	15 k	1 w			304-153
R703	101-3000X	68 k	$\frac{1}{2}$ w			302-683
R704	101-3000X	27 k	$\frac{1}{2}$ w			302-273
R706	101-3000X	2.7 meg	$\frac{1}{2}$ w			302-275
R707	101-3000X	2.7 meg	$\frac{1}{2}$ w			302-275
R708	101-3000X	12 Ω	1 w			304-120
R710	101-3000	33 k	$\frac{1}{2}$ w			302-333
	3001-up	237 k	1 w	Prec.	1%	310-124
R711	101-3000	100 k	$\frac{1}{2}$ w			302-104
	3001-up	100 k	$\frac{1}{2}$ w	Prec.	1%	Use 323-385
R712	101-3000	100 k	$\frac{1}{2}$ w			302-104
	3001-5739	150 k	$\frac{1}{2}$ w			302-154
	5740-up	1 meg	$\frac{1}{2}$ w			302-0105-00
R713	101-3000X	1 k	$\frac{1}{2}$ w			302-102
R715	101-3000X	50 k	1 w			310-086
R716	101-3000X	10 k	2 w	Var.	WW	-150 V Adj. 311-015
R717	101-3000X	100 k	$\frac{1}{2}$ w			302-104
R718	101-3000X	68 k	1 w	Prec.	1%	310-054
R719	101-3000X	470 k	$\frac{1}{2}$ w			302-474
R720	101-3000X	10 Ω	$\frac{1}{2}$ w			302-100
R723	X3001-up	1.5 meg	$\frac{1}{2}$ w			302-155
R724	101-3000X	1 k	25 w	WW	5%	308-037
R726	101-3000X	1 k	$\frac{1}{2}$ w			302-102
R727	101-3000	1 k	$\frac{1}{2}$ w			302-102
	3001-up	1 meg	$\frac{1}{2}$ w			302-105
R728	101-3000	150 k	$\frac{1}{2}$ w			302-154
	3001-up	560 k	$\frac{1}{2}$ w			302-564

Resistors (continued)

							Tektronix Part Number
R729	101-3000	1 meg	1/2 w				302-105
	3001-up	47 k	1/2 w				302-473
R730	X1191-3000	22 Ω	2 w				306-220
	3001-up	10 Ω	1 w				304-100
R731	X1191-3000	22 Ω	2 w				306-220
	3001-up	10 Ω	1 w				304-100
R732	101-3000	10 Ω	1 w				304-100
	3001-5739X	82 k	2 w				306-823
R733	101-3000X	10 Ω	1 w				304-100
R734	X3001-up	1 k	1/2 w				302-102
R735		100 k	1/2 w				302-104
R736	101-3000	50 Ω	2 w	Var.	WW	SCALE ILLUM	311-055
	3001-up	3.8 k	25 w		WW	5%	308-044
R737	X3001-up	3.8 k	25 w		WW	5%	308-044
R740	101-3000	10 Ω	1 w				304-100
	3001-up	220 k	1 w		Prec.	1%	310-055
R741	X1191-3000	7.5 Ω	10 w		WW	5%	308-125
	3001-up	720 k	1 w		Prec.	1%	310-059
R742	101-3000X	47 k	1/2 w				302-473
R743	101-3000X	39 k	1/2 w				302-393
R744	101-3000X	680 k	1/2 w				302-684
R747	101-3000X	1.5 meg	1/2 w				302-155
R748	101-3000X	3 k	10 w		WW	5%	308-020
R749	101-3000X	750 Ω	10 w		WW	5%	308-016
R750	101-3000X	333 k	1 w		Prec.	1%	310-056
R751	101-3000X	490 k	1 w		Prec.	1%	310-057
R752		2.2 Ω	1/2 w		WW	5%	308-116
R753	X1191-3000	1 Ω	1/2 w		WW	5%	*308-141
	3001-up	1 meg	1/2 w				302-105
R754	X1191-3000X	10 Ω	2 w				306-100
R755	X1191-3000X	10 Ω	2 w				306-100
R756	101-3000X	10 Ω	2 w				306-100
R757	101-3000	270 k	1/2 w				302-274
	3001-up	150 k	1/2 w				302-154
R758	101-3000	56 k	1/2 w				302-563
	3001-up	120 k	1/2 w				302-124
R759	X3001-up	27 k	1/2 w				302-273
R760	101-3000	1.5 meg	1/2 w				302-155
	3001-up	10 Ω	1/2 w				302-100
R762	101-300	2.5 k	10 w		WW	5%	308-018
	301-3000X	2 k	20 w		WW	5%	308-031
R763	101-3000X	1.5 meg	1/2 w				302-155
R764	101-3000X	2.2 meg	1/2 w				302-225
R765	101-3000X	180 k	1/2 w				302-184
R766	101-3000X	82 k	1 w				304-823
R767	101-3000	1 k	1/2 w				302-102
	3001-up	3 k	10 w		WW	5%	308-020
R770	101-3000X	2.2 meg	1/2 w				302-225
R771	101-3000X	220 k	1 w		Prec.	1%	310-055
R772	101-3000X	333 k	1 w		Prec.	1%	310-056
R775	X1191-3000X	22 Ω	2 w				306-220
R776	X1191-3000X	22 Ω	2 w				306-220

Resistors (continued)

							Tektronix Part Number
R777	101-3000X	10 Ω	1 w				304-100
R778	101-3000X	82 k	2 w				306-823
R779	101-3000X	2.2 meg	1/2 w				302-225
R780	101-3000X	10 Ω	1 w				304-100
R781	101-3000X	1 meg	1/2 w				302-105
R782	101-3000X	560 k	1/2 w				302-564
R783	101-3000X	47 k	1/2 w				302-473
R784	101-3000X	1.5 meg	1/2 w				302-155
R785	101-3000X	2.4 k	20 w		WW	5%	308-068
R786	101-3000X	2.4 k	20 w		WW	5%	308-068
R787	101-3000X	237 k	1 w		Prec.	1%	Use 310-124
R788	101-2289	100 k	1/2 w		WW	1%	Use 309-334
	2290-3000X	100 k	1/2 w		Prec.	1%	309-334
R789	101-3000X	1 k	1/2 w				302-102
R790	101-3000X	10 Ω	1/2 w				302-100
R791	101-3000X	150 k	1/2 w				302-154
R792	101-3000X	120 k	1/2 w				302-124
R793	101-3000X	27 k	1/2 w				302-273
R794	101-3000X	1 meg	1/2 w				302-105
R795	101-3000X	3 k	8 w		WW	5%	308-113
R797	101-3000X	220 k	1 w		Prec.	1%	310-055
R798	101-3000X	720 k	1 w		Prec.	1%	310-059
R800		1 k	1/2 w				302-102
R803		56 k	2 w				306-563
R804		100 k	1/2 w				302-104
R805		1 k	1/2 w				302-102
R807		390 Ω	2 w				306-391
R810		470 k	1/2 w				302-474
R811		2 meg	2 w	Var.		HV Adj.	311-042
R812		2.2 meg	1/2 w				302-225
R813		4.7 meg	1/2 w				302-475
R814		4.7 meg	1/2 w				302-475
R815		4.7 meg	1/2 w				302-475
R825		1 meg	1/2 w				302-105
R827	X3001-up	1.8 meg	1/2 w				302-185
R828	X3001-up	1.8 meg	1/2 w				302-185
R829	X3001-up	33 k	1/2 w				302-333
R830		47 k	1/2 w				302-473
R831	101-5529	1 meg	1/2 w	Var.		INTENSITY	311-0041
R831	5530-up	1 meg	1/2 w	Var.		INTENSITY	311-0041-02
R832		4.7 meg	2 w				306-475
R833		4.7 meg	2 w				306-475
R834	101-1659	100 k	1/2 w				302-104
	1660-up	33 k	1/2 w				302-333
R835		1 meg	1/2 w				302-105
R836	X3001-up	22 k	1/2 w				302-223
R838		100 Ω	1/2 w				302-101
R840		68 k	2 w				306-683
R841		47 Ω	1/2 w				302-470
R842		100 k	2 w	Var.		Geom Adj.	311-026
R850		2.2 meg	2 w				306-225
R851		2.2 meg	2 w				306-225
R852	101-5529	2 meg	1/2 w	Var.		FOCUS	311-043
R852	5530-up	2 meg	1/2 w	Var.		FOCUS	311-0043-02

Resistors (continued)

				Tektronix Part Number	
R853		1 meg	2 w		306-105
R855		10 k	1/2 w		302-103
R856		27 k	1/2 w		302-273
R857		1 meg	1/2 w		302-105
R860		50 k	2 w	Var.	ASTIGMATISM 311-023
R870	X3001-up	150 k	1/2 w		302-154
R871	X3001-up	2.7 meg	1/2 w		302-275
R872	X3001-up	1 k	1/2 w		302-102
R874	X3001-up	3.9 meg	1/2 w		302-395
R875	X3001-up	68 k	1/2 w		302-683
R876	X3001-up	1 k	1/2 w		302-102
R878	X3001-up	33 k	1 w		304-333
R879	X3001-up	10 k	2 w	Var.	Cal Adj. 311-016
R880	X3001-up	100 k	1/2 w		302-104
R883	X3001-up	100 Ω	1/2 w		302-101
R885	X3001-up	9.5 k	1/2 w		Prec. 1% 309-121
R886	X3001-up	6.375 k	1/2 w		Prec. 1% 309-119
R887	X3001-up	2.1 k	1/2 w		Prec. 1% 309-117
R888	X3001-up	1.025 k	1/2 w		Prec. 1% 309-116
R889	X3001-up	610 Ω	1/2 w		Prec. 1% 309-113
R890	X3001-up	200 Ω	1/2 w		Prec. 1% 309-073
R891	X3001-up	100 Ω	1/2 w		Prec. 1% 309-112
R892	X3001-up	60 Ω	1/2 w		Prec. 1% 309-067
R893	X3001-up	40 Ω	1/2 w		Prec. 1% 309-066
R896	X3001-up	100 k	1/2 w		Prec. 1% 309-045
R897	X3001-up	100 Ω	1/2 w		Prec. 1% 309-112
R898	X3001-up	100 Ω	1/2 w		302-101
R899	X3001-up	.25 Ω	1 w		WW *308-090

Switches

				Unwired	Wired
SW10A	101-300	Rotary	TRIGGER SLOPE	*260-099 use	*262-561
SW10B	101-300	Rotary	TRIGGER MODE		
SW10A	301-up	Rotary	TRIGGER SLOPE		
SW10B	301-up	Rotary	TRIGGER MODE		
SW110†			PRESET	311-096	
SW120	101-5439	Lever	SINGLE SWEEP RESET	260-190	
SW120	5450-up	Lever	SINGLE SWEEP RESET	260-0190-02	
SW160††	101-320	Rotary	TIME/CM	*260-203	*262-147
SW160††	321-30000	Rotary	TIME/CM	*260-230	*262-147
SW160††	3001-5389	Rotary	TIME/CM	*260-230	*262-244
SW160††	5390-up	Rotary	TIME/CM	260-0230-00	*262-0244-01
SW160Y††				311-0108-00	
SW310		Rotary	HORIZ. VOLTS/CM	*260-207 *262-152	
SW360	101-1022		Repl. Kit	*260-210 Use *050-163	
SW360	1023-3000	Rotary	HORIZ. DISPLAY	*260-210 *262-151	
SW360	3001-5539	Rotary	HORIZ. DISPLAY	*260-210 *262-412	
SW360	5540-up	Rotary	HORIZ. DISPLAY	260-0210-01 *262-0412-00	
SW601	X3001-up	Toggle	POWER ON	260-134	
SW670	101-3000X	Rotary	VOLTS MILLIVOLTS OFF	*260-177 *262-132	
SW680	101-3000X	Rotary	SQUARE WAVE CALIBRATOR		

† SW110 concentric with R17 and ganged with R110. Furnished as a unit.

†† SW160 concentric with SW160Y and R160Y.

Switches (continued)

**Tektronix
Part Number**

SW701	101-3000X	Toggle	POWER ON	260-134
SW800		Toggle	CRT CATHODE SELECTOR	260-209
SW870	X3001-up	Rotary	AMPLITUDE CALIBRATOR	*260-253 *262-207

Thermal Cutout

TK601	X3001-up	Thermo switch 133°	260-208
TK701	101-3000X	Thermal Cutout	260-070

Transformers

T601	X3001-up	L.V. Power, Domestic and Export range	Use *120-140
T700	101-3000X	Plate & Heaters 117 V	*120-037
		Plate & Heaters 234 V	*120-086
T801		CRT Supply	*120-036

Electron Tubes

S/N 100640

V24	101-300	6BQ7A	154-028
V24	301-up	6DJ8	154-187
V45	101-300	6U8	154-033
V45	301-up	6DJ8	154-187
V125		6AU6	154-022
V133	101-300	6BQ7A	154-028
V133	301-up	6DJ8	154-187
V135	101-300	6BQ7A	154-028
V135	301-up	6DJ8	154-187
V146		12BY7	154-047
V152		6AL5	154-016
V154	101-300	6U8	154-033
V154	301-up	6DJ8	154-187
V161	101-5309	12AU6	154-0040-00
V161	5310-up	8426	154-0040-05
V173	101-300	6BQ7A	154-028
V173	101-300	6DJ8	154-187
V183	101-300	6BQ7A	154-028
V183	301-up	6DJ8	154-187
V193	101-300	6BQ7A	154-028
V193	301-up	6DJ8	154-187
V246	101-300	6BQ7A	154-028
V246	301-3000X	12AU7	154-041
V324	101-300	6BQ7A	154-028
V324	301-up	6DJ8	154-187
V343		12AU6	154-040

Electron Tubes (continued)

			Tektronix Part Number
V354		6EW6/6DK6	Use 154-212
V364		6EW6/6DK6	Use 154-212
V374		6BA8	154-163
V384		6BA8	154-163
V394		8136/6DK6	154-367
V504†		12BY7	*157-053
V524†		12BY7	*157-053
V533	101-300	6BQ7A	154-028
	301-up	6DJ8	154-187
V543	101-300	6BQ7A	154-028
	301-up	6DJ8	154-187
V554		6197	154-146
V564		6197	154-146
V584	101-300	6U8	154-033
	301-up	6DJ8	154-187
V593	101-300	6BQ7A	154-028
	301-up	6DJ8	154-187
V609	X3001-up	5651	154-052
V624	X3001-up	12AX7	154-043
V627	X3001-up	12B4	154-044
V634	X3001-up	6AU6	154-022
V637	X3001-up	12B4	154-044
V647	X3001-up	12B4	154-044
V664	X3001-up	6AU6	154-022
V670	101-300	6U8	154-033
	301-3000X	6AU6	154-022
V677	X3001-up	6080	154-056
V684	X3001-up	12AX7	154-043
V694	X3001-up	6AU6	154-022
V700	101-3000X	6AU6	154-022
V710	101-3000X	5651	154-052
V712	101-3000X	12AX7	154-043
V724	X3001-up	6AU6	154-022
V725	101-3000X	12B4	154-044
V726	101-3000X	12B4	154-044
V727	101-3000X	12B4	154-044
V737	X3001-up	6080	154-056
V742	101-3000X	6AU6	154-022
V748	101-3000X	6080	154-056
V754	X3001-up	6AU6	154-022
V757	101-3000X	6AU6	154-022
V765	101-3000X	12AX7	154-043
V767	X3001-up	12B4	154-044

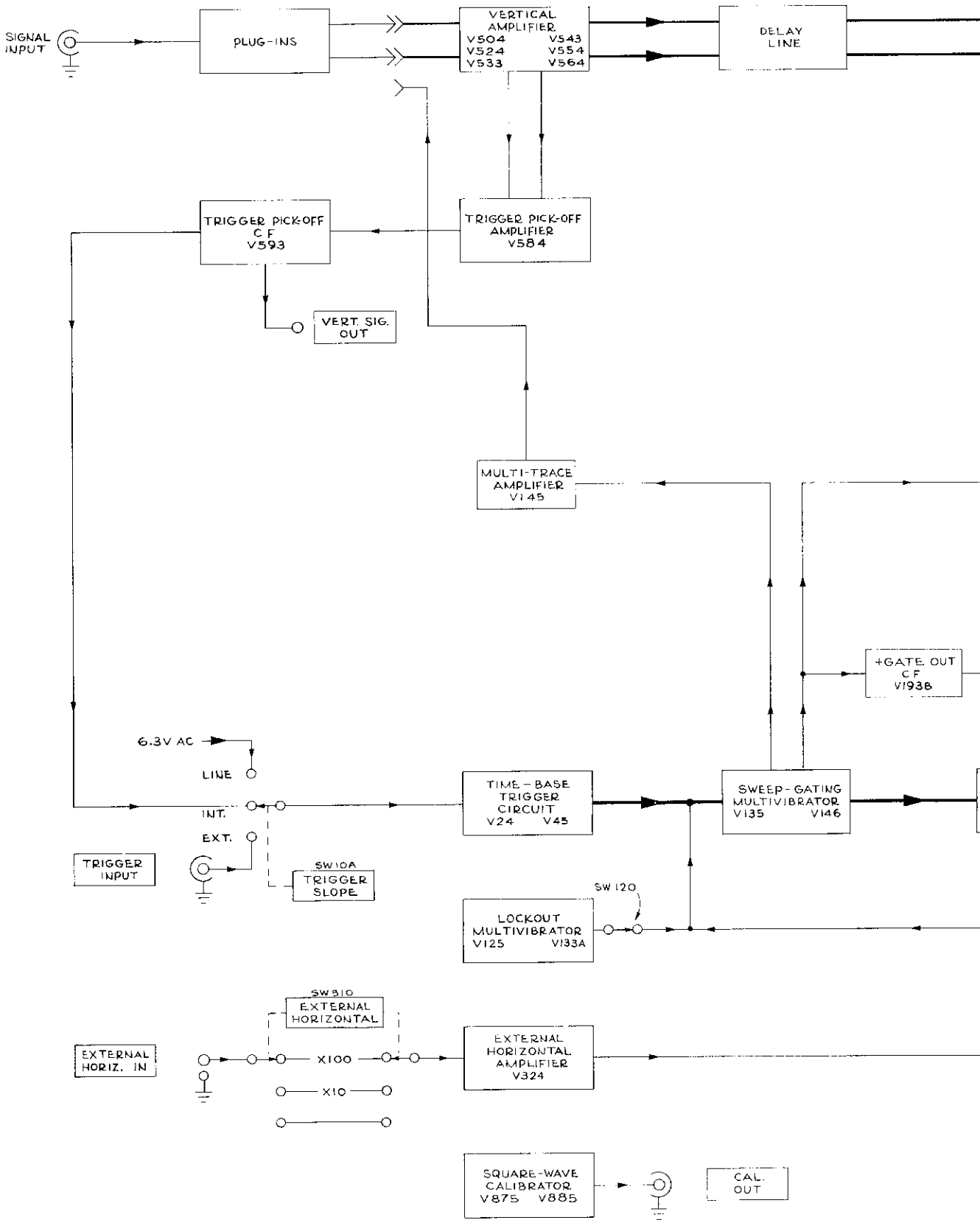
† V504 and V524 furnished as a unit.

Electron Tubes (continued)

			Tektronix Part Number
V782	101-3000X	6AU6	154-022
V784	101-3000X	6080	154-056
V791	101-3000X	6AU6	154-022
V794	101-3000X	12B4	154-044
V800		6AU5GT	154-021
V814		12AU7	154-041
V822†	X1780-up	5642	154-051
V832†	X1780-up	5642	154-051
V842†	X1780-up	5642	154-051
V852†	X1780-up	5642	154-051
V859		T5330-2 CRT Standard Phosphor	*154-165
V862†	X1780-up	5642	154-051
V875	X3001-up	6AU6	154-022
V885	X3001-up	12AU7	154-041

FREE SCAN IN THE PUBLIC DOMAIN

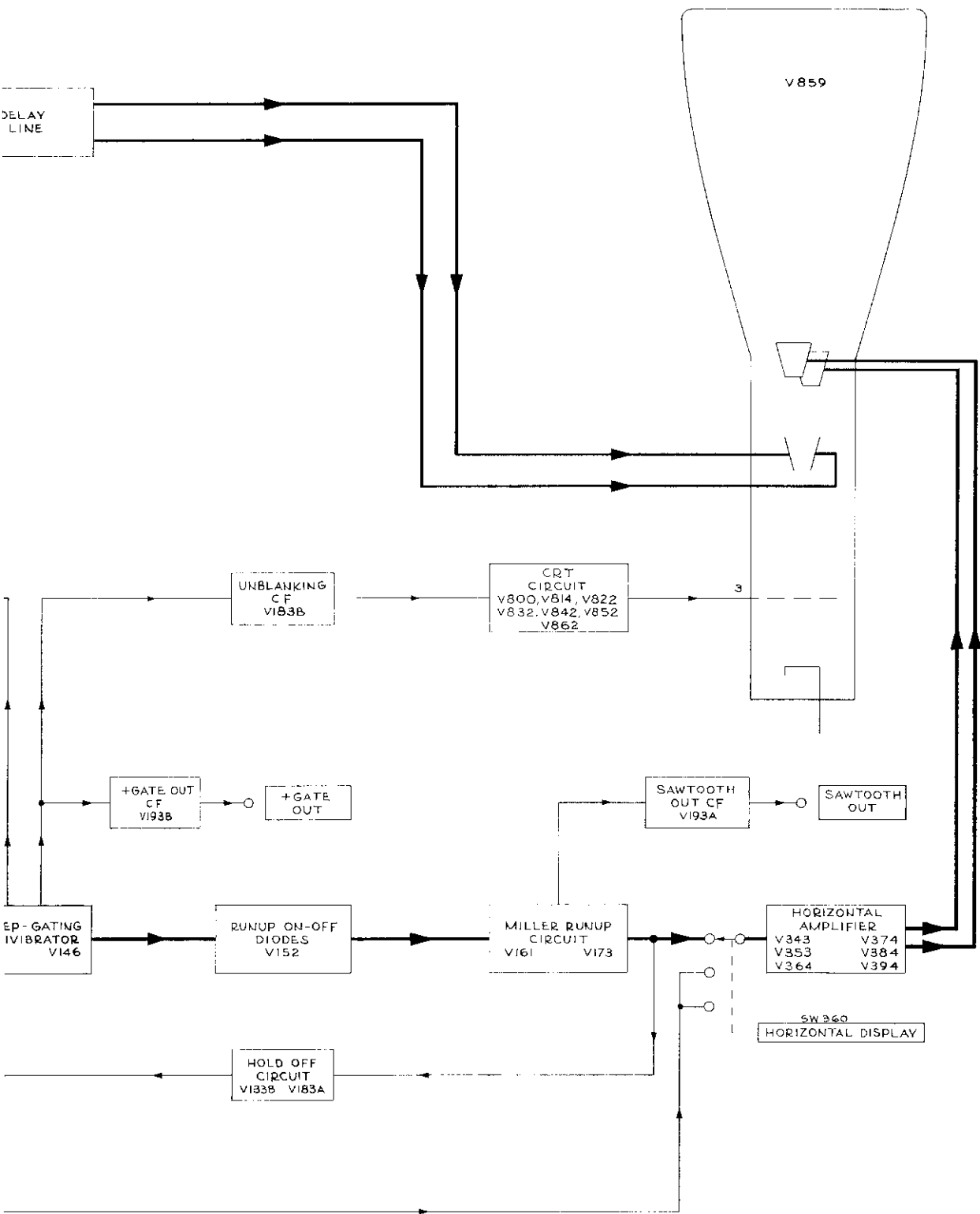
†S/N 101-1779, V862 was V820, V852 was V823, V842 was V822, V832 was V821, V822 was V824.



TYPE 533/533A OSCILLOSCOPE

AA,

FREE SCAN IN PUBLIC DOMAIN



AA,

JN
10-17-62
BLOCK DIAGRAM

FREE SCAN IN PUBLIC DOMAIN

IMPORTANT

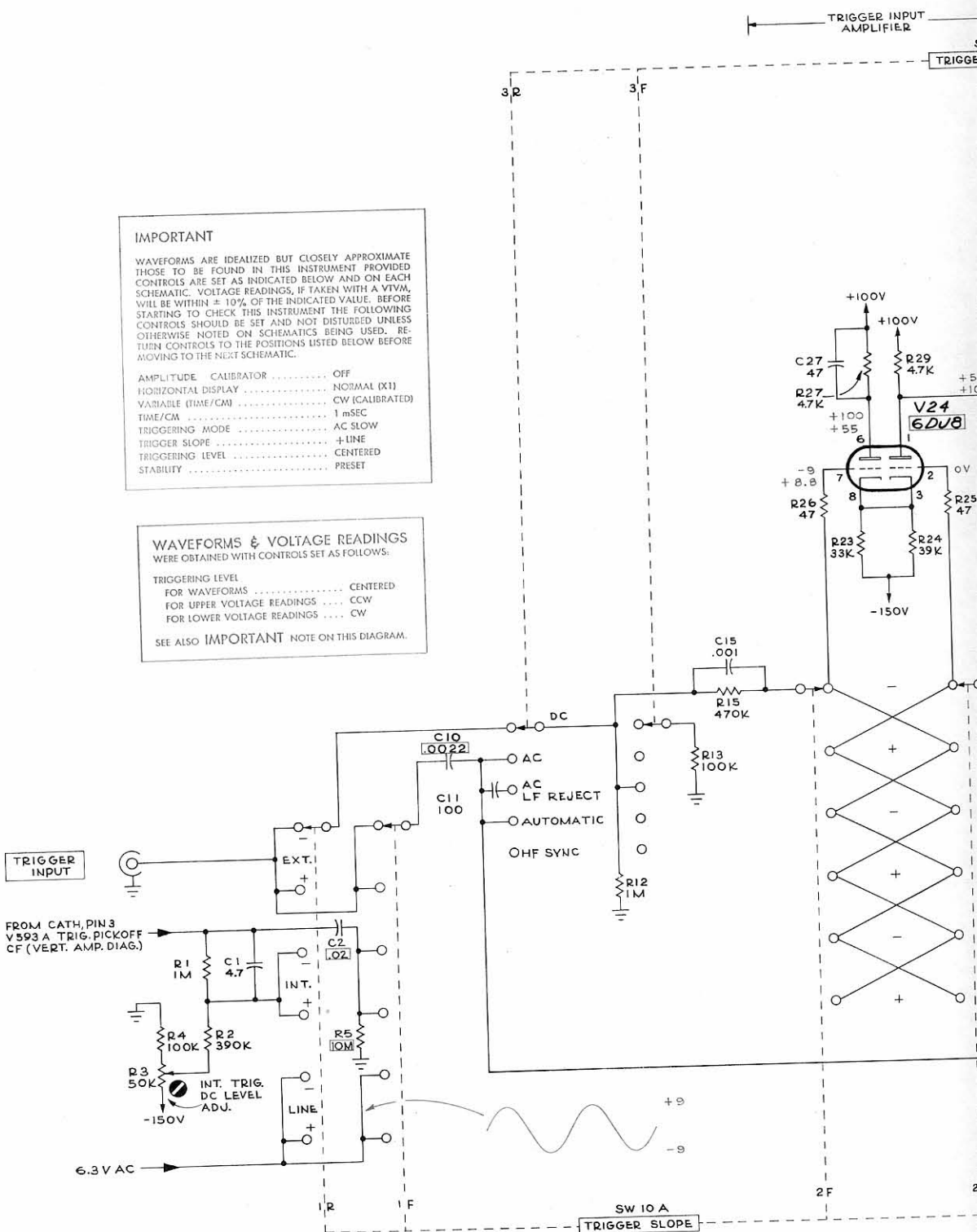
WAVEFORMS ARE IDEALIZED BUT CLOSELY APPROXIMATE THOSE TO BE FOUND IN THIS INSTRUMENT PROVIDED CONTROLS ARE SET AS INDICATED BELOW AND ON EACH SCHEMATIC. VOLTAGE READINGS, IF TAKEN WITH A VTVM, WILL BE WITHIN $\pm 10\%$ OF THE INDICATED VALUE. BEFORE STARTING TO CHECK THIS INSTRUMENT THE FOLLOWING CONTROLS 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.

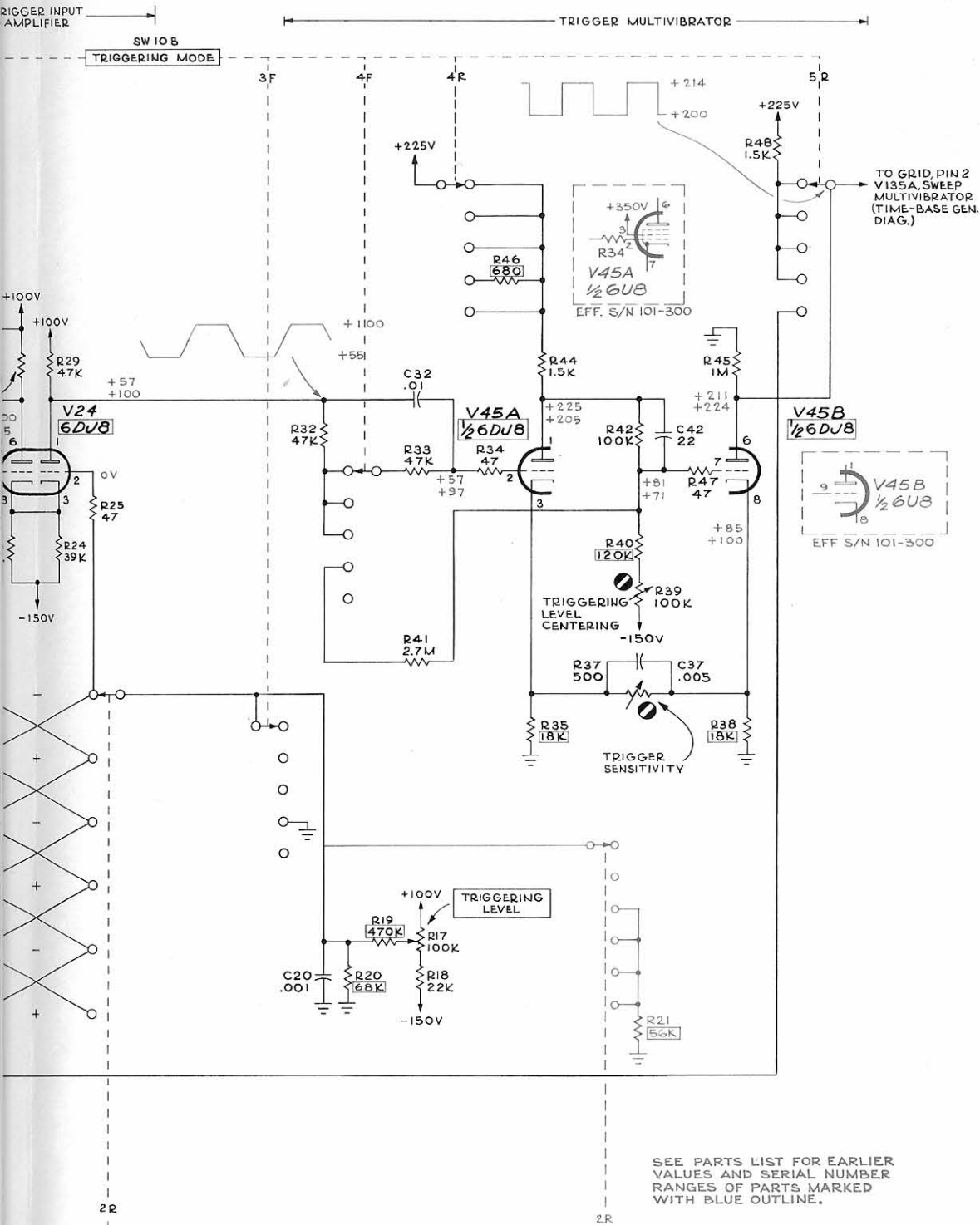
AMPLITUDE CALIBRATOR OFF
 HORIZONTAL DISPLAY NORMAL (X1)
 VARIABLE (TIME/CM) CW (CALIBRATED)
 TIME/CM 1 mSEC
 TRIGGERING MODE AC SLOW
 TRIGGER SLOPE +LINE
 TRIGGERING LEVEL CENTERED
 STABILITY PRESET

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

TRIGGERING LEVEL CENTERED
 FOR WAVEFORMS CENTERED
 FOR UPPER VOLTAGE READINGS CW
 FOR LOWER VOLTAGE READINGS CW

SEE ALSO IMPORTANT NOTE ON THIS DIAGRAM.





TIME BASE TRIGGER

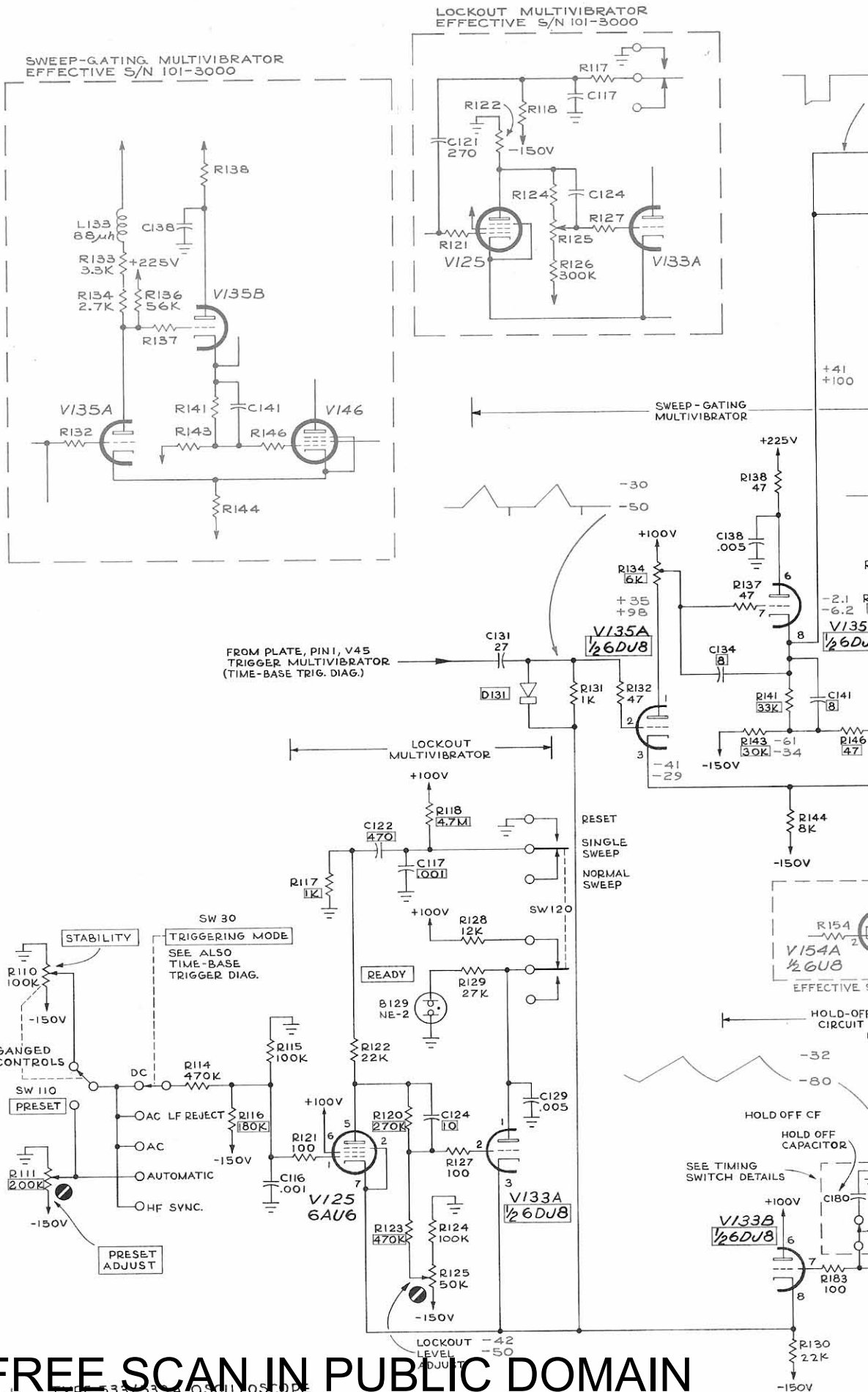
CIRCUIT NUMBERS
1 THRU 49

1166
JN

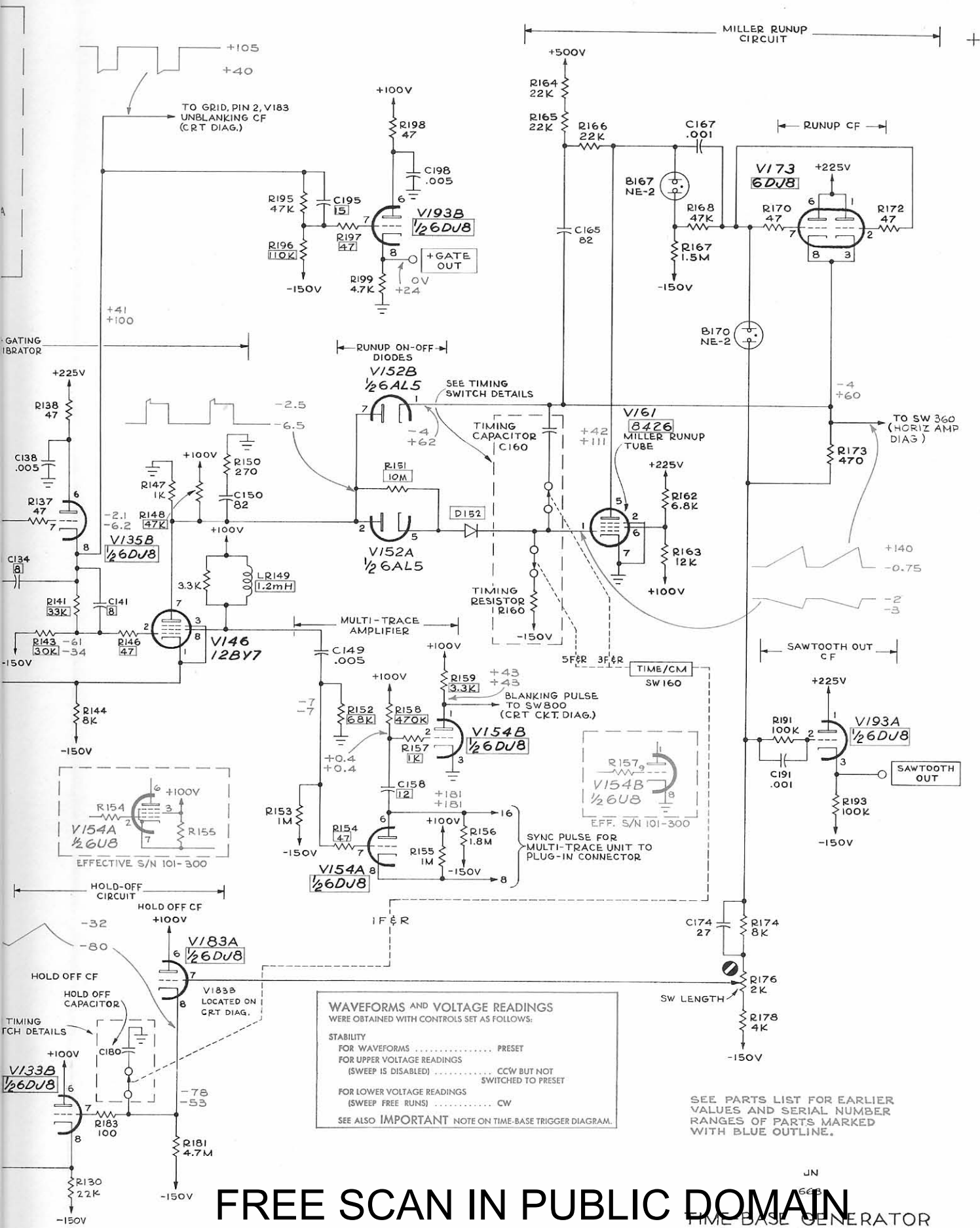
TIME-BASE TRIGGER

FREE SCAN IN PUBLIC DOMAIN

AD



FREE SCAN IN PUBLIC DOMAIN



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

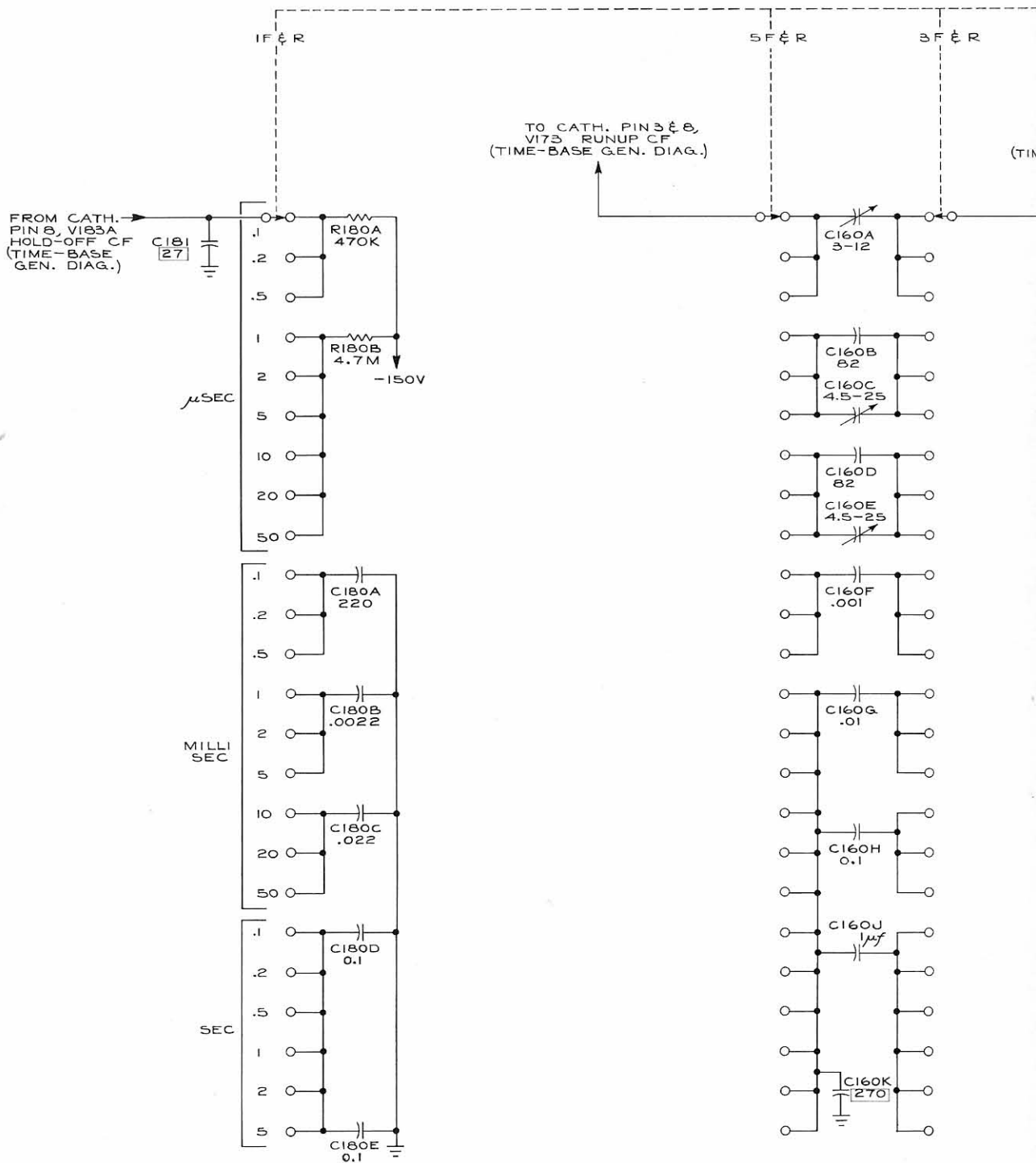
SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

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

FREE SCAN IN PUBLIC DOMAIN

CIRCUIT NUMBERS 110 THRU 199

TIME BASE GENERATOR



HOLD-OFF
RESISTORS & CAPACITORS

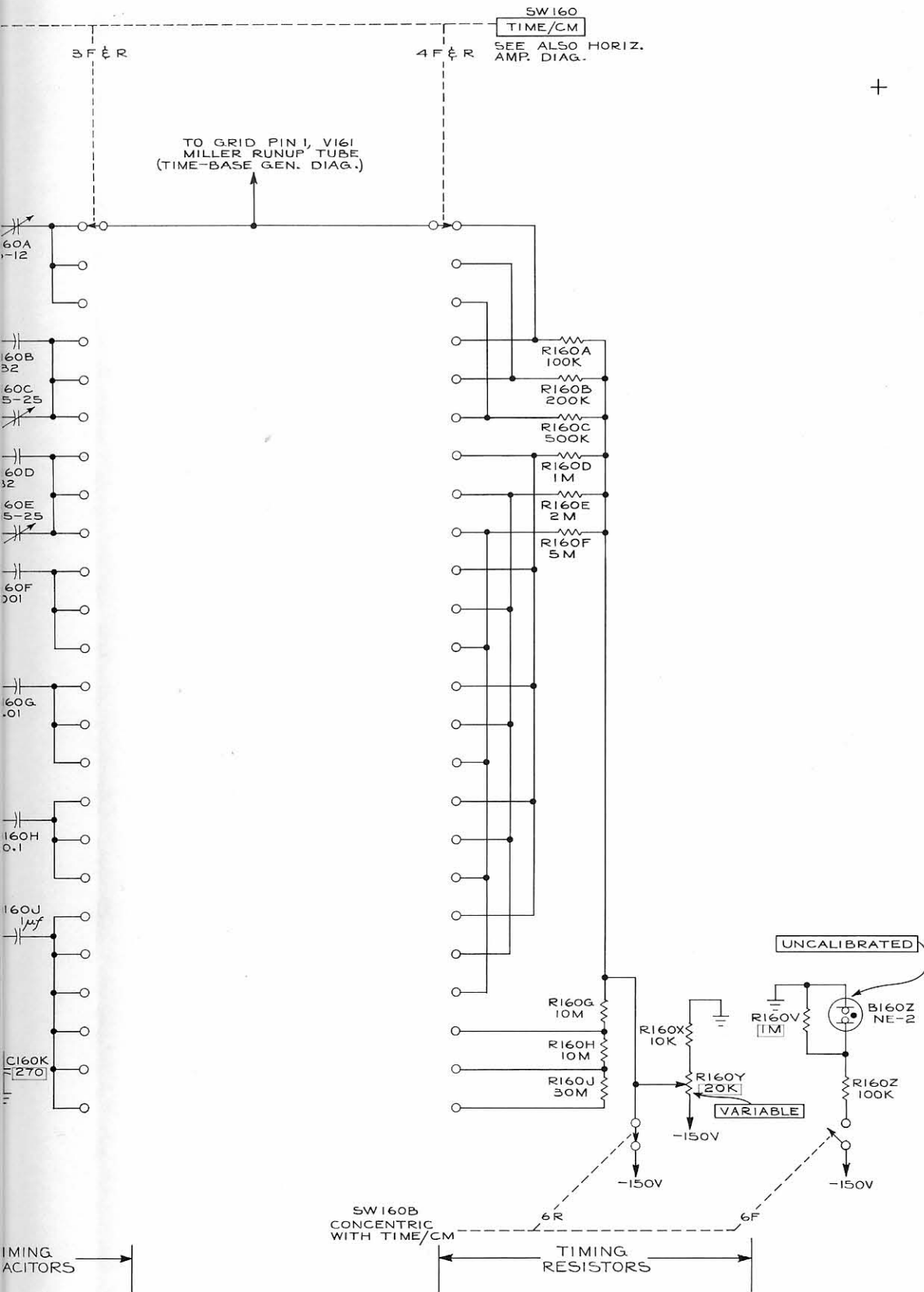
TIMING
CAPACITORS

+

TYPE 533/533A OSCILLOSCOPE
FREE SCAN IN PUBLIC DOMAIN

AB₂

SEE
VAL
RAN
WIT

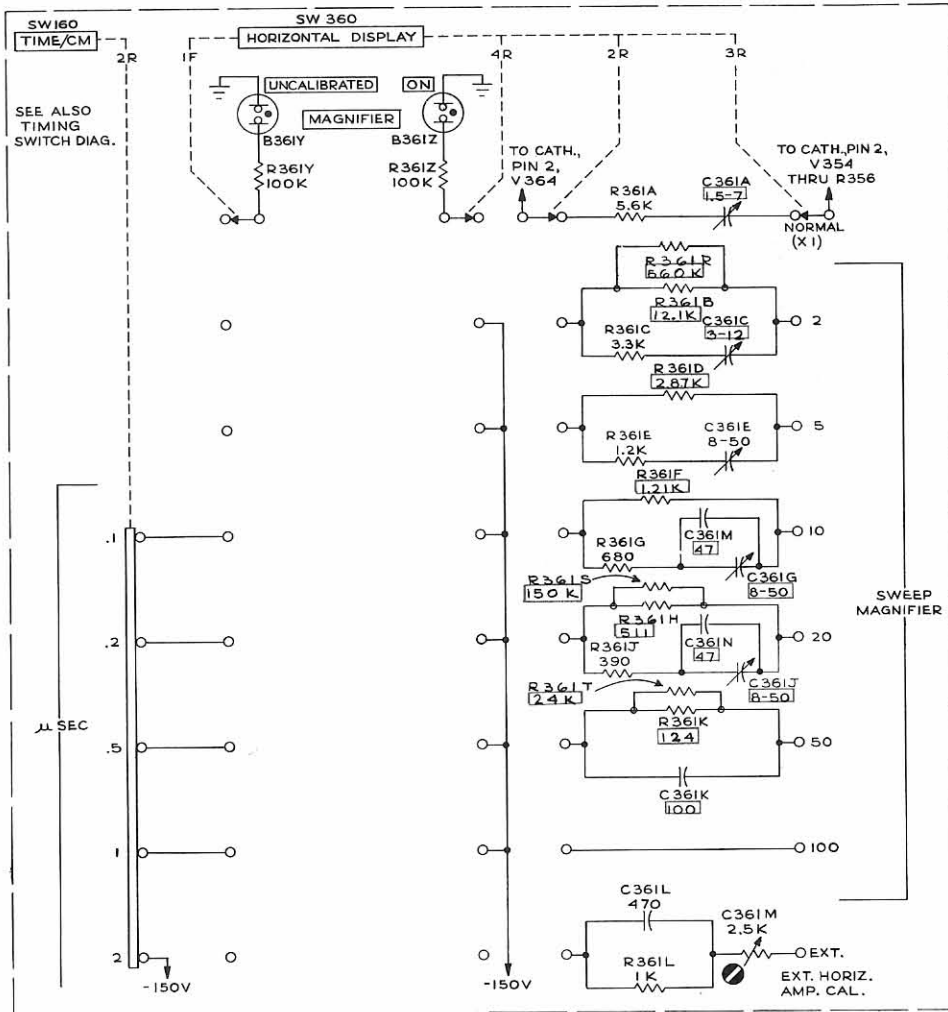


SEE PARTS LIST FOR EARLIER
VALUES AND SERIAL NUMBER
RANGES OF PARTS MARKED
WITH BLUE OUTLINE.

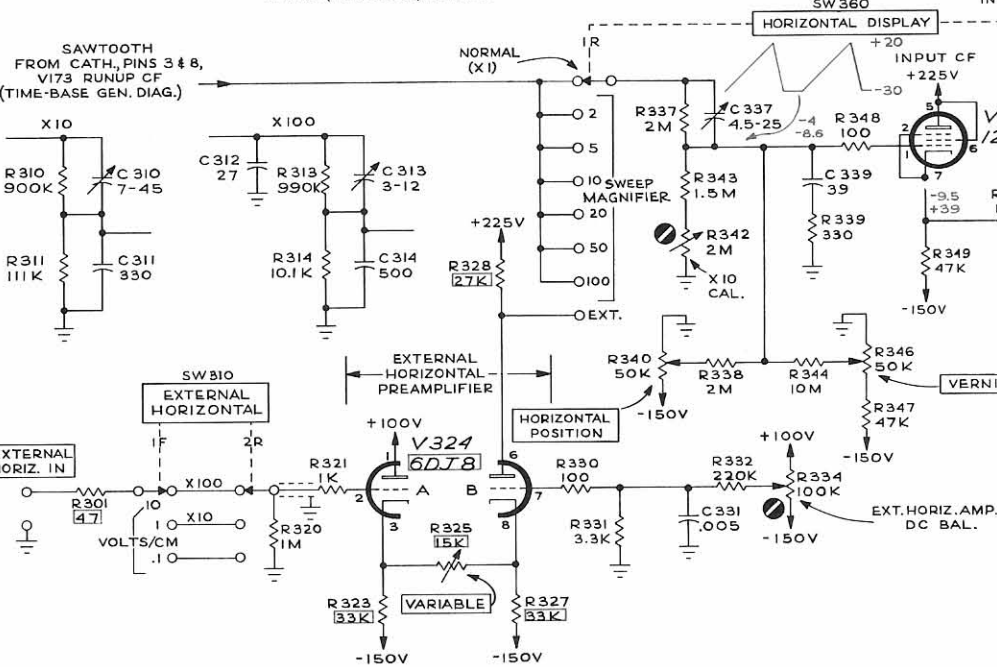
AB₂

PLM
664
TIMING SWITCH

FREE SCAN IN PUBLIC DOMAIN



SW 360 (HORIZ. DISP) DETAILS

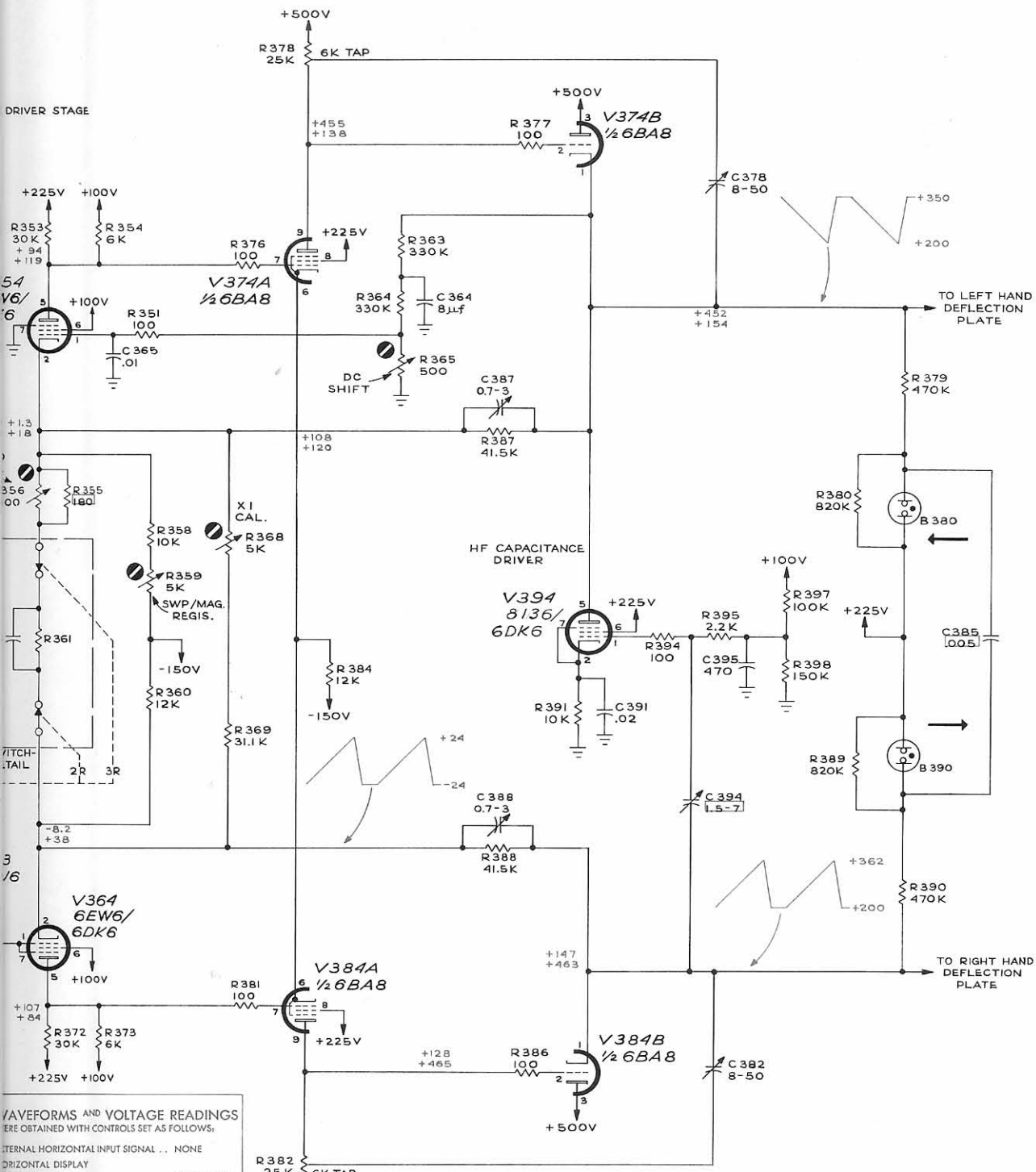


WAVEFORMS AND VOLTAGE RE...
 WERE OBTAINED WITH CONTROLS SET AS FO...
 EXTERNAL HORIZONTAL INPUT SIGNAL ...
 HORIZONTAL DISPLAY
 FOR WAVEFORMS N
 FOR VOLTAGE READINGS E
 HORIZONTAL POSITION
 FOR UPPER VOLTAGE READINGS C
 FOR LOWER VOLTAGE READINGS C
 EXTERNAL HORIZONTAL VOLTS/CM 1
 EXTERNAL HORIZONTAL VARIABLE C
 ALSO SEE IMPORTANT NOTE
 BASE TRIGGER DIAGRAM.

FREE SCAN IN PUBLIC DOMAIN

OUTPUT AMPLIFIERS

OUTPUT CF'S



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

INTERNAL HORIZONTAL INPUT SIGNAL ... NONE

HORIZONTAL DISPLAY

FOR WAVEFORMS NORMAL (X1)

FOR VOLTAGE READINGS EXT.

HORIZONTAL POSITION

FOR UPPER VOLTAGE READINGS CCW

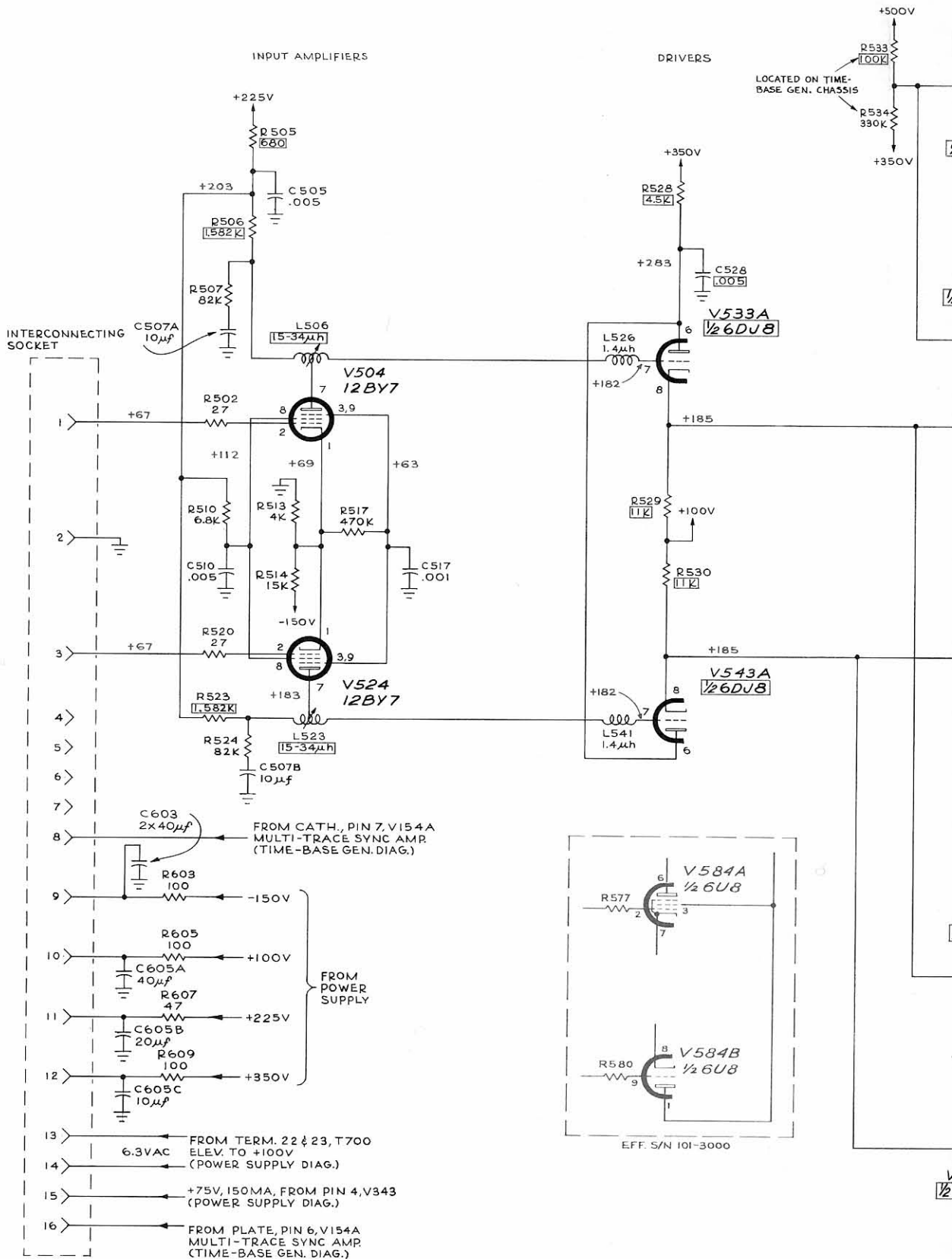
FOR LOWER VOLTAGE READINGS CW

INTERNAL HORIZONTAL VOLTS/CM 1

INTERNAL HORIZONTAL VARIABLE CW

SEE IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

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

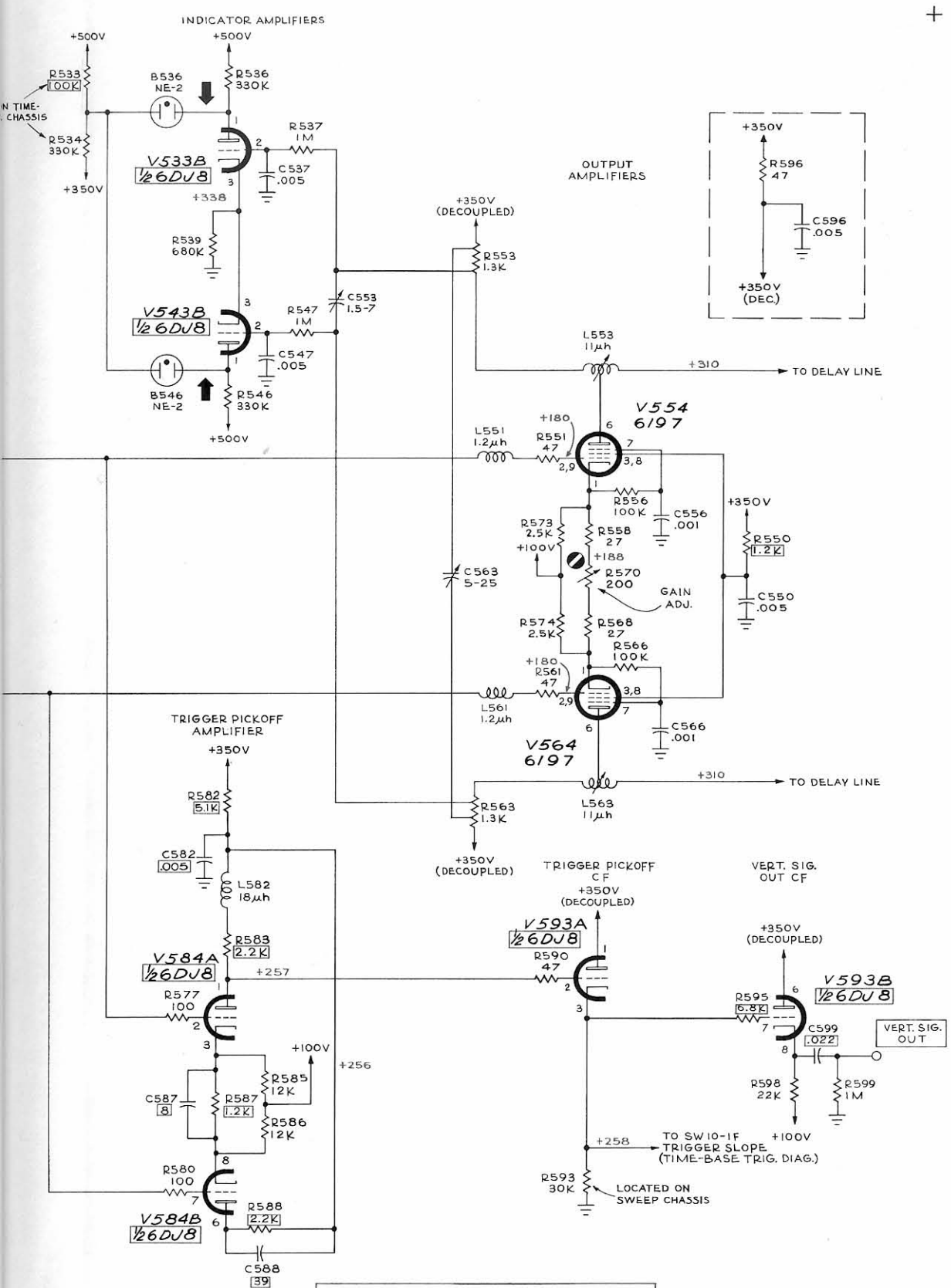


TYPE 533/533A OSCILLOSCOPE

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

AB₂

+ FREE SCAN IN PUBLIC DOMAIN

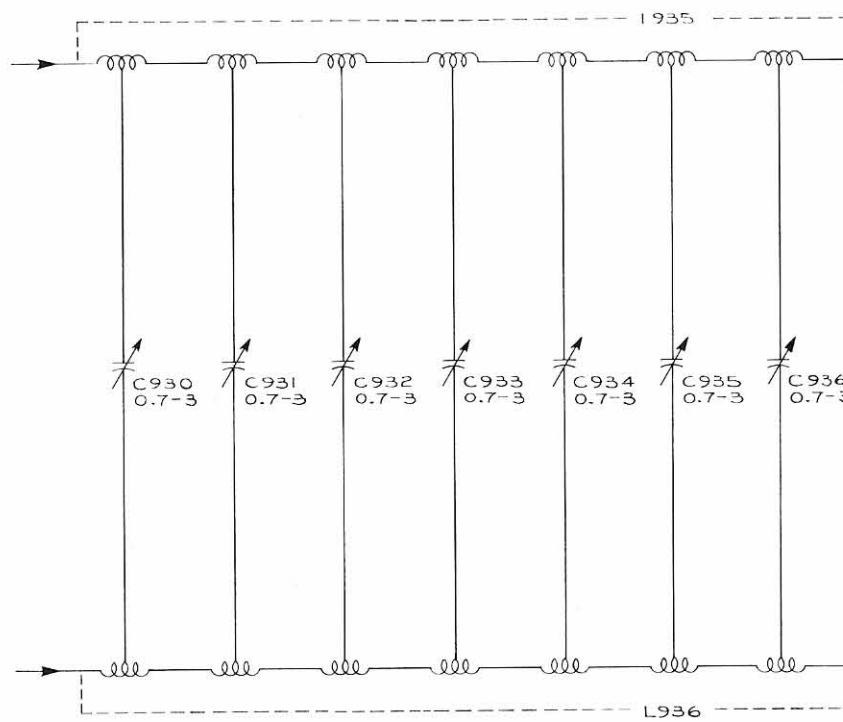
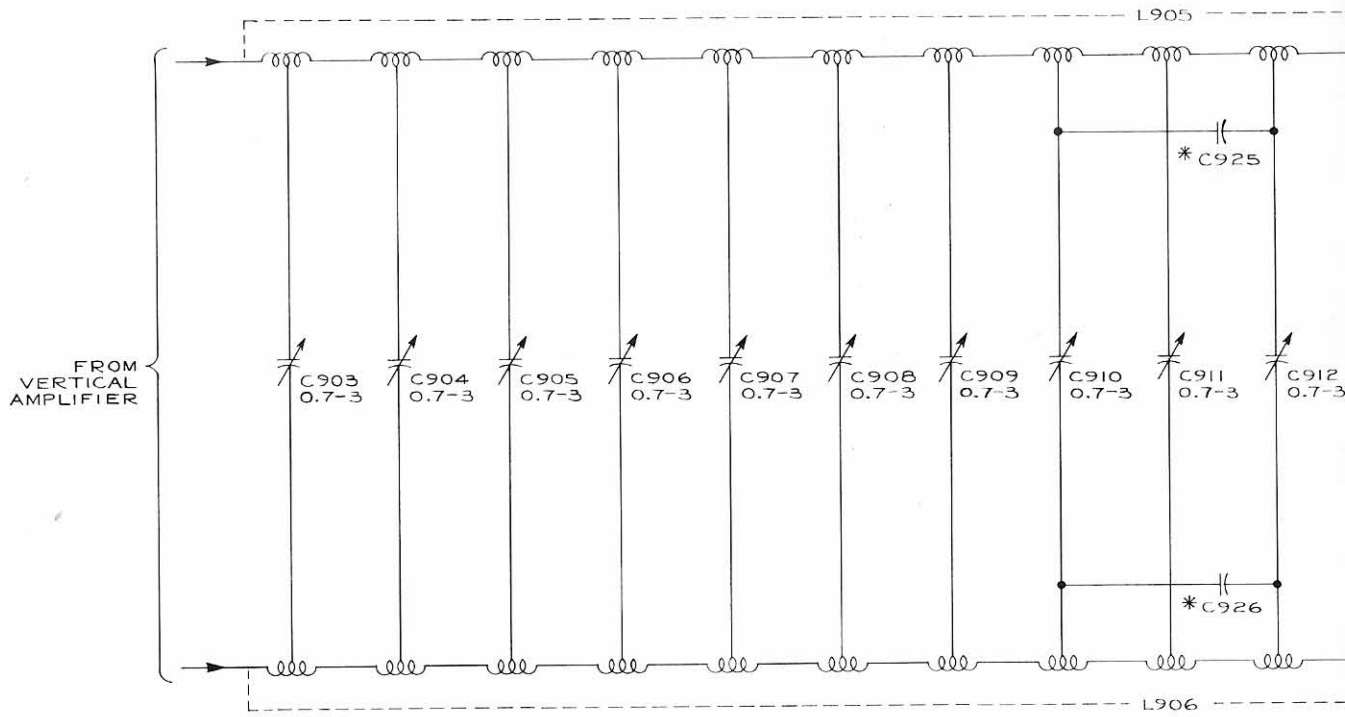


VOLTAGE READINGS WERE OBTAINED
 WITH CONTROLS SET AS FOLLOWS:
 VERTICAL INPUT SIGNAL NONE
 TRIGGERING MODE AUTOMATIC
 VERTICAL POSITION TRACE CENTERED

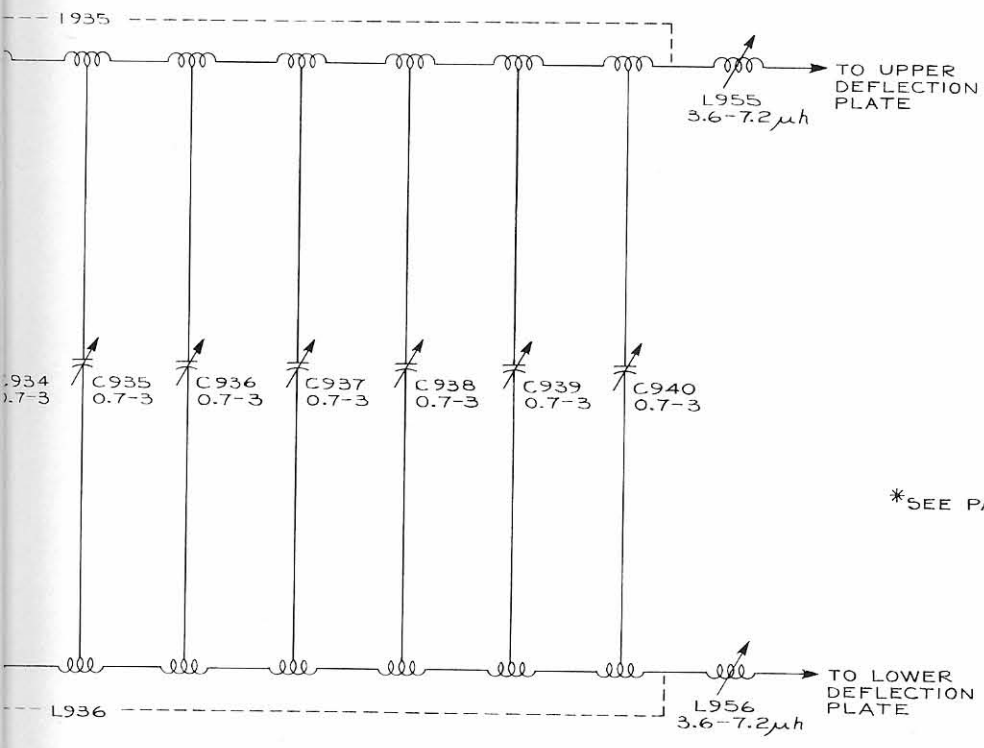
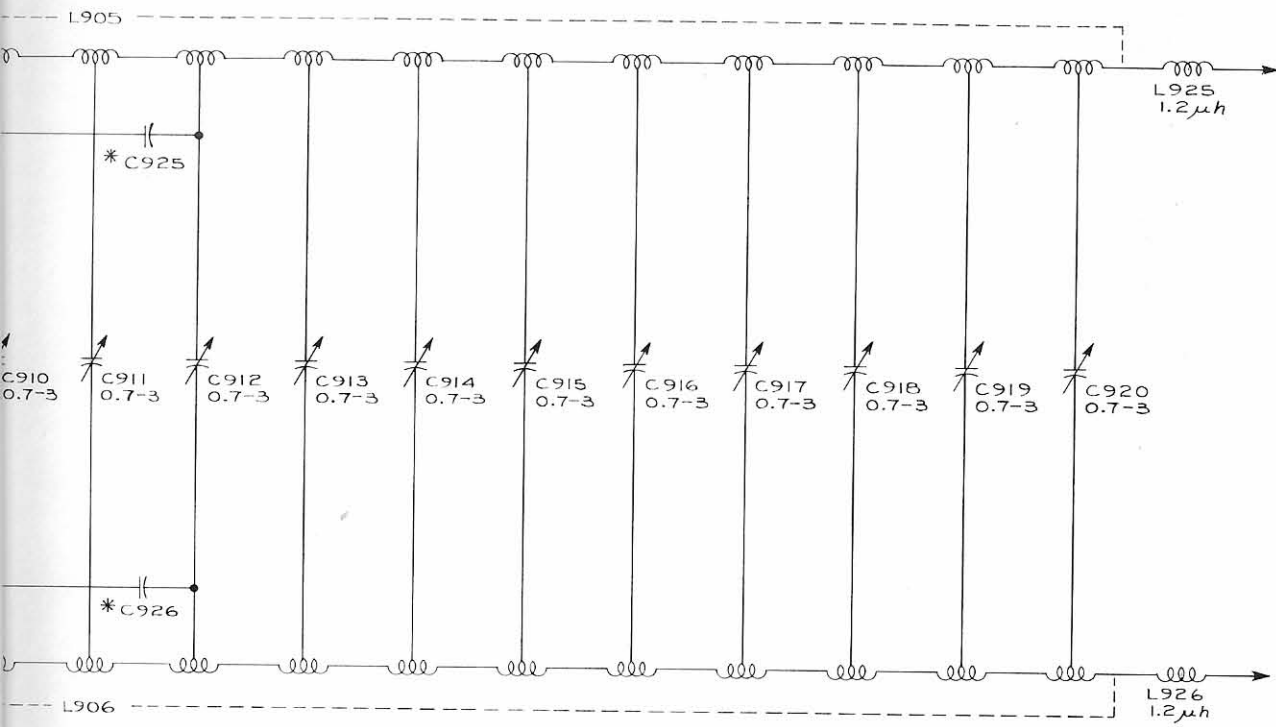
JN
 664
 VERTICAL AMPLIFIER
 CIRCUIT NUMBERS
 501 HR 618

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGERING DIAG.
 FREE SCAN IN PUBLIC DOMAIN

AB₂



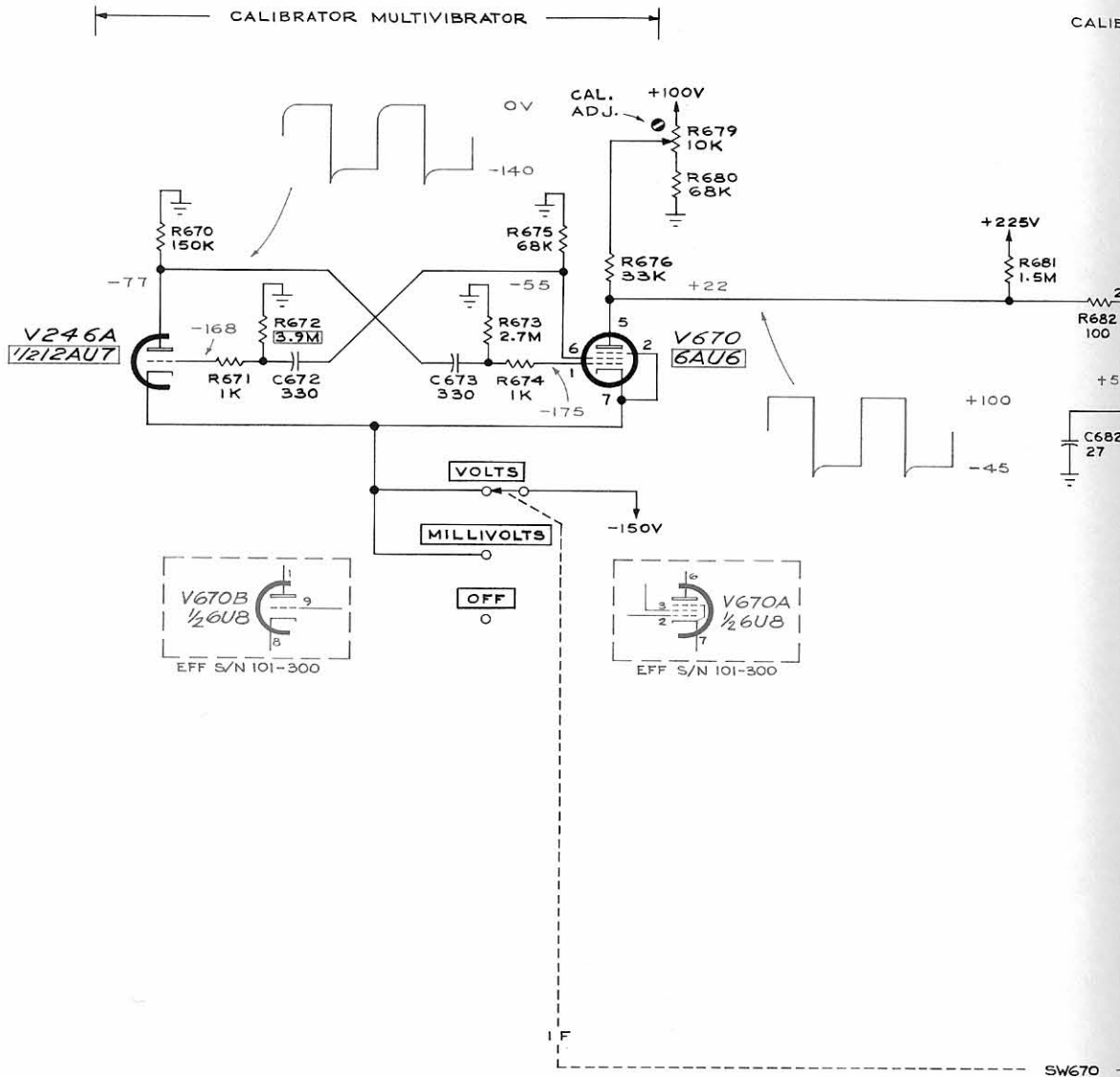
FREE SCAN IN PUBLIC DOMAIN



AA₁

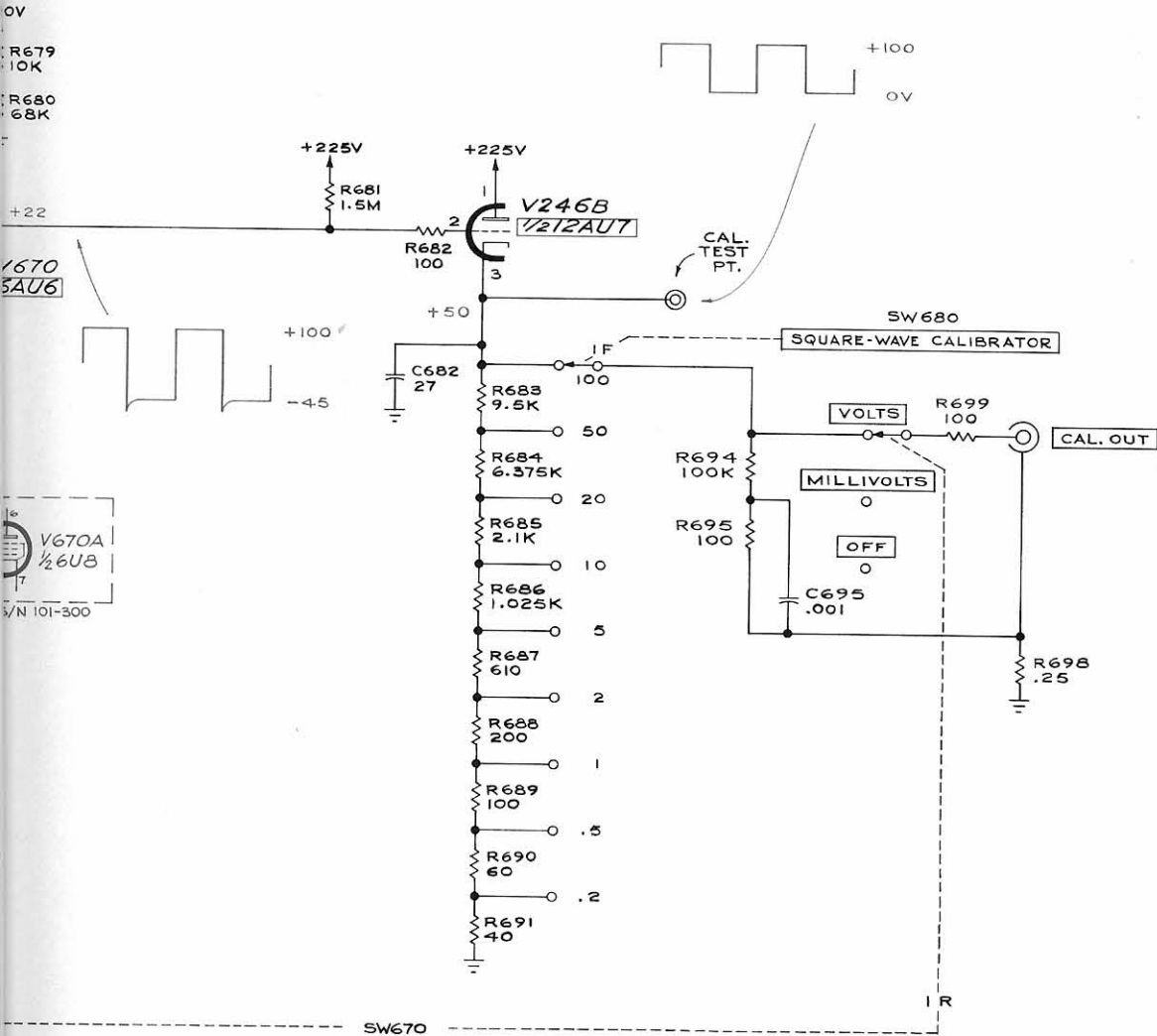
FREE SCAN IN PUBLIC DOMAIN

PLN
09-27-52
DELAY LINE
CIRCUIT NUMBERS
900 THRU 959



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

CALIBRATOR C. F.



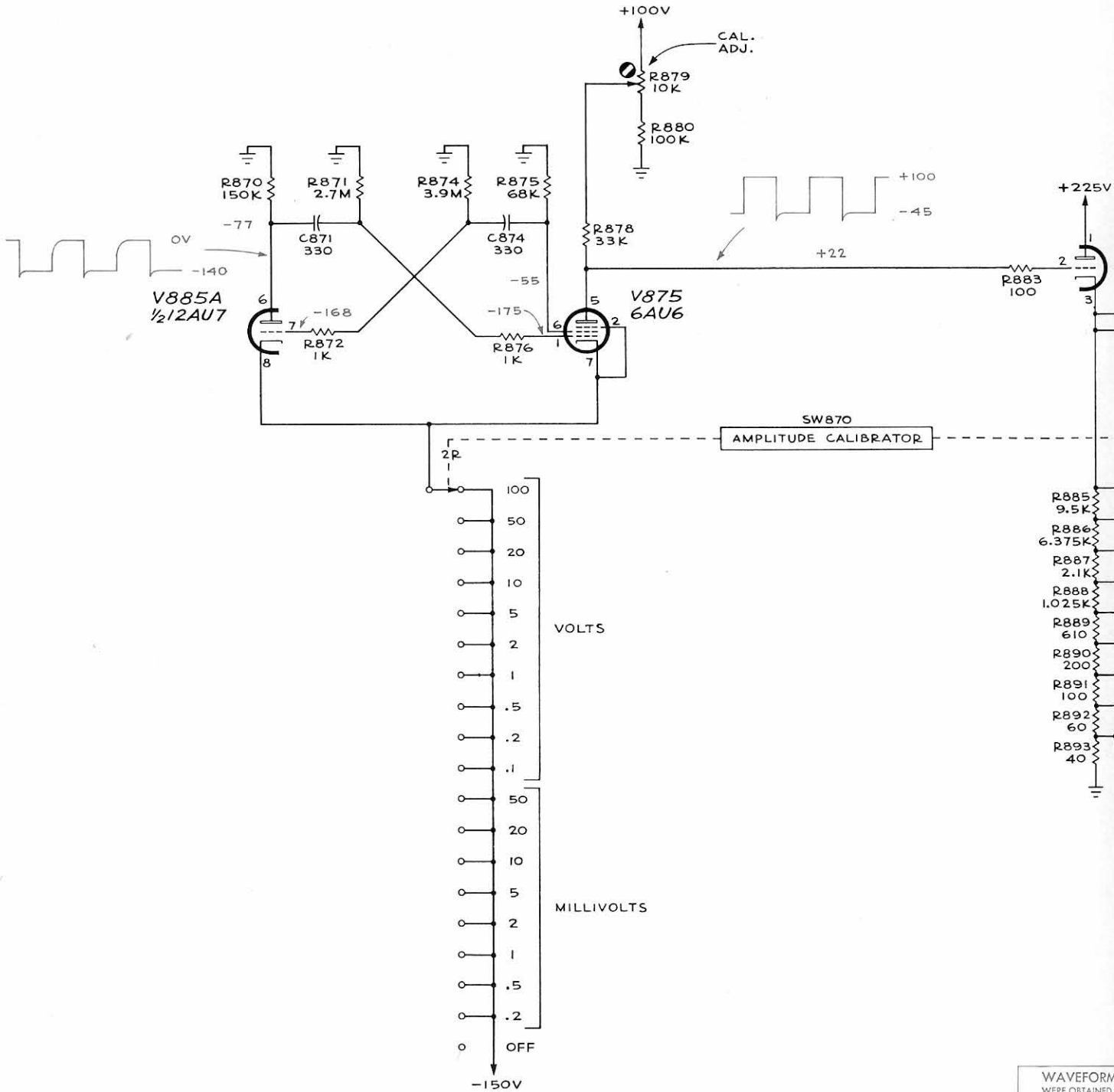
WAVEFORMS AND VOLTAGE READINGS
 WERE OBTAINED WITH CONTROLS SET
 AS FOLLOWS:
 SQUARE-WAVE CALIBRATOR ON

AA₄

MRH
 864
 CALIBRATOR
 S/N 101-3000
 CIRCUIT NUMBERS
 670 THRU 699

CALIBRATOR
MULTIVIBRATOR

CAL. OUT
CF



WAVEFORM
WERE OBTAINED
AMPLITUDE CA

533A

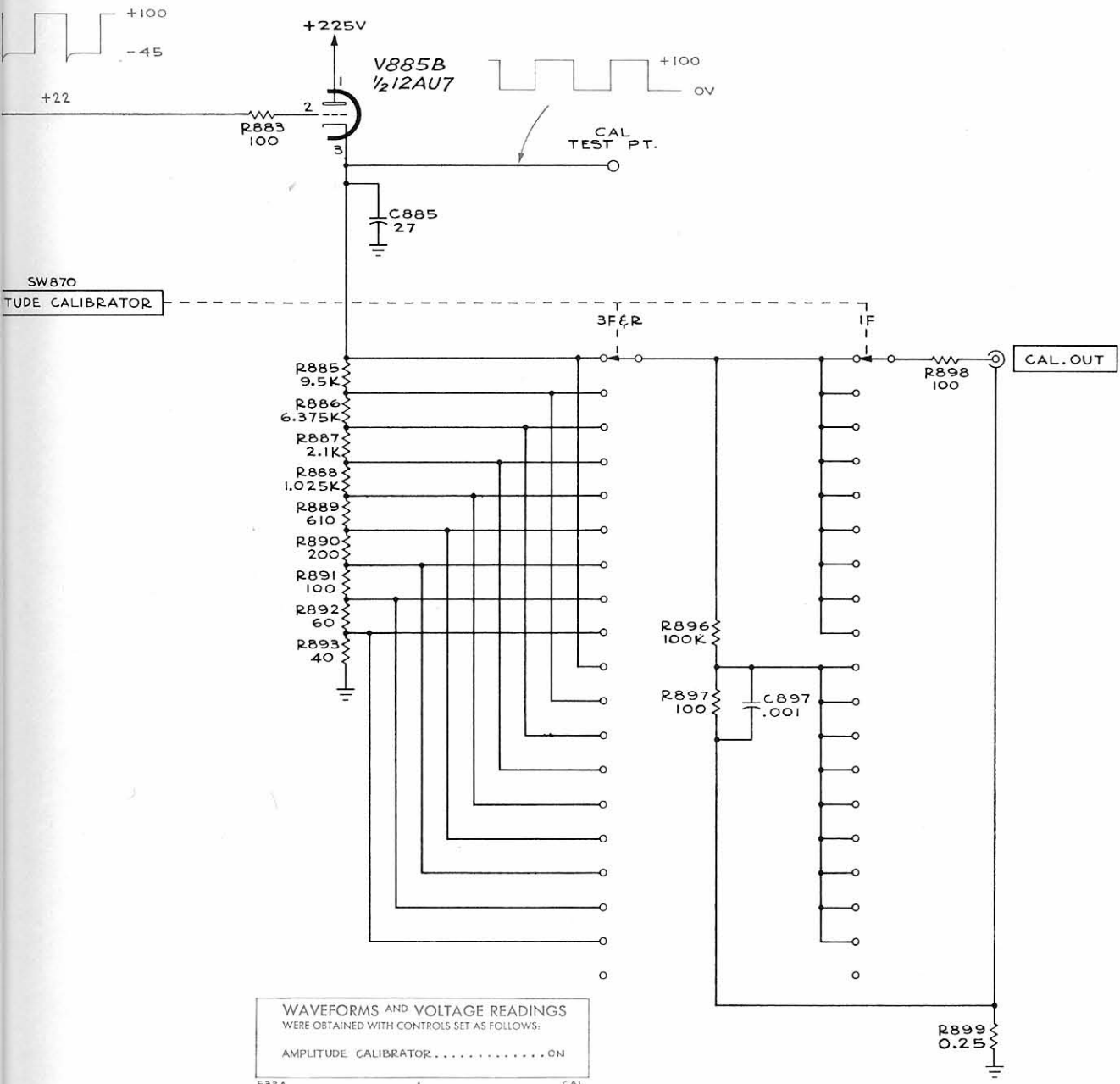
TYPE 533A OSCILLOSCOPE

AA₂

FREE SCAN IN PUBLIC DOMAIN

+

CAL. OUT
CF

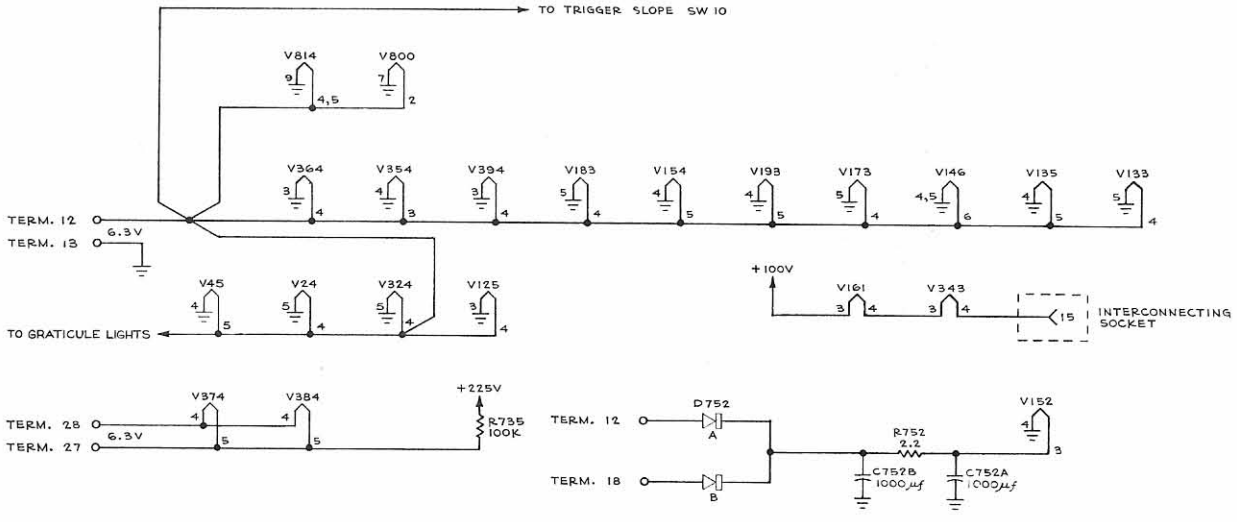


AA₂

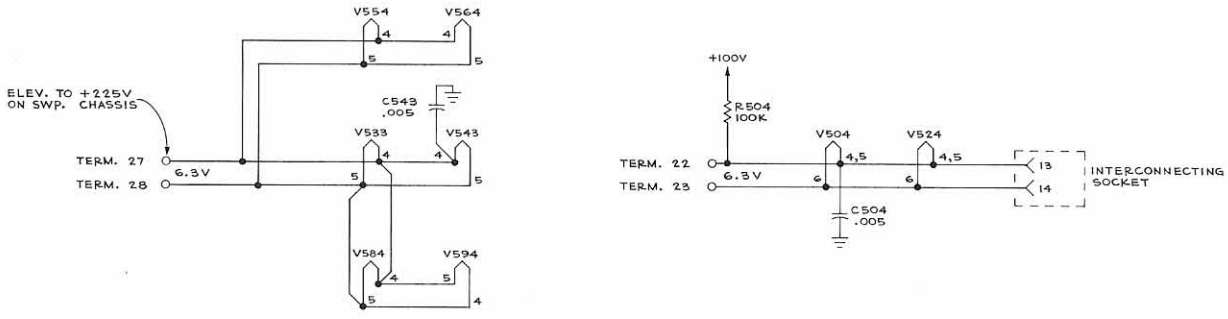
CALIBRATOR
S/N 3001 & UP

CIRCUIT NUMBERS
870 THRU 899

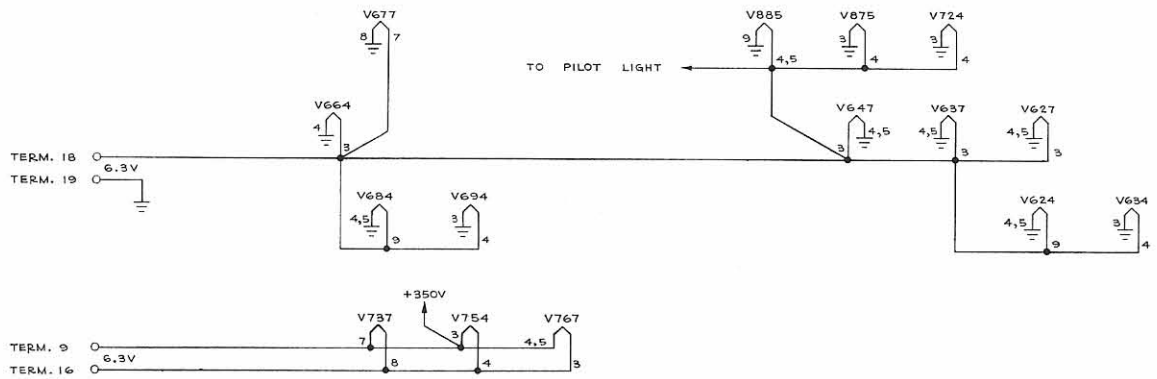
FREE SCAN IN PUBLIC DOMAIN



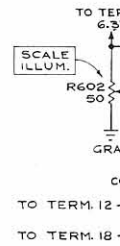
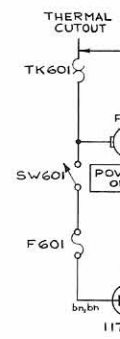
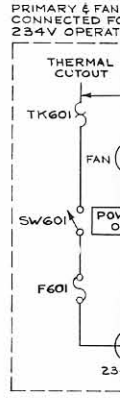
SWEEP CHASSIS

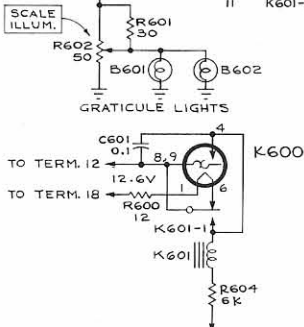
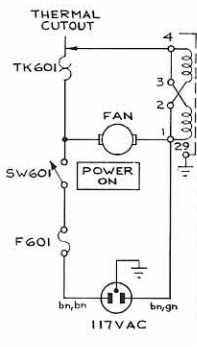
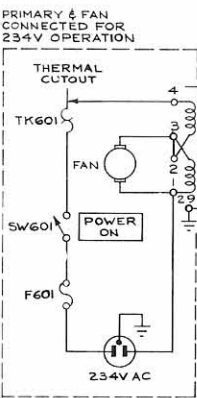
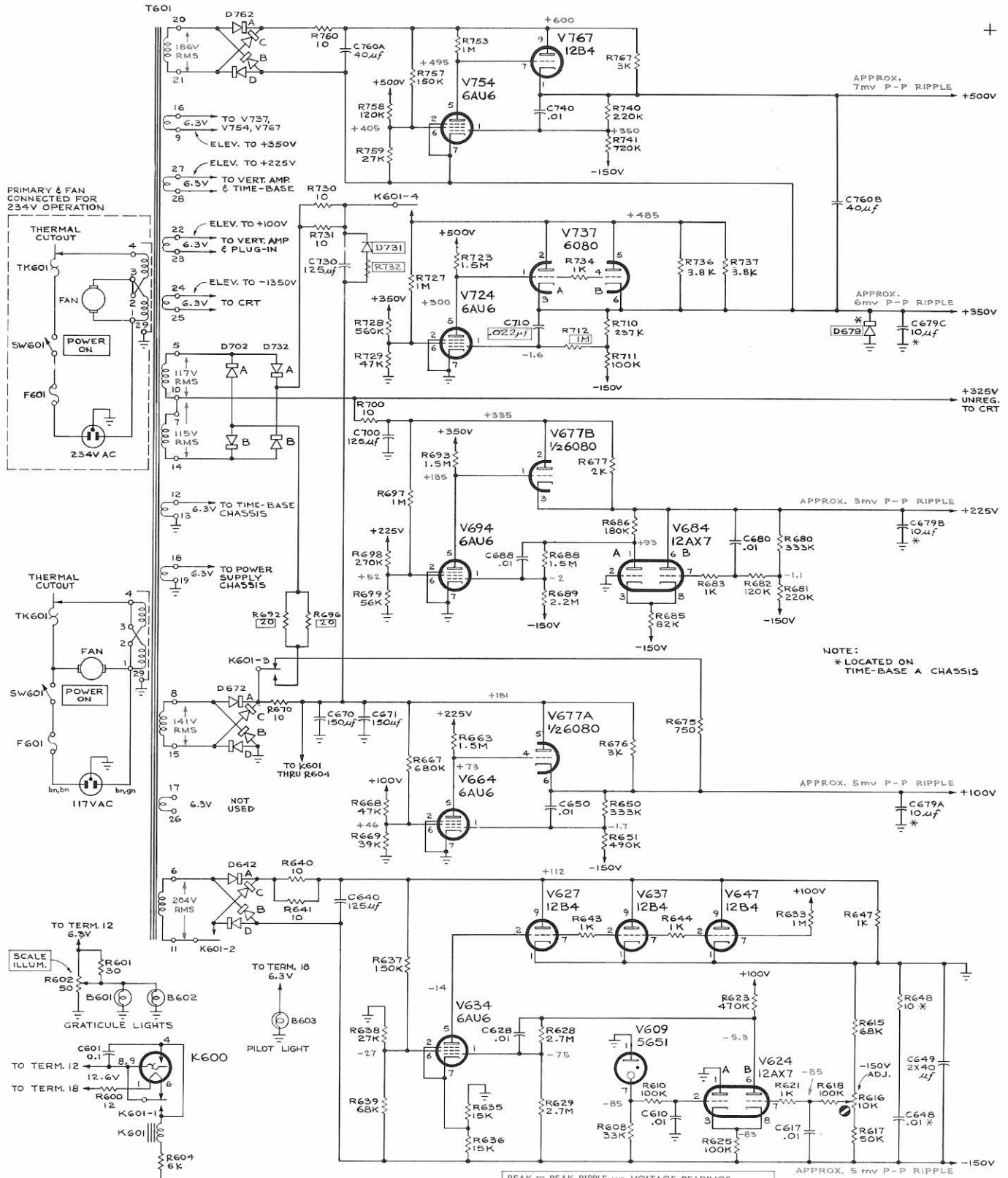


VERTICAL CHASSIS



POWER CHASSIS





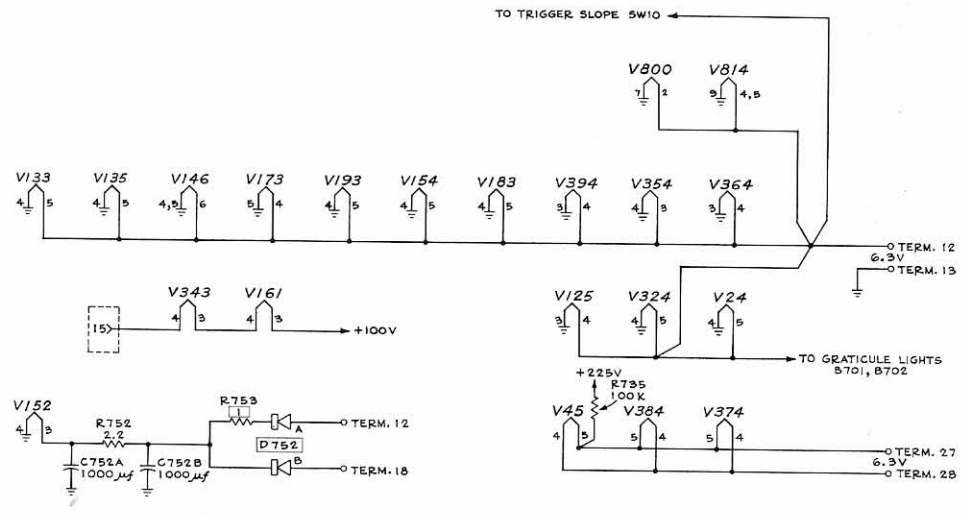
NOTE:
* LOCATED ON
TIME-BASE A CHASSIS

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

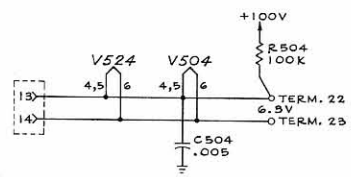
VERTICAL INPUT SIGNAL	NONE
TRIGGER INPUT SIGNAL	NONE
LINE VOLTAGE	117 VAC
STABILITY	CCW, BUT NOT SWITCHED TO PRESET

SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

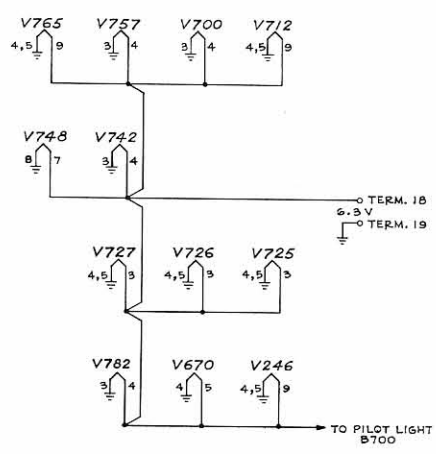
CIRCUIT NUMBERS
600 THRU 769



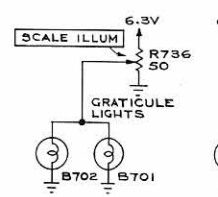
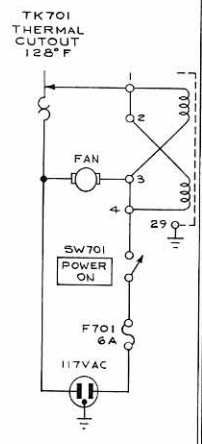
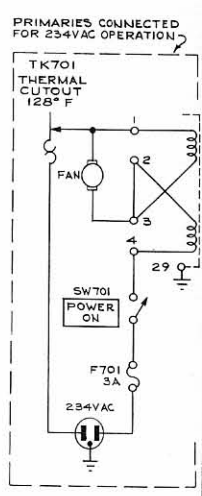
SWEEP CHASSIS



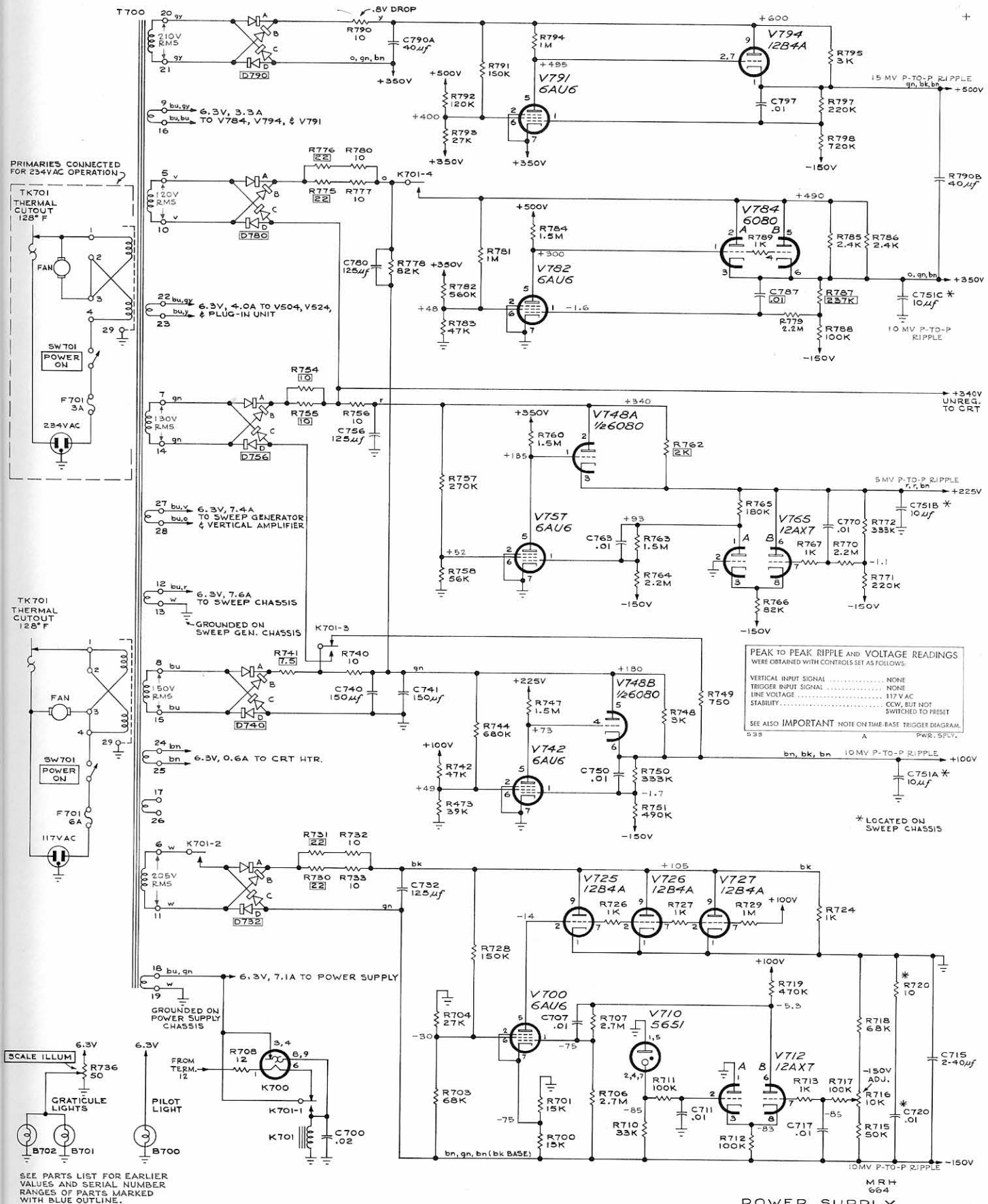
VERTICAL CHASSIS

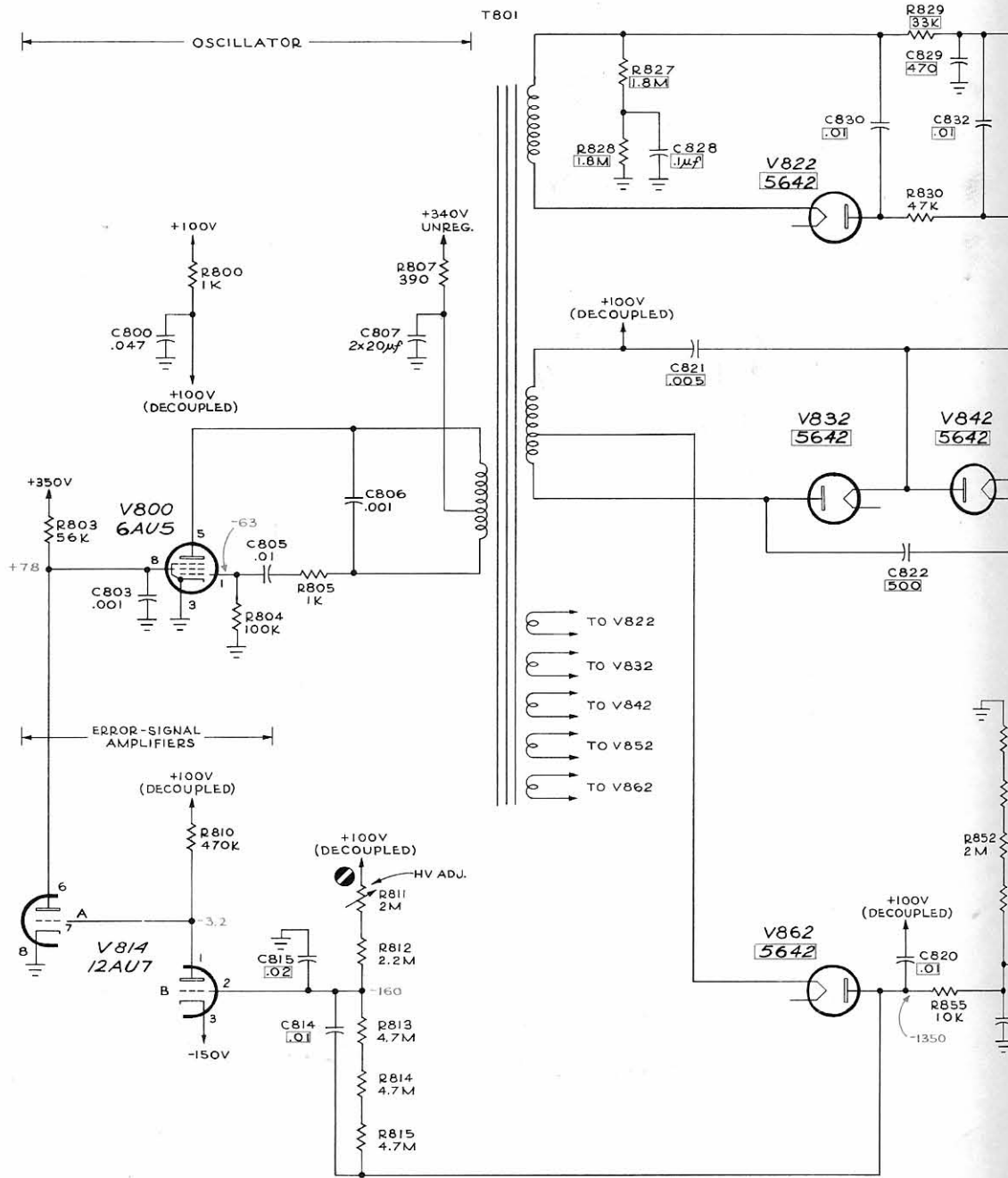


POWER SUPPLY CHASSIS

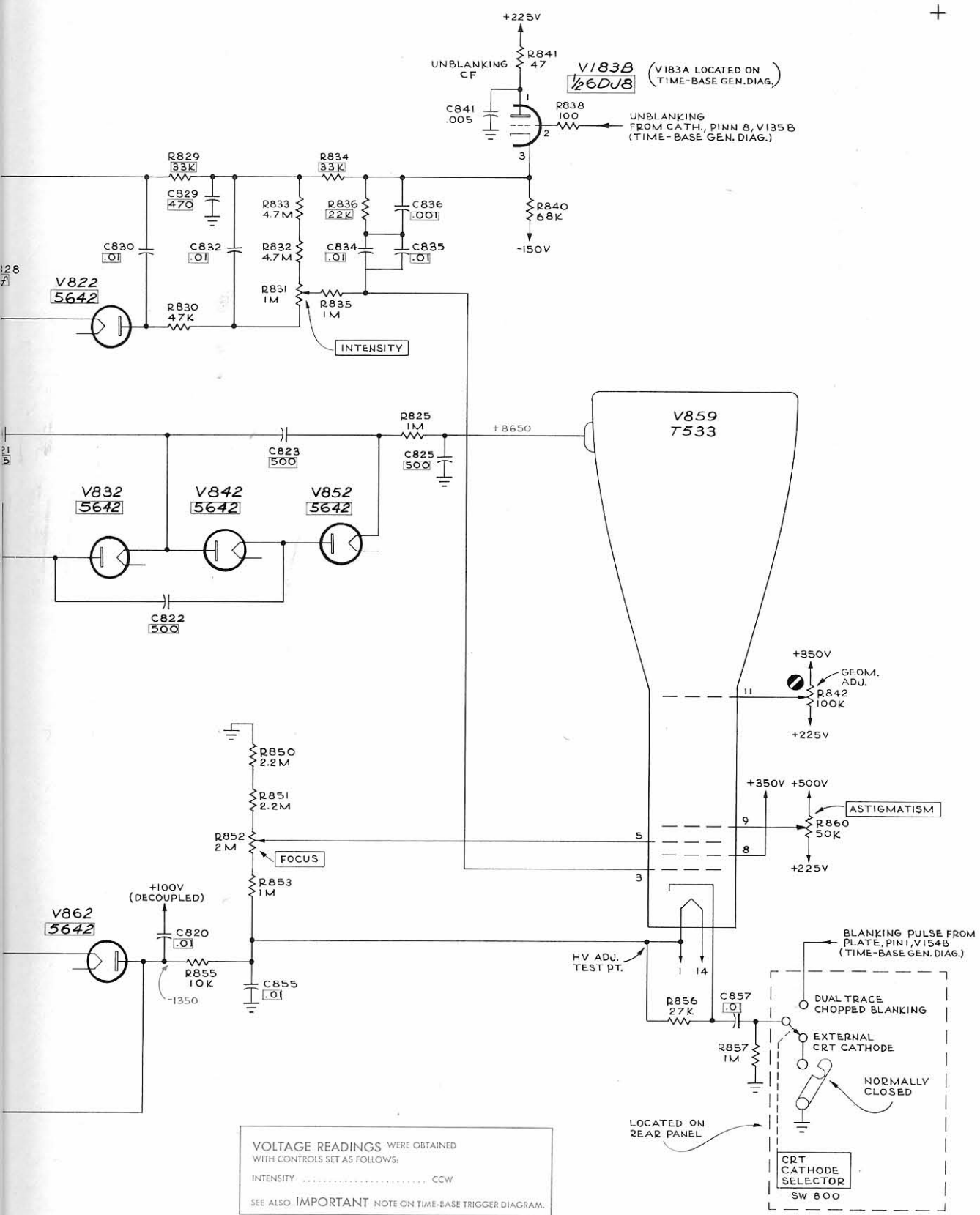


SEE PARTS LIST FOR EARLY VALUES AND SERIAL NUMBERS. RANGES OF PARTS MARKED WITH BLUE OUTLINE.



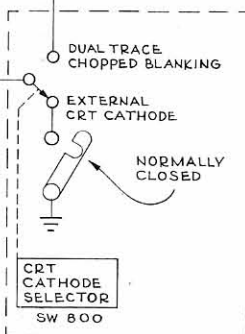


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:
 INTENSITY CCW
 SEE ALSO IMPORTANT NOTE ON TIME-BASE TRIGGER DIAGRAM.

LOCATED ON REAR PANEL



JN 664

CRT CIRCUIT

CIRCUIT NUMBER 853
 180 THRU 869

FREE SCAN IN PUBLIC DOMAIN

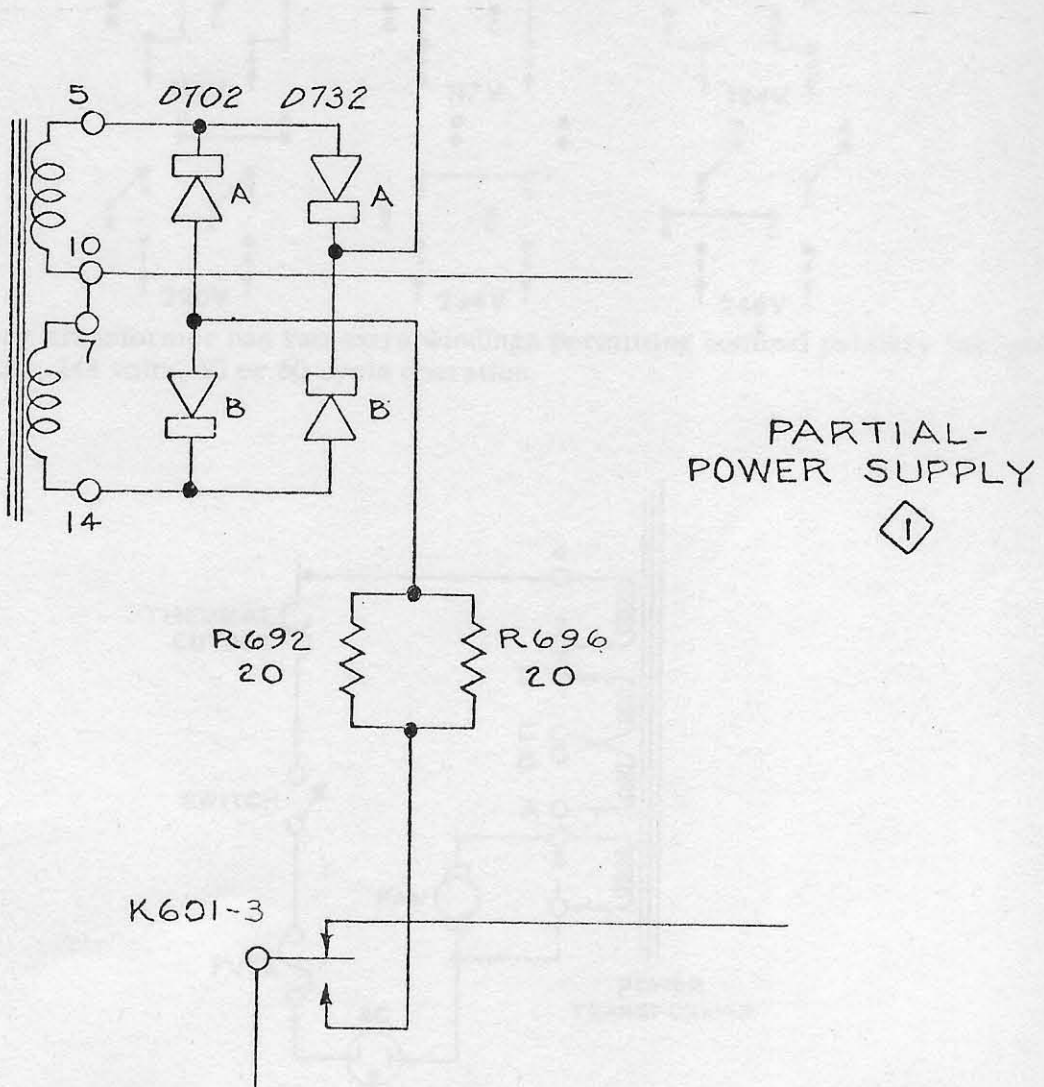
AB₃

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



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.

POWER TRANSFORMER HAS TWO EXTRA WINDINGS PERMITTING NOMINAL PRIMARY VOLTAGES OF 110, 117, 124, 220, 234, OR 248 V, 50 OR 60~ OPERATION.

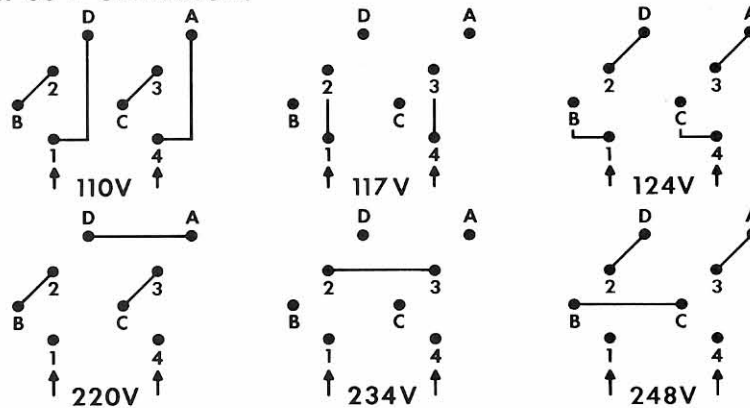


Fig.1. The power transformer has two extra windings permitting nominal primary voltages of 110, 117, 124, 220, 234, 248 volts, 50 or 60 cycle operation.

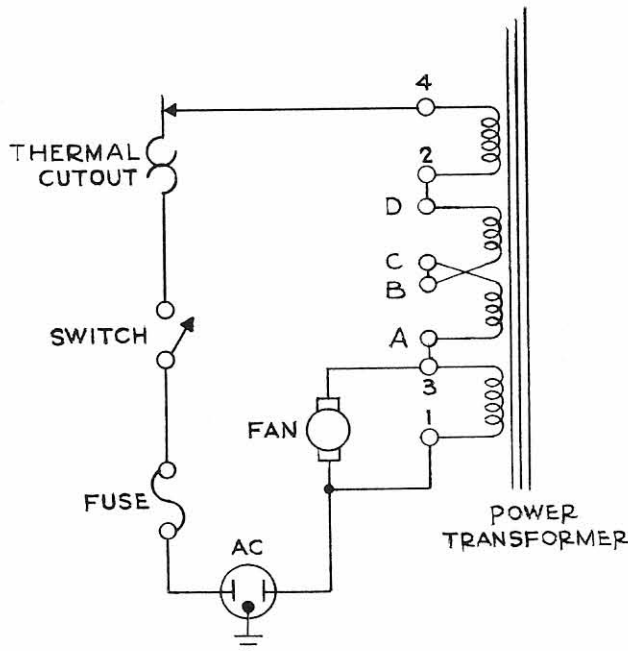


Fig. 2. When connecting the power transformer for operation with a supply voltage of 200 volts or more, be sure that the fan is connected between pins 1 and 3 of the primary. This is to insure that the fan is supplied with no more than 125 volts. Fig. 2 shows a typical high-voltage fan connection, using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

FREE SCAN IN PUBLIC DOMAIN