

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

OPERATOR, ORGANIZATIONAL
DS, GS, AND DEPOT MAINTENANCE MANUAL
OSCILLOSCOPE AN/USM-182A

This copy is a reprint which includes
current pages from Change 1.

HEADQUARTERS, DEPARTMENT OF THE ARMY
MARCH 1969

WARNING

Be careful when working on the 115-volt ac line connections and the +230 and -230-volt circuits. Serious injury or DEATH may result from contact with these terminals.

DON'T TAKE CHANCES!

TECHNICAL MANUAL

No. 11-662555-15

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 11 March 1969

**Operator, Organizational, Direct Support, General Support,
and Depot Maintenance Manual
OSCILLOSCOPE AN/USM-182A**

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Change 1 I

**SECTION A
INTRODUCTION**

A-1. Scope

a. This manual contains instructions for operator's, organizational, direct support, general support, and depot maintenance for Oscilloscope AN/USM-182A. It includes operation, maintenance, and calibration of the equipment. Textronix Type 535A Oscilloscope, nomenclature as Oscilloscope AN/USM-182A, is referred to as Type 535A Oscilloscope in this manual.

b. The maintenance allocation chart (MAC) appears in appendix C.

NOTE

Appendix C is current as of 9 September 1968.

c. To order this technical manual requisition through pinpoint account number if assigned; otherwise, through nearest Adjutant General facilities.

A-2. Indexes of Publications

a. *DA Pam 310-4*. Refer to the latest issue of *DA Pam 310-4* to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

b. *DA Pam 310-7*. Refer to *DA Pam 310-7* to determine whether there are modification work orders (MWO's) pertaining to the equipment.

A-3. Forms and Records

a. *Reports of Maintenance and Unsatisfactory Equipment*. Use equipment forms and records in accordance with instructions given in TM 38-750.

b. *Report of Packaging and Handling Deficiencies*. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58/NAVSUP PUB 378/AFR 71-4/MCO P4030.29, and DSAR 4145.8. c. *Discrepancy in Shipment Report (DISREP) (SF 361)*. Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAVSUPINST 4610.33/AFM 75-18/MCO P4610.19A, and DSAR 4500.15.

A-4. Reporting of Errors

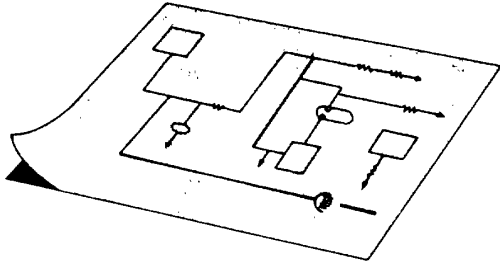
Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications and Blank Forms) and forwarded direct to Commander, US Army Electronics Command ATTN: AMSEL-MA-C, Fort Monmouth, NJ 07703.

A-5. Items Comprising an Operable Equipment

FSN	QTY	Nomenclature, part No., mfr code	Fig. No.
6625-133-1196		Oscilloscope AN/USM-192A Consisting of:	
6625-738-6751	2	Lead Test CX-11982/U (3 ft 11 in.)	8-8
6625-832-9487	1	Lead Electrical CX-11983/U (1 ft 6 in.)	8-5
6625-832-9488	1	Lead Electrical CX-11984/U (1 ft 6 in.)	8-3
5935-087-3844	1	Adapter, Connector UG 1858/U	8-7
5935-087-9148	1	Adapter, Connector 103-0013-00; 80009	8-2
6150-133-1198	1	Cable Assembly, Power, Electrical CX-9067A/U (8 ft)	8-1
6625-168-0175	1	Filter, Light, Cathode-Ray Tube: 378-05674-0: 80009	8-9
6625-133-1197	1	Oscilloscope OS-155A/USM-182	

Note

The part number is followed by the applicable 5-digit Federal supply code for manufactures (FSCM) identified in SB 708-42 and used to identify manufacturer, distributor, or Government agency, etc.



SECTION 1

CHARACTERISTICS

General Information

The Type 535A Oscilloscope is a wide-range general-purpose laboratory instrument providing accurate measurements in the dc to 15 mc range. The Type 535A can be operated with any Tektronix letter-series plug-in to satisfy the requirements for virtually any application.

Special circuits incorporated in the Type 535A Oscilloscope permit an accurate, continuously variable delay in the presentation of the sweep from 1 microsecond to 10 seconds after receipt of a triggering impulse. This feature permits observation of a small portion of the normal sweep, accurate measurement of waveform jitter, precise time measurements, as well as many other uses.

Vertical-Deflection System

All specifications for the Vertical-Deflection System of the Type 535A 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 (≤ 3 -db down at 15 mc)
Risetime	≤ 0.024 microseconds

Triggering Modes

Time Base A--Automatic, AC, DC, AC Low Frequency Reject, and High Frequency Sync.

Time Base B--Automatic, AC, and DC.

Triggering Signal Requirements

Internal triggering -- a signal producing 2 millimeters of vertical deflection except 4 millimeters is required in the DC mode.

External triggering -- a signal of 0.2 volts to 10 volts. Sweep will trigger on larger signals, but TRIGGERING LEVEL control operates over a +10 volt range.

High Frequency Sync.--Assures a stable display of sine wave signals to approximately 30 mc. Requires a signal producing 2 centimeters of vertical deflection or an external signal of more than 2 volts.

Sweep Rates

Time Base A--0.1 microseconds to 5 seconds per centimeter in 24 accurately calibrated steps. An uncalibrated control permits sweep rates to be varied continuously between 0.1 microseconds and approximately 12 seconds per centimeter. Calibrated sweep rates are typically within 1 %, and in all cases within 3%, of the indicated sweep rate.

Time Base B--2 microseconds to 1 second per centimeter in 18 accurately calibrated steps. Sweep rates are typically within 1%, and in all cases within 3%, of the indicated sweep rate.

Magnifier

Provides a 5-times magnification of the center 2-centimeter portion of the oscilloscope display. Extends the fastest *Time Base A* sweep rate to 0.02 microseconds per centimeter and the fastest *Time Base B* sweep rate to 0.4 microseconds per centimeter.

External Horizontal Input

Deflection factor -- approximately 0.2 to 20 volts per centimeter, continuously variable.

Frequency response -- from dc to 350 kHz. Response down 3 db at 350 kHz.

Delayed Sweep

Sweep delay continuously variable from 1 microsecond to 10 seconds. Actual delay steps (between 1.00 and 10.00) are within 1% of the indicated delay from 2 μ sec/cm to 0.1 sec/cm; within 3% from 0.2sec/cm to 1 sec/cm. Incremental delay accuracy is within 1% -4 minor divisions.

Time jitter-1 part in 20,000.

Cathode-Ray Tube

T533P2

Phosphors-Type P2 phosphor normally supplied; P1, P7, and P11 phosphors optional. Other phosphors available on special order.

Unblanking -- dc coupled.

Accelerating potential -- 10,000 volts.

Usable viewing area: -- 6 by 10 centimeters.

Characteristic-Type 535A

Graticule

Illumination-variable edge lighting.

Marked in 6 vertical and 10 horizontal 1-centimeter divisions with 2-millimeter markings on the centerlines.

Amplitude Calibrator

Waveform-square-waves at approximately 1,000 cycles.

Output voltage -- 0.2 millivolts peak-to-peak to 100 volts peak-to-peak in 18 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 volts ($\pm 9\%$ on each range).

Power – approximately 500 watts with a Type CA Plug-In Unit installed.

Line frequency-50 to 60 cycles.

Output Waveforms Available

Delayed trigger pulse -- approximately 5 volts in amplitude, occurring at the end of the delay period.

Positive Gate B -- approximately 20 volts peak-to-peak with some duration as sweep B Positive Gate A--approximately 20 volts peak-to-peak with same duration as sweep A.

Sawtooth A -- sweep A sawtooth waveform, approximately 130 volts peak.

Vertical signal output -- output from vertical deflection system.

Approximately 1.5 volts peak-to-peak per centimeter of vertical deflection.

Ventilation

Forced filtered air. Thermal relay interrupts instrument power in the event of overheating.

Construction

Aluminum-alloy chassis and three-piece cabinet. Anodized panel, blue wrinkle-finished cabinet.

Dimensions -- see Figure 1-2.

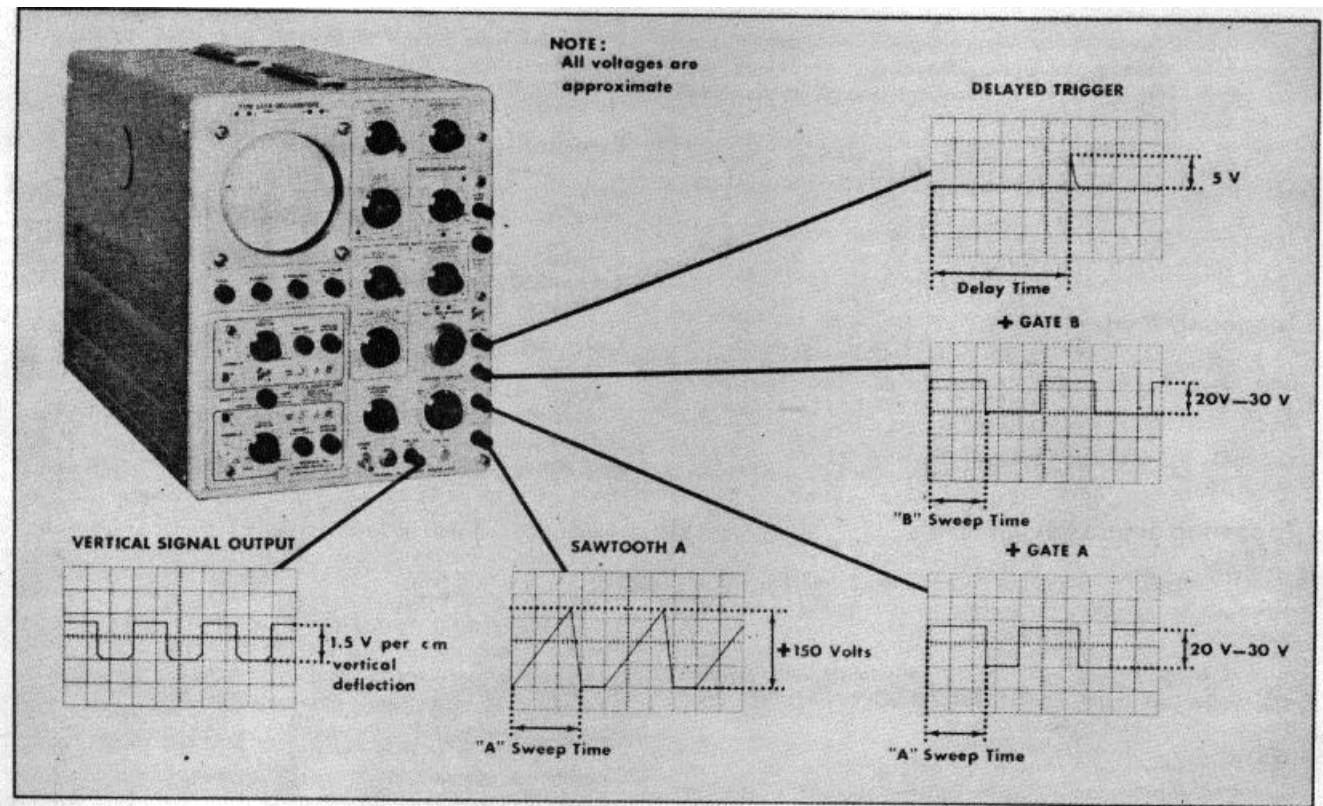


Fig. 1-1. Output waveforms available at the oscilloscope front panel.

Characteristics-Type 535A

Accessories

- 2---Type P6006 Probes, 010-127.
- 2---Type A510 Binding-Post Adapters, BNC, 103-033.
- 1---Test Lead (012-031).
- 1---Type F510-5 Green Filter (378-514).
- 2---Operator's Manuals
- 1---Operator's Handbook.
- 1---3 to 2-wire adapter, 103-013
- 1---3-conductor power cord, 161-010
- 1---Green Filter 378-514

Type N

The Type N Sampling Unit is designed for use with the 535A Oscilloscope. 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 10mv/cm with 2mv or less noise; and a dynamic range of ± 120 mv minimum linear range before overloading results.

Accidental overload of ± 4 volts dc is permissible.

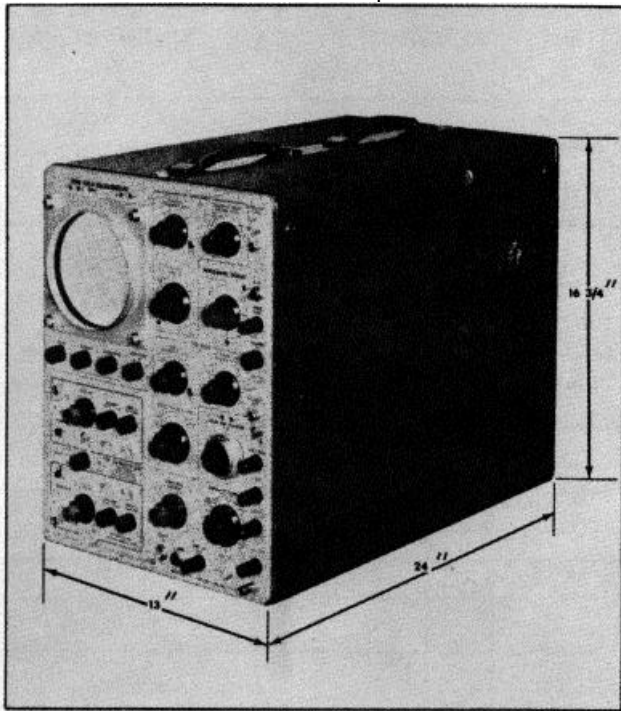


Fig. 1-2. Type 535A Oscilloscope Dimensions.

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 540-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 8 Type 535A Oscilloscopes 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 6kc; risetime is approximately 60 microsecond. 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 push-button 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 in 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 the 535A Oscilloscope. The slower risetime of the 535A Oscilloscope 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,

PLUG-IN PREAMPLIFIER CHARACTERISTICS FOR TYPE 535A OSCILLOSCOPES

PLUG-IN TYPE	CALIBRATED DEFLECTION FACTOR	PASSBAND	RISETIME	INPUT CAPACITANCE
TYPE A, Wide Band DC Coupled	0.05 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 2' 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 15 mc	23 nsec	20 pf
TYPE- D High Gain DC Coupled Differential	0.05 v/cm to 20 v/cm	dc to 2 mc	23 nsec	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 Coupled Differential Wide-Band,	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	32 nsec	47 pf
TYPE K Fast-Rise DC Coupled	0.5 v/cm to .20 v./cm	dc t'15mrøc	24 nsec	4/ pt
TYPE L Fast-Rise High-Gain DC- Coupled	5 mv/cm to 2 v/cm 0.05 v/cm to 20v/cm	3 c to 14 mHz dc to 15 mc	25 nsec 24 nsec	20 pt 4
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 Risetime	0.5ma/cm to 100 ma/cm		23 nsec	
TYPE S* Semiconductor Diode Recovery'	0.05 v/cm and 0.05 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	27 pf

*More data available on the special-purpose plug-in units in the following paragraphs.

Characteristics-Type 535A

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 0.05v/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 to 2 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 Unit extends the accuracy of oscilloscope

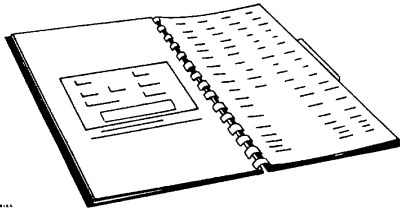
voltage measurements. It can be used in three modes of operation: (1) as a conventional preamplifier, (2) as a differential input preamplifier, or (3) as a calibrated differential comparator. With sensitivity of 50 mv/cm and insertion voltage range of \pm volts, the effective scale range is ± 2000 cm.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

As a differential input preamplifier, the Type Z accepts passband of dc to 10 mc for the 535A 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/7nsec, 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, zero to ± 100 volts.

SECTION 2



OPERATING INSTRUCTIONS

General

The Type 535A Oscilloscope is an extremely versatile instrument which is adaptable to a great number of applications. However, to make use of the full potentialities of the instruments, it is necessary that you understand completely the operation of each control.

Plug-In Units

The Type 535A Oscilloscope is 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. The plug-in units available will satisfy the requirements for most applications.

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. 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 535A Oscilloscope 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 tubes sufficient time to heat before the dc operating voltages are applied.

If the ac power is off for only an instant, the normal 25second 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. X10, 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 or triggering rate. The INTENSITY control is rotated clockwise to increase brightness and counterclockwise to decrease brightness. Care must be taken when using the INTENSITY control that the brightness is not turned up to the point where the face of the cathode-ray tube is permanently damaged. If the intensity of the beam is turned up too far, the phosphor on the face of the crt may be burned. The intensity of the beam should never be turned up to the point where a halo forms around the spot.

Graticule Illumination Control

The graticule used with the Type 535A 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.

The graticule is illuminated by two lamps located at the top edge of the graticule. This illumination can be controlled so that the graticule markings appear either red or white, as desired. The graticule markings are changed from red to white or from white to red by removing the graticule cover and rotating the graticule through 180°

Operating Instructions-Type 535A

about an axis through the center of the graticule. As a general rule, white graticule markings are superior to 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 rotating the control counterclockwise decreases the brightness. For convenience in photographic work, 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 Type 44 Polaroid film is used. Regardless of the type of film used, white graticule markings should be used. To obtain satisfactory waveform photographs, the intensity of the trace must approximately match the brightness of the graticule markings.

Positioning Controls

Three controls are used with the Type 535A Oscilloscope to allow you to position the trace to the desired point on the oscilloscope screen. Two of these controls are used to set the horizontal position of the trace and are located on the front panel of the instrument. The third control is used to set the vertical position of the trace 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 they are rotated counterclockwise. The combination of the two controls has a total positioning range of approximately 12 centimeters with the sweep magnifier off or approximately 60 centimeters with the sweep magnifier on. 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, as for example, when the sweep magnifier is used.

The vertical positioning control has sufficient range to allow the trace to be positioned completely off the top or bottom of the screen or to any intermediate point. The trace moves up when the control is rotated clockwise and down when the control is rotated 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 2-2

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 entirely unsatisfactory due to their tendency to pick up stray signals which produce erroneous oscilloscope displays. Shielded cables should be used whenever possible, with the shield connected to the chassis of both the oscilloscope and the signal source. Regardless of the type of input lead used, leads should be kept 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 pass band 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; however in some applications, loading caused by the oscilloscope may materially alter the results obtained. In such cases you may wish to reduce the amount of loading to a negligible amount through the use of a probe.

Use of Probes

Occasionally connecting the input of an oscilloscope to a signal source loads the source sufficiently to adversely affect both the operation of the source and the waveform displayed on the oscilloscope. In such cases an attenuator probe may be used to decrease both the capacitive and resistive loading caused by the oscilloscope to a negligible value.

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 observe 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. The probe is compensated by adjust

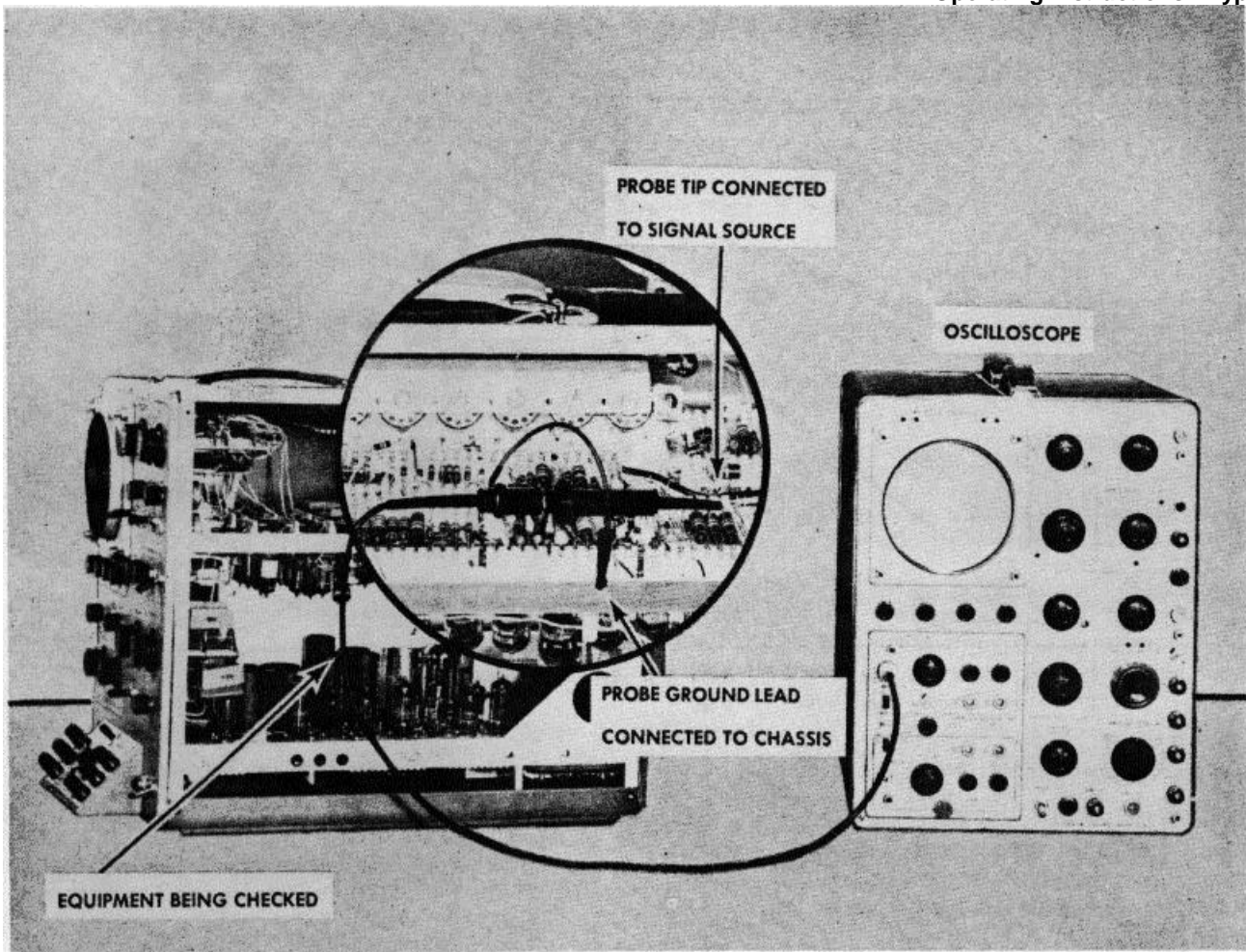


Figure 2-1. Proper connection of a probe to the input signal source.

ing the control located in the body of the probe. To adjust the probe compensation control, place the HORIZONTAL DISPLAY switch at A, the TIME BASE A TRIGGERING MODE switch at AUTO, and the TIME BASE A 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 A 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 (see Figure 2-2).

Horizontal Sweep

The usual oscilloscope display is a graphical presentation of instantaneous voltage versus time. Voltage information is presented by vertical deflection of the trace and time information is presented by horizontal deflection. To obtain a useful display, it is necessary for the spot formed by the electron beam to be deflected horizontally at a known rate so that any horizontal distance on the screen represents a

definite known period of time. The trace formed by the deflection of the spot across the screen is known as the horizontal sweep. Since the horizontal deflection of the spot bears a definite relationship to time and provides the means for making time measurements from the screen, the horizontal sweep is also known as the time base.

The Type 535A Oscilloscope features two independent time-base units: Time Base A and Time Base B. Either of the two time bases may be displayed on the oscilloscope screen at any time. Controls affecting Time Base A and Time Base B operation are in the correspondingly labeled blocks on the oscilloscope front panel. The HORIZONTAL DISPLAY switch determines which time base is used and the type of display to be presented. Time Base A is selected when the HORIZONTAL DISPLAY switch is in position A and Time Base B is selected when the switch is in position B.

The rate at which the spot is deflected across the screen is accurately controlled by the setting of the appropriate TIME/CM controls. The settings of the TIME/CM controls

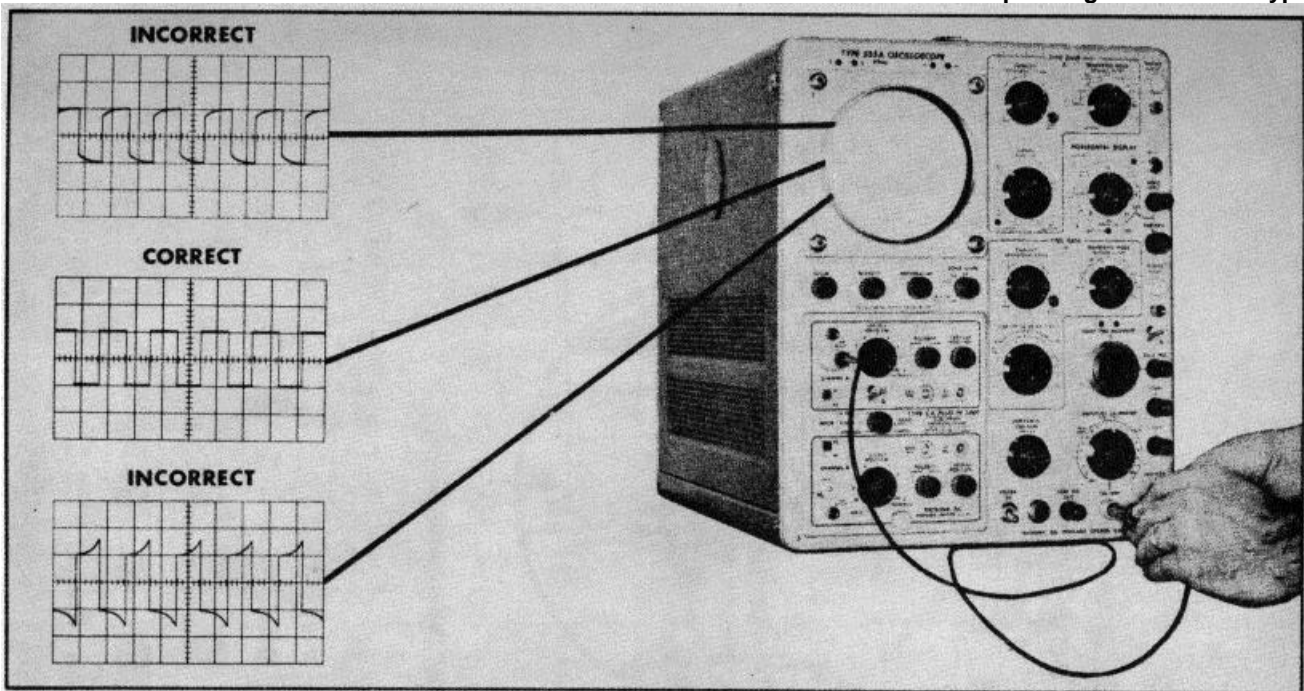


Figure 2-2. When compensating the probe it is adjusted to obtain an undistorted presentation of the calibrator square-waves.

determine the sweep speed and the horizontal size of the displayed waveform. The controls are set to display the portion of the waveform you wish to observe.

Time Base A has 24 accurately calibrated sweep rates ranging from .1 microseconds to 5 seconds per centimeter. These calibrated sweep rates are obtained only when the VARIABLE TIME/CM control is in the fully clockwise position. The VARIABLE TIME/CM control permits you to vary the sweep rates continuously between .1 microseconds and approximately 12 seconds per centimeter. All sweep rates obtained with the VARIABLE TIME/CM control in any position but fully clockwise are uncalibrated. Uncalibrated sweep rates are indicated when the UNCALIBRATED lamp is lit.

Time Base B has sweep rates ranging from 2 microseconds to 1 second per centimeter in 18 steps. There is no VARIABLE TIME/CM control for Time Base B. The red LENGTH control adjusts the sweep length between approximately 4 and 10 centimeters.

Sweep Triggering

The oscilloscope display is formed by the repetitive sweep of the spot across the oscilloscope screen. If the sweeps are allowed to occur at random or at a rate unrelated to the rate of occurrence of the input waveform, the displayed waveform will be traced out at a different point on the screen each time the sweep runs. This will either cause the waveform to drift across the screen or to be indistinguishable.

In most cases it is desirable for a repetitive waveform to appear stationary on the oscilloscope screen so that the characteristics of the waveform can be examined in detail. As

a necessary condition for this type of display, the start of the sweep must bear a definite, fixed-time relationship to the appearance of the input waveform. This means that the sweep must be synchronized with the input waveform. In the Type 535A Oscilloscope this is accomplished by starting (triggering) the sweep with the displayed waveform or with another waveform bearing a definite time relationship to the displayed waveform.

The following paragraphs outline the means for selecting the triggering source, triggering slope, and triggering level with specific information regarding the operation of the controls affecting triggering. Triggering controls for Time Base A and Time Base B are virtually identical so that the following information is applicable to both time-base units. Triggering of the sweep is adjusted by the respective STABILITY, TRIGGERING LEVEL, TRIGGERING MODE, and TRIGGER SLOPE controls.

Selecting Triggering Source

In preparing the Type 535A Oscilloscope for triggered operation of the sweep, it is first necessary to select the triggering signal which will provide the best display for the particular application. The sweep can be triggered by the displayed waveform, a line-frequency waveform, or by an externally derived waveform. This selection is made by the setting of the TRIGGER SLOPE control. Each type of triggering has certain advantages for some applications.

Triggering from the displayed waveform is the method most commonly used. The displayed waveform is selected when the TRIGGER SLOPE control is in either the + INT. or -INT. position. Internal triggering is convenient

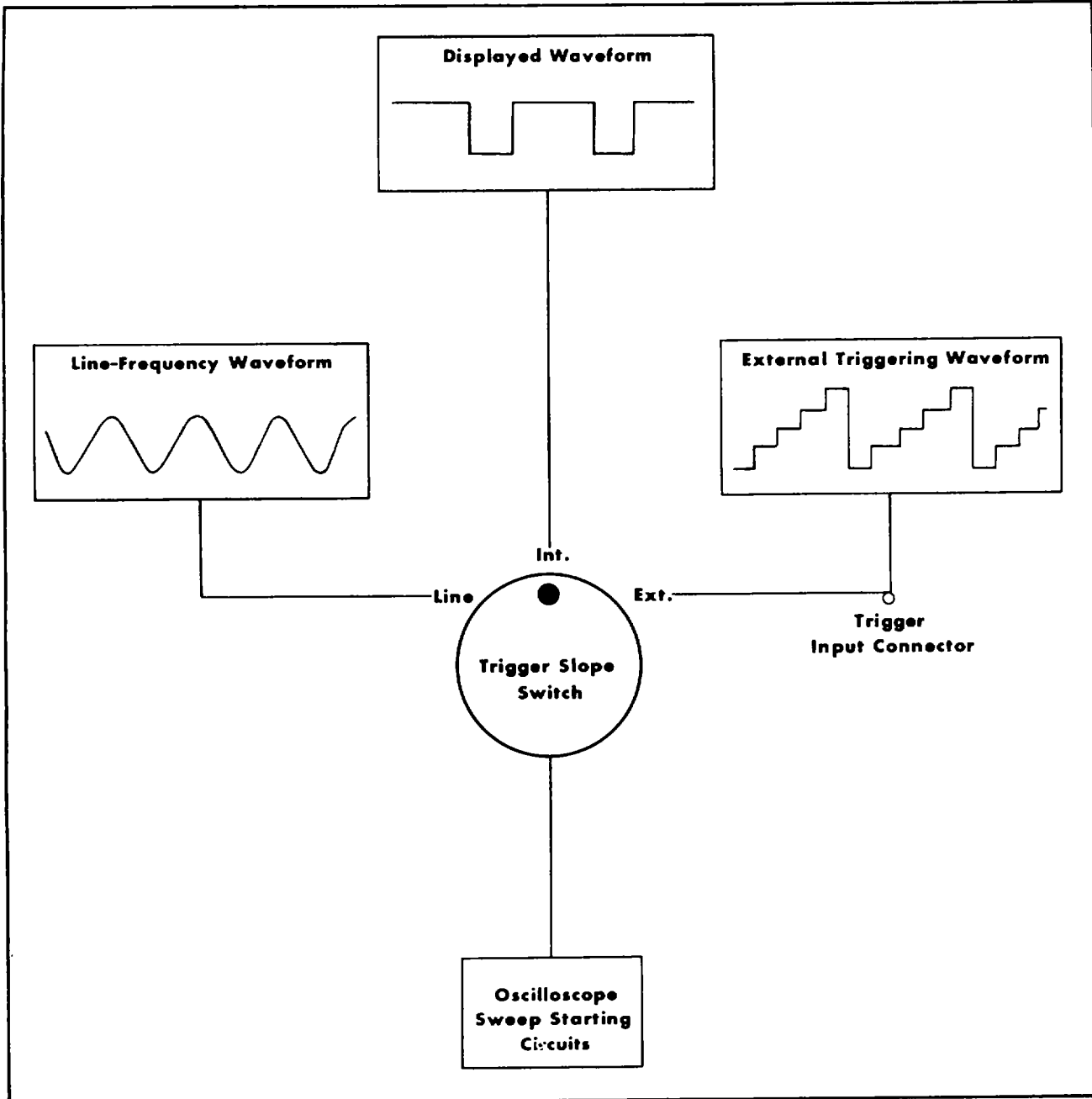


Figure 2-3. The trigger signal is selected from three possible sources with the TRIGGER SLOPE control

since no external triggering connections are required. Satisfactory results are obtained in most applications.

When you are observing a waveform which is related to the line frequency, you may wish to trigger the sweep from a line-frequency waveform. This can be done by placing the TRIGGER SLOPE switch in either the +LINE or the -LINE position. This type of triggering is useful in observing waveforms which bear a definite relationship to the line frequency. The shape and the amplitude of the triggering waveforms remains constant to provide extremely stable triggering.

To trigger the sweep from some external waveform, connect the triggering waveform to the appropriate TRIGGER INPUT connector and place the TRIGGER SLOPE switch in either the +EXT, or -EXT. position. External triggering provides definite advantages over other methods of triggering in certain cases. With external triggering, the triggering signal usually remains constant in amplitude and shape. It is thereby possible to observe the shaping and amplification of a signal in an external circuit without resetting the oscilloscope triggering controls for each observation. Also, time and phase relationships between the waveforms at different points in the circuit can be seen. If, for example the external triggering

signal, is derived from the waveform at the input to a circuit, the time relationship and phase of the waveforms at each point in the circuit-are compared to the input signal by the display presented on the oscilloscope screen.

When you are using external triggering and a stable triggering signal, it is possible to observe and accurately measure jitter of the displayed waveform. This is not possible when the sweep is triggered internally.

Selecting 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 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 Figure 2-4).

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 may wish to observe 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 rate, 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 observe the portion of the waveform you wish to check.

Selecting 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. Time Base A has five triggering modes while Time Base B has three. Not available for Time Base B are the HF SYNC and AC LF REJECT triggering modes.

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

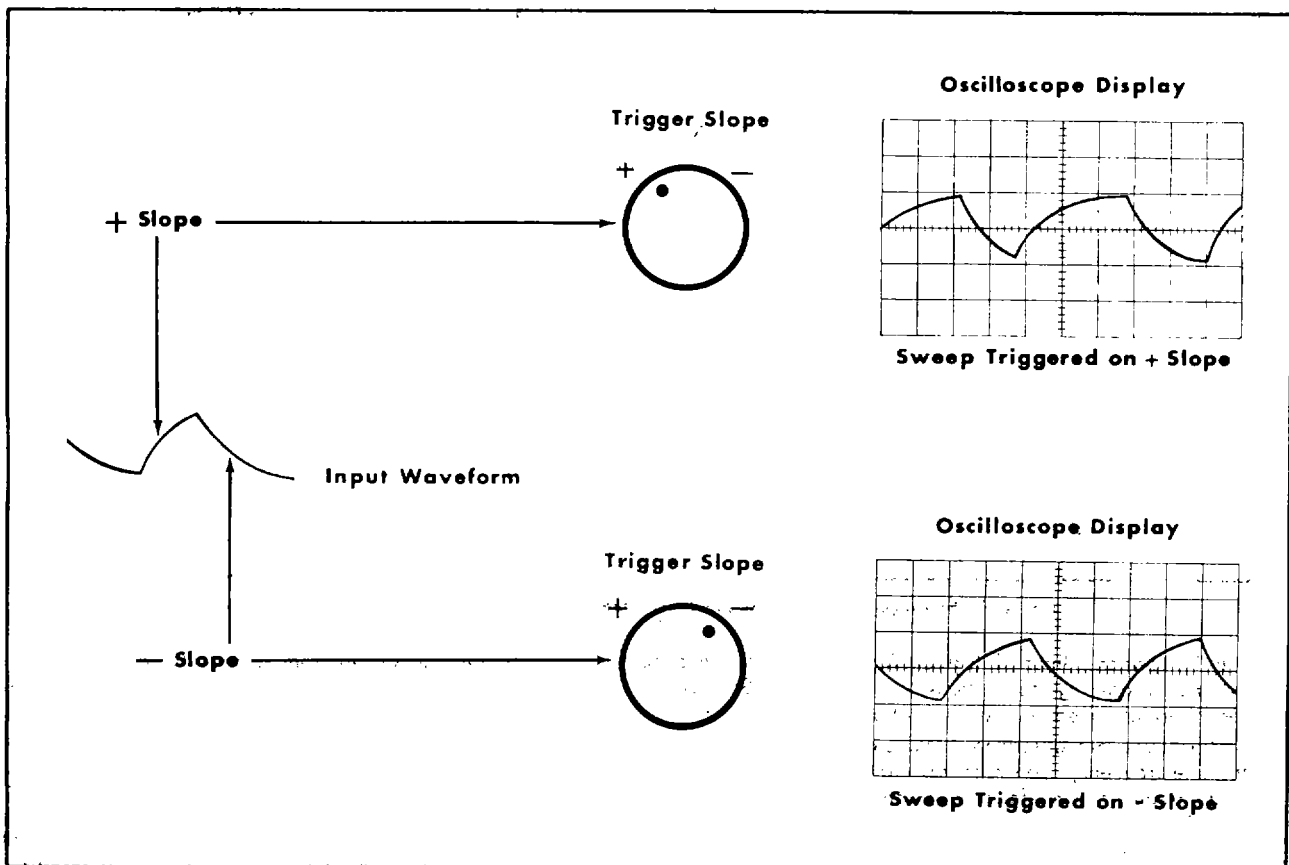


Fig. 2-4. Effects on the oscilloscope display produced by + and - settings of the TRIGGER SLOPE control.

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

The DC triggering mode is selected by placing the TRIGGERING MODE switch in the DC position. This mode permits excellent triggering on all types of waveforms in the frequency range from dc to approximately 5 mc. The DC mode also permits the selection of the point on the triggering waveform where the sweep is triggered through the use of the TRIGGERING LEVEL CONTROL.

To use the DC triggering mode you must set the STABILITY and TRIGGERING LEVEL controls after first selecting the triggering signal source and slope. The method used to set the STABILITY and TRIGGERING LEVEL controls is the same for the DC mode, AC mode, and AC Low Frequency Reject mode. The STABILITY control must be set properly before the TRIGGERING LEVEL control can be adjusted.

The STABILITY control has a PRESET position at the fully counterclockwise setting of the control. This position permits proper triggering in most applications without necessitating additional adjustment of the STABILITY control. If it becomes impossible or difficult 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 setting for the control is then obtained by rotating the knob slowly counterclockwise until the trace just disappears.

The TRIGGERING LEVEL control determines the point on the triggering waveform where triggering of the sweep occurs. This control is set to provide the display you want while at the same time causing stable triggering. Rotating the control clockwise causes the sweep to trigger at more positive points on the waveform while rotating 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. In the DC mode, rotating the vertical position control will change the point on the triggering waveform where the sweep is started.

The + and markings for the TRIGGERING LEVEL control should not be confused with similar markings for the TRIGGER SLOPE control. The markings on the TRIGGER SLOPE control indicate only whether triggering occurs on the rising or falling portion of the triggering waveform. The markings for the TRIGGERING LEVEL control indicate whether triggering occurs on the upper or lower portion of the waveform.

AC Triggering Mode

Selection of the AC triggering mode is made by placing the TRIGGERING MODE switch in the AC position. This mode provides useful triggering in the frequency range of approximately 15 cycles to 5mc. These frequency limits vary slightly depending upon the shape and amplitude of the triggering waveform. In the 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 triggering mode.

AC Low Frequency Reject Triggering Mode

The AC Low Frequency Reject triggering mode is used when the TRIGGERING MODE switch is in the AC LF REJECT position. This mode is similar to the 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 Low Frequency 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 trigger waveform is

Operating Instructions—Type 535A

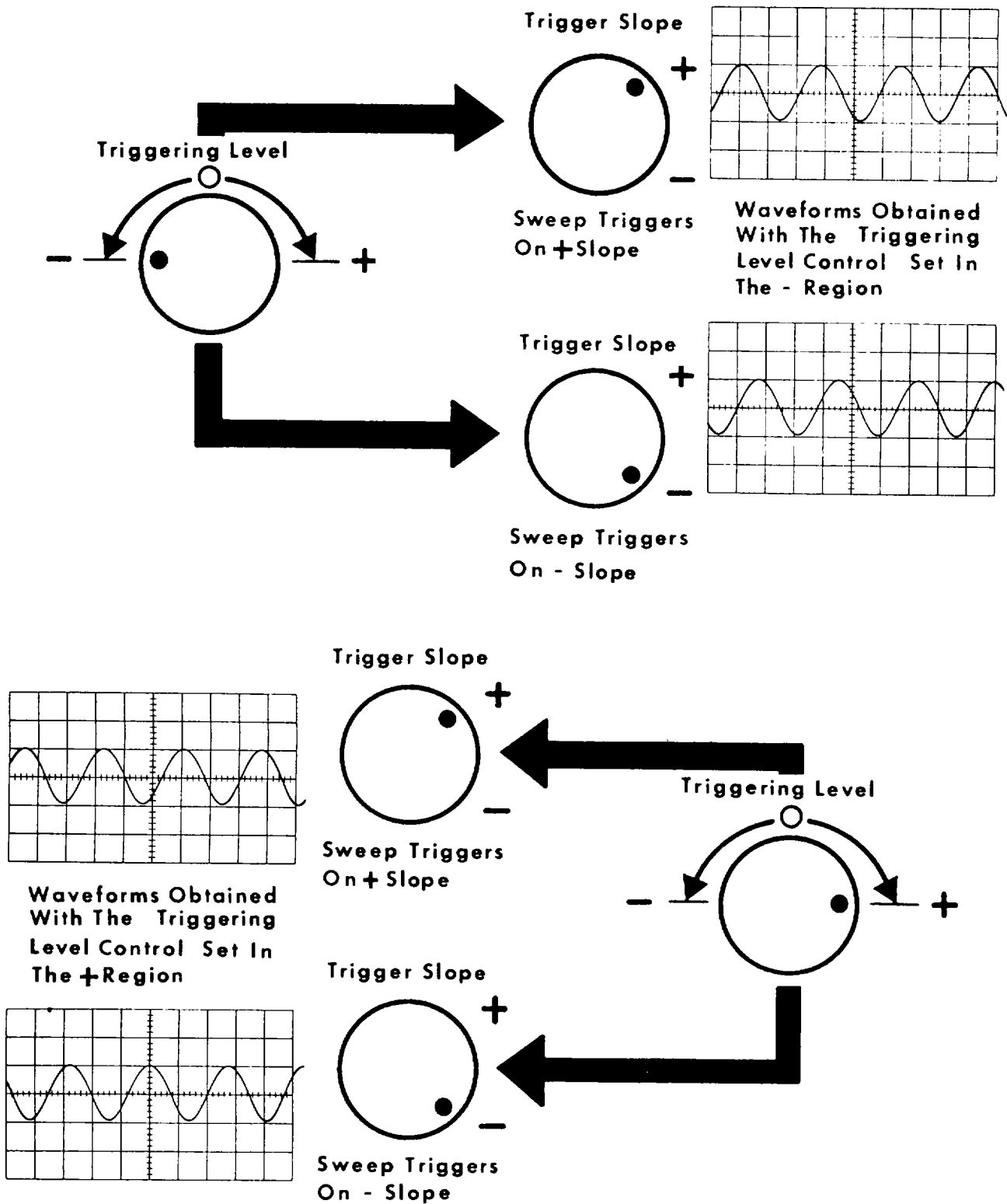


Fig. 2-5. Effects on the oscilloscope display produced by + and - settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the - region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising or falling portion of the input waveform.

passed to produce the stable triggering that you require. In all other respects the AC Low Frequency Reject triggering mode is identical to the AC mode.

High Frequency Synchronization 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. Rotate 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 or SAWTOOTH connectors is used to trigger or synchronize the input waveform (see Figure 2-6).

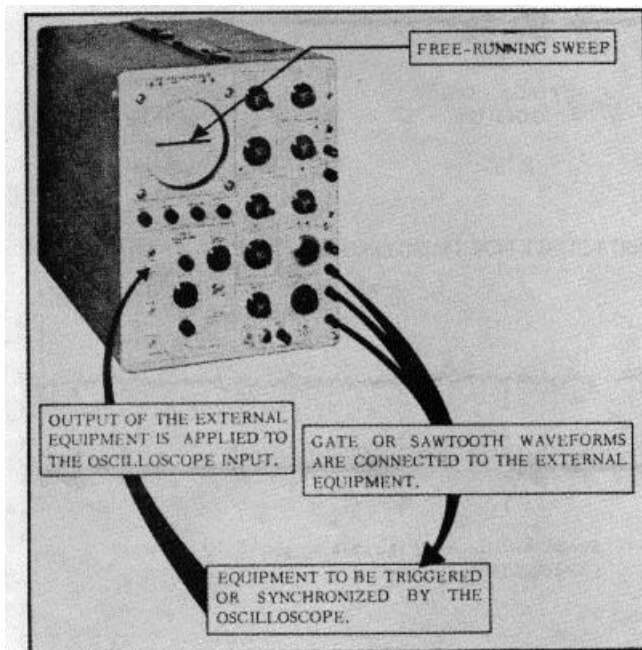


Fig. 2-6. Using the Gate or Sawtooth output waveforms to synchronize or trigger external equipment.

The sweep can be made to free run with any setting of the TRIGGERING mode switch by rotating the STABILITY

control fully clockwise. In all positions of the TRIGGERING MODE switch except AUTO, the number of sweeps per second is determined by the setting of the TIME/CM controls. In the AUTO position, the sweep repetition rate remains at approximately 50 sweeps per second regardless of the setting of the TIME/CM control.

In addition to providing the means for 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.

Delayed Sweep

With the Type 535A Oscilloscope the start of the horizontal sweep can be delayed for a period of from 1 microsecond to 10 seconds after application of the triggering waveform. This is done through simultaneous use of the Time Base A and Time Base B. In this application Time Base B is used to provide the accurate time delay while Time Base A presents a normal horizontal sweep at the end of the delay period. The duration of the sweep delay is controlled by the Time Base B TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER control.

The delayed sweep feature of the Type 535A Oscilloscope can be used in a number of special applications to increase the versatility of the instrument. Such applications include high magnification of a selected portion of an undelayed sweep, accurate time measurements, and accurate measurements of waveform jitter. Also, it is possible to pick off and display any desired line of a television scan or to check pulse-time modulation. In addition, the delayed sweep feature is readily adaptable to a great number of other applications.

The delayed sweep is selected when the HORIZONTAL DISPLAY switch is in the 'A' DEL'D BY 'B' position. The amount of delay occurring from the application of the triggering waveform until the sweep runs is indicated directly by the settings of the TIME/CM OR DELAY TIME switch and the DELAY TIME MULTIPLIER control. The settings of the two controls are multiplied together to obtain the actual delay time. For example, if the TIME/CM OR DELAY TIME switch is set at 1 MILLISEC and the vernier dial of the DELAY TIME MULTIPLIER control indicates 6.75, the delay time is 6.75 milliseconds. When the Time Base A STABILITY control is in the fully clockwise position, the horizontal sweep starts immediately at the completion of the delay period at a rate determined by the settings of the Time Base A TIME/CM controls.

There are actually two modes of delayed sweep operation available in the Type 535A Oscilloscope (see Figure 2-8). In one mode the delayed sweep is started immediately after the completion of the delay time. This is the mode described previously and is obtained with the Time Base A STABILITY control fully clockwise. This mode permits you to select continuously variable delay times and is the mode of operation used to make accurate time and waveform jitter measurements as well as most other measurements.

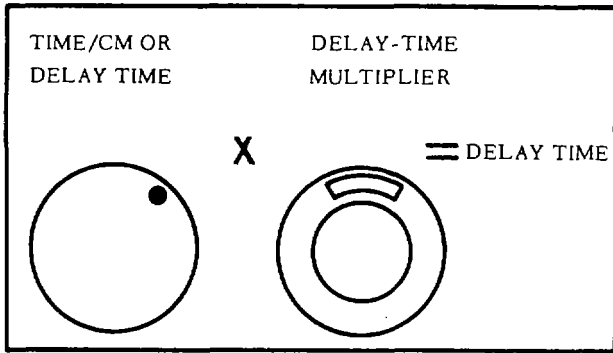


Fig. 2-7. Calculating delay time.

The second delayed-sweep mode is different from the first in that the sweep does not start at the completion of the delay until a triggering waveform is applied to Time Base A. The delay time in this mode is not continuously variable and is dependent not only on the settings of the delay-time controls, but on the occurrence of the Time Base A triggering waveform as well. The primary purpose of this mode is to eliminate jitter from the displayed waveform. Since the sweep

is triggered by the input waveform, jitter is eliminated from the display even though it is inherent in the input waveform.

The second delayed-sweep mode is also obtained with the HORIZONTAL DISPLAY switch in the 'A' DEL'D BY 'B' position. In this mode, however, the Time Base A triggering controls are set to provide normal triggering. The STABILITY control is not placed in the fully clockwise position.

When the HORIZONTAL DISPLAY switch is placed in the 'B' INTENSIFIED BY 'A' position, you can obtain a normal sweep presentation using Time Base B. If all other controls are set for delayed sweep operation and the Time Base A TIME/CM switch is set for a faster sweep rate than the Time Base B control, a portion of the displayed waveform will be brightened. The start of this brightened portion indicates the start of the delayed sweep and the length of the brightened portion indicates the delayed sweep duration. The start of the brightened portion can be positioned left or right with the DELAY-TIME MULTIPLIER control. The length of the brightened portion can be adjusted with the Time Base A TIME/CM control. Using these two controls, it is possible to include any portion of the displayed waveform in the brightened area.

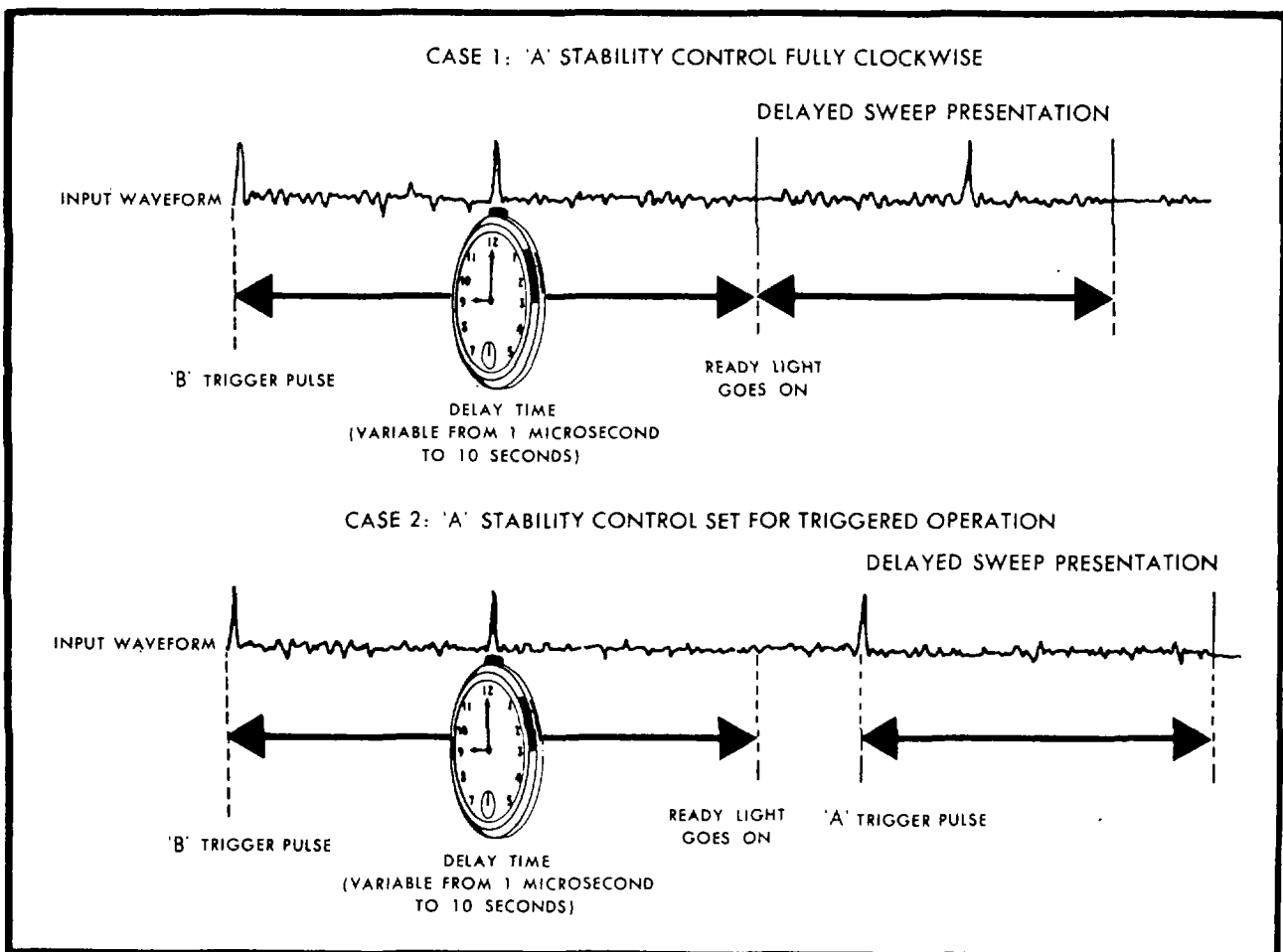


Fig. 2-8. Comparison of the two delayed-sweep modes. In each case the waveform shown represents the input to the oscilloscope. The waveform shown in the delayed-sweep presentation boxes represents the portion of the input waveform that is actually displayed on the oscilloscope screen. Note that in Case 2 an additional triggering pulse is required before the delayed sweep will occur.

To expand a portion of the display obtained with the HORIZONTAL DISPLAY switch in the 'B' INTENSIFIED BY 'A' position, adjust the DELAY-TIME MULTIPLIER and Time Base A TIME/CM controls to include the portion you wish to expand in the brightened area (see Figure 2-9). Then place the HORIZONTAL DISPLAY switch in the 'A' DEL'D BY 'B' position. This expands the brightened portion to the full width of the screen. The amount of magnification is the ratio of the Time Base B TIME/CM OR DELAY TIME control setting to the Time Base A TIME/CM control setting. For example, if the Time Base B TIME/CM OR DELAY TIME switch is set at 1 MILLISEC and the Time Base A TIME/CM switch is set at 1 μ SEC, the brightened portion of the sweep is magnified horizontally 1,000 times. Using this method, practical sweep magnifications up to approximately 10,000 times are attainable.

At times when you are using the delayed sweep with high magnification, the intensity of the trace will be so low that it is difficult to see. In many of these cases the intensity cannot be improved significantly with the INTENSITY control. However, the intensity can often be increased by using the Time Base B SWEEP LENGTH control to increase the duty cycle. To set the SWEEP LENGTH control, place the HORIZONTAL DISPLAY switch in the 'B' INTENSIFIED BY 'A' position. Adjust the SWEEP LENGTH control until the sweep runs to a point just past the brightened portion of the trace. Then return the HORIZONTAL DISPLAY switch to the 'A' DEL'D BY 'B' position.

Delayed Trigger

A delayed triggering pulse can be obtained from the DEL'D TRIG. connector of the oscilloscope any time from 0.1 microsecond to 50 seconds after the start of a sweep. When the oscilloscope is set for delayed sweep operation, the delayed trigger occurs at the start of the delayed

sweep. This delayed triggering pulse can be used to initiate some action after a known time interval, and when used with the delayed sweep, permits you to observe the resulting action.

In the B, 'B' INTENSIFIED BY 'A', 'A' DEL'D BY 'B', EXT X1, and EXT, X10 positions of the HORIZONTAL DISPLAY switch, the delayed trigger is controlled by Time Base B. In the other two positions of the HORIZONTAL DISPLAY switch, the delayed trigger is controlled by Time Base A.

To obtain a delayed trigger you must first adjust the appropriate time-base unit for triggered operation for free-running operation, depending upon the application. The delay is then set with the appropriate TIME/CM control and the DELAY-TIME MULTIPLIER. The lights above the DELAYTIME MULTIPLIER control indicate which time-base unit is used to produce the delayed trigger with each setting of the HORIZONTAL DISPLAY switch.

Single-Sweep Operation

The usual oscilloscope display formed by a repetitive sweep is entirely satisfactory for most applications. However, in applications where the displayed waveform is not repetitive or varies in amplitude, shape, or time interval, a repetitive sweep produces a jumbled display. When observing a waveform of this type, it is usually advantageous to use a single-sweep presentation.

The Type 535A Oscilloscope permits you to obtain a single-sweep presentation and to eliminate all subsequent sweep so that information is clearly recorded without the confusion resulting from multiple traces. The single-sweep feature is selected by placing the HORIZONTAL DISPLAY switch in the 'A SINGLE SWEEP' position. In this position, only Time Base A is used. The RESET button controls the start of the single sweep.

When the STABILITY control is set fully clockwise or the TRIGGERING MODE switch is in the AUTO. position, a single sweep runs immediately each time the RESET button is depressed. However, if Time Base A. is set for triggered operation with the TRIGGERING MODE switch in other than the AUTO. or HF SYNC positions, the single sweep does not occur when the RESET button is depressed unless a triggering signal is applied to Time Base A. Instead, the READY lamp lights to indicate that the sweep is ready to be triggered. When a triggering signal occurs, the single sweep runs and the READY light goes out. Each time the RESET button is depressed the procedure is repeated.

External Horizontal Input

For special applications you can deflect the trace horizontally with some externally derived waveform. This allows you to use the oscilloscope to plot one function versus another.

To use an external horizontal input, connect the externally derived waveform to the HORIZ. INPUT connector and place the HORIZONTAL DISPLAY switch in either EXT. position. The horizontal deflection factor is continuously variable from approximately 0.2 to approximately 20 volts per centimeter with the VARIABLE 10-1 control and the HORIZONTAL DISPLAY switch.

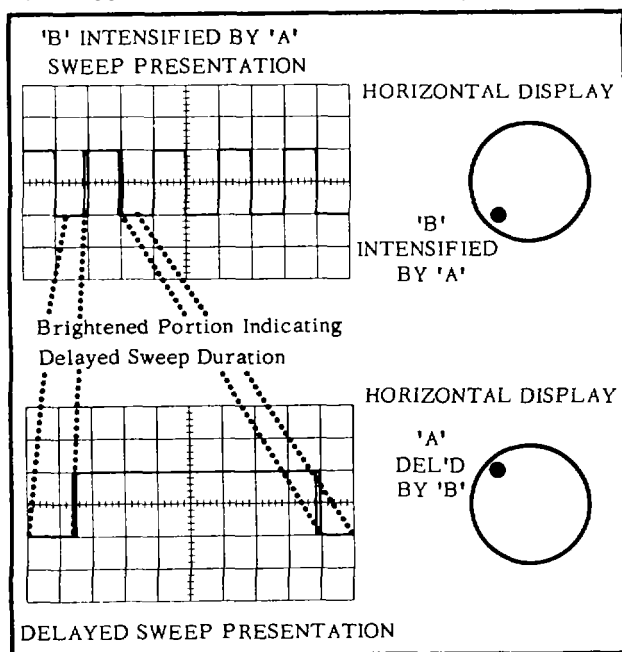


Fig. 2-9. Correlation of the 'B' INTENSIFIED BY 'A' and 'A' DEL'D BY 'B' positions of the HORIZONTAL DISPLAY switch.

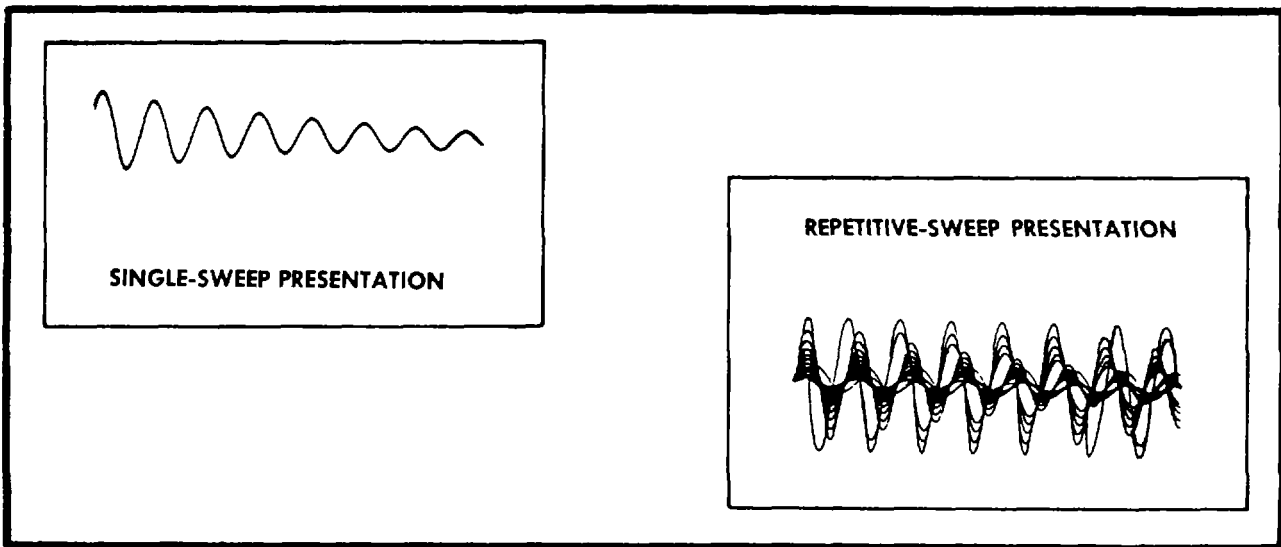


Fig. 2-10. Comparison of single sweep and repetitive sweep presentation of a damped sine wave. In the repetitive sweep presentation, it is difficult to determine what is being presented. However, in the single sweep presentation the damped sine wave can be clearly seen.

Sweep Magnifier

The sweep magnifier allows you to expand any two-centimeter portion of the displayed waveform to the full ten-centimeter width of the graticule. This is done by first using the HORIZONTAL POSITION control to move the portion of the display you wish to expand to the center of the graticule, then placing the 5X MAGNIFIER switch in the ON position. When the 5X MAGNIFIER switch is at ON, the 5X MAGNIFIER lamp lights to indicate the magnifier is on. Any portion of the original unmagnified display can

then be observed by rotating the HORIZONTAL POSITION controls. The sweep magnifier can be used with either time base unit.

In magnified sweep operation, the sweep rate indicated by the position of the TIME/CM control is divided by 5 to obtain the actual time required for the spot to move one centimeter. For example, if the TIME/CM control is set at 5 MILLISEC, the actual time per centimeter is 5 milliseconds divided by 5, or 1 millisecond per centimeter. The actual time per centimeter must be used for all measurements of time.

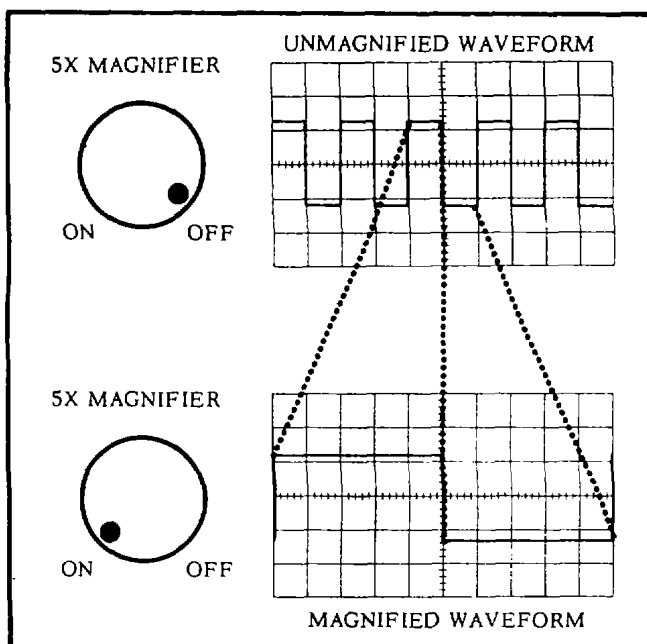


Fig. 2-11. Operation of the sweep magnifier.

Amplitude Calibrator

The amplitude 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 0.2 millivolt, peak-to-peak, to 100 volts, peak-to-peak, in 18 steps. The amplitude is controlled by the setting of the AMPLITUDE CALIBRATOR switch and is accurate within 3% of the AMPLITUDE CALIBRATOR switch setting when the output is connected to a high impedance load.

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 535A 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 DUALTRACE CHOPPED BLANKING position.

Intensity Modulation

The crt display of the Type 535A 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 and make your measurements directly from the time markers presented on the screen. A positive signal of approximately 25 volts is required to cut off the beam from normal intensity.

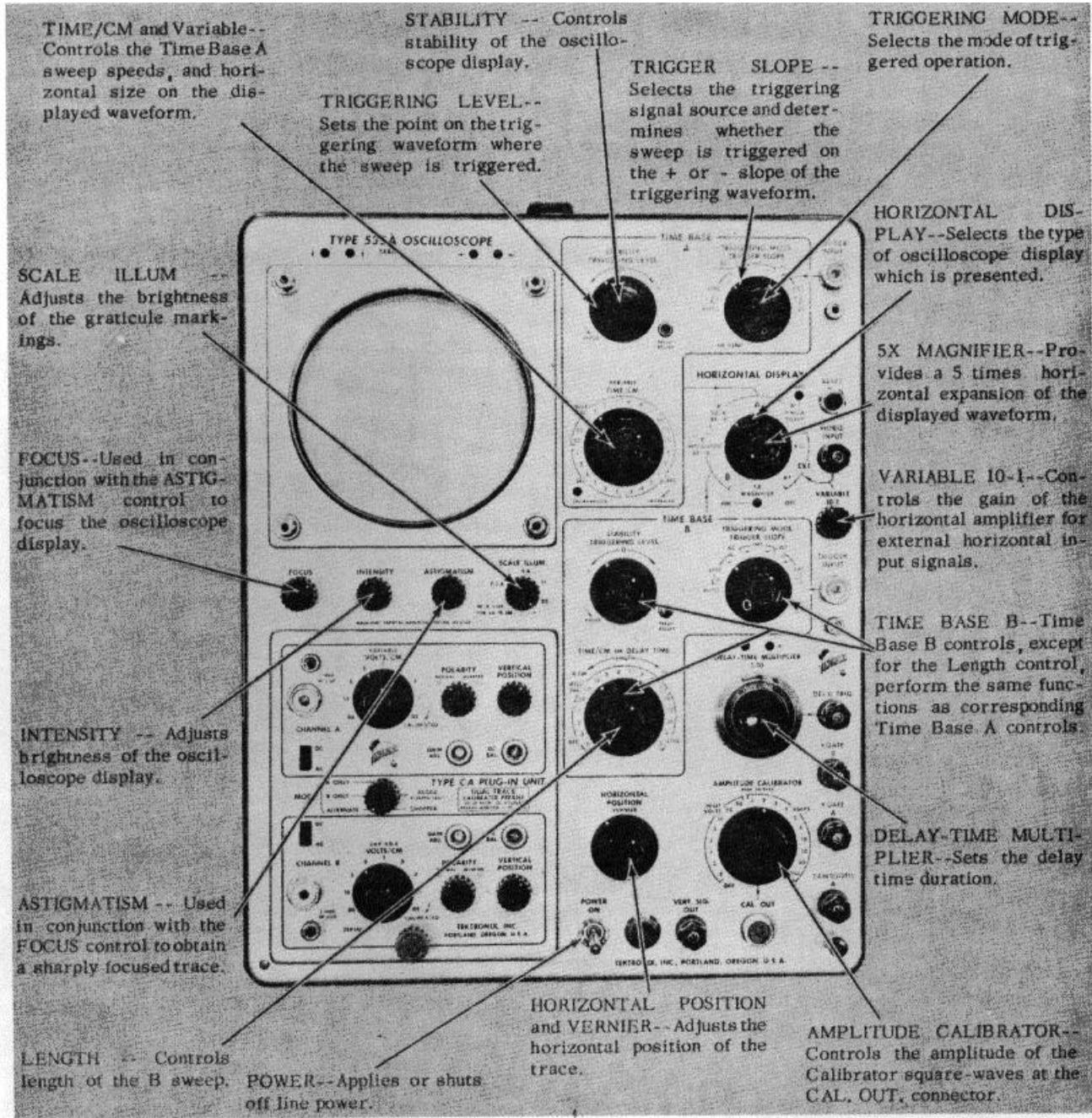
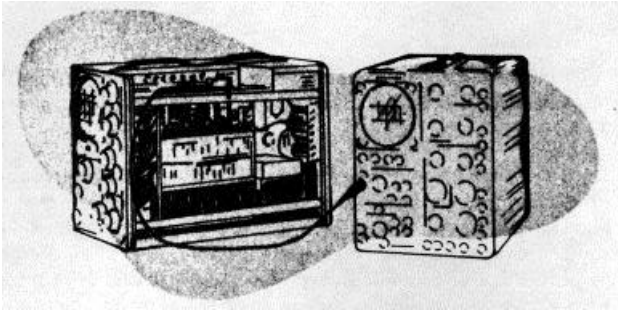


Fig. 2-12. Functions of the Type 535A Oscilloscope front panel controls.



SECTION 3

APPLICATIONS

Voltage Measurements

The Type 535A 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.

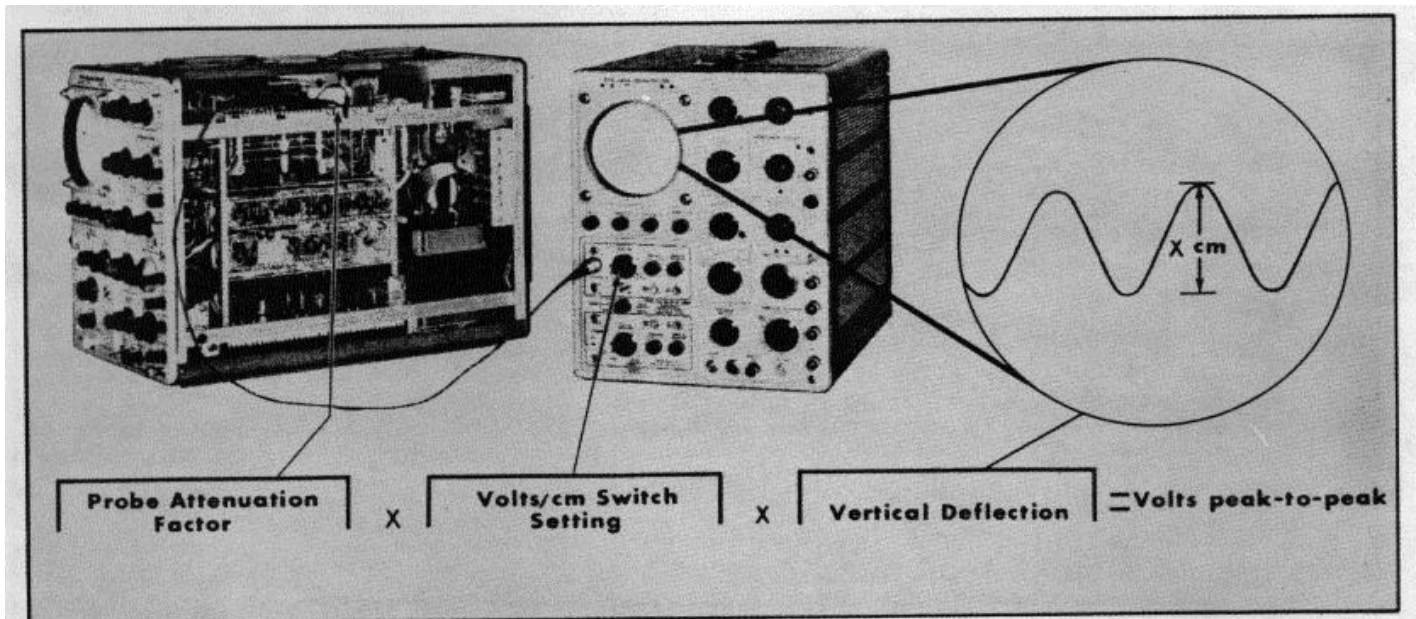


Fig. 3-1. Measuring the peak-to-peak ac component voltage of an applied waveform.

3. Multiply the indicated voltage by the attenuation factor of the probe used to obtain the actual peak-to-peak voltage.

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 measurement 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 measurement 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 settings 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).

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 the point you wish to check. In this case

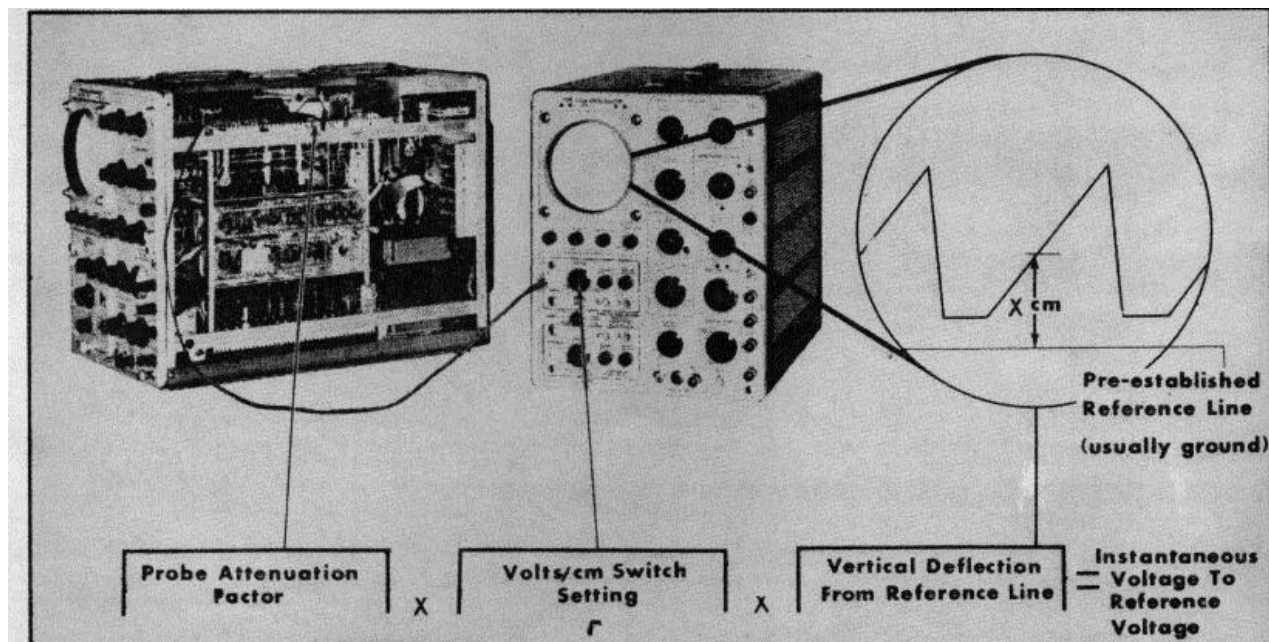


Fig. 3-2. Measuring the instantaneous voltage with respect to ground (or some other reference voltage).

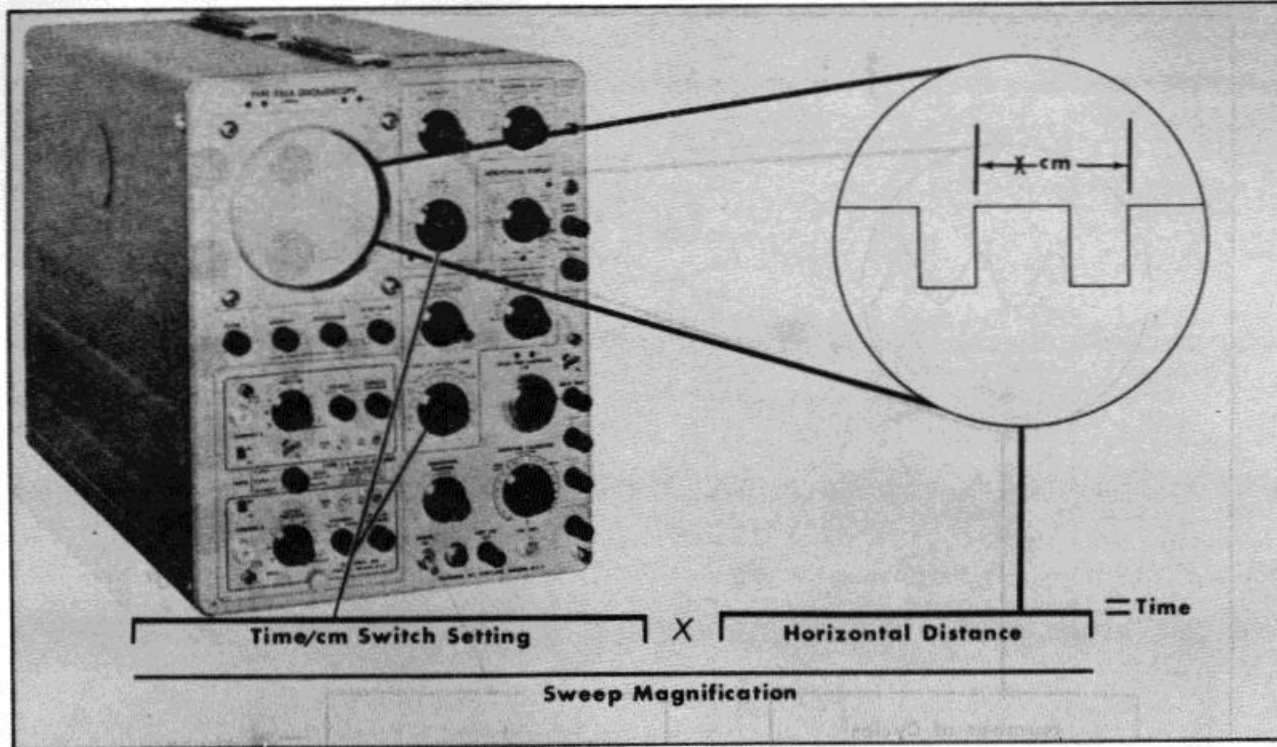


Fig. 3-3. Measuring time interval between events displayed on the oscilloscope screen.

then, 3 centimeters multiplied by .2 volts per centimeter gives you an indicated 0.6v. t. 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 535A Oscilloscope causes 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. One method which produces sufficient accuracy for most applications is as follows (see Figure 3-3):

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 appropriate 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 5 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 between events. In this example then, 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.

Another method for measuring time intervals involves the use of the delayed sweep feature of the Type 535A. In this method the HORIZONTAL DISPLAY switch is placed in the 'B' INTENSIFIED BY 'A' position to brighten a portion of the trace. The brightened portion of the trace and the DELAY TIME MULTIPLIER control are then used to make the time measurements. This method provides a very high degree of accuracy when care is taken in making the measurements. The method is summarized as follows:

1. Place the HORIZONTAL DISPLAY switch in the 'B' INTENSIFIED BY 'A' position and adjust the Time Base B triggering controls for a stable display of the input waveform. Adjust Time Base A for free-running operation.
2. Turn the intensity down until the brightened portion of the trace is easily distinguishable. Adjust the Time Base A TIME/CM controls to reduce the brightened area to a small spot or to cover as small a portion of the trace as possible.
3. Using the DELAY TIME MULTIPLIER control, position the start of the brightened portion to the beginning of the interval you wish to measure. Record the setting of the DELAY TIME MULTIPLIER control.
4. Using the DELAY TIME MULTIPLIER control, position the start of the brightened portion of the trace to the end of the interval you wish to measure. Again record the setting of the DELAY TIME MULTIPLIER control.

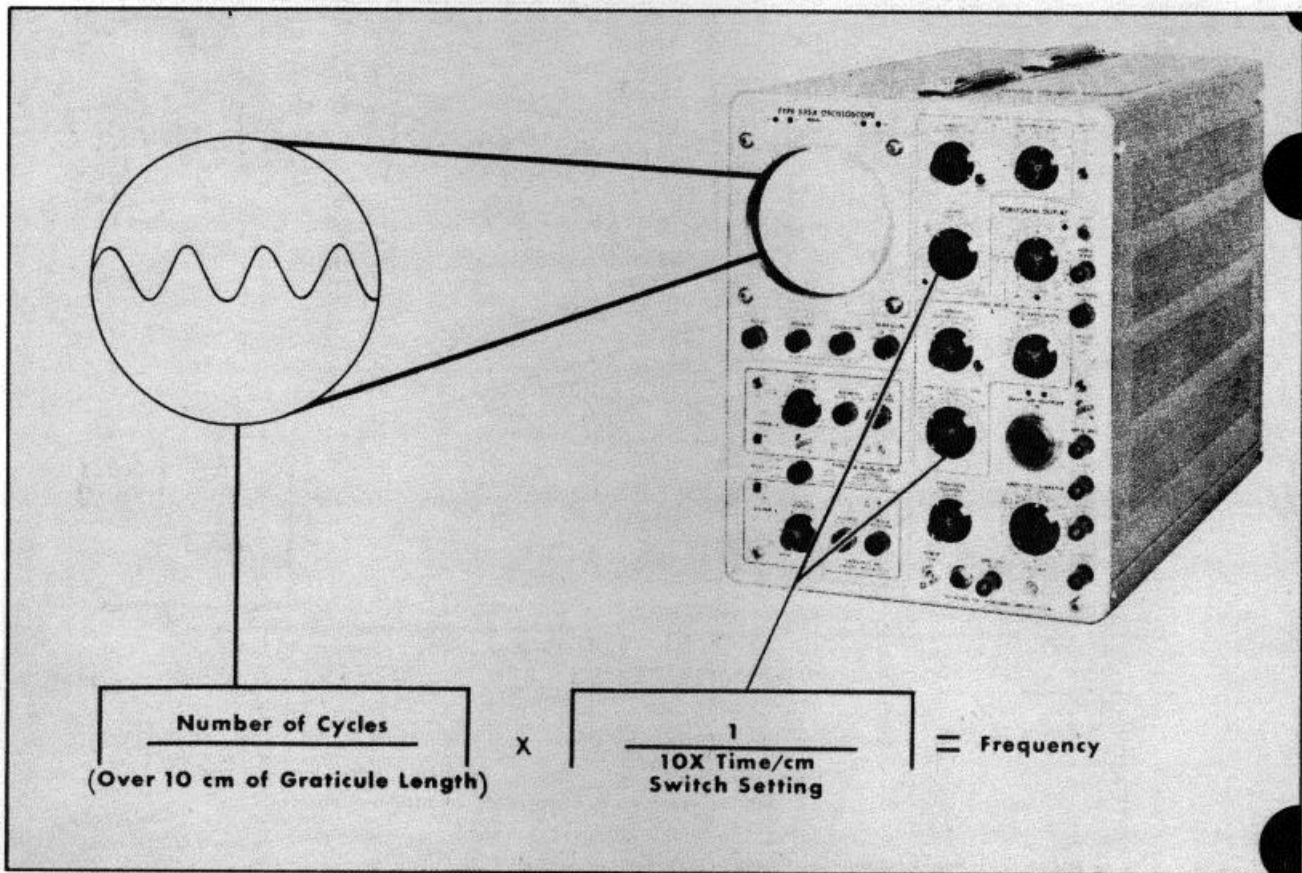


Fig. 3-4. Measuring the frequency of a repetitive input signal.

5. Subtract the first DELAY TIME MULTIPLIER control setting from the second and multiply the result by the setting of the Time Base B TIME/CM control. The figure obtained is the time interval between the two events. The figure obtained is correct regardless of whether the magnifier is on or off.

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 microsecond: the frequency is the reciprocal of 0.2 microsecond, or 5 mc. At any given oscilloscope sweep rate, 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.

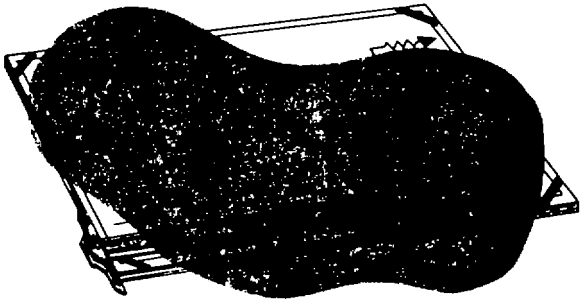
If you divide the cycles per unit of length by the time required for the input waveform to sweep this unit of length,

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.)

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 rate of 50 milliseconds per centimeter, you count 7.2 cy in 10 centimeters. The frequency is 7.2 cycles divided by 10 centimeters times 50 milliseconds, or 500 milliseconds. 500 milliseconds are 500x 0.001 seconds, or 0.5 second. 7.2 cycles per 0.5 second gives you 14.4 cycles per second.



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, V533B and V543B, and the Output Amplifier stage, V554 and V564. Other circuits of importance include the Trigger Pickoff Amplifier, V584A and V584B, the Trigger Pickoff C.F., V593A, the Vert. Sig. Out C.F., V593B, the Indicator Amplifiers, V533A and V543A, and the lamps, 8536 and 8546.

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 a ac "boost" network. R507A 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 1.6K in the range from dc to a fraction of a cycle, but reduces to 1.5K for higher 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, V533B and V543B. These Drivers isolate the Input Amplifiers from the Output Amplifiers, V554 and V564.

SECTION 4

CIRCUIT DESCRIPTION

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 Line.

The vertical signal is delayed 1/4-microsecond between the input to the Delay Line and the vertical deflection plates.

Beam-Position Indicators

The beam-position indicators, 8536 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 (block TRIGGER SLOPE knob is either in the + or - INT. position), a "sample" of the vertical signal is used to develop the triggering pulse. This "sample" is obtained from the trigger pickoff circuit consisting of the Trigger Pickoff Amplifier V584A and V584B, and Trigger Pickoff Cathode Follower, V593A.

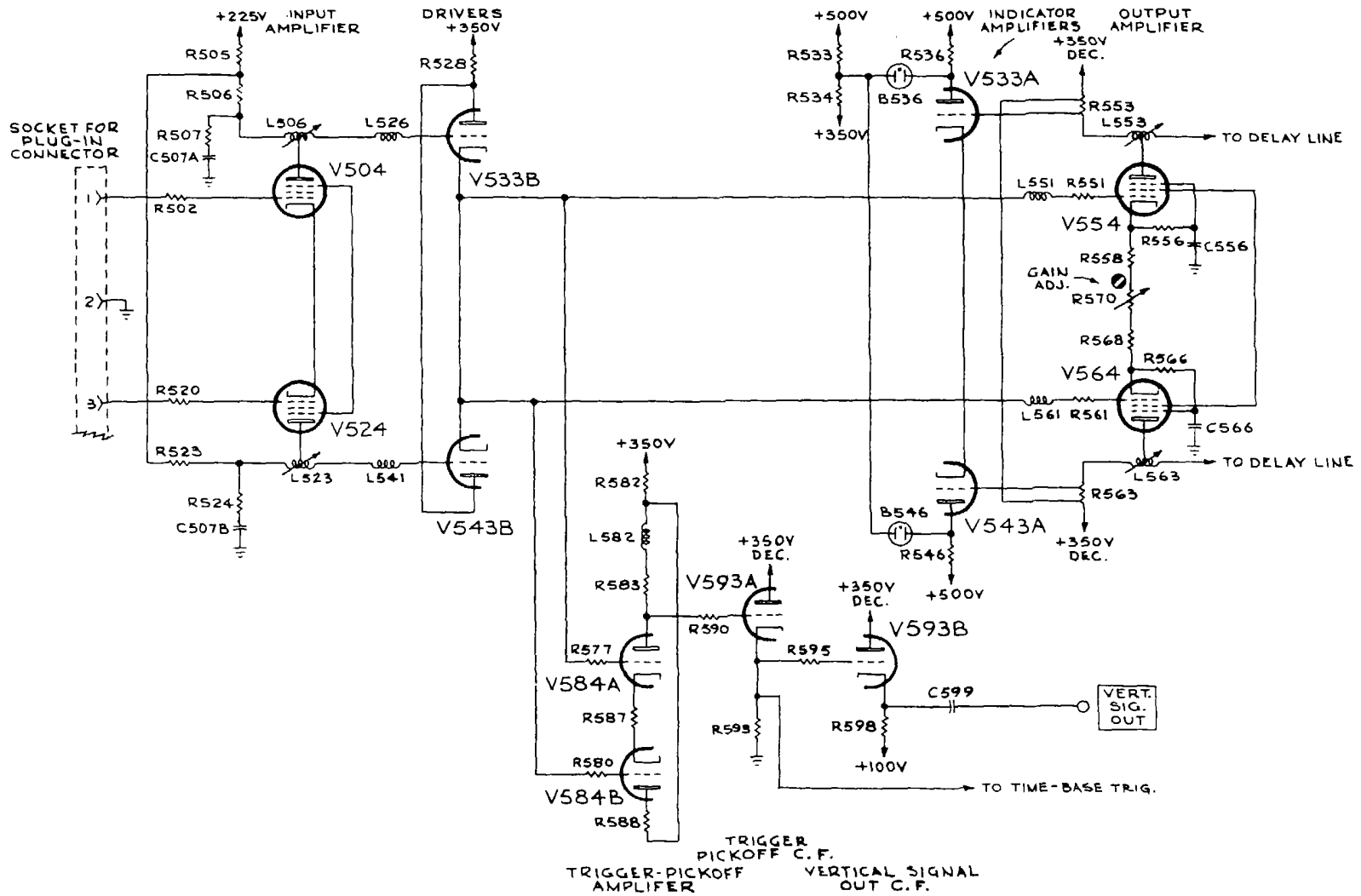


Fig. 4-1 Simplified Type 535A Vertical Amplifier.

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.

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 5 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 5 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 effected from external sources. 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 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 V45A 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 triode 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 sec

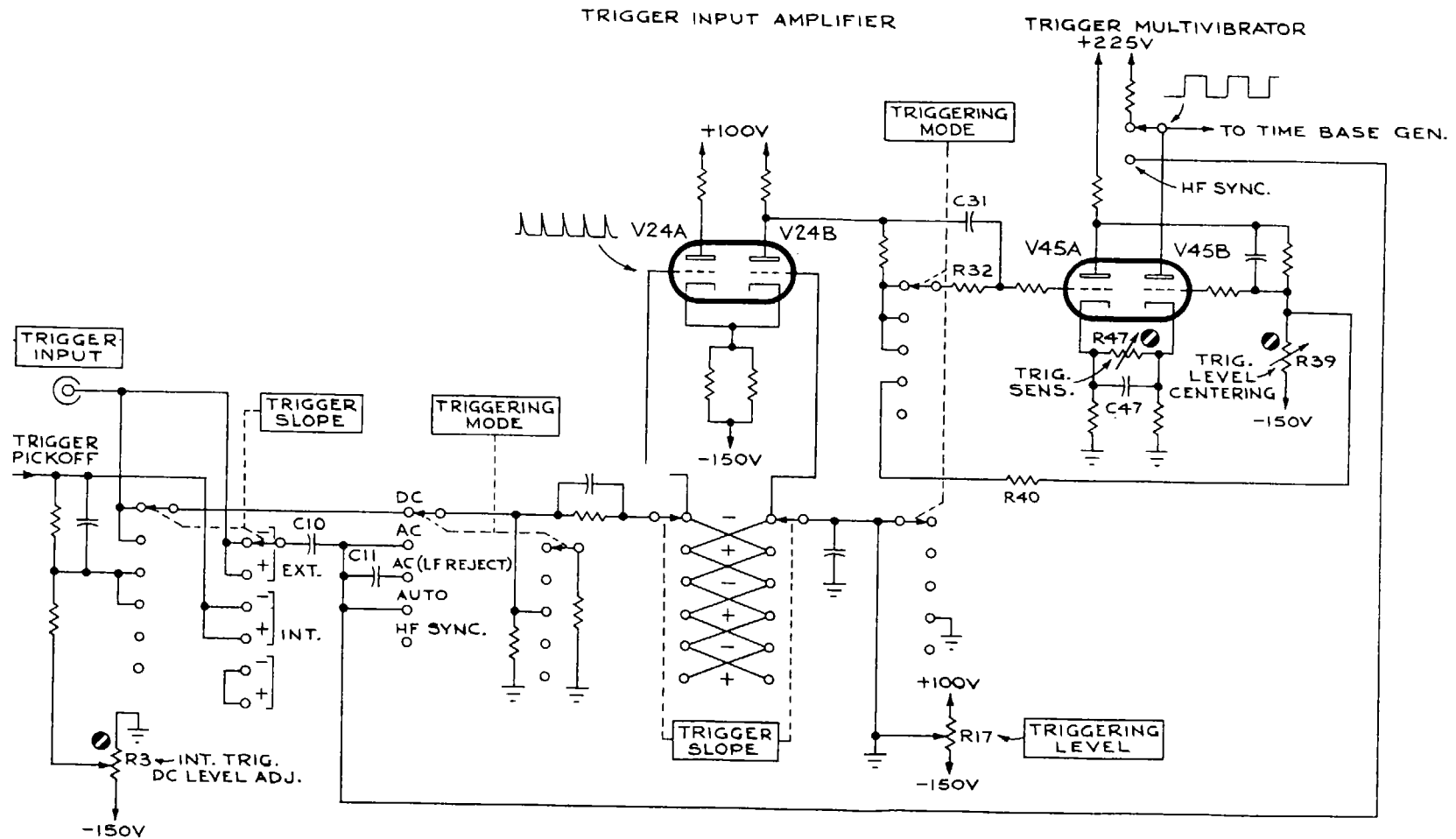


Fig. 4-2. Simplified Time-Based Trigger Circuit.

lion 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 dc coupling between the grid of the V45B section of the Trigger Multivibrator and the plate of the V45A section of the Trigger-Input amplifier is replaced by ac 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 R40. The grid of V45A is prevented from rising immediately by the action of C31, 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 towards cutoff. When the V45A section reaches cutoff, the circuit has completed one cycle of on 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 TRIGGERING 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 Time-Base Generator consists of three main circuits: the Sweep-Gating Multivibrator, the Miller Runup Circuit, and the Holdoff Circuit. The simplified schematic diagram of Fig. 4-3 shows the basic parts of each circuit, and the interconnections between circuits.

The Time-Base Trigger circuit furnishes the waveforms which initiates a cycle of action in the Time-Base Generator. Square waves from the output of the Trigger Multivibrator are fed to the Time-Base Generator where they are differentiated and used as trigger pulses. In analyzing the action of the Time-Base Generator we will assume it to be in the quiescent state, just before the arrival of a suitable trigger pulse.

In the quiescent state of the Time-Base Generator V135A is conducting.

Square waves, generated by the Time Base Trigger circuitry, are differentiated by the C131, R131 network.

If the STABILITY control, R110 is now advanced, the grid of V135A becomes more negative. As the grid of V135A becomes more negative, a point is reached at which a negative-going triggering pulse from the C131, R131 network will drive V135A into cutoff.

As V135A is driven to cutoff the plate voltage rises, carrying with it the grid of the cathode-follower stage, V135B V135B, used as a cathode follower between the two halves of the multivibrator, isolates the positive-going plate of V135A from the capacitance of the loads requiring a positive-going pulse. This results in a faster rise of the positive-going pulse at the plate of V135A.

The cathode of V135B follows the action of the grid closely. This cathode is long-tailed through the resistors R141, R143. Since the grid of V145 has a certain shunt capacitance to ground, C141 is connected in parallel with R141 to compensate for this capacitance.

The voltage rise at the cathode of V135B drives the grid of V145 above cutoff. As V145 begins to conduct its plate voltage drops rapidly. Any spiking which may occur is attenuated by the C141, R141 network.

When V145 is conducting at the maximum determined by circuit parameters the Sweep-Gating Multivibrator has reached its other stable state, and the action of the Miller Runup circuit has been initiated.

Miller Run-Up Circuit

The Miller Run-Up circuit is essentially a Class A amplifier employing negative feedback. The positive-going voltage at the plate of the Miller Tube is fed back to the grid through the Run-Up Cathode Follower, V173, in such a manner as to oppose the attempt of the grid to go negative. Because the gain of the Miller Tube is high, (approximately 200) it is possible to maintain an essentially linear rate of charge on the Timing Capacitor.

In the quiescent state of the Time-Base Generator the voltage at the plate of the Miller tube is determined by the voltage drop across a dc network formed by the neon lamp, B167, the Runup C.F., and the On-Off Diodes. The purpose of this dc network is to establish a voltage at the plate of the Miller Tube of such value that the tube will operate above the knee, and hence over the linear region of its characteristic curve.

The grid of the Miller Tube, V161, is returned to the --150volt supply through the Timing Resistor, R160. In the quiescent state of the Time-Base Generator the grid of the Miller Tube is held slightly negative, but well above cutoff, by the flow of the current through the A section of the On-Off Diode. When the On-Off Diodes stop conducting the grid of the Miller Tube tends to become more negative.

As the grid of the Miller Tube starts negative the plate becomes more positive. This positive-going excursion of the plate carries the grids of V173, the Run-Up Cathode Follower, with it. The voltage at the grids of V173 is maintained at a constant difference with respect to the. Miller

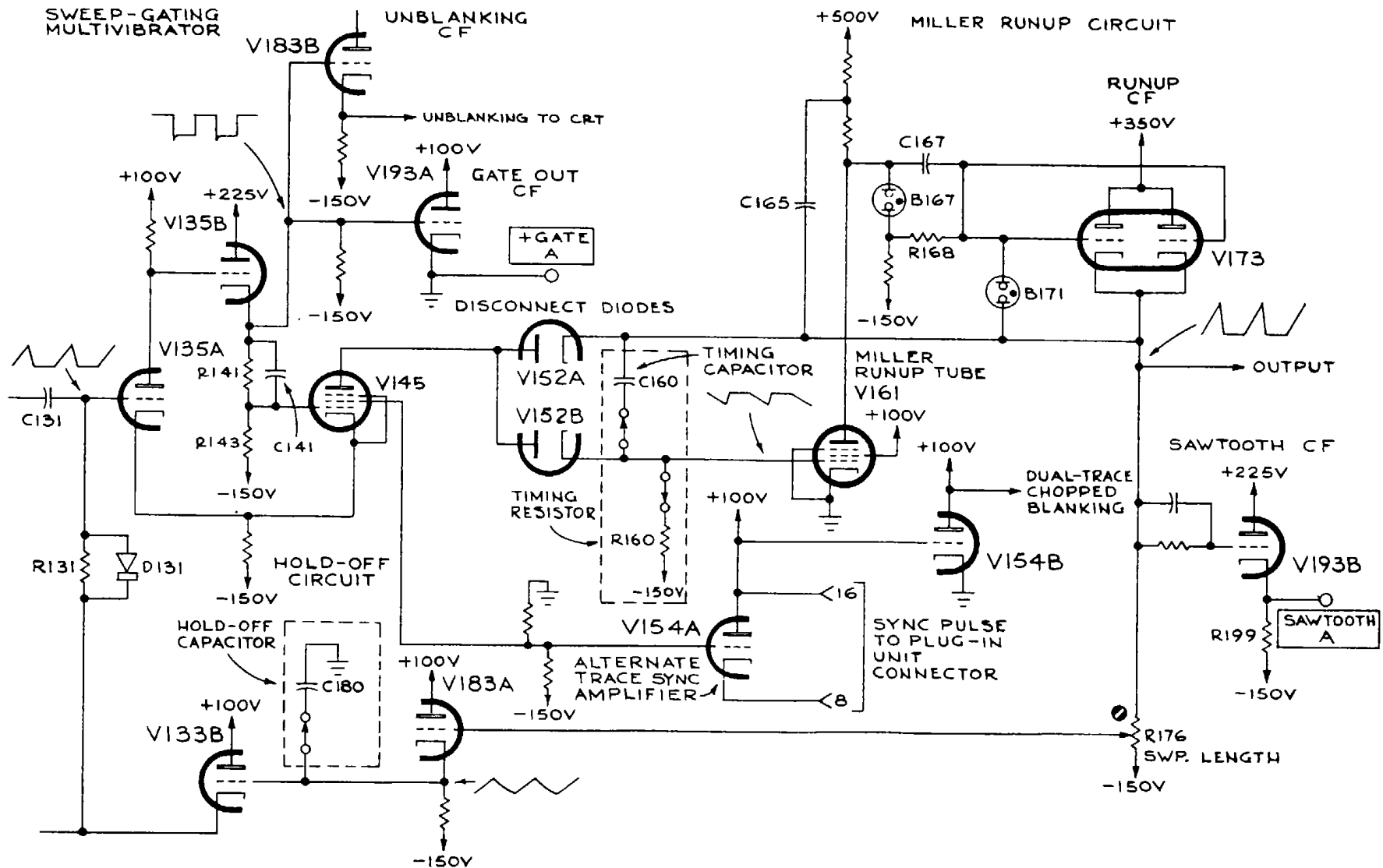


Fig. 4-3. Simplified Time-Base Generator.

Tube plate voltage by the voltage drop across the neon bulb, B167. C167 and R168 form a network connected around B167 to improve the risetime. A bootstrap capacitor, C165, is connected between a top on the Miller Tube plate load and the cathode of V173. This bootstrap capacitor increases the charging rate of the stray capacitances in the Miller Tube plate circuit. Its action is most important in the generation of fast time-bases.

The cathode of V173 follows the action of the grids closely. This results in a linear rise in the voltage at the upper end of the Timing Capacitor, C160. Since the charge on the capacitor cannot change instantaneously this voltage is coupled to the grid of the Miller Tube in a direction to correct for the attempt of the Miller Tube grid to go negative.

Current to charge the Timing Capacitor is supplied through the Timing Resistor, R160. Since the voltage across the Timing Resistor is virtually constant a constant current source is thus provided for charging the Timing Capacitor.

The linear voltage rise at the cathode of V173 is used as the Time-Base sawtooth. This voltage rise continues until a positive step from the Sweep-Gating Multivibrator raises the plate voltage of the On-Off Diodes to the point at which they begin to conduct.

The positive-going voltage at the cathode of V173 is coupled back to the input of the Sweep-Gating Multivibrator and causes that circuit to revert to its other state. It is kept from acting on further trigger pulses by the action of the Holdoff Circuit.

The waveform coupled to the Time-Base Generator from the Time-Base Trigger circuit contains both positive- and negative-going pulses. To prevent a negative-going pulse from triggering the Sweep-Gating Multivibrator before the action of the Time-Base Generator is completed the grid of V135A must be held above cutoff.

Holdoff Circuit

The Holdoff Circuit keeps the grid of V135A above cutoff until the capacitances in the Time-Base Generator have had time to reach their quiescent state. The point at which the Holdoff Circuit will allow the Sweep-Gating Multivibrator to return to its quiescent state is determined by the adjustment of R176.

The sawtooth present at the cathode of the Run-Up Cathode-Follower is coupled to the grid of V183A through R176. During calibration R176 is adjusted so that the time base terminates after it has passed the right-hand limit of the graticule. R176 adjusts the voltage at the grid of V183A and consequently at the cathode of V183A and on the capacitor C180.

The positive-going pulse from the cathode of V183A is coupled to the bus connecting the cathode of V183A and the grid of V133B. The action of the capacitor C180 retards the voltage at the grid of V133B. The value of C180 is chosen so that its capacitance will prevent the voltage at the grid of V133B from falling until all capacitances in the Time-Base Generator have returned to their quiescent level.

Output Waveforms

Various waveforms available during the cycle of action in the Time-Base Generator are made available through cathode followers for other functions. Shown in Fig. 4-3 are the unblanking pulse, the +Gate, and the Sawtooth from the Time-Base. The same signal used to provide the +Gate is used to provide the unblanking signal for the crt circuit.

Unblanking

In the quiescent state of the Time-Base Generator the crt beam is cut off. To allow the crt beam to be seen the potential at the control grid of the crt must be raised. The voltage rise appearing at the cathode of V135B in the Time-Base Generator is used to drive a cathode-follower in the crt circuit. This "unblanks" the beam during the time a sawtooth is generated, permitting the left-to-right motion of the beam to be seen.

The end of the unblanking pulse coincides with the end of the time-base, and the crt is blanked" during the retrace portion of the sweep, and during quiescent periods of the Time-Base Generator.

Sweep "B" Circuits

In the Type 535A, the operator is offered a selection of two sweep circuits of very similar configuration and operating principles. The Time-Base Trigger B and Time-Base Generator B circuits are practically identical to those found in Time-Base A. There are, however, some noticeable differences between the Time Base A and Time Base B Timing switches, due to the difference in sweep rate selections between the two circuits.

Delay Pickoff Circuit

Delayed triggers can be applied to Sweep Generator A from the Delayed Trigger Amplifier, V114, through V133A which acts as a coupling C.F. to apply delayed triggers to the Sweep-Gating Multivibrator. Delayed Trigger Pulses are applied to the grid of V114 from the cathode of V428B.

These pulses are shaped and amplified in the Delay Pickoff Circuit, comprised of V414, V424, V445 and V428. The first stage of this circuit, V414 and V424 combine to form a difference amplifier which picks off a sample of the sawtooth output from Sweep Generator A or B and converts it into a positive pulse of step form. Before the pickoff time, V414 is cut off. Its cathode is tied to the cathode of V424 which is conducting, and therefore determining the common-cathode voltage.

The common-cathode voltage is adjustable by means of R433, a 10-turn helical resistor, labeled DELAY-TIME MULTIPLIER 1-10 on the front panel. V428A is a constant-current triode supplying cathode current to the difference amplifiers from the -150-volt supply. This arrangement permits the cathode of V424 to follow its grid over a wide range with very little variation of cathode voltage.

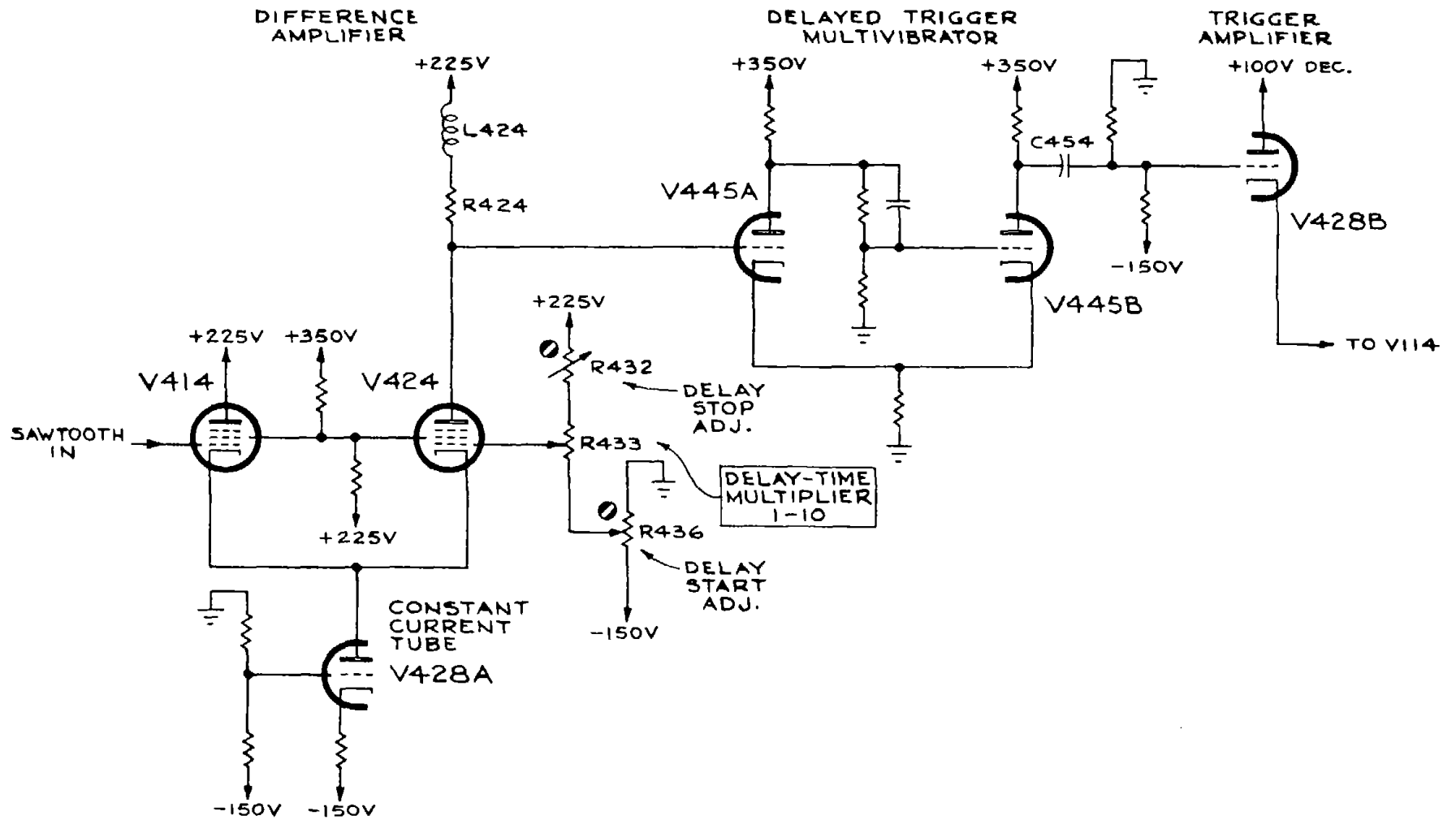


Fig. 4-4. Simplified Delay-Pickoff Circuit.

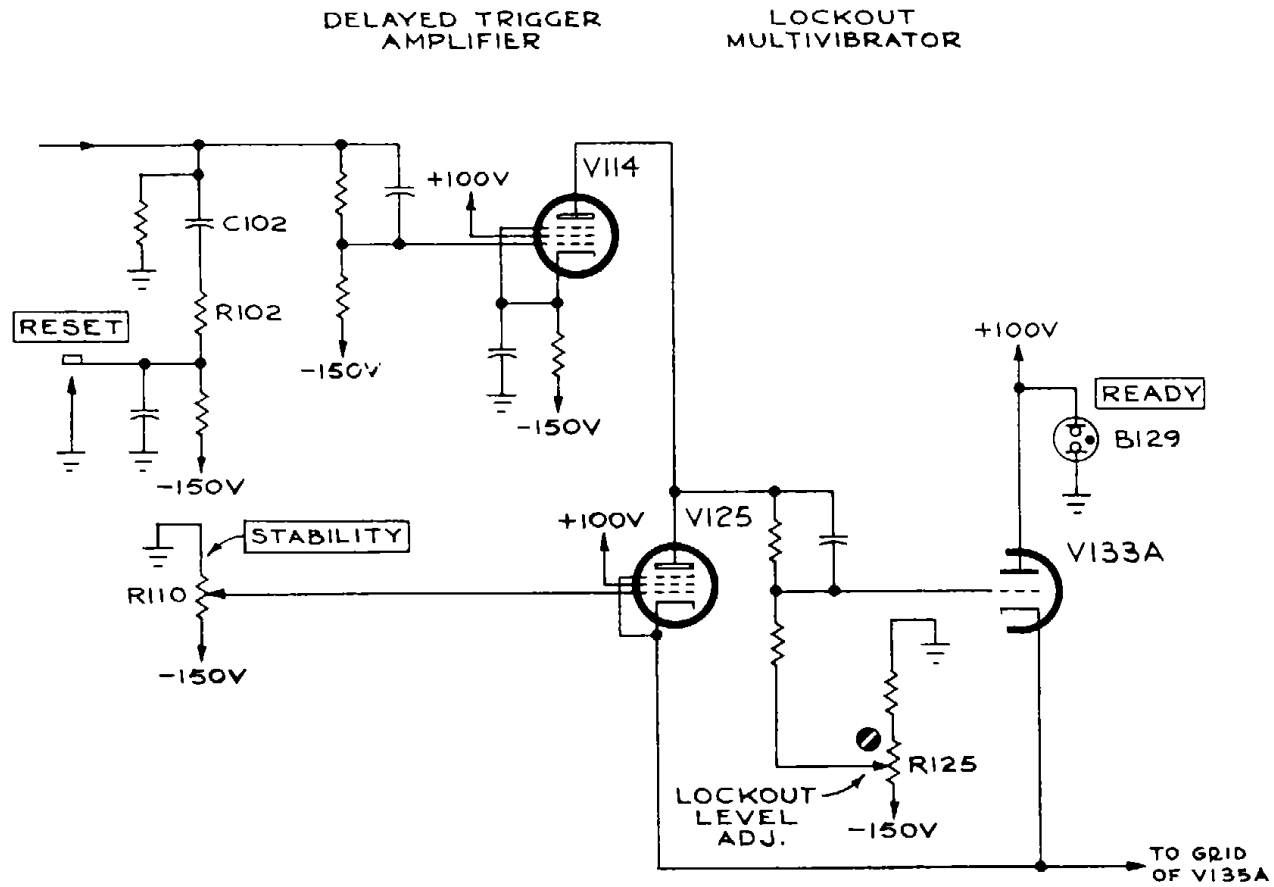


Fig. 4-5. Simplified Single-Sweep Circuit.

(A)(A)

Plate current through R424 and L424 therefore also remains very nearly constant while V424 is conducting, no matter at what voltage the grid is set by the DELAY-TIME MULTIPLIER control, R433. This is important because the plate voltage of V424 is required to hold the grid voltage of the shaper stage, V445A, near the triggering point.

The positive-going delaying-sweep sawtooth raises the grid of non-conducting V414 toward its cathode voltage. When the grid rises past the cathode voltage set by the DELAY-TIME MULTIPLIER control, V414 conducts and V424 cuts off.

Delayed-Trigger Multivibrator

When V424 cuts off because of conduction in V414, its plate rises, carrying the grid of trigger shaper V445A positive past its transition point. The trigger-shaper stage is regenerative so as to produce a fast transition, and the resulting positive step at the plate of V4458 is differentiated through C454 and used to arm or to trigger the main-sweep circuits. The sharp differentiated pulse is transmitted to the succeeding circuits through cathode follower V428B.

Two internal screwdriver controls located on the "B" sweep gate at the right side of your oscilloscope and labeled, respectively, Delay Start Adj. and Delay Stop Adj., precisely adjust the upper and lower V424 grid voltage limits set by the DELAY-TIME MULTIPLIER so that centimeters of delay can be read within a fraction of one percent directly from the micrometer dial of the DELAY-TIME MULTIPLIER.

Single Sweep Operation

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

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

Depressing the RESET switch rounds C102 and R102. The resulting positive pulse at the grid of V125 forces the Lockout Multivibrator into its other stable state with V125 conducting and V133A cut off. With V133A cut off, its plate voltage rises and ignites the READY light. With V125 conducting, the STABILITY control regains control over the grid level of V135A.

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

As the sweep begins, the rising sawtooth voltage pulls up the cathodes of V1338 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 cutoff for the remainder of the sweep and the READY light stays on. When the grid of V135A rises to the point at which the Sweep-Gating Multivibrator is reverted, the sweep is terminated.

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

Unblanking

The positive rectangular pulse at the cathode of V135B, in the Sweep-Gating Multivibrator circuit, is coupled through a cathode follower V183B (shown on the CRT circuit diagram, Fig. 4-10) to the grid supply for the crt. This pulse, whose start and duration are coincident with the rising portion of the sawtooth sweep waveform, pulls up the grid of the crt. This unblanks the crt during the trace portion of the sweep and permits the trace to be observed.

Output Waveforms

The positive pulse coupled to the crt circuit for unblanking is also coupled through a cathode follower V193A to a front-panel binding post labeled +GATE A. This positive gate waveform starts at ground and rises to +30 volts.

The sweep sawtooth voltage at the cathode of V173 is coupled through a cathode follower V193B to a front-panel binding post labeled SAWTOOTH A. This waveform, which starts at about ground, provides a 150-volt linear rise in voltage.

Dual Trace Sync and Blanking

Synchronizing pulses for dual-trace plug-in preamplifiers are supplied by V154A. When multi tube V145 cuts off a sharply differentiated positive pulse is developed at its screen. This pulse, coupled to the grid of V154A, produces a negative trigger at the plate of V154A. This trigger then switches the multivibrator in the dual-trace unit employed for alternate sweeps.

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

Alternate-Trace Operation

Alternate-trace operation is available with Tektronix convertible oscilloscopes by employing the 53C, 53/54C or Type CA plug-in preamplifiers. Additional circuitry in the Time-Base Generator circuit provides a pulse to "flip" a bistable multivibrator in the plug-in. This multivibrator provides a change in dc level at the inputs of the amplifiers in the plug-in. This change in dc level is used as a positioning voltage which separates the two traces a distance selected by the operator.

The Time-Base Generator circuitry necessary for alternate-trace operation utilizes an amplifier which amplifies the signal present at the grid of V154A. The signal at the plate of the amplifier, V154A, is connected to pin 16 of the interconnecting socket, while the signal at the cathode is connected to pin 8 of the interconnecting socket. Fig. 4-3 shows the Time-Base Generator circuitry involved. Fig. 4-6 shows the plug-in circuitry which affects the positioning.

Negative-going pulses, generated at the end of each time-base by the Sweep-Gating Multivibrator in the Time-Base Generator, are amplified by the amplifier, V154A. The pulses are coupled through the interconnecting socket to the Trigger Coupling Diode in the plug-in. Each trigger causes the multivibrator to "flip" from one stable state to another at a rate determined by the repetition rate of the Time-Base Generator.

The square waves present at the cathodes of the multivibrator tubes are used to drive the amplifiers, V3384A and V3384B. The signals from these amplifiers are used to drive V3393B and V3393A, cathode followers which isolate the multivibrator circuitry from the signal amplifiers. The output of the cathode followers raises or lowers the plate voltage of the Input Amplifiers as the multivibrator passes from one stable state to the other.

In later instruments an additional stage has been added in the Time-Base Generator to provide blanking when the plug-in is operated in the CHOPPED MODE. This is shown as V154B in Fig. 4-3. In the CHOPPED MODE of operation the multivibrator in the plug-in free runs at a rate determined by circuit constants. Transients generated during free-running operation are blanked from appearing on the crt screen by the action of V154B.

Horizontal Amplifier

The Horizontal Amplifier converts the single-ended sawtooth output of the Time-Base Generator into push-pull signal suitable for driving the horizontal plates of the crt. The gain of the amplifier may be varied by a factor of five by means of the 5X magnifier switch. In addition, controls are provided for horizontal positioning and adjustment of the horizontal linearity.

The sawtooth waveform from the Time-Base Generator is coupled to the Input Cathode Follower through the R330, C330 network. This network attenuates the input signal and provides a means of compensating the input circuitry for optimum frequency response. During calibration C330 is adjusted for best response to a square wave.

The HORIZONTAL POSITION and VERNIER controls adjust the dc level at the grid of V343A. This change in dc level changes the dc level on the signal path through the amplifier, thus changing the dc voltage applied to the crt horizontal deflection plates and affecting horizontal positioning.

Coupling between the Input CF and the Driver CF is made by the 5X MAGNIFIER switch. When this switch is in the OFF position the signal from the Input CF must pass through the network formed by C348 in parallel with the series combination R348, and R349. R348, a variable resistor, allows the operator to adjust the length of the time base by varying the attenuation applied to the signal. C348, a variable capacitor, is adjusted to provide optimum linearity of the time base on the fastest time bases.

This network attenuates the signal by a factor of five. To provide magnification of the time base, the network is removed when the 5X MAGNIFIER switch is turned to the ON position.

The gain of the Horizontal Amplifier is controlled by a negative feedback circuit. The signal appearing out the left-hand deflection plate is fed back to the input of the Driver CF. R358 is an adjustable resistor which allows the operator to vary the dc voltage applied to feedback loop.

By changing the dc voltage at this point the operator can adjust the position of the unmagnified sweep so that it will correspond with the position of the magnified sweep.

The output waveform from the Horizontal Amplifier is taken from V364A and V384A. The cathodes of these tubes are connected through a network which includes the Mag. Gain control. This control enables the operator to adjust the gain of the Horizontal Amplifier so that the ratio between the magnified and unmagnified sweeps is correct. C375, in parallel with the Mag. Gain control, has considerable effect on the linearity at the beginning of the time base, and is adjusted while displaying a signal with a high repetition rate.

Part of the signal appearing at the plates of the output amplifiers is used to drive the Output CFs. Note that the cathode of V364B is connected to the plate of V398, a pentode. The function of the Output CFs is to drive the capacitance of the horizontal deflection plates and the associated wiring. To assure a sufficient flow of current at fast time bases, the pentode, V398 is used to supply current to the Output CF which drives the negative-going, or left-hand deflection plate. A pentode is chosen as a current booster, since its plate characteristic provides a flat-topped pulse of current. The pulse to drive the grid of the pentode is derived from the waveform at the right-hand deflection plate. This waveform is differentiated by the C390, R390 network before being applied to the grid. Its amplitude is thus proportional to the time base. For the fastest time bases, the tube current is several times normal, but at the reduced duty cycle of the lime base, well within the dissipation rating of the tubes.

Bootstrap capacitors C364 and C384 are used to help supply the necessary charging current for fast time bases. During calibration these two capacitors are adjusted on the fastest time base for optimum linearity.

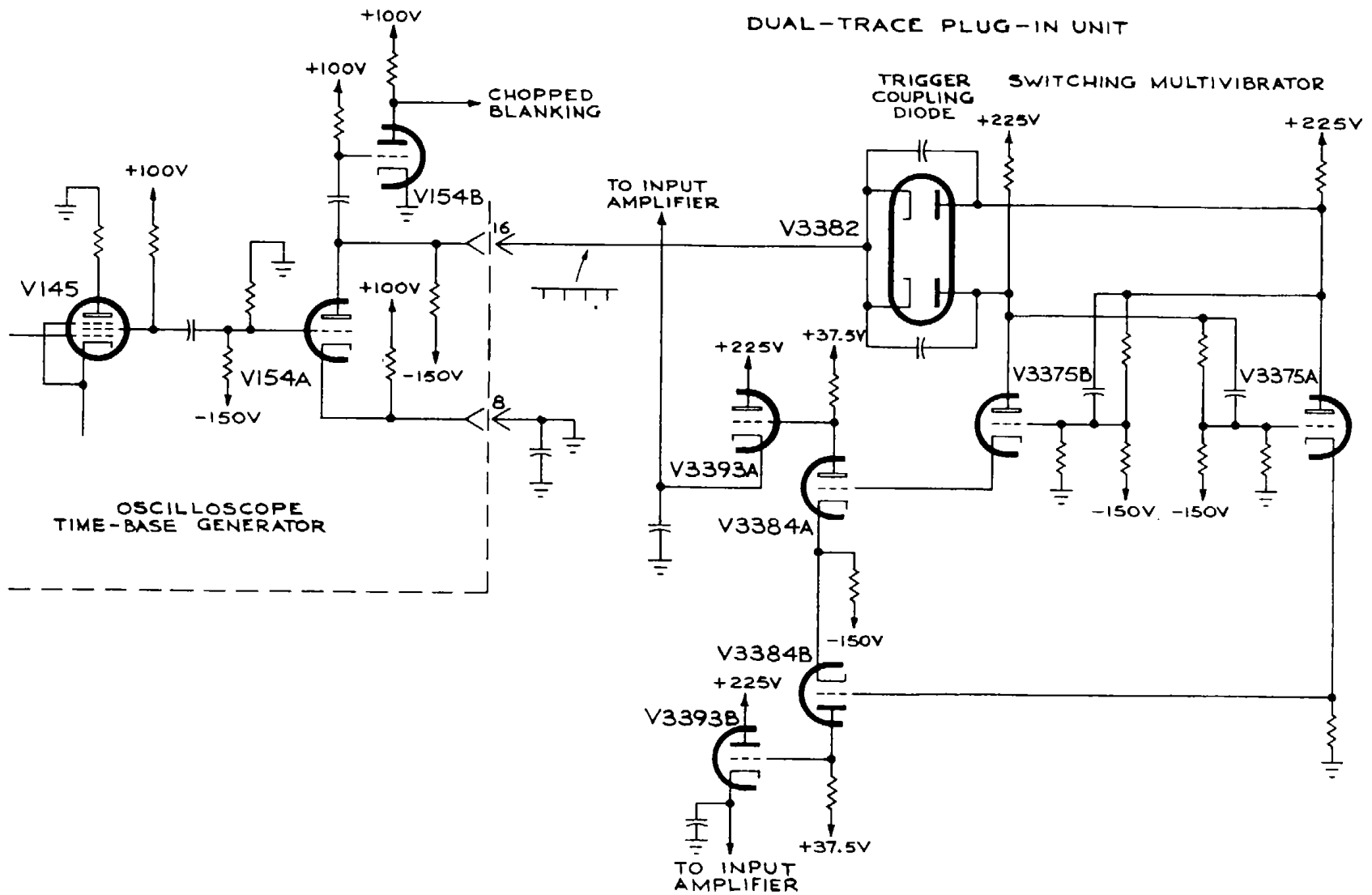


Fig. 4-6. Simplified Alternate - Trace Operation Circuitry.

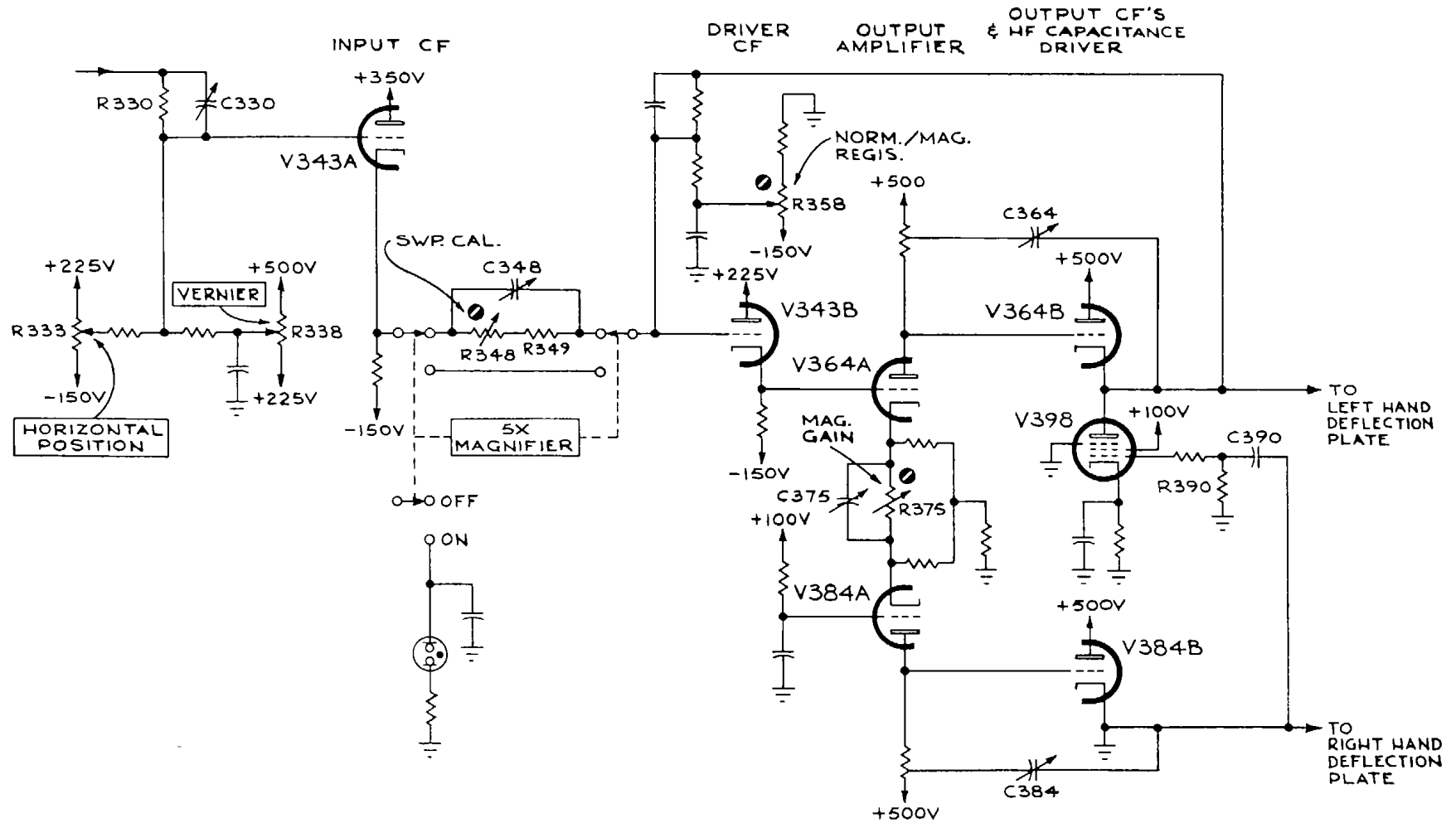


Fig. 4-7. Simplified Horizontal Amplifier.

LOW-VOLTAGE POWER SUPPLY

Plate and filament power for the tubes in the Type 535A is furnished by a single power transformer T601. The primary has two equal windings which may be connected in parallel for 117-volt operation, or in series for 234-volt operation. The power supply will maintain regulation over line voltage ranges of 105 to 125 volts, or 210 to 250 volts, rms, 50-60-cycles. Bridge rectifiers are employed for the five separate, full-wave, power supplies. The five supplies furnish regulated output voltages of -150, +100, +225, +350 and +500 volts.

-150-Volt Supply

Reference voltage for the -150-volt supply is furnished by a gas diode voltage-reference tube 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 R615, R616 and R617. 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 V624 and V634 and applied to the grids of the series tubes, V627, V637 and V647. 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, 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.

+ 100-Volt Supply

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 V667A 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 on V664 through R667. 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 +100-volt bus. This same circuit also improves the regulation in the presence of line-voltage variations.

(A)(A)

+ 225-Volt Supply

Rectified voltage from terminals 7 and 10 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 the 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.

+ 350-Volt Supply

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

+ 500-Volt Supply

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 K600 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.

CALIBRATOR

The Calibrator is a square-wave generator whose approximately 1-kc output is available at a front-panel connector labeled CAL. OUT. It consists of a Multivibrator V875 and V885A connected so as to switch the cathode follower V885B between two operating states... cutoff and conduction.

During the negative portion of the Multivibrator waveform the grid of V885B is driven well below cutoff and its cathode

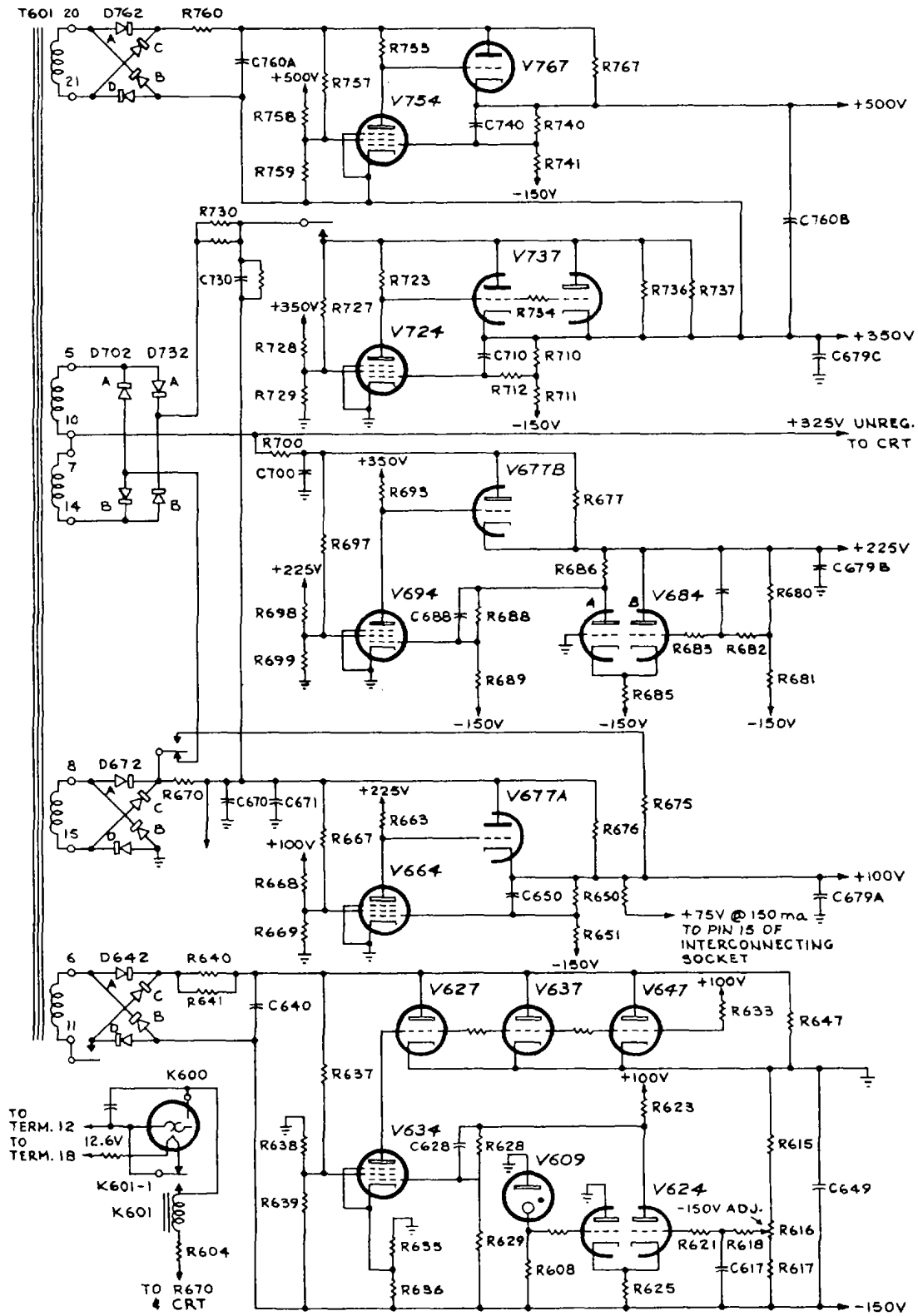


Fig. 4-8. Simplified Low-Voltage Power Supply.

(A)(A)

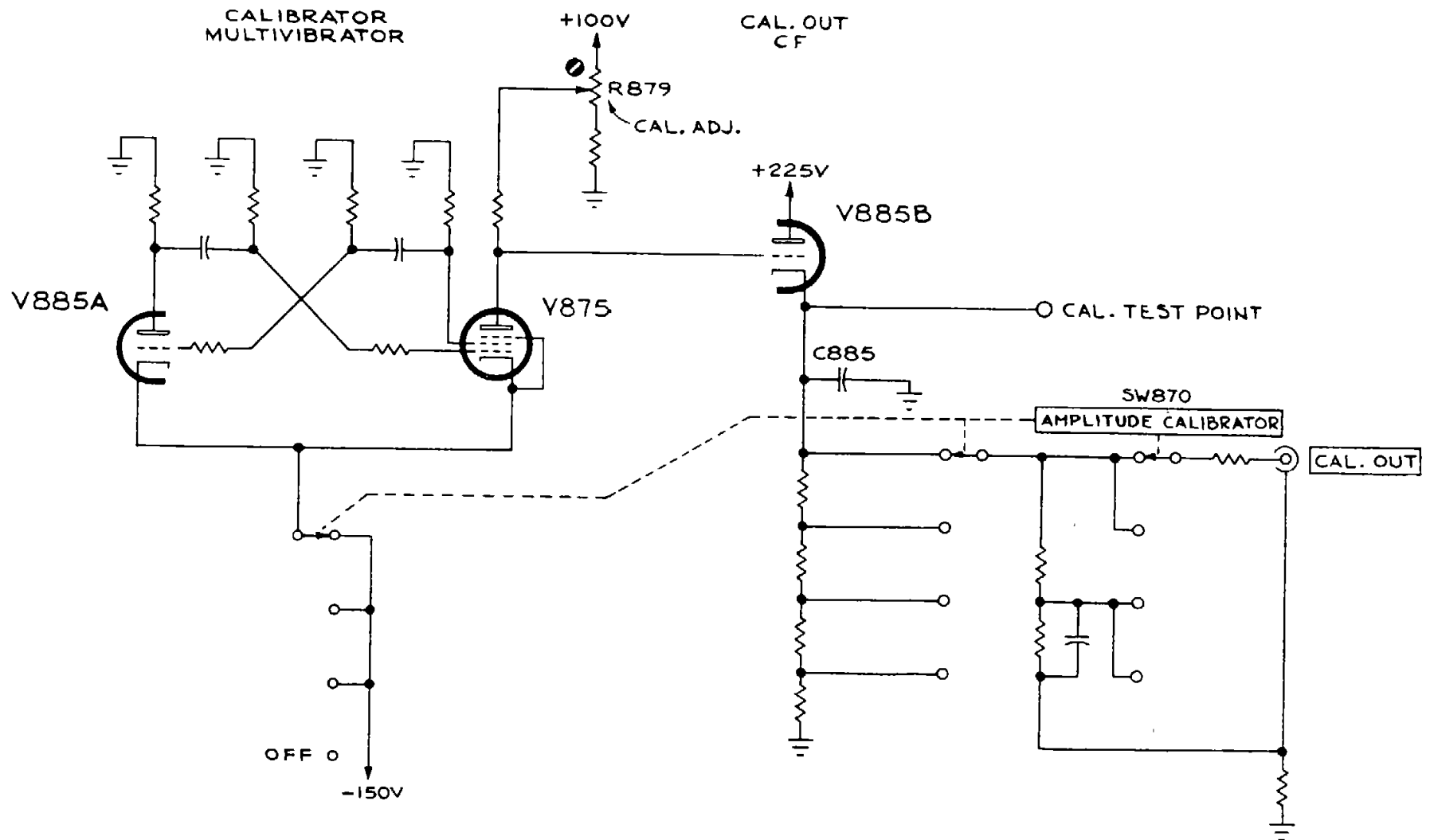


Fig. 4-9. Simplified Calibrator Circuit.

rests at ground potential. During the positive portion of the waveform V875 is cutoff and its plate rests slightly below +100 volts. The voltage at the plate of V875 when this tube is cutoff, is determined by the setting of the Cal Adj. control R879, part of the divider connected between + 100 volts and ground.

Cathode-follower V8858 has a precision, topped 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 1000/1 divider R896-R897, output voltages from 0.2 millivolt to 100 volts, in steps, are available. C885, connected between the cathode of V885B and ground, corrects the output waveform for a slight overshoot.

CRT CIRCUITS

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 during 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 circuit are the pentode VBOO and the primary of T801 tuned by C808.

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 R801-C801.

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 R840 labeled H.V. Adj. When this control is properly adjusted, the voltage of the H.V. Adj. Test Pt. 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 C827, R827, and R828 is employed. By this arrangement the fast leading edge of the unblanking pulse is coupled through C827 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 R827. This pulls up the floating supply and holds the grid at the unblanked potential for the duration of the unblanking pulse.

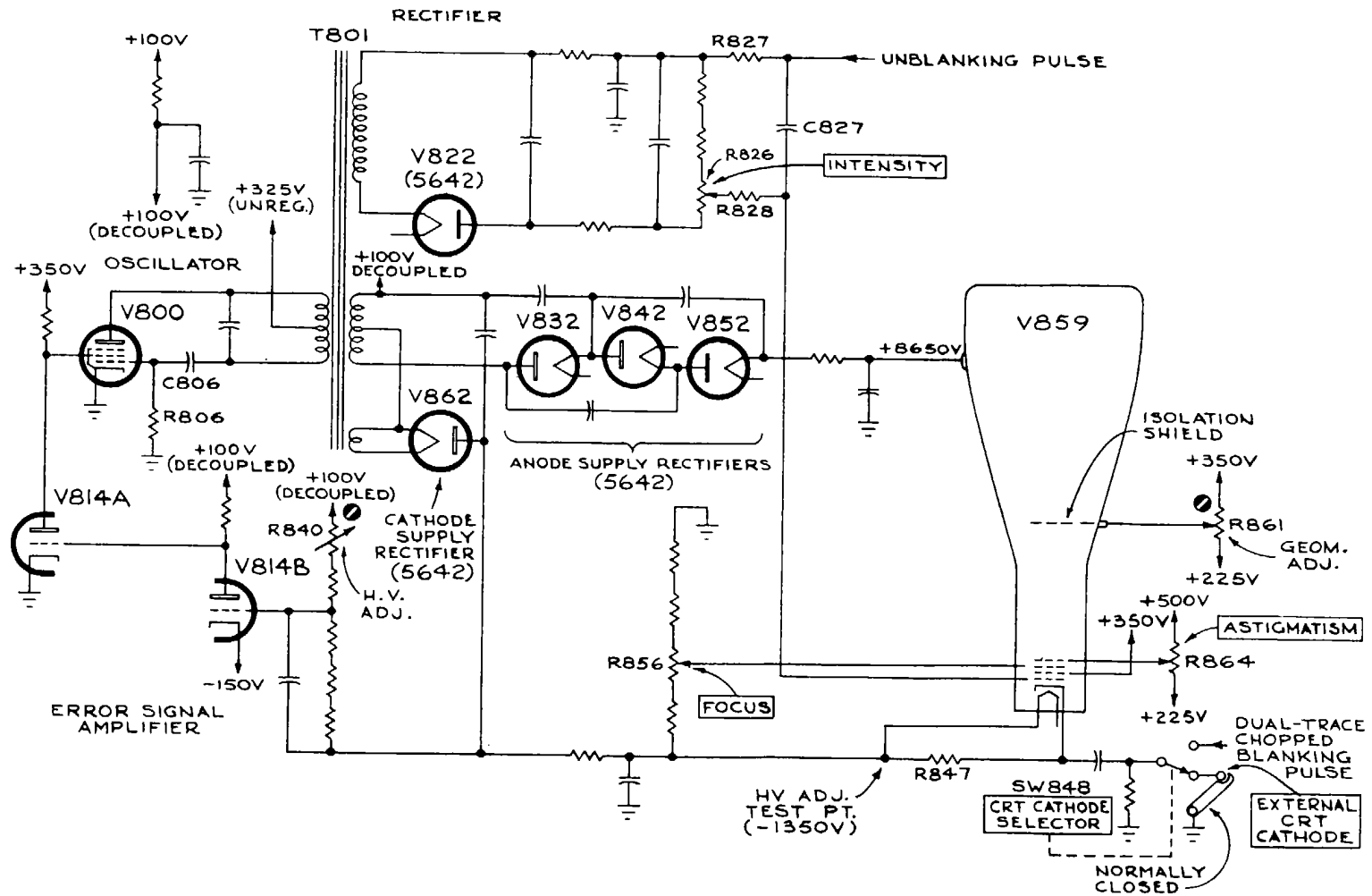


Fig. 4-10. Simplified Cathode-Ray Tube Circuit.

SECTION 5

MAINTENANCE

5-1. Scope of Maintenance

a. The maintenance duties assigned to the operator of the oscilloscope are listed below together with a reference to the paragraphs covering the specific maintenance functions. The duties assigned do not require tools or test equipment other than those issued with the equipment.

- (1) Operator's daily preventive maintenance checks and services (para 5-4).
- (2) Operator's weekly preventive maintenance checks and services (para 5-5).
- (3) Cleaning (para 5-7).

b. The maintenance duties assigned to the organizational maintenance repairmen of the oscilloscope are listed below, together with a reference to the paragraphs covering the specific functions. The duties assigned do not require tools or test equipment other than those issued with the equipment.

- (1) Organizational monthly preventive maintenance checks and services (para 5-6).
- (2) Rustproofing and painting (para 5-8).
- (3) Organizational troubleshooting chart (para 5-11).

5-2. Preventive Maintenance

Preventive maintenance is the systematic care, servicing, and inspection of equipment to prevent the occurrence of trouble, reduce downtime, and assure that the equipment is serviceable.

a. Systematic Care. The procedures given in paragraphs 5-4 through 5-7 cover routine systematic care and cleaning essential to proper upkeep and operation of the equipment.

b. Preventive Maintenance Checks and Services.

The preventive maintenance checks and services charts (para 5-4 and 55) outline functions to be performed at specific intervals. These checks and services are designed to maintain Army equipment in a combat-serviceable condition; that is, in good general (physical) condition and in good operating condition. To assist operators in maintaining combat serviceability, the charts indicate what to check, how to check, and the normal conditions; the *References* column lists the paragraphs that contain detailed repair or replacement procedures. If the defect cannot be remedied by the operator, a higher category of maintenance or repair is required. Records and reports of these checks and services must be made in accordance with instructions given in TM 38750.

- (1) Before the equipment is taken on a mission.
- (2) When the equipment is initially installed.
- (3) When the equipment is reinstalled after removal for any reason.
- (4) At least once a week, if the equipment is maintained in standby condition.

b. Paragraphs 5-5 and 5-6 specify additional checks and services that must be performed weekly and monthly. Perform the maintenance functions indicated in the monthly preventive maintenance checks and services chart (para 5-6) once each month. A month is defined as approximately 30 calendar days of 8-hour-per-day operation. If the equipment is operated 16 hours a day, the monthly preventive maintenance checks and services should be performed at 15-day intervals. Adjustment of the maintenance interval must be made to compensate for any unusual operating conditions. Equipment maintained in a standby (ready for immediate operation) condition must have monthly preventive maintenance checks and services. Equipment in limited storage (requires service before operation) does not require monthly preventive maintenance.

5-3. Preventive Maintenance Checks and Services Periods

Preventive maintenance checks and services of the AN/USM-182 are required daily, weekly, and monthly.

a. Paragraph 5-4 specifies the checks and services that must be accomplished daily, or under the special conditions listed below:

5-4. Operator's Daily Preventive Maintenance Checks and Services Chart

<i>Sequence No.</i>	<i>Item to be Inspected</i>	<i>Procedure</i>	<i>References</i>
1	Type 535A Oscilloscope.....	Check equipment for completeness and general condition.....	Para A-5.
2	Exterior surfaces.....	Clean exterior surfaces of equipment.....	Para 5-7.
3	External receptacles.....	Inspect external receptacles for breakage and for firm seating.	
4	Meter glass.....	Inspect front panel glass window for damaged housing, broken glass, physical damage, dust, or moisture.	
5	Knobs, controls, and switches.....	During operation (item 6), check knobs, controls, and switches for proper mechanical action. Action must be positive, without backlash, binding, or scraping.	
6	Operation.....	During operation, be alert for any abnormal indications.	

5-5. Operator's Weekly Preventive Maintenance Checks and Services Chart

<i>Sequence No.</i>	<i>Item to be Inspected</i>	<i>Procedure</i>	<i>References</i>
1	Cables.....	Inspect external cables for cuts, cracked, or gouged jackets, fraying, or kinks.	
2	Hardware.....	Inspect all exterior hardware for looseness and damage. The spectrum analyzer cover, carrying handle, hinges, and all bolts and screws must be tight and not damaged.	

<i>Sequence No.</i>	<i>Item to be Inspected</i>	<i>Procedure</i>	<i>References</i>
3	Preservation.....	Inspect equipment to determine that it is free of bare spots,..... rust, and corrosion. If these conditions exist, refer to a higher category maintenance for repair.	Para 5-7 and 5-8.

5-6. Organizational Monthly Preventive Maintenance Checks and Services Chart

<i>Sequence No.</i>	<i>Item to be Inspected</i>	<i>Procedure</i>	<i>References</i>
1	Publications	Check to see that publications are complete, serviceable,..... and current.	DA Pam 310-4.
2	Modification work orders.....	Check to see that all URGENT MWO's have..... have applied and that all NORMAL MWO's have been scheduled.	DA Pam 310-7.
3	Completeness.....	Check equipment for completeness and general condition.....	Para A-5.
4	Cleanliness	Clean exterior surfaces of equipment.....	Para 5-7.
5	Preservation.....	Inspect equipment to determine that it is free of bare..... spots, rust, and corrosion.	Para 5-7 and 5-8.
6	External receptacles.....	Inspect external receptacles for breakage and for firm seating.	
7	Meter glass	Inspect front panel glass window for damaged housing, broken glass, physical damage, dust, or moisture.	
8	Cables	Inspect external cables for cuts, cracked, or gouged jackets, fraying, or kinks.	

5-1.2 Change 1

5-6. Organizational Monthly Preventive Maintenance Checks and Services Chart (cont)

Sequence No.	Item to be Inspected	Procedure	References
9	Hardware.....	Inspect all exterior hardware for looseness and damage. The oscilloscope cover, carrying handle, hinges, and all bolts and screws must be tight and not damaged.	
10	Operation.....	During operation, be alert for any abnormal indications.	

5-1.5

5-7. Cleaning

Inspect the exterior of the Type 535A Oscilloscope. The exterior surface must be free of dust, dirt, grease, and fungus.

- a. Remove dust and loose dirt with a clean, soft cloth.

Warning: Prolonged breathing of cleaning compound is dangerous; provide adequate ventilation. Cleaning compound is flammable; do not use near a flame. Avoid contact with the skin; wash off any that spills on the hands.

- b. Remove grease, fungus, and ground-in dirt from the cases; use a cloth dampened (not wet) with Cleaning Compound (Federal stock No. 7930-395-9542).

- c. Remove dust or dirt from plugs and jacks with a brush.

Caution: Do not press on the meter face (glass) when cleaning; the meter may become damaged.

- d. Clean the front panel, meter, and control knobs; use a soft, clean cloth. If necessary, dampen the cloth with water; mild soap may be used for more effective cleaning.

5-8. Rustproofing and Painting

- a. **Rustproofing.** When the finish on the Type 535A Oscilloscope has become badly scarred or damaged, rust and corrosion can be prevented by touching up the bare surfaces. Use No. 000 sandpaper to clean the surface down to the bare metal. Obtain a bright, smooth finish.

- b. **Painting.** Remove rust and corrosion from metal surfaces by lightly sanding them with fine sandpaper. Brush two thin coats of paint on the bare metal to protect it from further corrosion. Refer to the applicable cleaning and refinishing practices specified in TB SIG 364.

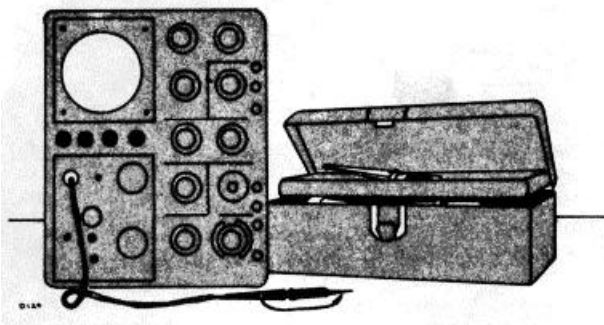
5-9. Lubrication Instructions

- a. Gasoline should not be used as a cleaning fluid for any purpose. When the Type 535A Oscilloscope is overhauled or repairs are made, clean the parts with cleaning compound.

- b. Do not use excessive amounts of Lubricating Oil, Instrument (OAI) (FSN 9150-664-6518) and do not allow connections to become greasy.

- c. Be sure that lubricants and points to be lubricated are free from Sand, grit, or dirt. Use cleaning compound to clean all parts. Before lubrication, clean all surfaces to be lubricated; use a lint-free cloth dampened with cleaning compound. Keep cleaning compound off surrounding parts.

- d. Lubrication intervals designated are for daily 8-hour periods of operation. For longer periods of operation, intervals should be shortened.



PREVENTIVE MAINTENANCE

Air Filter

Care must be taken to assure free ventilation of the Type 535A 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 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 port 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

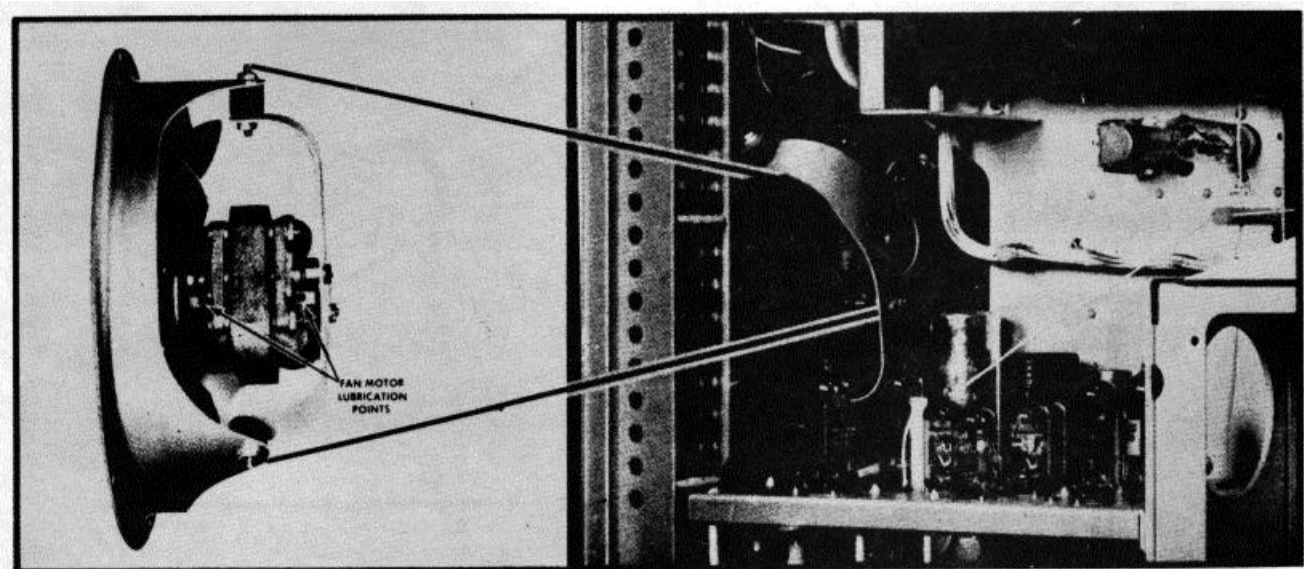


Fig. 5-1. Location of the fan motor lubrication points.

(A)(A)

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.

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

Fan Connections

The cooling fan is powered by a 117-volt ac motor. When the instrument is operating from a 117-volt line source, the fan is connected as illustrated in Fig. 5-2. The ceramic strip shown in the illustration is located adjacent to one corner of the power transformer.

If the instrument is converted to operate from a 234-volt line source, one of the fan connections must be changed so that the fan can operate from a 117-volt source. To make the change, 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. 5-2. 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.

Visual Inspection

You should visually inspect the entire oscilloscope every

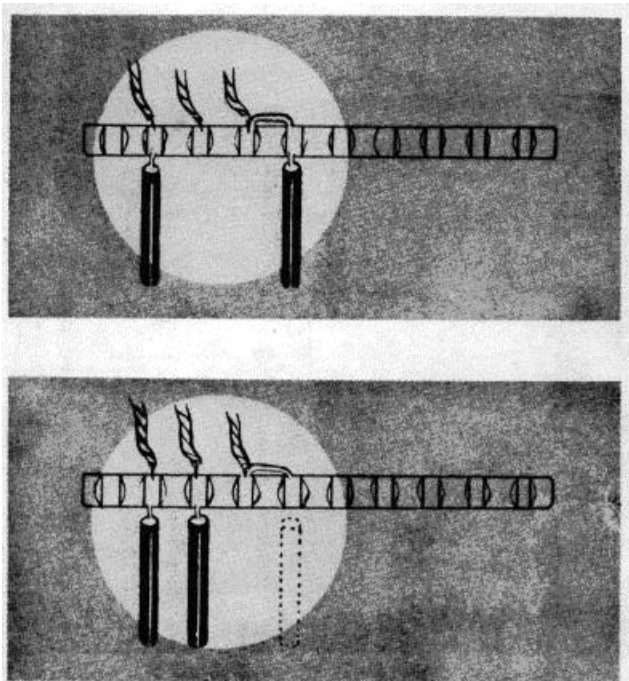


Fig. 5-2. Fan connections for 117 v ac operation. The dotted line indicates the fan lead change required for operation on 234 v ac.

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 instrument 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 the 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 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.

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. 5-3 will show you the correct shape 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.

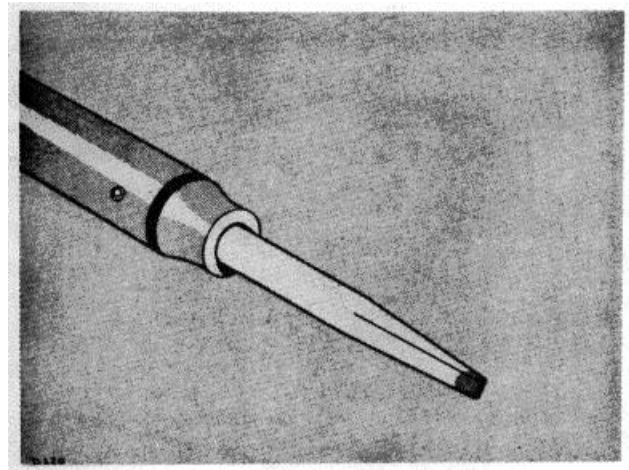


Fig. 5-3. Soldering iron properly shaped and tinned.

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 at about 75-watt rating.
2. Prepare the tip of the iron as shown in Fig. 5-3.
3. Tin only the first 1/16 to 1/8 inch of the tip. For solder 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. 5-4).
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. 5-5.

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. 5-6. 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 Figure 5-5.

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. 5-7. In soldering to terminal points mounted in

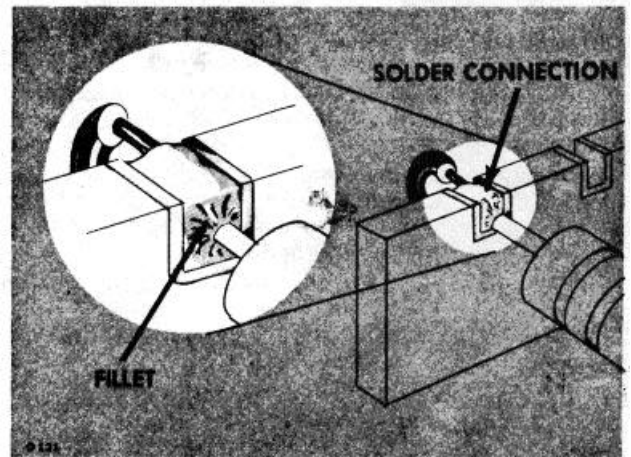


Fig. 5-5. A slight fillet of solder is formed around the wire when heat is applied correctly.

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. 5-9.

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

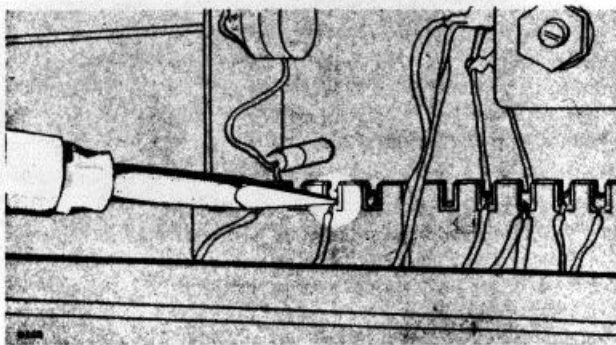


Fig. 5-4. Correct method of applying heat in soldering to a ceramic strip.

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. 5-8) makes a convenient tool for this purpose.

Ceramic Strips

Two distinct types of ceramic strips have been used in the Type 535 Oscilloscope. The earlier type mounted on the

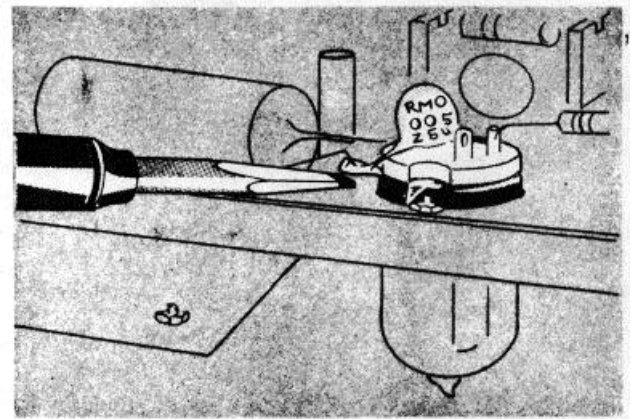


Fig. 5-6. Soldering to a terminal. Note the slight fillet of solder—exaggerated for clarity—formed around the wire.

drop of red glyptal. Insert the bolts through the holes in the chassis where the original strip was mounted, placing a #2 starwasher between each nut and the chassis. Place a second set of #2 starwashers on the protruding ends of the bolts, and fasten them firmly with another set #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 snips 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.

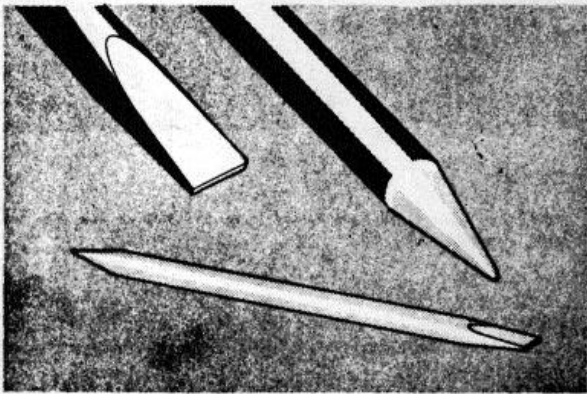


Fig. 5-7. A soldering aid constructed from a 1/4 inch wooden dowel.

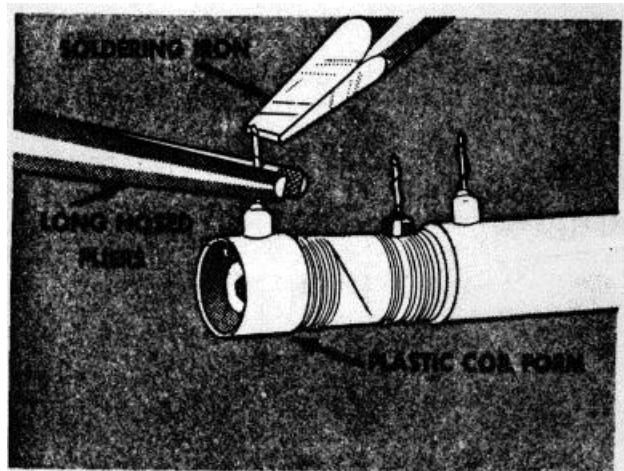


Fig. 5-8. Soldering to a terminal mounted in plastic. Note the use of the long-nosed pliers between the iron and the coil form to absorb the heat.

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 directly above the mounting rods.

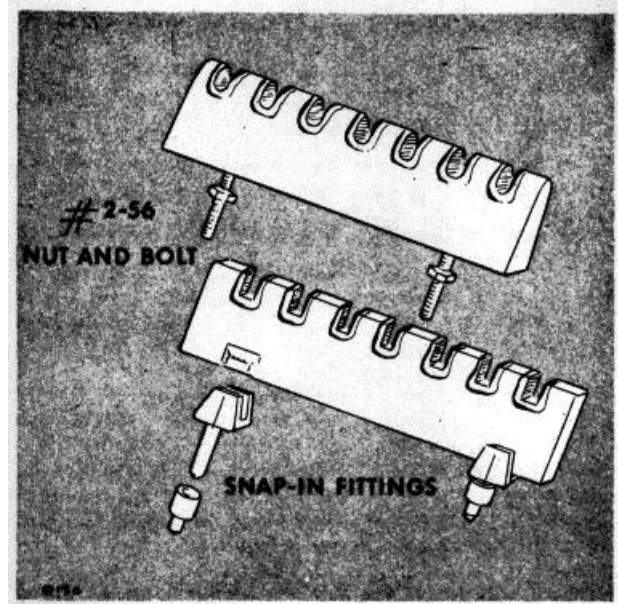


Fig. 5-9. Two types of ceramic strip mountings.

L.V. Power Transformer Connections

Unless tagged otherwise your 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 operate at 210 to 250 volts, 50 to 60 cycles (234 volts nominal). The power transformer T601 is provided with split input windings which are 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 group of four terminal lugs arranged in a square on the underside of the transformer, and numbered 1, 2, 3, and 4 in a clockwise direction.

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. 5-10 (a). To convert to 234-volt operation; remove the bare bus wires between these terminals and substitute a single connecting wire between terminals 2 and 3, as shown in (b), figure 5-10.

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

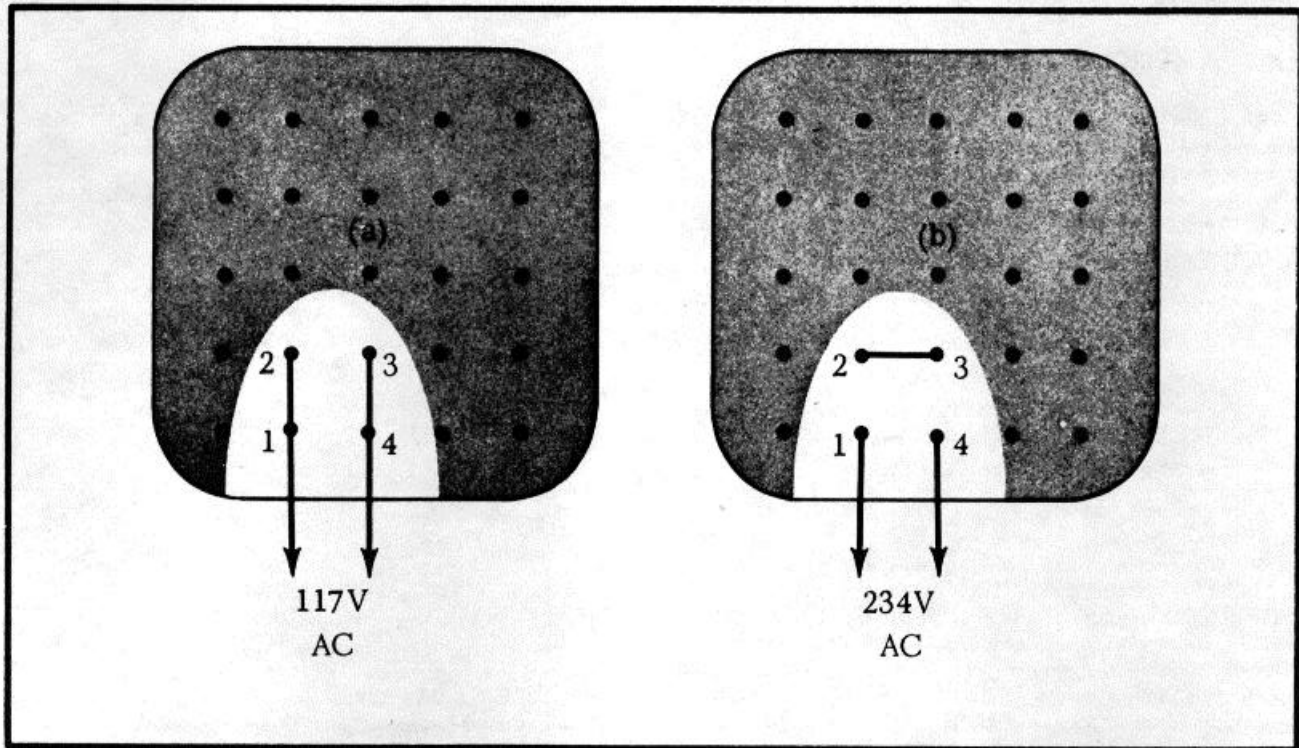


Fig. 5-10. Converting the power transformer from 105-125 volt operation to 210-250 volt operation.

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
200 series.....	Time-Base Generator B
300 series.....	Horizontal Amplifier
400 series.....	Delay Pickoff
500 series.....	Vertical Amplifier
600 series and	
700 series.....	Low-Voltage Power Supply
800 series.....	CRT Circuits and 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 portion 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 535A is a complex instrument, it can be thought of as consisting of eight 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 "A" Trigger Circuit.
5. Time-Base "B" Trigger Circuit.
6. Time-Base "A" Generator.
7. Time-Base "B" Generator
8. 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.

Front-Panel Checks

The following front-panel checks will help you to isolate the trouble in an instrument to a given circuit. The inter-relation 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 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 1 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
TRIGGER SLOPE	+ INT.

VARIABLE (TIME/CM)	full right
TIME/CM	5 MILLISEC
HORIZONTAL DISPLAY	A
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 AMPLITUDE 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.

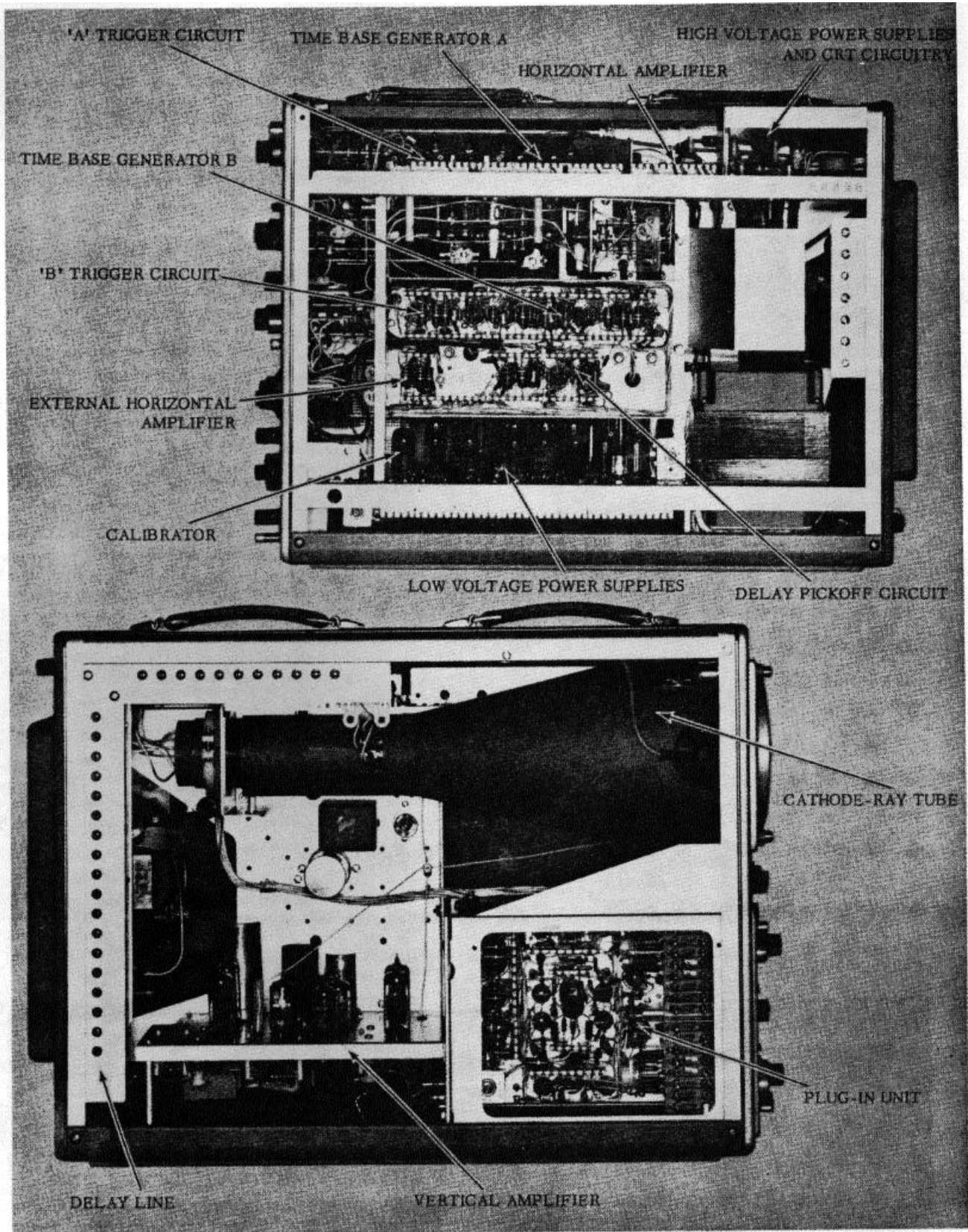


Fig. 5-11. Physical location of the circuits which compose Type 535A Oscilloscope.

TROUBLESHOOTING 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 millise/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 6 to 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 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 535A 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 risetime of 10 microsecond 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. 5-12.

Insufficient high-frequency peaking, which limits the risetime and consequently the band-width, will produce the "rolloff" or undershoot condition illustrated in Fig. 5-12a. 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. 5-12b. 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.

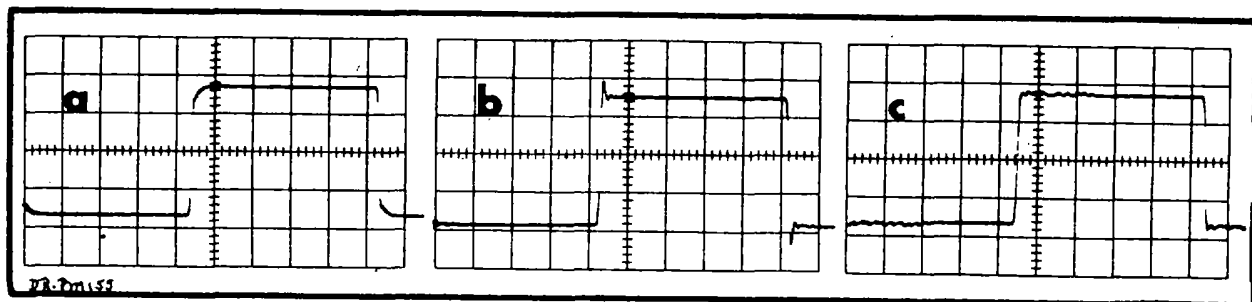


Fig. 5-12. Three types of high-frequency distortion.

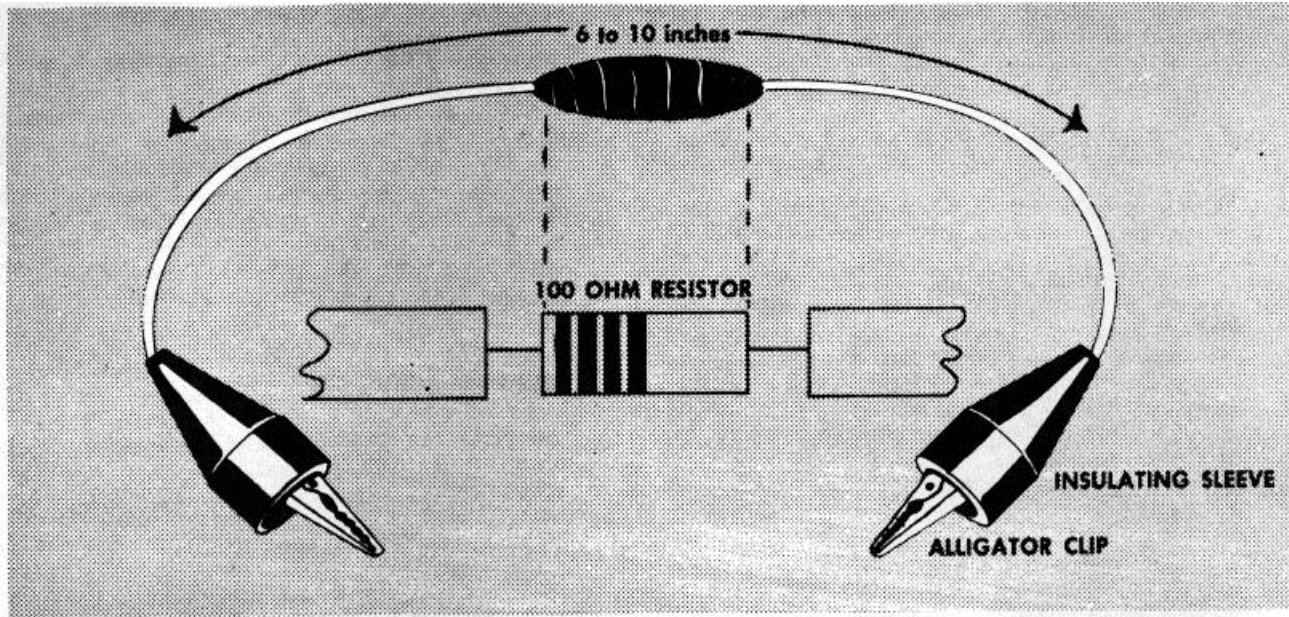


Fig. 5-13. Shorting strap useful in locating an unbalanced stage in a vertical or horizontal amplifier. Insulating tape covers the 100-ohm resistor.

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 0.1 to 3 μ sec, this effect is most noticeable on waveform 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. 5-12c. These wrinkles are caused by intersection 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 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 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 V1223 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 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, 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; Fig. 6-6), 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 R41, R37, C37 and R38 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 R41) should not exceed about 2.75 volts. It is the function of the Trig. 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 Trig. SENS control R47 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 the + 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.1 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 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 A 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 V152B, and the divider R147-148. 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 Q/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 5-10 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 foster 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 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 for 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 that Hold-Off Circuit in the Time-Base Generator, e.g. on 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 Calibration 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 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.

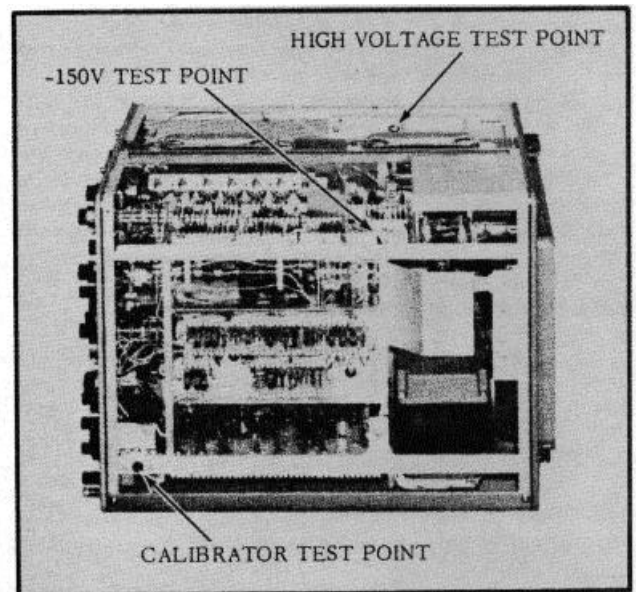


Fig. 5-14. Location of power supply and Calibrator test points.

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 Cutout Switch; the resistance of this switch is about 0.1 Ω. (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. 5-14 for a low-voltage check point location.

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 bus is coded red, red and brown on a white wire; the +350.volt bus is coded orange, and 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. Refer to your schematic diagram for the approximate resistance values.

If the resistance values 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 234 v) 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:

- a. For high line voltage.
- b. 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 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 being held cutoff 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. The triode in the Multivibrator is held cutoff for an interval determined by the discharge of C871 and the pentode is held cutoff for an interval determined by the discharge of C874. A change in the 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 C874, and the voltage at the screen of the pentode in the case of C871. 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.

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 out 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 will vary the voltage at the test point over about a 10-volt range. If this voltage cannot be set to exactly 4 100 volts, and if the tubes have been replaced, then one or more of the precision resistors in the divider have changed in value.

TROUBLESHOOTING 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 fully 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 H.V. Adj. Test Pt. In the majority of instruments the test point is located at the top left rear of the instrument. Fig. 5-14 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 H.V. Adj. Test Pt. 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 100K resistor and the 0.01 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 H.V. Adj. Test Pt. 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 or filament 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.

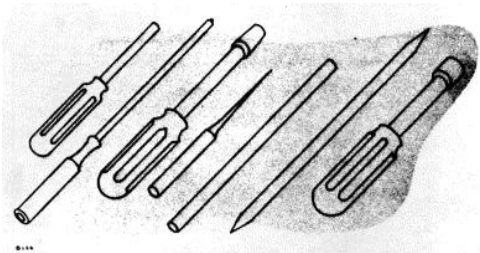
If the intensity of the trace is extremely low, check for an inoperative positive supply. Also check the anode connection to the crt, including R836 and C836.

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 H.V. Adj. Control is changed, it will be necessary to recalibrate the instrument.



CALIBRATION PROCEDURE

The Type 535A Oscilloscope is a stable instrument and should not require frequent calibration. However, it will be necessary to calibrate certain parts of the instrument when tubes or components are changed, and periodic calibration is desirable from the standpoint of preventive maintenance.

In the instructions that follow, the steps are arranged in the proper sequence for full calibration. Each numbered step contains the information necessary to make one adjustment. If a complete calibration is not necessary, you may perform individual steps, PROVIDING that the steps performed do not effect other adjustments. It is most important that you are fully aware of the interaction of adjustments. Generally speaking, the interaction of controls will be apparent in the schematic diagrams. If you are in doubt, check the calibration of the entire section on which you are working.

If you make any adjustments on the power supplies, you will have to check the calibration of the entire instrument. In particular the sweep rates and vertical deflection factors must be checked.

EQUIPMENT REQUIRED

The following equipment is necessary for a complete calibration of the Type 535A Oscilloscope:

(1) A DC voltmeter having a sensitivity of at least 5000 Ω/v and calibrated for an accuracy of at least 1% at 100, 150, 225, 350 and 500 volts, and for an accuracy of at least 3% at 1350 volts. Portable multimeters should be regularly checked against an accurate standard and corrected readings noted, where necessary, at the above listed voltages. **BE SURE YOUR METER IS ACCURATE.**

(2) An accurate rms-reading ac voltmeter, having a range of 0-150 volts. (0-250 or 0-300 for 234 v. operation).

(3) Variable auto-transformer (e.g. Powerstot or Variac) having a rating of at least 6.25 amperes.

(4) Time-mark Generator, Tektronix Type 180, 180A or equivalent, having markers at 1 μ sec, 10 μ sec, 50 μ sec, 100 μ sec, 1 msec, 5 msec, 10 msec, 100 msec, 1 sec, and 5 sec and sine-wave outputs of 10 mc and 50 mc, all having an accuracy of at least 1%.

(5) Square-Wave Generator, Tektronix Type 107 or equivalent, having a risetime of no more than 7

nanoseconds, and a frequency of approximately 500 kc. The top of the square-wave must be free of overshoot and wrinkles. A Tektronix Type P Unit may be used in place of the Type 107. A Type P52 Coaxial Cable and a Type B52R Terminating Resistor is required with the Type 107.

(6) Tektronix Type K or Type L Plug-In Unit. (If delayline adjustment is not required, other Tektronix Plug-In Units may be substituted.)

(7) Low-Capacitance Recalibration Tools: Tektronix part numbers 003-000-003-007 and 003-301. (See Recalibration Tools in Accessories Section of Operator's Manual and Fig. , 6-1).

(8) Tektronix Type P6000 Probe.

(9) Test Oscilloscope, Tektronix Type 316 or equivalent, providing triggered sweeps and a bandpass of at least dc to 10 mc.

(10) Gain Set Adapter, Tektronix Type EP53A.

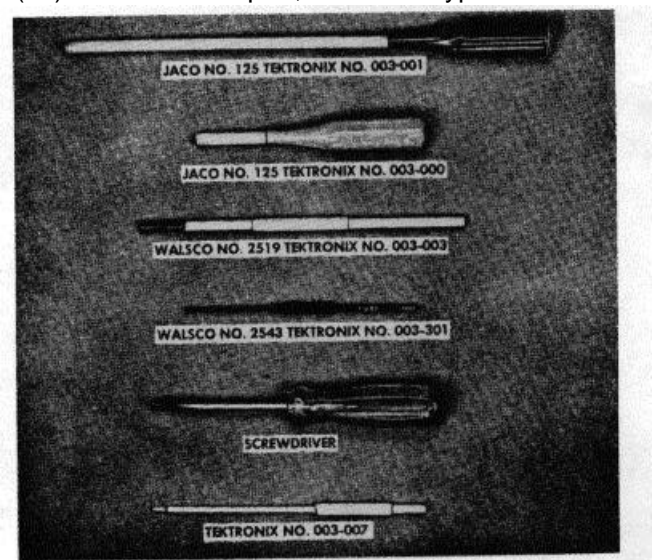


Fig. 6-1. Suggested Calibration Tools.

PRELIMINARY

Removing the side covers and bottom plate from the instrument to be calibrated and install the Type K or Type L Unit.

Set the front-panel controls as follows:

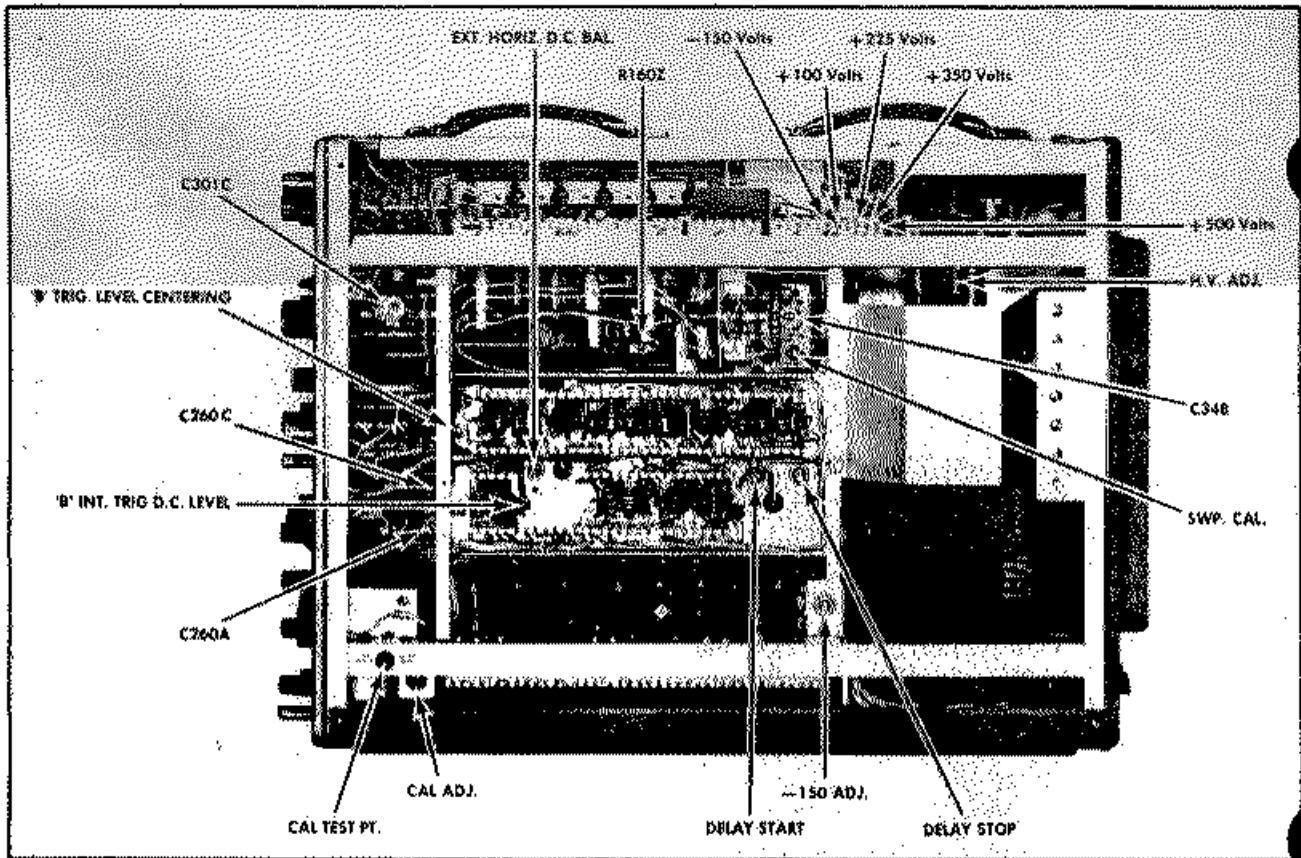


Fig. 6-2. Right Side View of the Type 535A Oscilloscope showing the locations of internal controls.

INTENSITY	full left
HORIZONTAL DISPLAY	A
TRIGGERING MODE (A and B)	AC
TRIGGER SLOPE (A and B)	+INT
STABILITY	full left, but not PRESET
TIME/CM (A and B)	5 MILLISEC
VARIABLE	CALIBRATED (full right)
CALIBRATOR	OFF
PLUG-IN UNIT	
AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED (full right)

NOTE

Setting for all controls not listed above are not pertinent to this part of the procedure and the controls may be left in any position.

Check the rear of the instrument to be sure the metal strap between EXTERNAL CRT CATHODE and GROUND binding posts is in place, and that the CRT CATHODE SELECTOR Switch is away from the DUAL-TRACE CHOPPED BLANKING position. Connect the

instrument and the ac meter to the autotransformer output and turn on all equipment. Adjust the out transformer to the design-center voltage for which your instrument is wired (117 or 234 v.) and allow at least 5 minutes warmup before making any adjustments.

PROCEDURE

1. Low-Voltage Power Supplies

Measure the output voltage of the -150v, +100 v, +225 v, +350 v and +500 v supplies at the points indicated on the right side view, Fig. 6-2. Be sure your meter is accurate (see Equipment Required, 6-1). The output voltage of the --150v supply must be between --147v and 153X and the other regulated supplies must be within 2% of the rate values. You should be able to set the -150v AG, control (see Right Side View, Fig. 6-2) so that all of these voltages are within the specified tolerance. Bear in mind that the calibration of the entire instrument is affected by changes in the power supply voltages Don't adjust the --150v unless one or more of the supplies is actually out of tolerance.

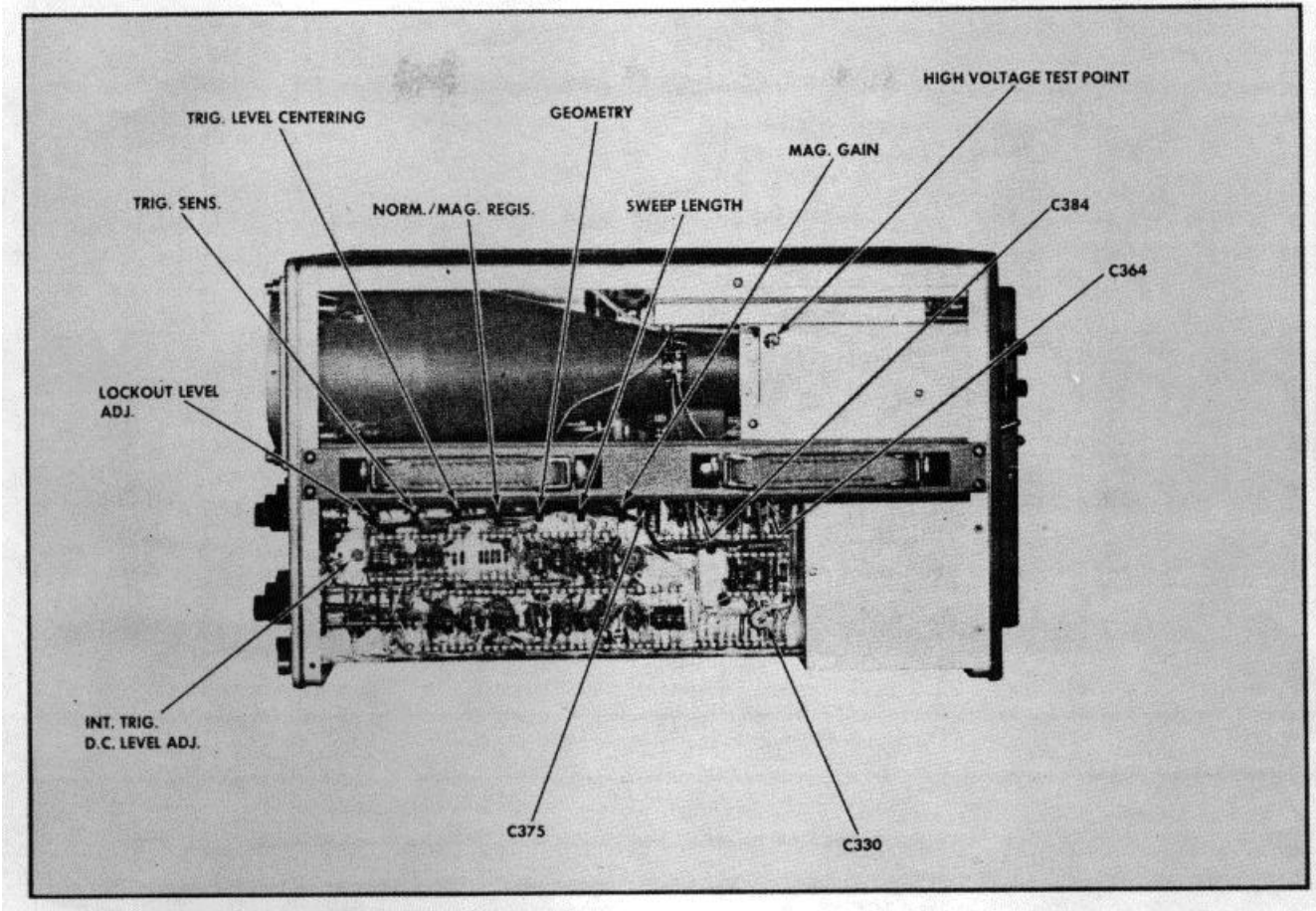


Fig. 6-3. Top View of the oscilloscope showing locations of internal controls.

To check the above supplies for proper regulation, vary the autotransformer voltage between 105 v and 125 v (or from 210 v to 250 v if the power transformer is connected for 234 v operation). All of the regulated voltages should remain essentially constant.

The ripple present on any of the regulated supplies, as measured with a test scope at the voltage check points, will be well under 10 mv., with AMPLITUDE CALIBRATOR-OFF, and neither sweep operating.

2. AMPLITUDE-CALIBRATOR Adjustment

The Cal. Adj. control should be set to provide a dc output of 100 volts when the AMPLITUDE CALIBRATOR switch is in the OFF position. Under these conditions, the calibrator output will be within 3% of the front-panel readings.

To make this adjustment connect the voltmeter between the Cal. Test Pt. jack and ground (see Right Side View, Fig. 6-2), turn the AMPLITUDE CALIBRATOR switch to the OFF position, and adjust the Cal. Adj. control for a reading of exactly 100 volts. To assure suitable symmetry of the calibrator waveform, the reading at this point should not be less than 45 v nor more than 55 volts when the calibrator is turned on (to

any of the output voltage settings) Readings outside this range are generally caused by unbalanced multivibrator tubes (V875 or V885A).

3. High-Voltage Power Supply Adjustment

This adjustment determines the total accelerating potential on the crt, and thus affects the deflection sensitivity.

Connect the voltmeter between ground and the high-voltage check point (see Top-View, Fig. 6-3), and set the H.V. Adj. (see Right Side View, Fig. 6-2) for a meter reading of exactly -1350 volts. If your meter has a full scale reading of 1200v, you can connect the positive meter lead to the --150 v supply, at any convenient point, and set the H.V. Adj. for a meter reading of --1200 v.

4. CRT Alignment

If the crt has been replaced, or if, due to considerable handling, the trace does not align with the graticule, you should make this adjustment before proceeding with the calibration.

With no vertical signal applied, free run TIME BASE A, by

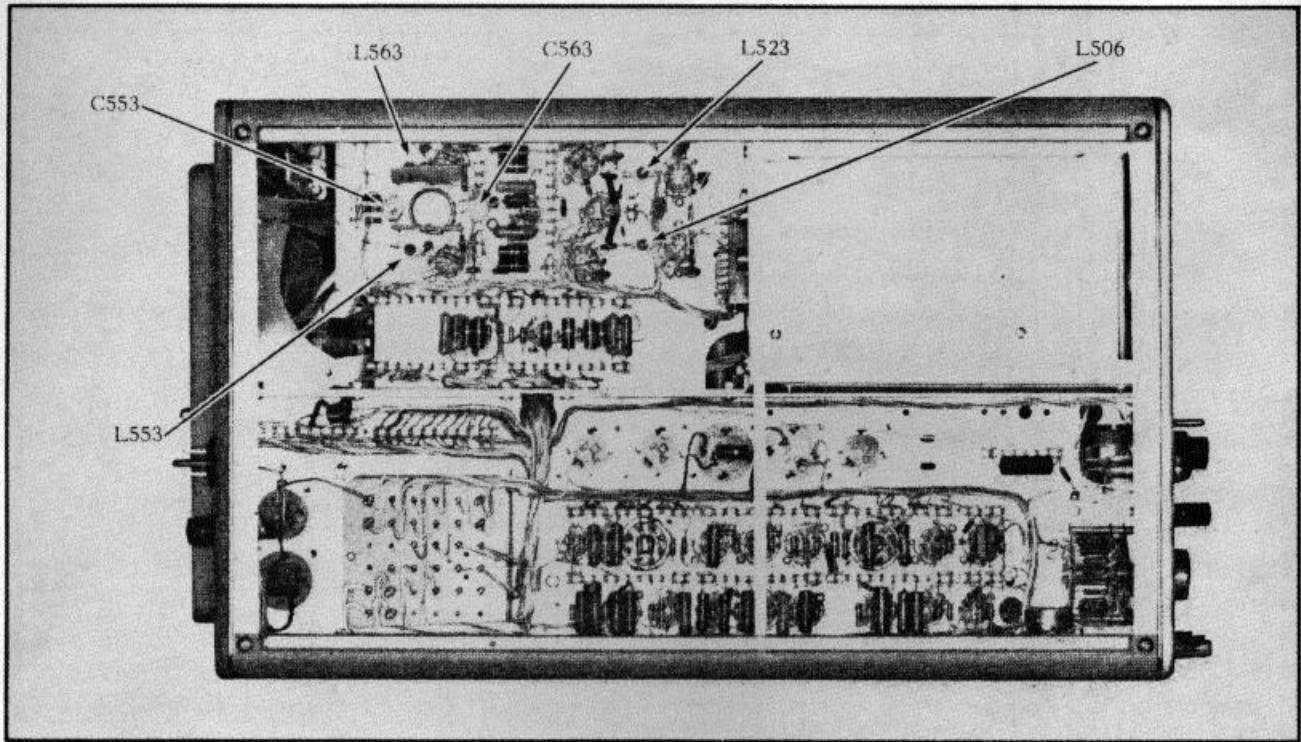


Fig. 6-4. Bottom View of the Type 535A Oscilloscope

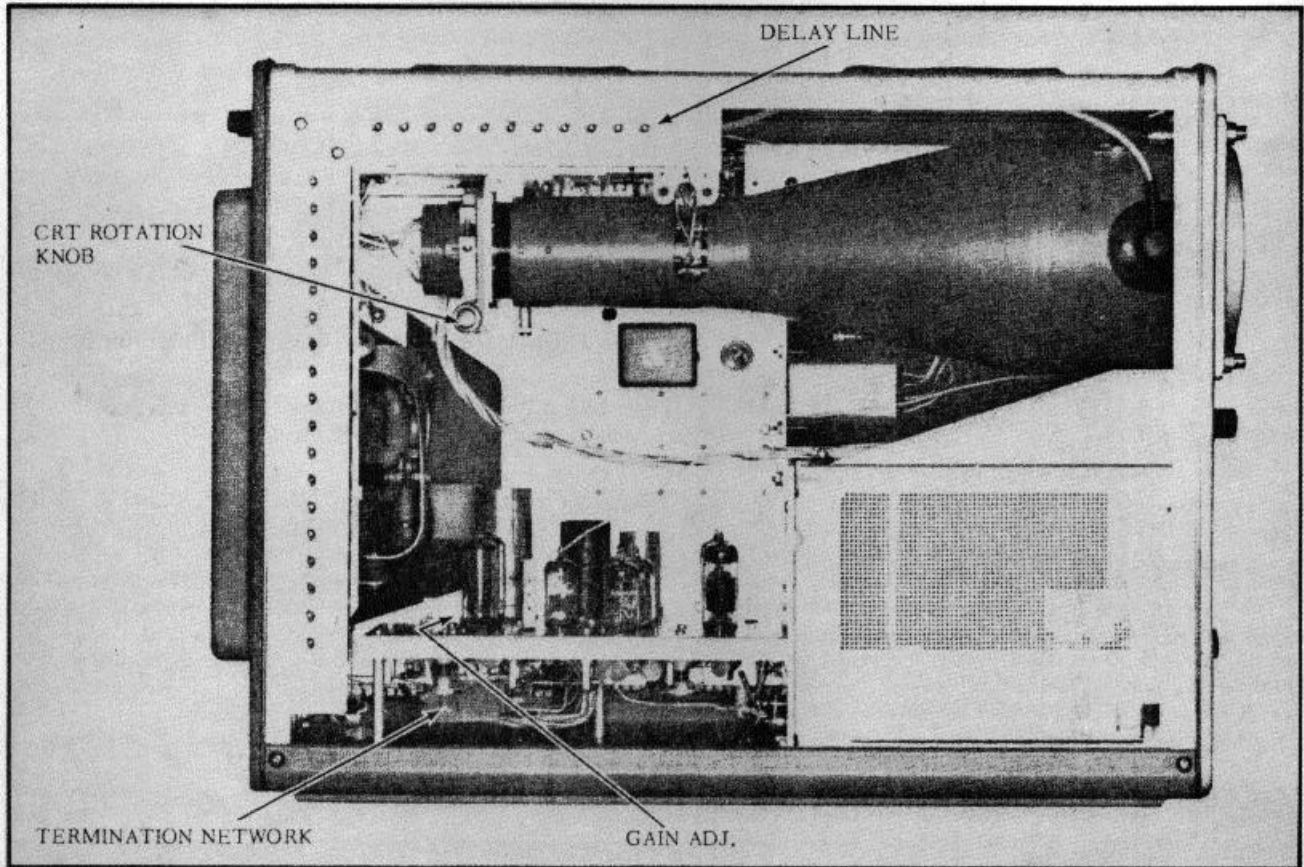


Fig. 6-5. Left Side View of the Type 535A Oscilloscope

turning the STABILITY control full right. Position the trace directly behind the center graticule line. If the trace and the graticule line do not coincide over the width of the graticule, rotate the crt until they are properly aligned.

After aligning, push the crt forward until it rests snugly against the graticule, and tighten the crt base clamp. Recheck the alignment of the trace after tightening the clamp to be sure the crt didn't rotate while the clamp was being tightened.

5. CRT Geometry

The geometry of the crt display is adjusted by means of the GEOMETRY control. To achieve optimum linearity, vertical lines are displayed on the crt and the GEOMETRY control is adjusted for minimum curvature of the lines. Nonlinearity is most noticeable at the edges of the graticule.

Set the front panel controls as follows (use TIME BASE A):

HORIZONTAL DISPLAY	A
TRIGGERING MODE	AC
TRIGGER SLOPE	+ INT
TIME/CM	.5 MILLISEC
VARIABLE	CALIBRATED (full right)
VOLTS/CM (plug-in)	.2

Connect 500 /sec markers from the Type 180 or 180A to the INPUT connector and position the base line of the timing comb below the bottom of the crt face so it is not visible. Adjust the GEOMETRY control for straight vertical lines running parallel to the left and right edges of the graticule.

NOTE

The amplitude calibrator may be used for this step, but due to the low intensity of the vertical lines, the adjustment is somewhat more difficult.

6. 'A' Triggering Level

Set the HORIZONTAL DISPLAY switch at A. Place the 'A' TRIGGERING MODE switch at DC and the 'A' TRIGGER SLOPE switch at +INT. Rotate the 'A' TRIGGERING LEVEL control to zero and the 'A' STABILITY control full left, but not to the PRESET position. Connect the dc voltmeter from the junction of R19 and R20 (see Fig. 6-6) to ground. Set the voltmeter on the lowest voltage range and adjust 'A' TRIGGERING LEVEL control for a meter reading of exactly zero volts. If the TRIGGERING LEVEL knob does not read exactly at the zero position, loosen the set screw and reposition the knob. The voltmeter should read zero, when the TRIGGERING LEVEL control is set at zero.

7. 'A' Trigger Level Centering and Trigger Sensitivity

Set TRIGGERING MODE switch at AC, TRIGGER SLOPE to -EXT., TIME/CM to .5 MILLISEC. Use clip

lead to ground junction of R19 and R20. Set Trig. Sens. (See top View, Fig. 6-3) to center of rotation. Connect jumper from CAL. OUT

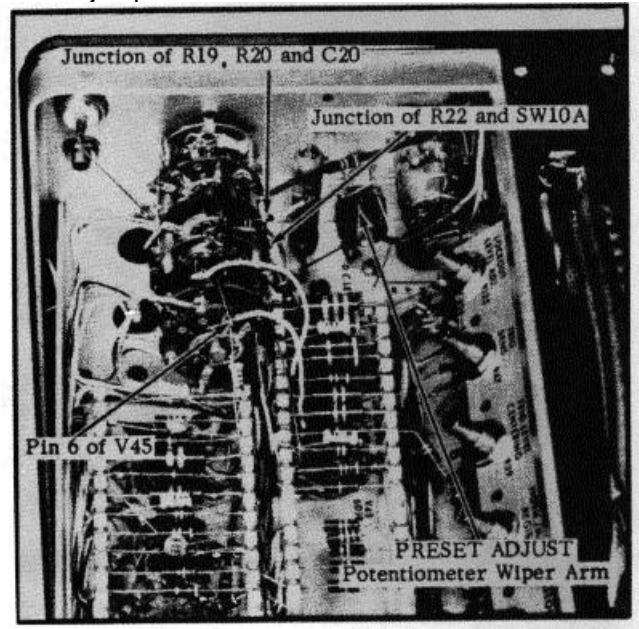


Fig. 6-6. Time Base A Triggering Circuit Test Points.

to TRIGGER INPUT, and set CALIBRATOR to 1 VOLT. Use 100X probe with test scope set to .5 VOLTS/CM and TIME/CM to .5 MILLISEC. Now, connect the probe tip to pin 6 of V45 and carefully adjust the Trig. Level Centering (see Top View, Fig. 6-3) control to the exact center of the area which gives a square-wave of approximately 1/2 cm on the test scope. Next, reduce the calibrator output to 0.2 volt and slowly turn the Trig. Sens. control to the right until the square-wave is again observed on the test scope. Carefully adjust this control to the point where the square-wave is jitter-free. Very slightly readjust Trig. Level Centering and Trig. Sens. controls for best response on the test scope. Do not turn the Trig. Sens. control any farther to the right than is necessary to provide stable triggering.

8. 'A' Internal Trigger DC Level

Set the 'A' STABILITY control for a free-running sweep, the TRIGGER SLOPE to -INT. and the TRIGGERING MODE to DC. Position the trace to the center of the graticule and connect the dc meter between ground, and the junction of R22 and SW10A. (See Fig. 6-6). Set the meter on the lowest voltage range and adjust the Int. Trig. DC Level Adj. (see Top View, Fig. 6-3) for exactly zero voltage.

9. 'A' Preset Adjust

Place the 'A' TRIGGERING MODE switch at AUTO. And the TRIGGER SLOPE switch at +LINE. Connect the dc voltmeter between the PRESET ADJUST potentiometer wiper arm

(see Fig. 6-6) and ground and rotate the potentiometer full left. Now, rotate the control slowly to the right until : trace first appears and note the meter reading at this point. Next, continue to rotate this control until the trace brightens and again note the meter reading. Finally, set the PRESET ADJUST control to obtain a meter reading midway between the two previously noted meter readings.

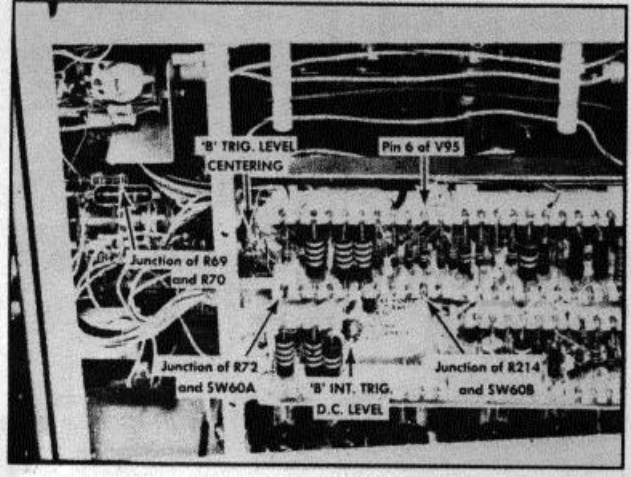


Fig. 6-7. Time Base B Triggering Circuit Test Points.

10. 'B' Triggering Level

Set the HORIZONTAL DISPLAY switch at B. Place the 'B' TRIGGERING MODE switch at DC and the 'B' TRIGGER SLOPE switch at +INT. Set the 'B' TRIGGERING LEVEL control at zero and the 'B' STABILITY control full left, but not to the PRESET position. Connect the voltmeter between ground and the junction of R69 and R70 (see Fig. 6-7). Set the voltmeter on the lowest range and adjust the 'B' TRIGGERING LEVEL control for a meter reading of exactly ZERO volts. If the TRIGGERING LEVEL knob does not read exactly at the zero position, loosen the set screw, and reposition the knob. The voltmeter should read zero when the TRIGGERING LEVEL control is set at zero.

11. 'B' Internal Triggering DC Level

Set the "B" STABILITY for a free-running sweep, the TRIGGER SLOPE to -INT., and the TRIGGERING MODE to DC. Position the trace to the center of the graticule and connect the dc meter between ground and the junction of R72 and SW60A (see Fig. 6-7). Set the meter on the lowest voltage range, and adjust the Int. Trig. DC Level (see Right Side View, Fig. 6-2) control for exactly zero voltage.

12. 'B' Trigger Level Centering

Set 'B' TRIGGERING MODE switch to AC and TRIGGER SLOPE to -EXT. Use a clip lead to ground the junction of R69 and R70 (see Fig. 6-7). Connect a jumper from CAL. OUT to 'B' TRIGGER INPUT, and set

CALIBRATOR to 0.2 volt. Use O1X Probe with test scope set to .5 VOLTS/CM and TIME/CM to .5 MILLISEC. Now, connect the probe tip to pin 6 of V95. (see Fig. 6-7), and carefully adjust the Trig. Level Centering (see Figures 6-2 and 6-7) control to the center of the area which gives a square-wave of approximately 1.5cm. Rotate the TRIGGER SLOPE switch back and forth between +EXT. and -EXT. and, if necessary, slightly readjust the Trig. Level Centering control for a completely stable pattern in both positions of the switch.

13. 'B' Preset Adjust

Place the 'B' TRIGGERING MODE switch at AUTO and the 'B' TRIGGER SLOPE switch at +LINE. Connect the dc voltmeter between ground and the junction of R214 and SW60B (see Fig. 6-7), and rotate the 'B' PRESET ADJUST control full left. Now, rotate the control slowly to the right until a trace first appears, and note the meter reading at this point. Next, continue to rotate this control until the trace brightens, and again note the meter reading. Finally, set the PRESET ADJUST control to obtain a meter reading midway between the two previously noted readings.

14. Adjust 5X Magnifier Gain

Set controls as follows:

HORIZONTAL DISPLAY	'B'
TRIGGERING MODE (B)	AC
TRIGGER SLOPE (B)	+INT.
TIME/CM (B)	1 MILLISEC
5X MAGNIFIER	ON
VOLTS/CM (Plug-In)	2

Connect 1 millisecond and 100 microsecond markers from the Type 180A to the vertical input and adjust the 'B' triggering for a stable display. If necessary adjust tag. Gain (see Top View Fig. 6-3) to display 1 large marker every 5cm, and 2 small markers every cm. Position the display horizontally to observe linearity on both ends. Check that the neon lamp lights when MAGNIFIER is switched on.

15. Adjust Sweep Magnifier Registration

With the MAGNIFIER ON, position the display so that the first time marker is directly behind the center graticule line. Turn the MAGNIFIER OFF and adjust Norm./Mag. Regis. (see Top View Fig. 6-3) so that the first time marker again falls directly behind the center graticule line.

16. Adjust External Horizontal DC Balance

Connect a jumper from the 'A' SAWTOOTH to the vertical INPUT, switch the HORIZONTAL DISPLAY to EXT. XI and turn 'A' STABILITY full right. Turn the HORIZONTAL POSITION control to the left to position a vertical trace to the left vertical graticule line. Now, adjust the Ext. Horiz. DC Bal. (see Right Side View, Fig.6-2) control for no horizontal

shift of the trace while turning the horizontal VARIABLE 10-1 front-panel control.

17. Check EXT. HORIZ. INPUT Deflection factor

With conditions as in Step 16 above, connect a jumper from CAL. OUT to HORIZ. INPUT, set CALIBRATOR for 0.2 volt and turn VARIABLE 10-1 control full right. At least one centimeter of horizontal deflection must be observed between the two vertical lines. Increase the CALIBRATOR to 2 VOLTS and adjust VARIABLE 10-1 for exactly 10cm of horizontal deflection between the vertical lines. Now switch HORIZONTAL DISPLAY to EXT. X10. Horizontal deflection should now be 1 centimeter. (Attenuator accuracy $\pm 2\%$).

18. Adjust External Horizontal Input Compensation

Connect a jumper from the 'A' SAWTOOTH to the vertical INPUT. Feed 0.5 VOLT from CAL. OUT. to both HORIZ. INPUT and 'A' TRIGGER INPUT. Set controls as follows:

HORIZONTAL DISPLAY	EXT. X1
TRIGGER SLOPE (A)	-EXT.
TIME/CM	1 MILLISEC
VOLTS/CM (Plug-In)	10

Adjust 'A' STABILITY and TRIGGERING LEVEL controls for a stable square-wave, displayed vertically. Adjust C330 (see Top View, Fig. 6-3) for optimum square wave response. Now switch the HORIZONTAL DISPLAY to EXT. X10, increase CALIBRATOR signal to 5 VOLTS, and adjust C301C (see Right Side View, Fig. 6-2) for optimum flattop.

19. Adjust Sweep Calibration

Set controls as follows:

HORIZONTAL DISPLAY	B
TIME/CM (B)	1 MILLISEC
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
5X MAGNIFIER	OFF
VOLTS/CM (Plug-In)	2

Connect 1 millisecond markers from the Type 180A to the Vertical INPUT and adjust 'B' triggering for a stable display. Adjust Sweep Col. (see Right Side View, Fig. 6-2) for 1 timemarker per centimeter. After this adjustment is made, the 5X Mag. Gain and the Sweep Mag. Register should be rechecked. (Steps 14 and 15.)

NOTE

Any non-linearity present in the sweep will always be in the first and last centimeter. Consequently, all timing adjustments should be made from the 1 cm line to the 9 cm line in the graticule.

20. Adjust Time Base A Sweep Length

Switch HORIZONTAL DISPLAY to A, set TIME/CM to 1 MILLISEC, VARIABLE to CALIBRATED, and adjust 'A' triggering for a stable display. Adjust R160Z (see Right Side View, Fig. 6-2) for the same timing as that obtained for the 'B' sweep in Step 19 above, +5%.

21. Adjust Time Base A Sweep Length

With control as in Step 20 above, adjust the Sweep Length control (see Top View, Fig. 6-3) for a sweep length of 10.5 centimeters.

22. Check Time Base B Sweep Rates

Starting with conditions as in Step 19 above, check TIME BASE B sweep rates according to the following table:

TIME BASE B	TYPE 180A	Markers displayed
1 MILLISEC	1 MILLISECOND	1/cm
2 MILLISEC	1 MILLISECOND	2/cm
5 MILLISEC	5 MILLISECOND	1/cm
10 MILLISEC	10 MILLISECOND	1/cm
20 MILLISEC	10 MILLISECOND	2/cm
50 MILLISEC	50 MILLISECOND	1/cm
0.1 SEC	100 MILLISECOND	1/cm
0.2 SEC	100 MILLISECOND	2/cm
0.5 SEC	500 MILLISECOND	1/cm
1 SEC	1 SECOND	1/cm

23. Check Time Base A Sweep Rates

Starting with conditions as in Step 20 above, check TIME BASE A sweep rates according to the following table:

TIME BASE A	TYPE 180A	Markers displayed
MILLISEC	1 MILLISECOND	1/cm
MILLISEC	1 MILLISECOND	2/cm
MILLISEC	5 MILLISECOND	1cm
0 MILLISEC	10 MILLISECOND	1/cm
0 MILLISEC	10 MILLISECOND	2/cm
0 MILLISEC	50 MILLISECOND	1/cm
.1 SECOND	100 MILLISECOND	1/cm
.2 SECOND	100 MILLISECOND	2/cm
.5 SECOND	500 MILLISECOND	1/cm
SECOND	1SECOND	1cm
2 SECOND	1 SECOND	2/cm
5 SECOND	5 SECOND	1/cm

24. Check Time Base A-Variable Time/CM control and Uncalibrated Neon.

The VARIABLE control provides for a complete range of control between the calibrated TIME/CM steps. To check operation of this control, set TIME/CM to 1 MILLISEC-CALIBRATED

Calibration Procedure - Type 535A

connect 5 MILLISECOND markers from the Type 180A to the Vertical INPUT and trigger the oscilloscope for a stable display consisting of 1 marker for each 5 cm. Next, turn the VARIABLE control full left. The display should now consist of markers every 2 cm or less. Check to see that the UNCALIBRATED neon indicator lamp is lit in all positions of the VARIABLE control except when switched to the CALIBRATED position.

25. Adjust Time Base A Sweep rates, 50 μsec/cm to .02 /μsec/cm.

Set TIME BASE A TIME/CM to .1 MILLISEC, apply 10 MICROSECOND markers from the Type 180A to the Vertical INPUT, and adjust the triggering for a stable display. Turn the 5X MAGNIFIER to ON and horizontally position the trace so that the first time marker is aligned with the center graticule line. Then switch the TIME/CM switch to 50 /SEC and check for horizontal shift of the first marker. If shift occurs, adjust C330 (see Top View, Fig. 6-31) until the first marker of both the .1 MILLISEC and 50 MICROSEC positions occur at the same point.

Turn the 5X MAGNIFIER to OFF, TIME BASE A TIME/CM to 10 ,SEC and proceed with the following adjustments:

TIME/CM	TYPE 180A	Adjustments	Observe
10 μSEC	10 MICROSECOND	C160E	1 marker/cm.
1 μSEC	1 MICROSECOND	C160C	1 marker/cm.
0.5μSEC	1 MICROSECOND	C160A	1 marker/2cm. Position 2nd marker to 2nd line on graticule
0.1 μSEC	10 MC	†C375 for linearity and C348 for time	1 cycle/cm
2 μSEC	1 MICROSECOND	Check timing range	2 markers/cm.
5 μSEC	5 MICROSECOND	Check timing range	1 marker/cm.
0.1 μSEC	50 MC*	C364 and C384	1 cycle/cm
X5		(See Fig. 6-4)	

† C375 only affects the first part of the display. There is considerable reaction between C348 and both 160A and 160C. The adjustment of C348 and C160A should be repeated back and forth several times to obtain optimum linearity with correct timing, after which C160C should be readjusted if necessary. Timing adjustments should be made, as usual, between the first and ninth centimeter lines of the graticule.

• Couple 50 MC from Type I BOA through a small capacitor (100 .μmf) directly to one of the vertical plates of the crt. C364 and C384 should be set as nearly at the same capacity as possible. It may be necessary to slightly readjust C375 to obtain best possible linearity.

26. Check 'B' Sweep Length

Place the HORIZONTAL DISPLAY switch at B, the 'B' TIME/CM switch at .5 MILLISEC, and adjust for a free running sweep. Rotate the LENGTH control and check that

the sweep length changes between approximately 3.5 and 10.5 centimeters. If the sweep length range is incorrect, substitute resistance values for R277 and R278 which will allow the proper range. R277 is normally between 12K and 18K; R278 is usually between 47K and 68K.

27. Set Delay Start and Delay Stop Adjustments

Set the HORIZONTAL DISPLAY Switch at 'B' INTENSIFIED BY 'A'. Apply 500, SEC markers from the time-mark generator to the oscilloscope vertical input. Set the 'A' TIME/ CM switch at 50/ SEC and the 'B' TIME/CM switch at .5 MILLISEC. Adjust the 'B' triggering controls for a stable display. Rotate the 'A' STABILITY control fully clockwise. A portion of the display will be brightened. Set the DELAYTIME MULTIPLIER control at 1.00. Adjust the DELAY START (see right side view, Fig. 6-2) control until the brightened portion starts at the first time mark (one centimeter from the start of the trace). Set the DELAY-TIME MULTIPLIER control at 9.00 and adjust the DELAY STOP (see right side view, Fig. 6-2) control until the brightened portion starts at the ninth time mark (nine centimeters from the start of the trace). Repeat the DELAY START and DELAY STOP adjustments until a satisfactory setting is obtained for both controls. Set the DELAY-TIME MULTIPLIER control at 1.00 and place the HORIZONTAL DISPLAY switch at 'A' DEL'D BY 'B'. Adjust the DELAY START control so that the leading edge of the time mark is at the start of the trace. Set the DELAY TIME MULTIPLIER control at 9.00 and adjust the DELAY STOP control until the leading edge of the time mark is at the start of the trace.

28. Adjust Time Base B Sweep Rates

Place the HORIZONTAL DISPLAY switch at 'B' INTENSIFIED BY 'A'. Set the 'A' TIME/CM switch at 5/ SEC and the 'B' TIME/CM switch at 50/ SEC. Connect 50/ second time markers to the oscilloscope vertical input and adjust the 'B' triggering controls for a stable display. Rotate the 'A' STABILITY control fully clockwise. Adjust the DELAY-TIME MULTIPLIER control to place the start of the brightened portion of the trace at the first marker lone centimeter from the start of the trace). Place the HORIZONTAL DISPLAY switch at 'A' DEL'D BY 'B' and adjust the DELAY-TIME MULTIPLIER control so that the leading edge of the time marker is at the start of the trace. Record the DELAY-TIME MULTIPLIER control setting. Adjust the DELAY-TIME MULTIPLIER control for a setting 8.00 higher than the setting recorded. Adjust C260C (see right side view, Fig. 6-2) until the leading edge of the ninth time marker is at the start c the trace.

Repeat the procedure outlined in the previous paragraph with the 'A' TIME/CM switch at .5/ SEC, the 'B' TIME/CM switch at 5 .SEC, and 5 ,second markers connected to the oscilloscope. The adjustment should be made with C260A (see right side view, Fig. 6-2).

Calibration Procedure - Type 535A**29. Set Lockout Level Adjust**

Set the HORIZONTAL DISPLAY switch at 'A' DEL'D BY 'B' the 'B' STABILITY control fully clockwise, and the 'A' TIME/CM switch at .1 MILLISEC. Slowly adjust the 'A' STABILITY control until the sweep first appears. Connect the test oscilloscope through a O1X probe to pin 3 of V133 using dc coupling. Adjust the test oscilloscope so that the displayed waveform has a vertical amplitude of four divisions. Adjust the Lockout Level Adj. control (see top view, Fig. 6-3) until the square-wave portion of the displayed waveform is 2.4 divisions in amplitude. During adjustments, the 'A' STABILITY control should be checked frequently to be sure that it is set where the sweep just runs. At the completion of the adjustment, the square wave portion should be 2.4 centimeters in amplitude, the sawtooth portion should be 1.6 centimeters in amplitude.

30. Set Vertical Gain

Connect the EP53A Gain Set Adapter between the oscilloscope and plug-in unit. Connect a jumper from the CAL. OUT connector to the connector of the gain set adapter. Place the AMPLITUDE CALIBRATOR switch in the .2 VOLTS position and adjust the oscilloscope for a stable display. Set the Gain Adj. (see Figure 6-5) control for exactly 2 centimeters of vertical deflection.

31. Adjust Delay Line and High Frequency Compensations

Delay Line adjustments are probably the most difficult adjustments to make. This is due to interaction between the large number of controls. The adjustments can be made properly with a minimum of difficulty if the proper procedure is followed and if care is used in making the adjustments. In general, it is not necessary to completely readjust the delay line. Rather it is a case of occasionally touching up the line for best results. Before attempting to adjust the line, briefly run through this procedure to establish the basic concepts in your mind. This will make the actual adjustments considerably easier. Be sure that the line requires adjustment before attempting to adjust it.

In general the procedure for adjusting the delay line and high frequency controls involves application of a fast rising pulse or square wave to the vertical amplifier. The delay line is then adjusted for minimum distortion of the pulse wave displayed on the screen. In particular, the delay line and amplifier high frequency controls are adjusted for three characteristics of the displayed waveform; fastest possible risetime without overshoot, minimum irregularities on the top of the pulse, and minimum slope of the top of the waveform.

Displaying the Test Signal

To determine the extent of misadjustment of the delay line in your instrument, you will need to closely examine a displayed fast rising pulse or square wave. The waveform used to make this examination should have a risetime of no more than 7 millimicroseconds. A Tektronix Type

107 Square-Wave Generator or a Tektronix Type P Plug-In Unit is recommended.

If a Type 107 Square-Wave Generator is used, the frequency control should be set to obtain approximately 400 kc squarewaves. The output of the generator should be connected through a 52-ohm coaxial cable and termination resistor to the input of either a Type K or a Type L Plug-In Unit. The termination resistor should be connected at the input to the plug-in unit.

When a Type P Plug-In Unit is used, it is only necessary to insert the unit into the plug-in compartment of the oscilloscope. The pulse frequency of the P Unit is fixed. If it is necessary to use a signal generator other than a Type 107 or Type P, you must check the output waveform from the generator for suitability. Obviously a waveform which is distorted in any manner is not suitable for adjusting the delay line of an oscilloscope. A good check on the suitability of your test equipment is to display the output waveform on another Type 535 Oscilloscope with a delay line known to be correctly adjusted.

When the input signal has been connected, adjust the oscilloscope triggering controls for a stable display using Time Base A. Rotate the TIME/CM control to .1 /,SEC and adjust the oscilloscope and signal source for approximately 3 centimeters of vertical deflection.

With the oscilloscope display, it is possible to check the delay line and amplifier adjustments for proper setting. There are three general characteristics which you will have to appraise, and to do this, you will need to use three different sweep rates. The first characteristic to look for is the level of the display; the second is the amount of bumpiness contained in the flat top of the displayed waveform; and the third is the risetime of the displayed waveform.

Determining the Level of the Display

The level of the display refers to the top of the displayed waveform. The waveform should show neither an upward nor a downward slope anywhere along the top of the waveform. Any slope of the waveform can be most easily seen with a sweep speed of approximately 5 μ seconds per centimeter.

Checking the Bumpiness of the Display

The next characteristic to look for in the displayed waveform is the bumpiness in the top portion of the waveform immediately following the rise. This is the portion of the waveform affected by the delay line adjustments. To make this observation, use a sweep speed of approximately .2 μ seconds per centimeter.

There are two general types of bumps to be found in a poorly adjusted delay line. The first type is the irregularity caused by the misadjustment of a group of capacitors. This type is indicated by a fairly long duration bump. If the bumps occur at random intervals along the delay line, they are probably due to misadjustment of the delay line and can usually be corrected by a few slight adjustments. However,

if there is a certain rhythmic waviness or symmetry to their appearance, the trouble may be due to a faulty adjustment in the terminating network. The trouble could also be on improper adjustment of the amplifier high frequency compensation. In either case a complete adjustment may be necessary.

The second kind of bump is caused by misadjustment of a single delay line capacitor. This is indicated by a very short duration bump. This type can be easily corrected by readjustment of the misadjusted capacitor. The proper capacitor can be determined by observing the location of the bump on the displayed waveform.

Checking the Rise of the Displayed Waveforms

The third characteristic to be investigated in the displayed waveform is the extreme leading edge and corner. This part of the waveform is affected by the vertical amplifier high frequency peaking coils and the delay line adjustments closest to the cathode-ray tube neck connections. These adjustments collectively determine the high frequency response of the vertical deflection system and for that reason are of the utmost importance.

The leading edge of the displayed waveform is best observed with a sweep speed of approximately .1 usecond per centimeter. The corner should be as sharp as possible with no overshoot. While it is necessary that the corner be as sharp as possible for optimum frequency response, it is also necessary that there be no wrinkles or bumpiness in this portion of the display.

There is a good deal of similarity in the effect of the amplifier peaking coils and the delay line adjustments. For this reason, it is sometimes difficult to ascertain which adjustments are faulty. The adjustment at fault can usually be determined by the location and occurrence of the waveform irregularities.

Physical Presetting

Perhaps the most important single bit of information for a line tuner is knowledge of the approximate positions of the various adjustments in a properly adjusted instrument. This knowledge will give him a good starting off point. And later, during the adjustment procedure, he can use the information as a check on his progress.

The variable inductors in the vertical amplifier and at the neck connections to the crt are normally preset so that the slugs are just out of the coils. They can be set by shining a light through the coil forms and adjusting the slugs. By presetting the slugs in this manner you will reduce the effects of the inductors during the delay line adjustment procedure. Then, during the last step of the adjustment procedure, you will move the slugs into the coils (usually about two or three turns).

If in your preliminary investigation, you detected a cyclic waviness in the display, or if there was extreme overshoot at the leading edge, you will probably save yourself considerable time by presetting the variable inductors. Usually, turning the slugs too far out of the coil will only result in a rounding off of the leading edge. However, turning the slugs too far into the coil windings will result in severe wrinkles in the displayed waveform, wrinkles which

can frequently be reduced by misadjusting the delay line. This might give you the impression that the delay line was at fault instead of the high frequency peaking coils.

The variable capacitors in the delay line will not, as a rule, require presetting. If the performance of the instrument has deteriorated as a result of normal use and handling, the delay line should require only touching up. The original physical positions of the capacitors should be very nearly correct. On the other hand, if the instrument has been tampered with, or if it has been subject to severe vibration or rough handling, it may be desirable to preset the delay line capacitors as described in the following paragraph.

In a properly adjusted delay line, the adjusting screw extends above the capacitor body about 3/8 inch. The important characteristic is that the tops of all the delay line adjusting screws be about the same height. It is very important to keep this characteristic in mind as you adjust the delay line. Normally, trimmers located at points where fixed capacitors are connected across the delay line are somewhat higher than other trimmer capacitors.

If you can observe a waviness in the height of the adjusting screws. (while at the same time, the display is level), the trouble is probably due to misadjustment of the inductors in the vertical amplifier. In this event, you should recheck the physical positions of the slugs as described in the previous paragraphs.

if, in the preliminary inspection, you noticed a bump following the termination bump that is, on the portion of the delay line not normally affected by delay line adjustments), be sure to check the termination inductors for balance. The slugs in both inductors should be equidistant from the coil windings. When you adjust the slugs, be sure to adjust each slug the same amount.

As a final step in the physical presetting procedure, dress the leads to the crt vertical-deflection plates. They are to be uniformly spaced both with respect to each other and with respect to the crt shield.

Establishing a Level Display

The level of the flat top of the displayed waveform is determined by the collective effect of all the delay line capacitors. When the delay line is properly adjusted, the top of the displayed waveform should be almost perfectly flat.

To make the display level, adjust each delay line capacitor a small amount in a direction that will result in a level display. Start at the termination network by adjusting the inductors and capacitors for a termination bump of minimum amplitude. Then, advance from capacitor to capacitor on the delay line, working toward the crt end. During your first attempt, you will probably find it most convenient to use a sweep speed of approximately 5 useconds per centimeter. After you have adjusted all of the capacitors to gain an average level over the length of the flat top of the displayed waveform, you can advance the sweep speed to

Calibration Procedure - Type 535A

2 μseconds per centimeter and repeat the procedure. This time, however, try to adjust the capacitors for a smooth transition from bump to bump, while at the same time maintaining a satisfactory level. The important thing to remember is to reduce the amplitude of all of the bumps by the same amount and try to achieve a perfectly straight line at this time.

Removing the Bumps and Wrinkles

After you have established a level display with the amplitude of the bumps and wrinkles reduced to within a trace width of the level line, you can start to remove the wrinkles and bumps over smaller sections of the display. It is usually best to start at the terminated end of the delay and work toward the crt end.

Set TIME/CM switch at .5 μSEC. and proceed to remove the bumps caused by the termination network. Do not try to arrive at a perfectly straight line during your first attempt. Just reduce the bumps by one-half. Then advance to the first group of 4 or 5 capacitors in the delay line and adjust them for a smooth line over the portion of the display that they affect. Keep in mind that each capacitor will only require a slight adjustment a mere touch, and that it is the combined effect of the group of capacitors that you should be concerned with.

While you are adjusting a group of capacitors to remove a bump or wrinkle, be sure to frequently turn to a sweep rate of 2 or 5 microseconds/centimeter and check the level of the display.

Advance along the delay line from each group of capacitors to the next until you have traversed the entire length. Then, turn the TIME/CM switch to .02 /SEC and repeat the process. This time, however, you must be extra careful. The capacitors that require adjustment will only need a slight touch, to do otherwise might nullify all of your efforts up to this point. Be sure to check the level of the display frequently. It is very easy to concentrate on removing a particularly stubborn bump and, in so doing, introduce an upward or downward slope in the display.

At this point in the adjustment procedure, it will not be necessary to adjust every capacitor. Touching up here and there will probably produce the desired results.

Adjusting the High Frequency Compensation

If you have successfully completed the adjustment procedure up to this point, the display should be level and free of bumps and wrinkles with a pronounced rolloff on the leading edge. During this final part of the adjustment procedure, you will strive for a square corner on the leading edge, while at the same time maintaining the proper level without introducing wrinkles or bumps.

Set the TIME/CM switch at .2 μSEC and position the display to afford a good view of the leading edge and corner. The inductors in the vertical amplifier and near the crt affect this portion of the waveform. The delay line capacitors nearest the crt also affect the leading edge of the waveform. It is important that you adjust each pair of inductors in conjunction with each other. Each inductor should be set at the same position as its corresponding opposite inductor.

Adjust the inductors, in pairs for the squarest possible corner. It may be necessary to readjust the first two or three capacitors closest to the crt in order to achieve a wrinkle free corner.

At this time the displayed waveform should be level on top, there should be virtually no bumps or wrinkles, and the risetime of the displayed waveform should be within specifications for the instrument. A risetime check on the displayed waveform gives a very good check on the completeness of the adjustments.

BANDPASS CHECKS

Install a properly calibrated Type K Unit in the oscilloscope and connect the output cable from the Constant Amplitude Signal Generator to the INPUT Connector of the Type K Unit. Set the front-panel controls as follows:

STABILITY	full right
TRIGGERING LEVEL	any position
TRIGGER SLOPE	INT. (+ or -)
TRIGGERING MODE	AC FAST, AC SLOW or DC
TIME/CM	1 MILLISEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	A
Type K Unit	
AC/DC	DC
VOLTS/CM	.05
VARIABLE	CALIBRATED

Set the frequency controls on the Signal GENERATOR for an output frequency of 500 kc, and adjust the amplitude controls for a vertical deflection of exactly 6 centimeters. Position the display on the crt (with the VERTICAL POSITION control) so that the deflection extends exactly from the top graticule mark to the bottom graticule mark.

Then increase the output frequency of the Signal Generator to 15 mc (make sure the VOLTS/CM and VARIABLE controls are set at .05 and CALIBRATED, respectively); the deflection should be at least 4.2 centimeters at 15 mc. If not, the Vertical Amplifier and the Delay Line (and possibly the Type K Unit) are in need of further adjustment.

**Type 535A
SECTION 7
ELECTRICAL PARTS LIST**

Note: Order parts through normal supply channels.
Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	S/N Range	Description
Bulbs			
B129	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B129	150-0030-00	33660	Type NE-2V Neon Bulb
B160W	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B160W	150-0030-00	33660	Type NE-2V Neon Bulb
B167	Use 150-0027-00		Type NE-23 Neon Bulb
B171	Use 150-0027-00		Type NE-23 Neon Bulb
B267	Use 150-0027-00		Type NE-23 Neon Bulb
B271	Use 150-0027-00		Type NE-23 Neon Bulb
8347	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B347	150-0030-00	33660	Type NE-2V Neon Bulb
B386	Use 150-0027-00		Type NE-23 Neon Bulb
B397	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B397	150-0030-00	33660	Type NE-2V Neon Bulb
B398	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B398	150-0030-00	33660	Type NE-2V Neon Bulb
B434A	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B434A	150-0030-00	33660	Type NE-2V Neon Bulb
B434B	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B434B	150-0030-00	33660	Type NE-2V Neon Bulb
B536	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B536	150-0030-00	33660	Type NE-2V Neon Bulb
B546	Use 150-0027-00	20001	33659 Type NE-23 Neon Bulb
B546	150-0030-00	33660	Type NE-2V Neon Bulb
B601	150-0001-00	Bulb #47	
B602	150-0001-00	Bulb #47	
B603	150-0001-00	Bulb #47	

Capacitors

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

C1	281-0501-00			4.7 pF	Cer	500 V	± 1 pF
C2	283-0006-00	X31260		0.02 μ F	Cer	600 V	
C10	Use 285-0543-00	20001	22899	0.0047 μ F	PTM	400 V	
C10	285-0543-00	22900		0.0022 μ F	PTM		
C11	281-0523-00			100 pF	Cer	350 V	± 20 pF

Ckt. No.	Tektronix Part No.	S/N Range	Description		
C15	283-0000-00		0.001 μ F	Cer 500 V	
C20	283-0000-00		0.001 μ F	Cer 500 V	
C24	281-0518-00		47 pF	Cer 500 V ±9.4 pF	
C31	285-0510-00		0.01 μ F	PTM 400 V	
C37	281-0510-00		22 pF	Cer 500 V ±4.4 pF	
C47	283-0001-00		0.005 μ F	Cer 500 V	
C51	281-0541-00		6.8 pF	Cer 500 V	
C52	283-0002-00	X31260	0.01 μ F	Cer 500 V	
C60	285-0501-00		0.001 μ F	TM 600 V	
C65	283-0000-00		0.001 μ F	Cer 500 V	
C70	283-0000-00		0.001 μ F	Cer 500 V	
C74	283-0001-00	X20230	0.005 μ F	Cer 500 V	
C76	283-0001-00	X20230	0.005 μ F	Cer 500 V	
C78	283-0000-00		0.001 μ F	Cer 500 V	
C81	283-0001-00		0.005 μ F	Cer 500 V	
C87	281-0511-00		22 pF	Cer 500 V ±2.2 pF	
C102	281-0511-00		22 pF	Cer 500 V ±2.2 pF	
C103	283-0000-00		0.001 μ F	Cer 500 V	
C105	283-0000-00		0.001 μ F	Cer 500 V	
C109	283-0001-00		0.005 μ F	Cer 500 V	
C116	283-0000-00		0.001 μ F	Cer 500 V	
C123	281-0504-00		10 pF	Cer 500 V ±1 pF	
C129	283-0001-00		0.005 μ F	Cer 500 V	
C131	281-0513-00		27 pF	Cer 500 V ±5.4 pF	
C134	281-0503-00		8 pF	Cer 500 V ±0.5 pF	
C138	283-0001-00		0.005 μ F	Cer 500 V	
C141	281-0503-00		8 pF	Cer 500 V ±0.5 pF	
C150	281-0528-00		82 pF	Cer 500 V ±8.2 pF	
C151	283-0001-00		0.005 μ F	Cer 500 V	
C157	281-0506-00		12 pF	Cer 500 V ±1.2 pF	
C160A	281-0007-00		3-12 pF, Var	Cer	
C160B	283-0534-00		82 pF	Mica 5%	
C160C	281-0010-00		4.5-25 pF, Var	Cer 500 V	
C160D	283-0534-00		82 pF	Mica 5%	
C160E	281-0010-00		4.5-25 pF, Var	Cer 500 V	
C160F	*291-0008-00	20001-34269	0.001 μ F	mylar ½%	
C160G	*291-0007-00	20001-34269	0.01 μ F	mylar timing series ½%	
C160H			0.1 μ F		
C160J			1 μ F		
C160F	*295-0102-00	34270	0.001 μ F	Timing Capacitor Assembly	
C160G			0.01 μ F		
C160H			0.1 μ F		
C160J			1 μ F		
C160K	281-0543-00	X26870	270 pF	Cer 500 V	
C165	281-0528-00	20001	20005	82 pF	Cer 500 V ±8.2 pF
C165	281-0525-00	20006		470 pF	Cer 500 V ±94 pF
C167	283-0000-00			0.001 μ F	Cer 500 V
C180A	283-0536-00			220 pF	Mica 10%
C180B	285-0543-00			0.0022 μ F	PTM 400 V

†C160F,G,H,I and C260D,E,F,G SN 34270-up furnished as a unit.

Ckt. No.	Tektronix Part No.	S/N Range		Description		
Capacitors (Cont)						
C180C	285-0515-00			0.022 μ F	PTM 400 V	
C180D	285-0526-00			0.1 μ F	PTM 400 V	
C180E	285-0526-00			0.1 μ F	PTM 400 V	
C181	281-0517-00	20001	20079	39 pF	Cer 500 V	\pm 3.9 pF
C181	281-0515-00	20080		27 pF	Cer 500 V	\pm 1.35 pF
C187	283-0001-00			0.005 μ F	Cer 500 V	
C190	Use 281-0509-00	20001	20449	18 pF	Cer 500 V	
C190	281-0509-00	20450		15 pF	Cer 500 V	+10%
C193	283-0001-00			0.005 μ F	Cer 500 V	
C196	283-0000-00			0.001 μ F	Cer 500 V	
C221	281-0518-00			47 pF	Cer 500 V	
C234	281-0504-00			10 pF	Cer 500 V	\pm 1 pF
C241	281-0534-00			3.3 pF	Cer 500 V	\pm 0.25 pF
C250	281-0516-00			39 pF	Cer 500 V	\pm 3.9 pF
C260A	281-0007-00			3-12 pF, Var	Cer 500 V	
C260B	283-0533-00			39 pF	Mica 500 V	5%
C260C	281-0012-00			7-45 pF, Var	Cer 500 V	
C260D } C260E } C260F } C260G }	291-0026-00	20001	34269	{ 480 pF 0.005 μ F 0.05 μ F 0.5 μ F }	Manufactured by Tektronix	
C260D } † C260E } C260F } C260G }	*295-0102-00	34270		{ 480 pF 0.005 μ F 0.05 μ F 0.5 μ F }	Timing Capacitor Assembly	
C267	283-0000-00			0.001 μ F	Cer 500 V	
C280A	281-0510-00			22 pF	Cer 500 V	\pm 4.4 pF
C280B	281-0525-00			470 pF	Cer 500 V	\pm 94 pF
C280C	285-0506-00			0.0047 μ F	PTM 400 V	
C280D	285-0519-00			0.047 μ F	PTM 400 V	
C280E	285-0519-00			0.047 μ F	PTM 400 V	
C295	281-0509-00			15 pF	Cer 500 V	\pm 1.5 pF
C301C	281-0012-00			7-45 pF, Var	Cer 500 V	
C301E	281-0546-00			330 pF	Cer 500V	\pm 10%
C301H	281-0511-00	20001	20005	22 pF	Cer 500 V	
C301H	281-0506-00	20006		12 pF	Cer 500 V	\pm 1.2 pF
C320	283-0001-00			0.005 pF	Cer 500 V	
C330	281-0010-00			4.5-25 pF, Var	Cer 500 V	
C336	283-0001-00			0.005 pF	Cer 500 V	
C340	281-0501-00			4.7 pF	Cer 500V	\pm 1 pF
C347	283-0000-00			0.001 μ F	Cer 500 V	
C348	281-0007-00			3-12 pF, Var	Cer 500 V	
C355	281-0526-00			1.5 pF	Cer 500 V	\pm 0.5 pF
C356	283-0001-00			0.005 μ F	Cer 500 V	
C364	281-0036-00			3-12 pF, Var	Cer 500 V	
C375	281-0023-00			9-180 pF, Var	Mica	
C380	290-0000-00			6.25 μ F	Elect. 300 V	
C384	281-0036-00			3-12 pF, Var	Cer 500 V	
C390	281-0501-00			4.7 pF	Cer 500 V	\pm 1 pF
C393	285-0519-00			0.047 μ F	PTM 400 V	

†C260D,E,F,G and C160F,G,H,I SN 34270-up furnished as a unit.

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Capacitors (Cont)					
C396	283-0001-00	X21920	0.005 μ F	Cer	500 V
C421	283-0002-00		0.01 μ F	Cer	500 V
C426	283-0001-00		0.005 μ F	Cer	500 V
C444	281-0511-00		22 pF	Cer	500 V ±2.2 pF
C454	281-0518-00		47 pF	Cer	500 V ±9.4 pF
C457	283-0001-00		0.005 μ F	Cer	500 V
C505	283-0001-00		0.005 μ F	Cer	500 V
C507A, B	Use 290-0075-00		2 x 10 μ F	Elect.	250 V
C510	283-0001-00		0.005 μ F	Cer	500 V
C517	283-0000-00		0.001 pF	Cer	500 V
C528	283-0001-00		0.005 μ F	Cer	500 V
C537	283-0001-00		0.005 μ F	Cer	500 V
C543	283-0001-00		0.005 μ F	Cer	500 V
C547	283-0001-00		0.005 μ F	Cer	500 V
C550	283-0001-00		0.005 μ F	Cer	500 V
C553	281-0034-00		1.5-7 pF	Cer	500 V
C556	283-0000-00		0.001 μ F	Cer	500 V
C563	281-0011-00		5-25 pF, Var	Cer	500 V
C566	283-0000-00		0.001 μ F	Cer	500 V
C582	283-0001-00		0.005 μ F	Cer	500 V
C587	281-0503-00		8 pF	Cer	500 V ±5 pF
C588	281-0516-00		39 pF	Cer	500 V
C596	283-0001-00		0.005 μ F	Cer	500 V
C599	285-0517-00		0.022 μ F	PTM	600 V
C601	283-0004-00	20001 24349	0.02 μ F	Cer	150 V
C601	283-0008-00	24350	0.1 μ F	Cer	500 V
C603	Use 290-0012-00		2 x 40, F	Elect.	250 V
C605A } C605B } C605C }	Use 290-0062-00		{ 40 μ F } { 20 μ F } { 10 μ F }	Elect.	475 V
C610	285-0510-00		0.01 μ F	PTM	400 V
C617	285-0510-00		0.01 μ F	PTM	400 V
C628	285-0510-00		0.01 μ F	PTM	400 V
C640	Use 290-0016-00		125 μ F	Elect.	350 V
C648	283-0002-00		0.01 μ F	Cer	500 V
C649	Use 290-0012-00		2 x 40 μ F	Elect.	250 V
C650	285-0510-00		0.01 μ F	PTM	400 V
C670	Use 290-0019-00		150 μ F	Elect.	250 V
C671	Use 290-0019-00		1 50 μ F	Elect.	250 V
C679A,B,C	Use 290-0005-00		3 x 10 μ F	Elect.	450 V
C680	285-0510-00		0.01 μ F	PTM	400 V
C688	2850510-00		0.01 μ F	PTM	400 V
C700	Use 290-0017-00		125 μ F	Elect.	450 V
C710	Use 285-0511-00	20001 20989	0.01 μ F	PTM	400 V
C710	285-0511-00	20990	0.01 μ F	PTM	600 V

Ckt. No.	Tektronix Part No.	S/N Range		Description		
Capacitors (Cont)						
C730	Use 290-0016-00			125 μ F	Elect.	350 V
C740	285-0510-00			0.01 μ F	PTM	400 V
C760A,B	Use 290-0013-00			2 x 40 μ F	Elect.	450 V
C780	283-0001-00			0.005 μ F	Cer	500 V
C783	283-0002-00			0.01 μ F	Cer	500 V
C785	283-0002-00			0.01 μ F	Cer	500 V
C801	285-0519-00			0.047 μ F	PTM	400 V
C802	Use 290-0010-00			2 x 20 μ F	Elect.	450 V
C803	285-0501-00			0.001 μ F	PTM	600 V
C806	285-0510-00			0.01 μ F	PTM	400 V
C808	285-0501-00			0.001 μ F	PTM	600 V
C819	Use 283-0057-00	X25050		0.1 μ F	Cer	200 V
C820	285-0508-00	20001	22899	0.0068 μ F	PTM	3000 V
C820	283-0011-00	22900		0.01 μ F	Cer	2000 V
C821	285-0513-00	20001	21979	0.015 μ F	PTM	3000 V
C821	283-0011-00	21980		0.01 μ F	Cer	2000 V
C822	281-0525-00	X20080		470 pF	Cer	500 V
C827	285-0513-00	20001	21979	0.015 μ F	PTM	3000 V
C827	283-0011-00	21980		0.01 μ F	Cer	2000 V
C828	283-0011-00	X21980		0.01 μ F	Cer	2000 V
C829	283-0000-00	X25050		0.001 μ F	Cer	500 V
C831	285-0508-00	20001	22899	0.0068 μ F	PTM	3000 V
C831	283-0011-00	22900		0.01 μ F	Cer	2000 V
C832	Use 283-0034-00	20001	22269	0.0068 μ F	PTM	5000 V
C832	283-0034-00	22270		0.005 μ F	Cer	4000 V
C833	Use 281-0556-00	20001	21861	0.00047 μ F	PTM	10,000 V
C833	281-0556-00	21862		500 pF	Cer	10,000 V
C834	Use 281-0556-00	20001	21861	0.00047 μ F	PTM	10,000 V
C834	281-0556-00	21862		500 pF	Cer	10,000 V
C836	Use 281-0556-00	20001	21861	0.00047 μ F	PTM	10,000 V
C836	281-0556-00	21862		500 pF	Cer	10,000 V
C841	Use 283-0006-00			0.02 μ F	Discap	600 V
C842	285-0508-00	20001	22899	0.0068 μ F	PTM	3000 V
C842	283-0011-00	22900		0.01 μ F	Cer	2000 V
C845	285-0513-00	20001	21979	0.015 μ F	PTM	3000 V
C845	283-0011-00	21980		0.01 μ F	Cer	2000 V
C848	285-0513-00	20001	21979	0.015 μ F	PTM	3000 V
C848	283-0011-00	21980		0.01 μ F	Cer	2000 V
C871	283-0518-00			330 pF	Mica	500 V
C874	283-0518-00			330 pF	Mica	500 V
C885	281-0513-00			27 pF	Cer	500 V
C897	283-0000-00			0.001 μ F	Cer	500 V
C903	281-0037-00			7-3 pF, Var	Tub	
C904	281-0037-00			7-3 pF, Var	Tub	
C905	281-0037-00			7-3 pF, Var	Tub	

±94 pF

10%

10%

±5.4 pF

Ckt. No.	Tektronix Part No.	S/N Range	Description			
Capacitors (Cont)						
C906	281-0037-00		7-3 pF, Var	Tub		
C907	281-0037-00		7-3 pF, Var	Tub		
C908	281-0037-00		7-3 pF, Var	Tub		
C909	281-0037-00		7-3 pF, Var	Tub		
C910	281-0037-00		7-3 pF, Var	Tub		
C911	281-0037-00		7-3 pF, Var	Tub		
C912	281-0037-00		7-3 pF, Var	Tub		
C913	281-0037-00		7-3 pF, Var	Tub		
C914	281-0037-00		7-3 pF, Var	Tub		
C915	281-0037-00		7-3 pF, Var	Tub		
C916	281-0037-00		7-3 pF, Var	Tub		
C917	281-0037-00		7-3 pF, Var	Tub		
C918	281-0037-00		7-3 pF, Var	Tub		
C919	281-0037-00		7-3 pF, Var	Tub		
C920	281-0037-00		7-3 pF, Var	Tub		
C925 ¹	302-0106-00		10M Ω	½ W	Comp	10%
C926 ¹	302-0106-00		10M Ω	½ W	Comp	10%
C930	281-0037-00		7-3 pF, Var	Tub		
C931	281-0037-00		7-3 pF, Var	Tub		
C932	281-0037-00		7-3 pF, Var	Tub		
C933	281-0037-00		7-3 pF, Var	Tub		
C934	281-0037-00		7-3 pF, Var	Tub		
C935	281-0037-00		7-3 pF, Var	Tub		
C936	281-0037-00		7-3 pF, Var	Tub		
C937	281-0037-00		7-3 pF, Var	Tub		
C938	281-0037-00		7-3 pF, Var	Tub		
C939	281-0037-00		7-3 pF, Var	Tub		
C940	281-0037-00		7-3 pF, Var	Tub		
Diodes						
D122	152-0008-00			T12G or HD2607		
D131	152-0008-00	X20540		T12G		
D152	152-0246-00	X33900		Silicon, Low Leakage, 0.25 W, 40 V		
D252	152-0246-00	X33900		Silicon, Low Leakage, 0.25 W, 40 V		
D642A,B,C,D	152-0047-00	20001	33899	Silicon		
D642A,B,C,D	152-0066-00	33900		Silicon 1N3194		
D672A,B,C,D	152-0047-00	20001	33899	Silicon		
D672A,B,C,D	152-0066-00	33900		Silicon 1N3194		
D679	152-0047-00	X25230	33899	Silicon		

¹C925 and C926 used in delay line for their capacitive properties.

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Diodes (Cont)					
D679	152-0066-00	33900			Silicon 1N3194
D702A,B	152-0047-00	20001	33899		Silicon
D702A,B	152-0066-00	33900			Silicon 1N3194
D732A,B	152-0047-00	20001	33899		Silicon
D732A,B	152-0066-00	33900			Silicon 1N3194
D762A,B	152-0047-00	20001	33899		Silicon
D762A,B,C,D	152-0066-00	33900			Silicon 1N3194
Fuses					
F601	159-0013-00				6 amp, Fast-Blo 3AG for 117V Operation 60 cycle
F601	159-0015-00				3 amp, Fast-Blo 3AG for 234 V Operation 60 cycle
F601	159-0011-00				6.25 amp, Slo-Blo 3AG for 117V Operation 50 cycle
F601	159-0005-00				3 amp, Slo-Blo 3AG for 234V Operation 50 cycle
Relays					
K600	148-0002-00				Amperite 6N045T
K601	148-0004-00	20001	24349		6.3 V, AC Relay
K601	148-0016-00	24350			DC Relay Coil 2000 Ω
Inductors					
L249	108-0165-00				4.7 μ H
L424	108-001 5-00				255 μ H
L506	114-0121-00	20001	25049		15-34, μ H, Var core 276-0511-00
L506	114-0100-00	25050	25409		10-21 μ H, Var core 276-0511-00
L506	114-0121-00	25410			15-34 μ H, Var core 276-0511-00
L523	114-0121-00	20001	25049		15-34 μ H, Var core 276-0511-00
L523	114-0100-00	25050	25409		10-21 μ H Var core 276-0511-00
L523	114-0121-00	25410			15-34 μ H, Var core 276-0511-00
L526	108-0095-00				1.4 μ H
L541	108-0095-00				1.4 μ H
L551	108-0056-00				1.2 μ H
L553	114-0102-00				11-28 μ H, Var core 276-0511-00
L561	108-0056-00				1.2 μ H
L563	114-0102-00				11-28 μ H, Var core 276-0511-00
L582	108-0129-00				18 μ H
L905	Use 108-0178-00	20001	20969		18 section, Delay Line
L905	108-0178-00	20970			18 section, Delay Line
L906	Use 108-0178-00	20001	20969		18 section, Delay Line
L906	108-0178-00	20970			18 section, Delay Line
L925	108-0056-00				1.2 μ H

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Inductors (Cant)					
L926	108-0056-00			1.2 μ H	
L935	Use 108-0179-00	20001	20969	11 section, Delay Line	
L935	108-0179-00	20970		11 section, Delay Line	
L936	Use 108-0179-00	20001	20969	11 section, Delay Line	
L936	108-0179-00	20970		11 section, Delay Line	
L955	114-0105-00			3.6-7.2 μ H, Var	core 276-0506-00
L956	114-0105-00			3.6-7.2 μ H, Var	core 276-0506-00
LR149	108-0164-00			1.2 μ H	
Resistors					
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.					
R1	301-0105-00			1 M Ω	$\frac{1}{2}$ W 5%
R2	301-0394-00			390 k Ω	$\frac{1}{2}$ W 5%
R3	311-0023-00			50 k Ω , Var	2 W 20%
R4	302-0104-00			100 k Ω	$\frac{1}{2}$ W
R5	302-0106-00	X31260		10 M Ω	$\frac{1}{2}$ W
R12	302-0105-00			1 M Ω	$\frac{1}{2}$ W
R13	302-0104-00			100 k Ω	$\frac{1}{2}$ W
R15	302-0474-00			470 k Ω	$\frac{1}{2}$ W
R17 ²	311-0096-00			2 x 100 k Ω , Var	$\frac{1}{2}$ W 20%
R18	302-0223-00			22 k Ω	$\frac{1}{2}$ W
R19	302-0474-00	20001	34099	470 k Ω	$\frac{1}{2}$ W
R19	301-0474-00	34100		470 k Ω	$\frac{1}{2}$ W 5%
R20	302-0563-00	20001	34099	56 k Ω	$\frac{1}{2}$ W
R20	301-0683-00	34100		68 k Ω	$\frac{1}{2}$ W 5%
R22	302-0470-00			47 Ω	$\frac{1}{2}$ W
R23	302-0470-00			47	$\frac{1}{2}$ W
R24	304-0472-00			4.7 k Ω	1 W
R25	304-0472-00			4.7 k Ω	1 W
R28	306-0333-00			33 k Ω	2 W
R29	306-0393-00			39 k Ω	2 W
R31	302-0473-00			47 k Ω	$\frac{1}{2}$ W
R32	302-0473-00			47 k Ω	$\frac{1}{2}$ W
R33	302-0470-00			47 Ω	$\frac{1}{2}$ W
R34	302-0681-00			680 Ω	$\frac{1}{2}$ W
R35	302-0152-00			1.5 k Ω	$\frac{1}{2}$ W
R37	302-0104-00			100 k Ω	$\frac{1}{2}$ W
R38	302-0124-00			120 k Ω	$\frac{1}{2}$ W
R39	311-0026-00			100 k Ω , Var	2 W 20%
R40	302-0275-00			2.7 M Ω	$\frac{1}{2}$ W
R41	302-0470-00			47	$\frac{1}{2}$ W

²Concentric with R110 and SW110. Furnished as a unit.

Ckt. No.	Tektronix Part No.	S/N Range	Description			
Resistors (Cont)						
R43	Use 302-0152-00	20001	20539	820 Ω	$\frac{1}{2}$ W	
R43	302-0152-00	20540		1.5 k Ω	$\frac{1}{2}$ W	
R44	302-0105-00			1 M Ω	$\frac{1}{2}$ W	
R46	304-0183-00			18 k Ω	1 W	
R47	311-0005-00			500 Ω , Var	2 W	
R48	304-0183-00			18 k Ω	1 W	
R51	Use 301-0105-00	20001	21509	1 M Ω	$\frac{1}{2}$ W	
R51	301-0105-00	21510		1 M Ω	$\frac{1}{2}$ W	5%
R52	Use 301-0394-00	20001	21509	390 k Ω	$\frac{1}{2}$ W	
R52	301-0394-00			390 k Ω	$\frac{1}{2}$ W	5%
R53	311-0125-00			50 k Ω , Var	0.2 W	
R54	302-0104-00			100 k Ω	$\frac{1}{2}$ W	
R55	302-0106-00	X31260		10 M Ω	$\frac{1}{2}$ W	
R62	302-0105-00			1 M Ω	$\frac{1}{2}$ W	
R65	302-0474-00			470 k Ω	$\frac{1}{2}$ W	
R67 ³	311-0096-00			2 x100 k Ω , Var	$\frac{1}{2}$ W	20%
R68	302-0223-00			22 k Ω	$\frac{1}{2}$ W	
R69	302-0474-00	20001	34099	470 k Ω	$\frac{1}{2}$ W	
R69	301-0474-00	34100		470 k Ω	$\frac{1}{2}$ W	5%
R70	302-0563-00	20001	34099	56 k Ω	$\frac{1}{2}$ W	
R70	301-0683-00	34100		68 k Ω	$\frac{1}{2}$ W	5%
R72	302-0101-00			100 Ω	$\frac{1}{2}$ W	
R73	302-0101-00			100 Ω	$\frac{1}{2}$ W	
R74	302-0470-00	X20230		47 Ω	$\frac{1}{2}$ W	
R75	306-0333-00			33 k Ω	2 W	
R76	302-0470-00	X20230		47 Ω	$\frac{1}{2}$ W	
R78	311-0066-00			500 Ω , Var	0.2 W	20%
R79	306-0333-00			33 k Ω	2 W	
R81	302-0224-00			220 k Ω	$\frac{1}{2}$ W	
R82	302-0224-00			220 k Ω	$\frac{1}{2}$ W	
R83	302-0101-00			100 Q	$\frac{1}{2}$ W	
R84	302-0152-00			1.5 k Ω	$\frac{1}{2}$ W	
R85	Use 301-0152-00	20001	20659	1.8 k Ω	$\frac{1}{2}$ W	5%
R85	301-0152-00	20660		1.5 k Ω	$\frac{1}{2}$ W	5%
R87	302-0104-00			100 k Ω	$\frac{1}{2}$ W	
R88	302-0274-00			270 k Ω	$\frac{1}{2}$ W	
R90	Use 302-0225-00			2.2 M Ω	$\frac{1}{2}$ W	
R91	302-0101-00			100 Ω	$\frac{1}{2}$ W	
R93	302-0122-00			1.2 k Ω	$\frac{1}{2}$ W	
R96	306-0333-00			33 k Ω	$\frac{1}{2}$ W	

³Concentric with R210 and SW210. Furnished as a unit.

Ckt. No.	Tektronix Part No.	S/N Range		Description		
Resistors (Cont)						
R101	302-0102-00			1 k Ω	1/2 W	
R102	302-0223-00			22 k Ω	1/2 W	
R103	302-0226-00			22 M Ω	1/2 W	
R105	302-0394-00			390 k Ω	1/2 W	
R106	302-0105-00			1 M Ω	1/2 W	
R107	302-0470-00			47 Ω	1/2 W	
R109	302-0224-00			220 k Ω	1/2 W	
R110 ⁴	311-0096-00			100 k Ω , Var	1/2 W	20%
R111	Use 311-0219-00	20001	23319	100 k Ω , Var	0.2 W	20%
R111	311-0219-00	23320		200 k Ω , Var	0.2 W	20%
R114	301-0474-00			470 k Ω	1/2 W	5%
R115	301-0104-00			100 k Ω	1/2 W	5%
R116	301-0184-00			180 k Ω	1/2 W	5%
R121	302-0470.00			47 Ω	1/2 W	
R122	304-0683-00			68 k Ω	1 W	
R123	302-0274-00			270 k Ω	1/2 W	
R124	302-0474-00			470 k Ω	1/2 W	
R125	311-0023-00			50 k Ω , Var	2 W	20%
R126	302-0104-00			100 k Ω	1/2 W	
R127	302-0470-00			47 Ω	1/2 W	
R128	302-0123-00			12 k Ω	1/2 W	
R129	302-0103-00			10 k Ω	1/2 W	
R130	306-0223-00			22 k Ω	2 W	
R131	302-0102-00			1 k Ω	1/2 W	
R132	302-0470-00			47	1/2 W	
R134 ⁵	*310-0555-00			6 k Ω	3 W	Prec
R137	302-0470-00			47 Ω	1/2 W	
R138	302-0470-00			47 Ω	1/2 W	
R141	310-0070-00			33 k Ω	1 W	Prec
R143	310-0072-00			30 k Ω	1 W	Prec
R144	308-0053-00			8 k Ω	5 W	WW
R146	302-0470-00			47 2	1/2 W	
R147	302-0102-00			1 k Ω	1/2 W	
R148	302-0473-00			47 k Ω	1/2 W	
R150	302-0271-00			270 Ω	1/2 W	
R151	301-0683-00			68 k Ω	1/2 W	5%
R152	301-0105-00			1 M Ω	1/2 W	5%
R153	302-0103-00	20001	34619	10 k Ω	1/2 W	
R153	302-0470-00	34620		47 Ω	1/2 W	
R154	302-0585-00	X34100		6.8 M Ω	1/2 W	
R155	302-0185-00			1.8 M Ω	1/2 W	

⁴Concentric with R17 and ganged SW 10. Furnished as a unit.

⁵Center Tap.

Ckt. No.	Tektronix Part No.	S/N Range	Description			
Resistors (Cont)						
R156	302-0105-00		1 M Ω	1/2 W		
RI 57	302-0474-00		470 k Ω	1/2 W		
R158	302-0102-00		1 k Ω	1/2 W		
R159	306-0332-00		3.3 k Ω	2 W		
R160A	309-0045-00		100 k Ω	1/2 W	Prec	1%
R1608	309-0051-00		200 k Ω	1/2 W	Prec	1%
R160C	309-0003-00		500 k Ω	1/2 W	Prec	1%
R160D	309-0014-00		1 M Ω	1/2 W	Prec	1%
R1 60E	309-0023-00		2 M Ω	1/2 W	Prec	1%
R160F	309-0087-00		5 M Ω	1/2 W	Prec	1%
R160G	310-0107-00		10M Ω	1 W	Prec	1%
R160H	310-0107-00		10M Ω	1 W	Prec	1%
R160J	310-0505-00		30 M Ω	2 W	Prec	1%
R160T	304-0563-00	X22450	56 k Ω	1 W		
R160V	302-0105-00	X22450	1 M Ω	1/2 W		
R160W	302-0104-00		100 k Ω	1/2 W		
R160X	302-0103-00		10 k Ω	1/2 W		
R160Y ⁶	311-0108-00		20 k Ω , Var	2W	WW	
R160Z	311-0066-00		500 Ω , Var	0.2 W		20%
R164	306-0223-00		22 k Ω	2 W		
R165	306-0223-00		22 k Ω	2 W		
R166	306-0223-00		22 k Ω	2 W		
R167	302-0155-00		1.5 M Ω	1/2 W		
R168	302-0473-00		47 k Ω	1/2 W		
R171	302-0470-00		47 Ω	1/2 W		
R172	302-0470-00		47 Ω	1/2 W		
R173	302-0471-00		470 Ω	1/2 w		
R174	308-0053-00		8 k Ω	5 W	WW	5%
R176	311-0008-00		2 k Ω , Var	2 W		
R178	308-0051-00		4 k Ω	5 W	WW	5%
R180A	302-0474-00		470 k Ω	1/2 W		
R180B	302-0475-00		4.7 M Ω	1/2 W		
R181	302-0475-00		4.7 M Ω	1/2 W		
R183	302-0470-00		47 Ω	1/2 W		
R186	302-0470-00		47 Ω	1/2 W		
R187	302-0470-00		47 Ω	2 W		
R189	306-0563-00		56 k Ω	2 W		
R190	302-0473-00		47 k Ω	1/2 W		
R191	Use 301-0114-00	20001	22449	120 k Ω	1/2 W	
R191	301-0114-00	22450		110k Ω	1/2 W	5%

⁶Concentric with SW160 and SW160Y.

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Resistors (Cont)					
R192	302-0470-00		47 Ω	$\frac{1}{2}$ W	
R193	302-0470-00		47 Ω	$\frac{1}{2}$ W	
R194	304-0472-00		4.7 k Ω	1 W	
R196	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R199	304-0104-00		100 k Ω	1 W	
R210 ⁷	311-0096-00		2 x 100 k Ω , Var	$\frac{1}{2}$ W	
R211	Use 311-0110-00		100 k Ω , Var	0.5 W	20%
R214	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R215	301-0273-00		27 k Ω	$\frac{1}{2}$ W	5%
R216	301-0393-00		39 k Ω	$\frac{1}{2}$ W	5%
R221	302-0101-00		100	$\frac{1}{2}$ W	
R230	304-0223-00		22 k Ω	1 W	
R232	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R233	309-0132-00		5.6 k Ω	$\frac{1}{2}$ W	Prec 1%
R234	309-0159-00		5 k Ω	$\frac{1}{2}$ W	Prec 1%
R235	302-0274-00		270 k Ω	$\frac{1}{2}$ W	
R237	302-0101-00		100	$\frac{1}{2}$ W	
R241	310-0070-00		33 k Ω	1 W	Prec 1%
R243	310-0072-00		30 k Ω	1 W	Prec 1%
R244	308-0108-00		15 k Ω	5 W	WW 5%
R246	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R247	302-0222-00		2.2 k Ω	$\frac{1}{2}$ W	
R248	302-0473-00		47 k Ω	$\frac{1}{2}$ W	
R249	302-0822-00		8.2 k Ω	$\frac{1}{2}$ W	
R250	302-0272-00		2.7 k Ω	$\frac{1}{2}$ W	
R254	316-0106-00	X34100	10M Ω	$\frac{1}{4}$ W	
R260A	312-0567-00		404 k Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R260B	312-0568-00		606 k Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R260C	312-0571-00		1.01 M Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R260D	312-0571-00		4.04 M Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R260E	312-0576-00		6.06 M Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R260F	312-0577-00		10.1 M Ω	$\frac{1}{2}$ W	Prec $\frac{1}{4}$ %
R264	306-0224-00		220 k Ω	2 W	
R267	302-0155-00		1.5 M Ω	$\frac{1}{2}$ W	
R268	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R271	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R274	306-0153-00		15 k Ω	2 W	
R276	Use 311-0016-00	20001 20149	10 k Ω , Var	2 W	
R276	311-0016-00	20150	10 k Ω , Var	2 W	
R277 ⁸	Selected				

⁷Concentric with R67 and ganged with SW210. Furnished as a unit.

⁸See Calibration Procedure.

Ckt. No.	Tektronix Part No.	S/N Range			Description		
Resistors (Cont)							
R278 ⁸	Selected						
R279	306-0123-00			12 kΩ	2 W		
R280	302-0125-00			1.2 M	½ W		
R281	302-0475-00			4.7 MΩ	½ W		
R282	302-0102-00			1 kΩ	½ W		
R283	Use 302-0102-00	20001	21169	1000Ω	½ W		
R283	302-0102-00	21170		1 kΩ	½ W		
R291	302-0101-00			100 Ω	½ W		
R293	306-0823-00			82 kΩ	2 W		
R295	302-0393-00			39 kΩ	½ W		
R296	302-0104-00			100 kΩ	½ W		
R297	302-0101-00			100 Ω	½ W		
R299	302-0103-00			10 kΩ	½ W		
R300	302-0470-00			47 Ω	½ W		
R301C	309-0111-00	20001	34819	900 kΩ	½ W	Prec	1%
R301C	323-0611-00	34820		900 kΩ	½ W	Prec	1%
R301E	309-0046-00	20001	34819	111 kΩ	½ W	Prec	1%
R301E	323-0610-00	34820		111 kΩ	½ W	Prec	1%
R303	302-0105-00			1 MΩ	½ W		
R311	302-0102-00			1 kΩ	½ W		
R313	306-0333-00			33 kΩ	2 W		
R314	Use 311-0571-00			15 kΩ, Var	½ W		
R315	306-0333-00			33 kΩ	2 W		
R317	311-0026-00			100 kg, Var	2 W		20%
R319	302-0224-00			220 kΩ	1/2 W		
R320	302-0332-00			3.3 kΩ	1/2 W		
R321	302-0101-00			100 Ω	1/2 W		
R324	Use 306-0273-00	20001	21169	22 kΩ	2 W		
R324	306-0273-00	21170		27 kΩ	2 W		
R330	309-0017-00			1.5 MΩ	½ W	Prec	1%
R332	309-0086-00			3.5 MΩ	½ W	Prec	1%
R3339	311-0149-00			100 kΩ, Var	2 W		20%
R336	309-0268-00	20001	34059	12.1 MΩ	½ W	Prec	1%
R336	310-0069-00	34060		13 MΩ	1 W	Prec	2%
R338 ⁹	311-0149-00			200 kΩ, Var	2 W		20%
R340	302-0222-00			2.2 kΩ	½ W		
R341	302-0101-00			100 Ω	½ W		
R345	304-0104-00			100 kΩ	1 w		
R347	302-0104-00			100 kΩ	½ W		
R348	311-0125-00			50 kΩ, Var	10.2 W		
R349	Use 309-0091-00	20001	22269	111 kΩ	½ W	Prec	1%
R349	309-0091-00	22270		120 kΩ	½ W	Prec	1%

⁸See Calibration Procedure.

⁹R333 and R338 are concentric. Furnished as a unit.

Ckt. No.	Tektronix Part No.	S/N Range		Description			
Resistors (Cont)							
R351	302-0101-00			100 Ω	½ W		
R353	304-0104-00			100 kΩ	1 W		
R355	310-0094-00			400 kΩ	1 W	Prec	1%
R356	310-0094-00			400 kΩ	1 W	Prec	1%
R357	Use 304-0223-00	20001	24839	22 kΩ	½ W		
R357	304-0223-00	24840		22 kΩ	1 W		
R358	Use 311-0018-00			20 kΩ, Var	2 W		
R361	302-0470-00			47 Ω	½ W		
R364	*310-0506-00			6-25 kΩ	7 W	Prec	1%
R366	302-0470-00			47 Ω	½ W		
R373	304-0222-00			2.2 kΩ	1 W		
R375	311-0008-00			2 kΩ, Var	2 W		
R376	304-0222-00			2.2 kΩ	1 W		
R377	308-0052-00			6 kΩ	5 W	WW	5%
R380	302-0101-00			100 Ω	½ W		
R381	302-0470-00			47 Ω	½ W		
R384	*310-0507-00			6-30 kΩ	7 W	Prec	1%
R386	302-0101-00			100 Ω	½ W		
R387	306-0393-00			39 kΩ	2 W		
R388	306-0393-00			39 kΩ	2 W		
R390	302-0222-00			2.2 kΩ	2 W		
R391	302-0470-00			47Ω	½ W		
R393	302-0391-00			390 Ω	½ W		
R396	302-0474-00			470 kΩ	½ W		
R397	302-0824-00			820 kΩ	½ W		
R398	302-0824-00			820 kΩ	½ W		
R399	302-0474-00			470 kΩ	½ W		
R410	302-0105-00			1 MΩ	½ W		
R411	302-0101-00			100 Ω	½ W		
R415	302-0473-00			47 kΩ	½ W		
R416	302-0123-00			12 kΩ	½ W		
R421	302-0101-00			100 Ω	½ W		
R424	302-0103-00			10 kΩ	½ W		
R425	302-0104-00			100 kΩ	½ W		
R426	302-0473-00			47 kΩ	½ W		
R427	302-0101-00			100 Ω	½ W		
R428	302-0103-00			10 kΩ	½ W		
R431	308-0054-00			10 kΩ	5 W	WW	5%
R432	311-0015-00			10 kΩ, Var	2 W	WW	
R433	311-0022-00			30 kΩ, Var	3 W	WW	1%
R434	302-0104-00			100 kΩ	½ W		
R436	311-0141-00			2 kΩ, Var	2W	WW	5%
R437	308-0108-00			15 kΩ	5W	WW	5%
R441	302-0101-00			100 Ω	½ W		
R443	302-0272-00			2.7 kΩ	½ W		

Ckt. No.	Tektronix Part No.	S/N Range		Description		
Resistors (Cont)						
R444	309-0044-00			95 k Ω	1/2 W	Prec 1%
R446	309-0049-00			150 k Ω	1/2 W	Prec 1%
R447	306-0393-00			39 k Ω	2 W	
R451	302-0101-00			100 Ω	1/2 W	
R453	302-0332-00			3.3 k Ω	1/2 W	
R454	302-0103-00			10 k Ω	1/2 W	
R455	302-0274-00			270 k	1/2 W	
R456	302-0101-00			100	1/2 W	
R457	302-0470-00			47 Ω	1/2 W	
R458	302-0102-00			1 k Ω	1/2 W	
R502	302-0270-00			27 Ω	1/2 W	
R505	305-0681-00			680 Ω	2 W	5%
R506	309-0029-00			1.582 k Ω	1/2 W	Prec 1%
R507	316-0823-00			82 k Ω	1/4 W	
R510	304-0682-00			6.8 k Ω	1 W	
R513	308-0051-00			4 k Ω	5 W	WW 5%
R514	308-0108-00			15 k Ω	5 W	WW 5%
R517	302-0474-00			470 k Ω	1/2 W	
R520	302-0270-00			27 Ω	1/2 W	
R523	309-0029-00			1.582 k Ω	1/2 W	Prec 1%
R524	316-0823-00			82 k Ω	1/4 W	
R528	308-0092-00			4.5 k Ω	5 W	WW 5%
R529	305-0113-00			11 k Ω	2 W	5%
R530	305-0113-00			11 k Ω	2 W	5%
R533	302-0154-00	20001	25049	150 k Ω	1/2 W	
R533	302-0104-00	25050		100 k Ω	1/2 W	
R534	302-0334-00			330 k Ω	1/2 W	
R536	302-0334-00			330 k Ω	1/2 W	
R537	302-0105-00			1 M Ω	1/2 W	
R539	302-0684-00			680 k Ω	1/2 W	
R546	302-0334-00			330 k Ω	1/2 W	
R547	302-0105-00			1 M Ω	1/2 W	
R550	304-0122-00			1.2 k Ω	1 W	
R551	302-0470-00			47 Ω	1/2 W	
R553	*310-0549-00			1.3 k Ω	6 W	Prec 1%
R556	302-0104-00			100 k Ω	1/2 W	
R558	302-0270-00			27 Ω	1/2 W	
R561	302-0470-00			47 Ω	1/2 W	
R563	*310-0549-00			1.3 k Ω	6 W	Prec 1%
R566	302-0104-00			100 k Ω	1/2 W	
R568	302-0270-00			27 Ω	1/2 W	
R570	311-0004-00			200 Ω , Var	2 W	
R573	308-0103-00			2.5 k Ω	5 W	WW 1%
R574	308-0103-00			2.5 k Ω	5 W	WW 1%
R577	302-0101-00			1 00 Ω	1 W	

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Resistors (Cont)					
R580	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R582	305-0512-00		5.1 k Ω	2 W	5%
R583	301-0222-00		2.2 k Ω	$\frac{1}{2}$ W	5%
R585	305-0123-00		12 k Ω	2 W	5%
R586	305-0123-00		12 k Ω	2 W	5%
R587	301-0122-00		1.2 k	$\frac{1}{2}$ W	5%
R588	301-0222-00		2.2 k	$\frac{1}{2}$ W	5%
R590	302-0470-00		47 Ω	$\frac{1}{2}$ W	
R593	308-0027-00		30 k Ω	10 W	WW 5%
R595	302-0682-00		6.8 k Ω	$\frac{1}{2}$ W	
R596	302-0470-00		47 Ω	$\frac{1}{2}$ W	
R597	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R598	306-0223-00		22 k Ω	2 W	
R599	302-0105-00		1 M Ω	$\frac{1}{2}$ W	
R600	304-0120-00		12 Ω	1 W	
R601	308-0142-00		30 Ω	3 W	WW 5%
R602	311-0055-00		50 Ω , Var	2 W	WW
R603	304-0101-00		100 Ω	1 W	
R604	308-0052-00	X24350	6 k Ω	5 W	WW 5%
R605	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R607	302-0470-00		47 Ω	$\frac{1}{2}$ W	
R608	302-0333-00		33 k Ω	$\frac{1}{2}$ W	
R609	302-0101-00		100 Ω	$\frac{1}{2}$ W	
R610	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R615	310-0054-00		68 k Ω	1 W	Prec 1%
R616	311-0015-00		10 k Ω , Var	2 W	WW 20%
R617	310-0086-00		50 k Ω	1 W	Prec 1%
R618	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R621	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R623	302-0474-00		470 k Ω	$\frac{1}{2}$ W	
R625	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R628	302-0275-00		2.7 M	$\frac{1}{2}$ W	
R629	302-0275-00		2.7 M	$\frac{1}{2}$ W	
R633	302-0105-00		1 M Ω	$\frac{1}{2}$ W	
R635	304-0153-00		15 k Ω	1 W	
R636	304-0153-00		15 k Ω	1 W	
R637	302-0154-00		150 k Ω	$\frac{1}{2}$ W	
R638	302-0273-00		27 k Ω	$\frac{1}{2}$ W	
R639	302-0683-00		68 k Ω	$\frac{1}{2}$ W	
R640	304-0100-00		10 k Ω	1 W	
R641	304-0100-00		10 k Ω	1 W	
R643	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R644	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R647	Use 308-0155-00	20001	20089	750 Ω	25W WW 5%
R647	308-0155-00	20090		800 Ω	25W WW 5%

Ckt. No.	Tektronix Part No.	S/N Range		Description			
Resistors (Cont)							
R648	302-0100-00			10	½ W		
R650	310-0056-00			333 kΩ	1 W	Prec	1%
R651	310-0057-00			490 kΩ	1 W	Prec	1%
R663	302-0155-00			1.5 M	½ W		
R667	302-0684-00			680 kΩ	½ W		
R668	302-0473-00			47 kΩ	1/2 W		
R669	302-0393-00			39 kΩ	1/2 W		
R670	306-0100-00			10 Ω	2 W		
R675	Use 308-0147-00	20001	20199	750 Ω	10 W	WW	5%
R675	308-0147-00	20200		750 Ω	25 W	WW	5%
R676	308-0055-00			1.5 kΩ	10 W	WW	5%
R677	Use 308-0040-00	20001	20089	1.25 kΩ	25W	WW	5%
R677	308-0040-00	20090		1.5 kΩ	25 W	WW	5%
R680	310-0056-00			333 kΩ	1 W	Prec	1%
R681	310-0055-00			220 kΩ	1 W	Prec	1%
R682	302-0124-00			120 kΩ	½ W		
R683	302-0102-00			1 kΩ	½ W		
R685	304-0823-00			82 kΩ	1 W		
R686	302-0184-00			180 kΩ	½ W		
R688	302-0155-00			1.5 MΩ	½ W		
R689	302-0225-00			2.2 MΩ	½ W		
R693	302-0155-00			1.5 MΩ	½ W		
R697	302-0105-00			1 MΩ	½ W		
R698	302-0274-00			270 kΩ	½ W		
R699	302-0563-00			56 kΩ	½ W		
R700	306-0100-00			10 Ω	2 W		
R710	Use 310-0124-00			237 kΩ	1 W	Prec	1%
R711	Use 323-0385-00			100 kΩ	½ W	Prec	1%
R712	302-0154-00			150 kΩ	½ W		
R723	302-0155-00			1.5 MΩ	½ W		
R727	302-0105-00			1 MΩ	½ W		
R728	302-0564-00			560 kΩ	½ W		
R729	302-0473-00			47 kΩ	½ W		
R730	304-0100-00			10 Ω	1 W		
R731	304-0100-00			10 Ω	1 W		
R732	306-0823-00			82 kΩ	2 W		
R734	302-0102-00			1 kΩ	½ W		
R736	308-0041-00			2.4 kΩ	25 W	WW	5%
R737	308-0041-00			2.4 kΩ	25 W	WW	5%
R740	310-0055-00			220 kΩ	1 W	Prec	1%
R741	310-0059-00			720 kΩ	1 W	Prec	1%
R753	302-0105-00			1 MΩ	½ W		
R757	302-0154-00			150 kΩ	½ W		
R758	302-0124-00			120 kΩ	½ W		
R759	302-0273-00			27 kΩ	½ W		

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Resistors (Cont)					
R760	302-0100-00		10 Ω	$\frac{1}{2}$ W	
R767	308-0113-00		3 k Ω	8 W	WW
R780	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R785	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R801	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R802	306-0391-00		390 Ω	2 W	
R803	306-0563-00		56 k Ω	2 W	
R806	302-0104-00		100 k Ω	$\frac{1}{2}$ W	
R807	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R814	302-0474-00		470 k Ω	$\frac{1}{2}$ W	
R818	302-0185-00	X25050	1.8 M Ω	$\frac{1}{2}$ W	
R819	302-0185-00	X25050	1.8 M Ω	$\frac{1}{2}$ W	
R820	302-0473-00		47 k Ω	$\frac{1}{2}$ W	
R822	302-0333-00	X25050	33 k Ω	$\frac{1}{2}$ W	
R824	306-0475-00		4.7 M Ω	2 W	
R825	306-0475-00		4.7 M Ω	2 W	
R826	311-0041-00		1 M Ω , Var	$\frac{1}{2}$ W	
R827	302-0104-00	20001	100 k Ω	$\frac{1}{2}$ W	
R827	302-0333-00	21980	33 k Ω	$\frac{1}{2}$ W	
R828	302-0105-00		1 M Ω	$\frac{1}{2}$ W	
R829	302-0223-00	X25050	22 k Ω	$\frac{1}{2}$ W	
R836	302-0105-00		1 M Ω	$\frac{1}{2}$ W	
R840	311-0042-00		2 M Ω , Var	2 W	
R841	302-0225-00		2.2 M Ω	$\frac{1}{2}$ W	
R842	302-0475-00		4.7 M Ω	$\frac{1}{2}$ W	
R843	302-0475-00		4.7 M Ω	$\frac{1}{2}$ W	
R844	302-0475-00		4.7 M Ω	$\frac{1}{2}$ W	
R845	302-0103-00		10 k Ω	$\frac{1}{2}$ W	
R847	302-0273-00		27k Ω	$\frac{1}{2}$ W	
R848	302-0105-00		1 MD Ω	$\frac{1}{2}$ W	
R853	306-0225-00		2.2 M Ω	2 W	
R854	306-0225-00		2.2 M Ω	2 W	
R856	311-0043-00		2 M Ω , Var	2 W	
R857	306-0105-00		1 M Ω	2 W	
R861	311-0026-00		100 k Ω , Var	2 W	20%
R864	311-0023-00		50 k Ω , Var	2 W	
R870	302-0154-00		150 k Ω	$\frac{1}{2}$ W	
R871	302-0275-00		2.7 M Ω	$\frac{1}{2}$ W	
R872	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R874	302-0395-00		3.9 M Ω	$\frac{1}{2}$ W	
R875	302-0683-00		68 k Ω	$\frac{1}{2}$ W	
R876	302-0102-00		1 k Ω	$\frac{1}{2}$ W	
R878	304-0333-00		33 k Ω	1 W	
R879	311-0016-00		10 k Ω , Var	2 W	
R880	302-0104-00		100 k Ω	$\frac{1}{2}$ W	

Electrical Parts List-Type 535A

Ckt. No.	Tektronix Part No.	S/N Range	Description				
Resistors (Cont)							
RB83	302-0101-00		100 Ω	½ W			
R885	309-0121-00		9.5 kΩ	½ W	Prec	1%	
R886	309-0119-00		6.375 kΩ	½ W	Prec	1%	
R887	309-0117-00		2.1 kΩ	½ W	Prec	1%	
R888	309-0116-00		1.025 kΩ	½ W	Prec	1%	
R889	309-0113-00		610 Ω	½ W	Prec	1%	
R890	309-0073-00		200 Ω	½ W	Prec	1%	
R891	309-0112-00		100 Ω	½ W	Prec	1%	
R892	309-0067-00		60 Ω	½ W	Prec	1%	
R893	309-0066-00		40 Ω	½ W	Prec	1%	
R896	309-0045-00		100 kΩ	½ W	Prec	1%	
R897	309-0112-00		100 Ω	½ W	Prec	1%	
R898	302-0101-00		100 Ω	½ W			
R899	*308-0090-00		0.25 Ω	1 W	WW		
Switches							
Wired or Unwired							
SW10A	Use	Wired *262-0561-00		TRIGGER SLOPE	} TIME BASE A		
SW10A		260-0099-00					
SW10B	Use	Wired *262-0561-00		TRIGGERING MODE			
SW10B		260-0099-00					
SW60A ¹⁰	Use	Wired *262-0562-00		TRIGGER SLOPE	} TIME BASE B		
SW60A ¹⁰		260-0261-00					
SW60B ¹⁰	Use	Wired *262-0562-00		TRIGGERING MODE			
SW60B ¹⁰		260-0261-00					
SW103		260-0017-00		RESET, push button, SPSI			
SW110 ¹¹		311-0096-00		PRESET TIME BASE A			
SW160 ¹²	Wired	*262-0206-00					
SW160 ¹²		260-0230600	20001	20079	TIME/CM (TIME BASE A)		
SW160 ¹²	Wired	*262-0245-00					
SW160 ¹²		260-0230-00	20080	34269	TIME/CM (TIME BASE A)		
SW160 ¹²	Wired	*262-0245-01					
SW160 ¹²		260-02530-00	34270		TIME/CM (TIME BASE A)		
SW160Y		311-0108-00					
SW210 ¹³		311-0096-00			PRESET TIME BASE B		
SW260	Wired	*262-0208-00					
5W260		26020260800	20001	34269	TIME/CM or DELAY TIME (TIME BASE B)		
SW260		260-0260-00					
SW260		260-0208-01	34270		TIME/CM or DELAY TIME (TIME BASE B)		
SW260		260-0260-00					
SW301 ¹⁴	Use	Wired *262-0531-00	20001	34819	HORIZONTAL DISPLAY (front)		
SW301 ¹⁴		Use 260-0502-00					
SW3U1 ¹⁴	Wired	*262-0655-00	34820		HORIZONTAL DISPLAY (front)		

¹⁰SW60A and SW60B are concentric controls.

¹¹Concentric with R17 and ganged with R10. Furnished as a unit.

¹²Concentric with R160Y and SW160Y.

¹³Concentric with R67 and ganged with R210. Furnished as a unit.

¹⁴SW301 and SW347A are ganged.

Electrical Parts List-Type 535A

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Switches (Cont)					
	Use				
SW347A ¹⁵	Wired *050-0079-00	20001	31259		
SW347A ¹⁵	Use *050-0078-00	20001	31259	HORIZONTAL DISPLAY	
SW347A ¹⁵	Wired *262-0534-00	31260			
SW347A ¹⁵	260-0503-00	31260		HORIZONTAL DISPLAY	
	Use				
SW347B ¹⁶	Wired *050-0079-00	20001	31259		
SW347B ¹⁶	Use *050-0078-00	20001	31259	5X MAGNIFIER	
SW347B ¹⁶	Wired *262-0534-00	31260			
SW347B ¹⁶	260-0503-00	31260		5X MAGNIFIER	
SW601	260-0134-00			POWER ON, SPST	
SW848	260-0209-00			CRT CATHODE SELECTOR, SPDT	
SW870	Wired 262-0207-00			AMPLITUDE CALIBRATOR	
SW870	260-0253-00			AMPLITUDE CALIBRATOR	
Transformers					
T601	Use *120-0140-00			L. V. Power Transformer, Domestic and Export Voltage Range	
T801	*120-0036-00			High-Voltage Oscillator Transformer	
Thermal Cutout					
TK601	260-0208-00			133° F	
Vacuum Tubes					
V24	154-0187-00			6DJ8	
V45	154-0187-00			6DJ8	
V74	154-0187-00			6DJ8	
V95	154-0187-00			6DJ8	
V114	154-0022-00			6AU6	
V125	154-0022-00			6AU6	
V133	154-0187-00			6DJ8	
V135	154-0187-00			6DJ8	
V145	154-0047-00			12BY7	
V152	Use *157-0104-02	20001	33899	6AL5	Selected
V152	154-0016-00	33900		6AL5	
V154	154-0187-00			6DJ8	
V161	154-0031-00			6CL6	
V173	154-0187-00			6DJ8	
V183	154-0187-00			6DJ8	

¹⁵SW301 and SW347A are ganged.

¹⁶SW347B concentric with SW301 and SW347A.

Electrical Parts List-Type 535A

Ckt. No.	Tektronix Part No.	S/N Range	Description		
Vacuum Tubes (Cont)					
V193	154-0187-00			6DJ8	
V233	154-0187-00			6DJ8	
V235	154-0187-00			6DJ8	
V245	154-0022-00			6AU6	
V252	Use *157-0075-00	20001	33899	12AL5	Checked
V252	154-0038-00	33900		12AL5	
V261	154-0040-00	20001	33849	12AU6	
V261	154-0040-00	33850		8426	
V283	154-0187-00			6DJ8	
V293	154-0187-00			6DJ8	
V314	154-0187-00			6DJ8	
V343	154-0187-00			6DJ8	
V364	154-0187-00			6DJ8	
V384	154-0187-00			6DJ8	
V398	154-0031-00			6CL6	
V414	154-0022-00			6AU6	
V424	154-0022-00			6AU6	
V428	154-0187-00			6DJ8	
V445	154-0187-00			6DJ8	
V504 ¹⁷	*157-0053-00			12BY7	Checked
V524 ¹⁷	* 157-0053-00			12BY7	Checked
V533	154-0187-00			6DJ8	
V543	154-0187-00			6DJ8	
V554	154-0146-00			6197	
V564	154-0146-00			6197	
V584	154-0187-00			6DJ8	
V593	154-0187-00			6DJ8	
V609	154-0052-00			5651	
V624	154-0043-00			12AX7	
V627	154-0044-00			12B4	
V634	154-0022-00			6AU6	
V637	154-0044-00			12B4	
V647	154-0044-00			12B4	
V664	154-0022-00			6AU6	
V677	154-0056-00			6080	
V684	154-0043-00			12AX7	
V694	154-0022-00			6AU6	
V724	154-0022-00			6AU6	
V737	154-0056-00			6080	
V754	154-0022-00			6AU6	

¹⁷V504 and V524 furnished as a unit.

Electrical Parts List-Type 535A

Ckt. No.	Tektronix Part No.	S/N Range	Description
Vacuum Tubes (Cont)			
V767	154-0044-00		12B4
V800	154-0021-00		6AU5
V814	154-0041-00		12AU7
V822	154-0051-00		5642
V832	154-0051-00		5642
V842	154-0051-00		5642
V852	154-0051-00		5642
V859	*154-0165-00		T5330-2 Standard Phosphor
V862	154-0051-00		5642
V875	154-0022-00		6AU6
V885	154-0041-00		12AU7

Mechanical Parts List-Type 535A

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS
(Located behind diagrams)

- FIG. 1 FRONT & SWITCHES
- FIG. 2 REAR & DELAY LINE
- FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD & DELAY SWEEP CHASSIS
- FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE
- FIG. 5 VERTICAL AMPLIFIER CHASSIS & PLUG-IN HOUSING
- FIG. 6 CATHODE RAY TUBE SHIELD, FOCUS & INTENSITY CHASSIS
- FIG. 7 CABINET & FRAME RAILS
- FIG. 8 ACCESSORIES

SECTION 8

MECHANICAL PARTS LIST
FIG. 1 FRONT & SWITCHES

Note: Order parts through normal supply channels.

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-1	333-0479-00			1	PANEL, front
	-----			-	mounting hardware: (not included w/panel)
-2	213-0088-00			1	SCREW, thread forming, 4-40 x 1/4 inch, PHS
-3	200-0382-00			1	COVER, graticule
	-----			-	cover includes:
	354-0116-00			1	RING, ornamental
	-----			-	mounting hardware: (not included w/cover)
-4	210-0816-00			4	WASHER, rubber, 0.200 IDx0.620 inch OD
-5	210-0424-00			4	NUT, knurled, 3/8-24 x 0.550 inch
-6	337-0187-00			1	SHIELD, graticule light
-7	331-0037-00			1	GRATICULE
-8	401-0004-00			1	CAM, plastic
	-----			-	mounting hardware: (not included w/cam)
-9	213-0012-00			1	SCREW, thread cutting, 4-40 x 3/8 inch, FHS
-10	129-0051-00			1	ASSEMBLY, binding post
	-----			-	assembly includes:
-11	355-0507-00			1	STEM, binding post
-12	200-0182-00			1	CAP, binding post
	-----			-	mounting hardware: (not included w/assembly)
-13	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-14	210-0455-00			1	NUT, hex., 1/4-28 x 3/8 inch
-15	129-0036-00	20001	33159	6	POST, binding, black
	129-0063-00	33160		6	POST, binding, charcoal
	-----			-	mounting hardware for each: (not included w/post)
-16	358-0036-00	20001	33159	1	BUSHING, plastic, black
	358-0169-00	33160		1	BUSHING, plastic, charcoal
	210-0206-00	20001	31419X	1	LUG, solder, SE #10
	210-0010-00	20001	31419X	1	LOCKWASHER, internal, #10
	210-0445-00	20001	31419	2	NUT, hex., 10-32 x 3/8 inch
-17	220-0410-00	31420		1	NUT, keps, 10-32 x 3/8 inch
-18	131-0064-00	20001	31259	1	CONNECTOR, coaxial, 1 contact, UHF
	131-0279-00	31260		1	CONNECTOR, coaxial, 1 contact, BNC
	-----			-	mounting hardware: (not included w/connector)
-19	406-0244-00			1	BRACKET, plastic, insulating
-20	211-0025-00			2	SCREW, 4-40 x 3/8 inch, 100° csk, FHS
	210-0812-00			2	WASHER, fiber, 0.190 ID x 0.380 inch OD
	210-0224-00			2	LUG, solder, SE #10, non-locking
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-21	210-0961-00	X31260	31808X	1	WASHER, plastic, 3/8 ID x 13/16 inch OD
-22	378-0518-00			1	JEWEL, pilot light
-23	136-0025-00			1	SOCKET, light (includes hardware)
-24	260-0134-00			1	SWITCH, toggle-POWER ON
	-----			-	switch includes:
-25	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch
	-----			-	mounting hardware: (not included w/switch)
-26	354-0055-00			1	RING, locking
	210-0902-00			1	WASHER, flat, 0.470 ID x 2/32 inch OD
-27	210-0473-00			1	NUT, 12 sided, 15/32-32 x 0.634 inch
-28	366-0038-00			1	KNOB, red-VERNIER
	213-0004-00			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-29	366-0040-00	20001	33159	1	KNOB, black-HORIZONTAL POSITION
	366-0160-00	33160		1	KNOB, charcoal-HORIZONTAL POSITION
	213-0004-00			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16, inch, HSS
-30	-----			7	RESISTOR, variable
	-----			-	mounting hardware for each: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-31	331-0022-00	20001	33159	1	DIAL, black-DELAY-TIME MULTIPLIER
	331-0091-00	33160		1	DIAL, charcoal-DELAY-TIME MULTIPLIER
	-----			-	dial includes:
	-----			1	SCREW, set, 4-40 x 3/8 inch, HSS
-32	-----			1	RESISTOR, variable (includes hardware)
-33	366-0060-00	20001	33159	1	KNOB, black-AMPLITUDE CALIBRATOR
	366-0115-00	33160		1	KNOB, charcoal-AMPLITUDE CALIBRATOR
	213-0004-00			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-34	262-0207-00			1	SWITCH, wired-AMPLITUDE CALIBRATOR
	260-0253-00			-	switch includes:
	260-0253-00			1	SWITCH, unwired
-35	210-0207-00	X29279		1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
	-----			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-36	343-0013-00	X21170		1	CLAMP, plastic, 3/8 inch
	-----			-	mounting hardware: (not included w/clamp)
-37	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-38	129-0053-00			1	ASSEMBLY, binding post assembly includes:
-39	355-0507-00			1	STEM, binding post
-40	200-0103-00			1	CAP, binding post mounting hardware: (not included w/assembly)
-41	210-0223-00			1	LUG, solder, 1/4 ID x 7/16, inch OD, SE
-42	210-0455-00	20001	21169	1	NUT, hex., 1/4-28 x 3/8 inch
	385-0142-00	21170		1	ROD, .hex., 1/4-28 x 3/8 x 5/8 inch long
-43	366-0038-00			1	KNOB, red-LENGTH knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-44	366-0058-00	20001	33159	1	KNOB, black-TIME/CM or DELAY TIME
	366-0144-00	33160		1	KNOB, charcoal-TIME/CM or DELAY TIME knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-45	262-0208-00	20001	34269	1	SWITCH, wired-TIME/CM or DELAY TIME
	262-0208-01	34270		1	SWITCH, wired-TIME/CM or DELAY TIME switch includes:
	260-0260-00			1	SWITCH, unwired
-46	384-0180-00			1	ROD, extension
-47	376-0014-00			1	COUPLING, wire
-48	386-0450-00	20001	20449	1	PLATE, switch
	406-0497-00	20450		1	BRACKET, switch mounting hardware: (not included w/bracket)
-49	210-0017-00			2	LOCKWASHER, spring, #5
-50	210-0449-00			2	NUT, hex., 5-40 x 1/4 inch
-51	-			1	RESISTOR, variable .-mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch mounting hardware: (not included w/switch)
-52	210-0803-00	X20450		4	WASHER, flat, 0.150 ID x 3/8 inch OD
-53	210-0407-00	X20450		2	NUT, hex., 6-32 x 1/4 inch
	210-0457-00	X20450		2	NUT, keps, 6-32 x 5/16, inch
-54	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch. OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-55	131-0081-00	20001	31259	2	CONNECTOR, coaxial, 1 contact, UHF (includes hardware)
	131-0126-00	31260		2	CONNECTOR, coaxial, 1 contact, BNC (includes hardware)
-56	352-0006-00	20001	33659	3	HOLDER, neon, double, black
	352-0064-00	33660		3	HOLDER, neon, double, gray mounting hardware for each: (not included w/holder)
-57	211-0031-00	20001	33659	1	SCREW, 4-40 x 1 inch, 100° csk, FHS
	211-0109-00	33660		1	SCREW, 4-40 x 7/8 inch, 100° csk, FHS
-58	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
1-59	378-0541-00	X33660		9	FILTER, lens, neon
-60	366-0038-00			2	KNOB, red-TRIGGERING MODE
				-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-61	366-0040-00	20001	33159	2	KNOB, black-TRIGGER SLOPE
	366-0160-00	33160		2	KNOB, charcoal-TRIGGER SLOPE
				-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-62	262-0174-00	20001	31259	1	SWITCH, wired-TRIGGER (TIME BASE A)
	262-0561-00	31260		1	SWITCH, wired-TRIGGER (TIME BASE A)
					switch includes:
	260-0099-00			1	SWITCH, unwired
				-	*mounting hardware: (not included w/switch)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-63	262-0209-00	20001	31259	1	SWITCH, wired-TRIGGER (TIME BASE B)
	262-0562-00	31260		1	SWITCH, wired-TRIGGER (TIME BASE B)
					switch includes:
	260-0261-00			1	SWITCH, unwired
				-	mounting hardware: (not included w/switch)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-64				2	RESISTOR, variable
					mounting hardware for each: (not included w/resistor)
-65	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-66	210-0471-00			1	NUT, hex., 1/4-32 x 5/16 x 19/32 inch long
-67	210-0223-00			1	LUG, solder, 1/, ID x 7/16 inch OD, SE
-68	358-0054-00			1	BUSHING, banana lack, 1/4-32 x 0.375 x 0.406 inch long
-69	366-0033-00	20001	33159	1	KNOB, black-VARIABLE 10-1
	366-0148-00	33160		1	KNOB, charcoal-VARIABLE 10-1
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-70	366-0039-00			2	KNOB, red-STABILITY
				-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-71	366-0046-00	20001	33159	2	KNOB, black-TRIGGERING LEVEL
	366-0159-00	33160		2	KNOB, charcoal-TRIGGERING LEVEL
				-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-72	366-0033-00	20001	33159	1	KNOB, black-SCALE ILLUM.
	366-0148-00	33160		1	KNOB, charcoal-SCALE ILLUM.
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-73	366-0033-00	20001	33159	1	KNOB, black-ASTIGMATISM
	366-0148-00	33160		1	KNOB, charcoal-ASTIGMATISM
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-74	366-0033-00	20001	33159	1	KNOB, black-INTENSITY
	366-0148-00	33160		1	KNOB, charcoal-INTENSITY
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-75	366-0033-00	20001	33159	1	KNOB, black-FOCUS
	366-0148-00	33160		1	KNOB, charcoal-FOCUS
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-76	366-0038-00			1	KNOB, red-VARIABLE
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16, inch, HSS
-77	366-0058-00	20001	33159	1	KNOB, black-TIME/CM
	366-0144-00	33160		1	KNOB, charcoal-TIME/CM
				-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16, inch, HSS
-78	262-0206-00	20001	20079	1	SWITCH, wired-TIME/CM
	262-0245-00	20080	34269	1	SWITCH, wired-TIME/CM
	262-0245-01	34270		1	SWITCH, wired-TIME/CM
					switch includes:
	260-0230-00			1	SWITCH, unwired
-79	384-0162-00			1	ROD, extension
-80	376-0014-00			1	COUPLING, wire
-81	406-0449-00			1	BRACKET, switch
					mounting hardware: (not included w/bracket)
	210-0202-00			1	LUG, solder, SE #6
	210-0017-00	20001	26869	1	LOCKWASHER, spring, #5
	210-0203-00	26870		1	LUG, solder, SE #6, long
	210-0449-00			2	NUT, hex., 5-40 x 1/4 inch
-82				1	RESISTOR, variable
					mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
-83				1	RESISTOR, variable
					mounting hardware: (not included w/resistor)
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
					mounting hardware: (not included w/switch)
-84	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	210-0803-00			4	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
-85	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-86	366-0038-00			1	KNOB, red-MAGNIFIER knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16, inch, HSS
-87	366-0040-00	20001	33159	1	KNOB, black-HORIZONTAL DISPLAY
	366-0160-00	33160		1	KNOB, charcoal-HORIZONTAL DISPLAY
				-	-knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-88	262-0210-00	20001	31259	1	SWITCH, wired-HORIZONTAL DISPLAY (front)
	262-0531-00	31260	34819	1	SWITCH, wired-HORIZONTAL DISPLAY (front)
	262-0655-00	34820		1	SWITCH, wired-HORIZONTAL DISPLAY (front)
				-	switch includes:
	260-0262-00	20001	31259	1	SWITCH, unwired
	260-0502-00	31260		1	SWITCH, unwired
-89	337-0279-00			1	SHIELD, switch
				-	mounting hardware: (not included w/shield)
	211-0007-00			2	SCREW, 4-40 x 3/16 inch, PHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
				-	-mounting hardware: (not included wswitch)
	210-0013-00			1	LOCKWASHER, internal, 3/8 ID x 11/16, inch OD
-90	210-0413-00			1	NUT, hex., 38-32 x 1/2 inch
-91	376-0007-00			1	COUPLING
					coupling includes:
	213-0005-00			2	SCREW, set, 8-32 x 1/8 inch, HSS
-92	262-0211-00	20001	22269	1	SWITCH, wired-HORIZONTAL DISPLAY (rear)
	262-0312-00	22270	31259	1	SWITCH, wired-HORIZONTAL DISPLAY (rear)
	262-0534-00	31260		1	SWITCH, wired-HORIZONTAL DISPLAY (rear)
					switch includes:
	260-0263-00	20001	31259	1	SWITCH, unwired
	260-0503-00	31260		1	SWITCH, unwired
-93	406-0450-00			1	BRACKET, component mounting
					mounting hardware: (not included w/bracket)
-94	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-95	210-0004-00			2	LOCKWASHER, internal, #4
-96	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-97				1	RESISTOR, variable
					mounting hardware: (not included w/resistor)
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-98				1	CAPACITOR, variable
				-	-mounting hardware: (not included w/capacitor)
	211-0013-00			2	SCREW, 4-40 x 3/8 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
					mounting hardware: (not included w/switch)
-99	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-10	0 210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-101	210-0413-00			1	NUT, hex., 3/8-32x 1/2 inch

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-102	406-0451-00			1	BRACKET, switch mounting hardware: (not included w/bracket)
	211-0510-00			2	SCREW, 6-32x 3/8 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-10	3	348-0002-00		3	GROMMET, rubber, 1/4 inch diameter
-10	4	348-0003-00		1	GROMMET, rubber, 5/16 inch diameter
-10	5	210-0202-00		2	LUG, solder, SE #6 mounting hardware for each: (not included w/lug)
		211-0503-00		1	SCREW, 6-32 x 3/16 inch, PHS
-10	6	260-0017-00		1	SWITCH, pushbutton-RESET mounting hardware: (not included w/switch)
		210-0207-00		1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
		210-0012-00		1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-107		210-0840-00		1	WASHER, flat, 0.390 ID x 9/16 inch OD
-108		210-0413-00		2	NUT, hex., 3/8-32 x 1/2 inch
-109		129-0053-00		1	ASSEMBLY, binding post assembly includes:
-110		355-0507-00		1	STEM, binding post
-111		200-0103-00		1	CAP, binding post mounting hardware: (not included w/assembly)
-112		210-0046-00		1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
		210-0455-00		1	NUT, hex., 1/4-28 x 3/8 inch
-113		352-0008-00	20001	3	HOLDER, neon, single, black
		352-0067-00	33660	3	HOLDER, neon, single, gray mounting hardware for each: (not included w/holder)
-114		211-0031-00	20001	1	SCREW, 4-40 x 1 inch, 100° csk, FHS
		211-0109-00	33660	1	SCREW, 4-40 x 7/8 inch, 100° csk, FHS
		210-0406-00		2	NUT, hex., 4-40 x 3/16 inch
-115		343-0004-00		1	CLAMP, plastic, 5/16 inch mounting hardware: (not included w/clamp)
		212-0023-00		1	SCREW, 8-32 x 3/8 inch, PHS
		210-0804-00		1	WASHER, flat, 0.170 ID x 3/8 inch OD
-116		384-0527-00		1	ROD, spacing
		210-0007-00		1	LOCKWASHER, external, #8
		212-0040-00		1	SCREW, 8-32 x 3/8 inch, 100° csk, FHS

Mechanical Parts List – Type 535A

FIG. 1 FRONT & SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
1-117	385-0074-00	20001	24879	1	ROD, plastic, 1 inch high
	385-0135-00	24880		1	ROD, plastic, 15/16, inch high
	211-0538-00	20001	24879	1	mounting hardware: (not included w/rod)
	213-0068-00	24880		1	SCREW, 6-32 x 5/16, inch, 100° csk, FHS
-118				1	SCREW, thread cutting, 6-32 x 5/16 inch, 100° csk, FHS
				1	RESISTOR, variable
	210-0207-00			1	mounting hardware: (not included w/resistor)
	210-0012-00			1	LUG, solder, 3/8 ID x 5/8 inch OD, SE
	210-0840-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0413-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
				1	NUT, hex., 3/8-32 x 1/2 inch
-119	386-0888-00			1	PLATE, sub-panel
					plate includes:
-120	354-0056-00			1	RING, ornamental
-121	355-0043-00			4	STUD, graticule (replacement)
				-	each stud includes:
	212-0507-00			1	SCREW, 10-32 x 3/8 inch, PHS
	210-0010-00			1	LOCKWASHER, internal, #10

Mechanical Parts List – Type 535A

FIG. 2 REAR & DELAY LINE

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-	636-0413-00			1	ASSEMBLY, delay line assembly includes:
-1	4 41-0176-00			1	CHASSIS, horizontal, outside
-2	3 86-0679-00	20001	31709	1	PLATE, horizontal
	387-0789-00	31710		1	PLATE, horizontal mounting hardware: (not included w/plate)
-3	2 11-0510-00			3	SCREW, 6-32 x 3/8 inch, PHS
-4	4 41-0114-00			1	CHASSIS, horizontal, inside
-5	3 52-0013-00			5	HOLDER, coil form
-6	3 43-0002-00			1	CLAMP, plastic, 3/16 inch mounting hardware: (not included w/clamp)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-7	4 06-0175-00			1	BRACKET, coil mounting hardware: (not included w/bracket)
	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-8	166-0103-00			2	TUBE, retaining, coil form
-9	175-0585-00			1	WIRE, CRT lead, 0.290 foot, striped brown wire includes:
	131-0049-00			1	CONNECTOR, CRT contact
	175-0593-00			1	WIRE, CRT lead, 0.333 foot, striped blue wire includes:
	131-0049-00			1	CONNECTOR, CRT contact
-10	441-0115-00			1	CHASSIS, vertical, inside
-11	386-0678-00	20001	31709	1	PLATE, vertical
	387-0788-00	31710		1	PLATE, vertical mounting hardware: (not included w/plate)
-12	211-0510-00			3	SCREW, 6-32 x 3/8 inch, PHS
-13	441-0177-00			1	CHASSIS, vertical, outside mounting hardware: (not included w/chassis)
-14	211-0565-00			2	SCREW, 6-32 x 1/4 inch, THS mounting hardware: (not included w/assembly)
-15	211-0537-00			3	SCREW, 6-32 x 3/8 inch, THS
-16	131-0102-00	20001	34189	1	ASSEMBLY, motor base connector
	131-0102-01	34190		1	ASSEMBLY, motor base connector assembly includes:
-17	129-0041-00	20001	34189	1	POST, ground
	129-0041-01	34190		1	POST, ground
-18	211-0015-00	20001	34189	1	SCREW, 4-40 x 1/2 inch, RHS
	213-0088-00	34190		1	SCREW, thread forming, 4-40x 1/4 inch, PHS
-19	200-0185-00	20001	34189	1	COVER, plastic
	200-0185-01	34190		1	COVER, plastic
-20	214-0078-00			2	PIN, connecting
-21	377-0041-00	20001	34189	1	INSERT, plastic
	377-0051-00	34190		1	INSERT, plastic
-22	386-0933-00			1	PLATE
-23	210-0003-00	20001	34189X	2	LOCKWASHER, external, #4
-24	210-0551-00	20001	34189X	2	NUT, hex., 4-40 x 1/4 inch
	211-0132-00	X34190		1	SCREW, 4-40 x 1/2 inch, RHS mounting hardware: (not included w/assembly)
-25	211-0537-00			2	SCREW, 6-32 x 3/8 inch, THS
-26	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch

Mechanical Parts List – Type 535A

FIG. 2 REAR & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-27	635-0409-00			1	ASSEMBLY, fan motor assembly includes:
-28	354-0053-00			1	RING, fan
-29	369-0007-00			1	FAN, 5 blade fan includes:
	213-0007-00			1	SCREW, set, 10-32 x 1/4 inch, HSS
-30	147-0001-00			1	MOTOR, fan - mounting hardware: (not included w/motor)
-31	355-0044-00			2	STUD, 10-32 x 27/16 inches
-32	210-0010-00			6	LOCKWASHER, internal, #10
-33	210-0410-00			4	NUT, hex., 10-32 x 5/16 inch
-34	426-0047-00			1	MOUNT, fan motor
-35	348-0008-00			3	SHOCKMOUNT, rubber - mounting hardware for each: (not included w/shockmount)
-36	210-0008-00			2	LOCKWASHER, internal, #8
-37	210-0409-00			2	NUT, hex., 8-32 x 5/16 inch - mounting hardware: (not included w/assembly)
-38	213-0104-00			6	SCREW, thread forming, 6-32 x 3/8 inch, THS
-39	334-0649-00			1	TAG, voltage rating mounting hardware: (not included w/tag)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch, PHS
-40	352-0002-00			1	ASSEMBLY, fuse holder assembly includes:
-41	352-0010-00			1	HOLDER, fuse
-42	200-0582-00			1	CAP, fuse
-43	210-0873-00			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
-44				1	NUT, fuse holder
-45	406-0435-00			1	BRACKET, resistor mounting hardware: (not included w/bracket)
-46	211-0537-00			2	SCREW, 6-32 x 3/8 inch, THS
-47				1	RESISTOR mounting hardware: (not included w/resistor)
-48	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches, Fil HS
-49	210-0008-00			1	LOCKWASHER, internal, #8
-50	210-0809-00			1	WASHER, centering, 0.173 ID x 5/8 inch OD
-51	210-0462-00			1	NUT, hex., resistor
-52	210-0228-00			1	LUG, solder, SE #8, long
-53	212-0004-00			1	SCREW, 8-32 x 5/16 inch, PHS

Mechanical Parts List – Type 535A

FIG. 2 REAR & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-54				1	RESISTOR
				-	mounting hardware: (not included w/resistor)
	211-0553-00	20001	20199	1	SCREW, 6-32 x 1 1/2 inches, RHS
	212-0037-00	20200		1	SCREW, 8-32 x 1 3/4 inches, Fil HS
	210-0601-00	20001	20199	1	EYELET, 0.183 ID x 0.323 inch OD
	210-0808-00	20200		1	WASHER, centering, 0.173 ID x 9/16 inch OD
	210-0478-00	20001	20199	1	NUT, hex., resistor
	210-0462-00	20200		1	NUT, hex., resistor
	211-0507-00	20001	20199	1	SCREW, 6-32 x 5/16, inch, PHS
	212-0004-00	20200		1	SCREW, 8-32 x 5/16, inch, PHS
-55				1	RESISTOR
					mounting hardware: (not included w/resistor)
-56	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
-57	210-0601-00			1	EYELET, 0.183 ID x 0.323 inch OD
-58	210-0478-00			1	NUT, hex., resistor
-59	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-60				3	RESISTOR
				-	mounting hardware for each: (not included w/resistor)
-61	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches, Fil HS
-62	210-0008-00			1	LOCKWASHER, internal, #8
-63	210-0809-00			1	WASHER, centering, 0.173 ID x 5/8 inch OD
-64	210-0462-00			1	NUT, hex., resistor
-65	212-0004-00			1	SCREW, 8-32 x 5/16 inch, PHS
-66				1	RESISTOR
					mounting hardware: (not included w/resistor)
-67	211-0516-00			1	SCREW, 6-32 x 7/8 inch, PHS
-68	210-0886-00			1	WASHER, centering, 0.170 ID X3/ inch OD
-69	210-0805-00			1	WASHER, flat, 0.204 ID x 7/16 inch OD
-70	210-0478-00			1	NUT, hex., resistor
-71	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-72	378-0011-00			1	FILTER, air
-73	380-0008-00	20001	22599	1	HOUSING, air filter
	380-0018-00	22600		1	HOUSING, air filter
				-	mounting hardware: (not included w/housing)
-74	212-0031-00			2	SCREW, 8-32 x 1/4 inches, RHS
-75	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-76	210-0894-00			2	WASHER, plastic, 0.190 ID x 7/16 inch OD
-77	210-0402-00			2	NUT, cap, hex., 8-32 x 5/16 inch
-78	386-0374-00			1	PLATE, ground strap

Electrical Parts List-Type 535A

FIG. 2 REAR & DELAY LINE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
2-79	129-0036-00	20001	33159	1	POST, binding, black
	129-0063-00	33160		1	POST, binding, charcoal
-80	210-0445-00	20001	31419	-	mounting hardware: (not included w/post)
	220-0410-00	31420		1	NUT, hex., 10-32 x 3/8 inch
	210-0010-00	20001	31419X	1	NUT, keps, 10-32 x 3/8 inch
-81	129-0036-00	20001	33159	1	LOCKWASHER, internal, #10
	129-0063-00	33160		1	POST, binding, black
-82	358-0036-00	20001	33159	1	POST, binding, charcoal
	358-0169-00	33160		-	mounting hardware: (not included w/post)
	210-0445-00	20001	31419	1	BUSHING, binding post, black
-83	220-0410-00	31420		1	BUSHING, binding post, charcoal
	210-0010-00	20001	31419X	2	NUT, hex., 10-32x 3/8 inch
	210-0206-00	20001	31419X	1	NUT, keps, 10-32 x 3/8 inch
				1	LOCKWASHER, internal, #10
-84	260-0209-00			1	LOCKWASHER, internal, #10
-84	260-0209-00			1	LUG, solder, SE #10, long
-84	260-0209-00			1	SWITCH, toggle-CRT CATHODE SELECTOR
-85	210-0414-00			1	mounting hardware: (not included w/switch)
-86	210-0902-00			1	NUT, hex., 15/32-32 x 9/16 inch
-87	210-0473-00			1	WASHER, flat, 0.470 ID x 21/32 inch OD
-88	386-0767-00	20001	22599	1	NUT, 12 sided, 15/32-32 x 0.634 inch
-88	387-0078-00	22600		1	PLATE, rear overlay
-89	213-0104-00			4	PLATE, rear overlay
-90	386-0766-00			1	mounting hardware: (not included w/plate)
-91	354-0056-00			1	SCREW, thread forming, 6-32 x 3/8 inch, THS
-91	354-0056-00			-	PLATE, rear
-91	354-0056-00			1	plate includes: RING, ornamental

Electrical Parts List-Type 535A

FIG. 3. SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
3-1	337-0287-00			1	SHIELD, high voltage mounting hardware: (not included w/shield)
	211-0541-00			2	SCREW, 6-32 x 1/4 inch, 100° csk, FHS
-2	211-0503-00			1	SCREW, 6-32 x 3/16 inch, PHS
-3	384-0135-00			1	ROD, spacing
-4	211-0507-00			1	SCREW, 6-32 x 5/16, inch, PHS
	621-0411-00			1	ASSEMBLY, high voltage power assembly includes:
-5	386-0358-00			1	PLATE, bakelite
-6	346-0001-00			1	STRAP, transformer mounting hardware: (not included w/strap)
-7	210-0004-00			2	LOCKWASHER, internal, #4
-8	210-0406-00			2	NUT, hex., 4-40 x 3/16, inch
-9	124-0100-00			1	STRIP, ceramic, 3/4 inch h, w/1 notch strip includes:
	355-0046-00			1	STUD, plastic mounting hardware: (not included w/strip)
	361-0009-00			1	SPACER, plastic, 0.406 inch long
-10	210-0205-00			1	LUG, solder, SE #8
-11	124-0088-00			1	STRIP, ceramic, 3/4 inch h, w/4 notches strip includes:
	355-0046-00			2	STUD, plastic mounting hardware: (not included w/strip)
-12	361-0009-00			2	SPACER, plastic, 0.406 inch long
-13	210-0205-00			2	LUG, solder, SE #8
-14	124-0086-00			4	STRIP, ceramic, 3/4 inch h, w/2 notches each strip includes:
	355-0046-00			1	STUD, plastic mounting hardware for each: (not included w/strip)
-15	361-0009-00			1	SPACER, plastic, 0.406 inch long mounting hardware: (not included w/assembly)
-16	211-0504-00			3	SCREW, 6-32 x 1/4 inch, PHS
-17	385-0080-00			3	ROD, hex.
-18	210-0006-00			3	LOCKWASHER, internal, #6
-19	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
-20	441-0240-00			1	CHASSIS, sweep mounting hardware: (not included w/chassis)
	212-0040-00			4	SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	212-0023-00			3	SCREW, 8-32 x 3/8 inch, PHS
	210-0804-00			2	WASHER, flat, 0.170 ID x 3/8 inch OD
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch

Electrical Parts List-Type 535A

FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS (cant)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
3-21				11	RESISTOR, variable
-22	210-0840-00			-	mounting hardware for each: (not included w/resistor)
-23	210-0413-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
				1	NUT, hex., 3/8-32 x 1/2 inch
-24	136-0015-00			21	SOCKET, tube, 9 pin, w/ground lugs
-	213-0044-00			2	mounting hardware for each: (not included w/socket) SCREW, thread forming, 5-32 x 3/16 inch, PHS
-25	136-0011-00			1	SOCKET, tube, 8 pin, w/ground lugs
	211-0538-00			2	mounting hardware: (not included w/socket) SCREW, 6-32 x 5/16, inch, 100° csk, FHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-26	337-0289-00			1	SHIELD, sweep amplifier
-27	211-0507-00			-	mounting hardware: (not included w/shield)
-28	210-0457-00			2	SCREW, 6-32 x 5/16 inch, PHS
				2	NUT, keps, 6-32 x 5/16 inch
-29	348-0002-00			9	GROMMET, rubber, 1/4 inch diameter
-30	348-0003-00			3	GROMMET, rubber, 5/16 inch diameter
-31	136-0008-00			4	SOCKET, tube, 7 pin, w/ground lugs
	213-0044-00			-	mounting hardware for each: (not included w/socket)
				2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-32	348-0006-00			1	GROMMET, rubber, 3/4 inch diameter
-33	136-0015-00			2	SOCKET, tube, 9 pin, w/ground lugs
	211-0033-00			2	mounting hardware for each: (not included w/socket) SCREW, sems, 4-40 x 5/16 inch, PHS
	210-0004-00			4	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-34	337-0005-00			2	SHIELD, socket
-35	337-0008-00			2	SHIELD, tube, 1 15/16 inches high
-36				2	CAPACITOR
					mounting hardware for each: (not included w/capacitor)
-37	386-0253-00			1	PLATE, small capacitor
-38	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
-39	210-0006-00			1	LOCKWASHER, internal, #6
-40	210-0202-00			1	LUG, solder, SE #6
-41	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch

Electrical Parts List-Type 535A

FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
3-42	385-0129-00			2	ROD, plastic, 15/8 inches high mounting hardware for each: (not included w/rod)
	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
-43	337-0009-00			1	SHIELD, tube, 2 13/32 inches high
-44	136-0022-00			1	SOCKET, tube, 9 pin, w/shield mounting hardware: (not included w/socket)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-45	136-0044-00			3	SOCKET, tube, 7 pin, w/ground lugs mounting hardware for each: (not included w/socket)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-46	105-0014-00			1	STOP, hex., 6-32 x 1/4 x 3/4, inch mounting hardware: (not included w/stop)
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-47	348-0004-00			5	GROMMET, rubber, 3/8 inch diameter
-48	348-0012-00			1	GROMMET, rubber, 5/8 inch diameter
-49	210-0201-00			1	LUG, solder, SE #4 mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-50				1	RESISTOR mounting hardware: (not included w/resistor)
-51	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
-52	210-0601-00			1	EYELET, 0.183 ID x 0.323 inch OD
-53	210-0478-00			1	NUT, hex., 6-32 x 5/16 x 21/32 inch
-54	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-55	385-0033-00	X20080		1	ROD, plastic, 5/8 inch high mounting hardware: (not included w/rod)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-56	406-0454-00			1	BRACKET, variable resistor mounting hardware: (not included w/bracket)
-57	212-0004-00			2	SCREW, 8-32 x 5/16 inch, PHS
-58	210-0804-00			2	WASHER, flat, 0.170 ID x 3/8 inch OD

Electrical Parts List-Type 535A

FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
3-59	-			1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16, inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-60	179-0300-00	20001	21922	1	CABLE HARNESS, sweep
	179-0405-00	21923		1	CABLE HARNESS, sweep
-61	124-0088-00			3	STRIP, ceramic, 3/4 inch h, w/4 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
					mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-62	124-0089-00			12	STRIP, ceramic, 3/4 inch h, w/7 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
					mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-63	124-0091-00			17	STRIP, ceramic, 3/4 inch h, w/11 notches
					each strip includes:
	355-0046-00			2	STUD, plastic
					mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-64	343-0043-00			5	CLAMP, wire, neon bulb
-65	381-0064-00			1	BAR, support
					mounting hardware: (not included w/bar)
	212-0008-00	20001	33279	2	SCREW, 8-32 x 1/2 inch, PHS
	212-0008-00	33280		1	SCREW, 8-32 x 1/2 inch, PHS
	212-0023-00	33280		1	SCREW, 8-32 x 3/8 inch, PHS
-66	210-0202-00			1	LUG, solder, SE #6
					mounting hardware: (not included w/lug)
	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-67	386-0496-00	20001	22395	1	PLATE, air deflection
	386-0921-00	22396		1	PLATE, air deflection
					mounting hardware: (not included w/plate)
-68	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
-69	211-0512-00			1	SCREW, 6-32 x 1/2 inch, 100° csk, FHS

Electrical Parts List-Type 535A

FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
3-70	337-0006-00			1	SHIELD, tube, 1 3/8 inches high
-71	136-0010-00			1	SOCKET, tube, 7 pin, w/shield
				-	mounting hardware: (not included w/socket)
-72	211-0033-00			2	SCREW, sems, 4-40 x 5/16 inch, PHS
-73	210-0004-00			1	LOCKWASHER, internal, #4
-74	210-0201-00			1	LUG, solder, SE #4
-75	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-76	441-0242-00			1	CHASSIS, delay sweep
				-	mounting hardware: (not included w/chassis)
-77	211-0529-00			2	SCREW, 6-32 x 1 1/4 inches, PHS
-78	166-0143-00			2	TUBE, spacing, 13/16 inch long
-79	214-0008-00			1	BOLT, captive
-80	210-0812-00			1	WASHER, fiber, 0.190 ID x 0.380 inch OD
-81	354-0048-00			1	RING, retaining
-82	381-0063-00			1	BAR, swivel
-83	210-0821-00			2	WASHER, flat, 1/4 ID x 1/2 inch OD
-84	105-0014-00			1	STOP, hex., 6-32 x 1/4 x 3/4 inch
-85	343-0013-00	20001	21169	1	CLAMP, plastic, 3/8 inch
	343-0004-00	21170		1	CLAMP, plastic, 5/16 inch
				-	mounting hardware: (not included w/clamp)
-86	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
-87	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-88	343-0005-00			1	CLAMP, plastic, 7/16 inch
					mounting hardware: (not included w/clamp)
-89	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-90	210-0201-00			1	LUG, solder, SE #4
				-	mounting hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16, inch, PHS
-91				1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
	210-0223-00			2	LUG, solder, 1/4 ID x 7/16 inch OD, SE
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-92				1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch

Electrical Parts List-Type 535A

FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD, & DELAY SWEEP CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
3-93	343-0001-00			3	CLAMP, plastic, 1/8 inch
-				-	mounting hardware for each: (not included w/clamp)
	211-0510-00			1	SCREW, 6-32x3/8 inch PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-94	179-0301-00	20001	20229	1	CABLE HARNESS, delay sweep #1
	179-0371-00	20230		1	CABLE HARNESS, delay sweep #1
-95	179-0302-00	20001	23909	1	CABLE HARNESS, delay sweep #2
	179-0506-00	20230		1	CABLE HARNESS, delay sweep #2

Electrical Parts List-Type 535A

FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
4-1				1	TRANSFORMER transformer includes:
-2	212-0524-00			4	SCREW, 10-32 x 3 1/4 inches, IHS
-3	210-0812-00			4	WASHER, fiber, 0.190 ID x 0.380 inch OD
				-	mounting hardware: (not included w/transformer)
-4	210-0010-00			4	LOCKWASHER, internal, #10
-5	210-0564-00	20001	30159	4	NUT, hex., 10-32 x 3/8 inch
	384-0599-00	30160		4	ROD, hex., support, 2 7/32 inches long
-6	166-0105-00	20001	30159X	1	TUBE, spacing, 0.245 ID x 3/8 OD x 2 19/32 inches
				-	mounting hardware: (not included w/tube)
	212-0511-00			1	SCREW, 10-32 x 3 inches, HHS
-7	381-0107-00	20001	30159	1	BAR, support
	381-0212-00	30160		2	BAR, support
				-	mounting hardware for each: (not included w/bar)
	211-0522-00	20001	30159	2	SCREW, 6-32 x 5/8 inch, 100° csk, FHS
	211-0544-00	30160		2	SCREW, 6-32 x 3/4 inch, THS
	210-0803-00	30160		2	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00	30160		1	NUT, keps, 6-32 x 5/16 inch
-8	211-0531-00	30160		1	SCREW, 6-32 x 3/8 inch, Fil HS
-9	210-0202-00			1	LUG, solder, SE #6
				-	mounting hardware: (not included w/lug)
	211-0534-00			1	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-10				1	CAPACITOR
				-	mounting hardware: (not included w/capacitor)
-11	386-0252-00			1	PLATE, fiber, small capacitor
-12	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-13	200-0256-00			1	COVER, capacitor
-14				3	CAPACITOR
				-	mounting hardware for each: (not included w/capacitor)
-15	386-0254-00			1	PLATE, fiber, large capacitor
-16	211-0543-00			2	SCREW, 6-32 x 5/16 inch, RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
-17	200-0258-00			2	COVER, capacitor
-18	348-0005-00			2	GROMMET, rubber, 1/2 inch diameter

Electrical Parts List-Type 535A

FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
4-19	343-0006-00	20001	33009X	1	CLAMP, plastic, 1/2 inch
				-	mounting hardware: (not included w/clamp)
	212-0008-00			1	SCREW, 8-32 x 1/2 inch, PHS
	210-0804-00			1	WASHER, flat, 0.170 ID x 3/8 inch OD
-20				1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
-21	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-22	210-0444-00			1	NUT, hex., 3/8-32 x 1/2 x 5/8 inch
-23	406-0108-00			1	BRACKET, variable resistor
				-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-24	348-0006-00	20001	33369	1	GROMMET, rubber, 3/4 inch diameter
	252-0564-00	33370		FT	GROMMET, plastic, extruded (2 inches)
-25				3	CAPACITOR
				-	mounting hardware for each: (not included w/capacitor)
-26	386-0255-00			1	PLATE, large capacitor
-27	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
	211-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-28	200-0293-00			1	COVER, capacitor
-29	136-0011-00			2	SOCKET, tube, 8 pin, w/ground lugs
				-	mounting hardware for each: (not included w/socket)
-30	211-0538-00			2	SCREW, 6-32 x 5/16, inch, 100° csk, FHS
-31	210-0006-00			2	LOCKWASHER, internal, #6
-32	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-33	136-0008-00			7	SOCKET, tube, 7 pin, w/ground lugs
				-	mounting hardware for each: (not included w/socket)
-34	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-35	136-0015-00			7	SOCKET, tube, 9 pin, w/ground lugs
				-	mounting hardware for each: (not included w/socket)
-36	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-37	348-0004-00			4	GROMMET, rubber, 3/8 inch diameter
-38	385-0076-00	20001	24879	1	ROD, plastic, 1 5/8 inches high
	385-0138-00	24880		1	ROD, plastic, 1 9/16 inches high
				-	mounting hardware: (not included w/rod)
	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS

Electrical Parts List-Type 535A

FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
4-39	136-0037-00			1	SOCKET, tip jack
				-	mounting hardware: (not included w/socket)
	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-40	406-0022-00			1	BRACKET, variable resistor
				-	mounting hardware: (not included w/bracket)
	210-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-41				1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
-42	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-43	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-44	337-0290-00			1	SHIELD, switch, lower
				-	mounting hardware: (not included w/shield)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-45	348-0002-00			2	GROMMET, rubber, 1/4 inch diameter
-46	441-0238-00			1	CHASSIS, power
				-	mounting hardware: (not included w/chassis)
-47	212-0023-00			5	SCREW, 8-32 x 3/8 inch, PHS
-48	212-0040-00			5	SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	210-0458-00			10	NUT, keps, 8-32 x 11/32 inch
-49	385-0074-00	20001	24879	1	ROD, plastic, 1 inch high
	385-0135-00	24880		1	ROD, plastic, 5/16 inch high
				-	mounting hardware: [not included w/rod)
	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
-50				2	CAPACITOR
				-	each capacitor includes:
	407-0277-00	X34270		1	BRACKET. capacitor
	124-0187-00	X34270		1	STRIP, ceramic, 7/16 inch h, w/5 notches
				-	strip includes:
	355-0046-00			2	STUD, plastic
	124-0187-01	X34270		1	STRIP, ceramic, 7/16 inch h, w/5 notches & silver band
				-	strip includes:
	355-0046-00			2	STUD, plastic
	361-0007-00	X34270		4	SPACER, plastic, 0.188 inch long
			-	mounting hardware for each: (not included w/capacitor)	
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch

Electrical Parts List-Type 535A

FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
4-51	343-0001-00	20001	21169	1	CLAMP, plastic, 1/8 inch
	343-0002-00	21170		1	CLAMP, plastic, 3/16 inch
				-	mounting hardware: (not included w/clamp)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
	210-0803-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-52	337-0291-00			1	SHIELD, switch, upper
				-	mounting hardware: (not included w/shield)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0202-00			1	LUG, solder, SE #6
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-53	179-0296-00			1	CABLE HARNESS, power chassis #1
-54	179-0306-00			1	CABLE HARNESS, 110 volt power
-55	179-0324-00			1	CABLE HARNESS, power chassis #2
-56	124-0088-00			3	STRIP, ceramic, 3/4 inch h, w/4 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
	361-0009-00			-	mounting hardware for each: (not included w/strip)
				2	SPACER, plastic, 0.406 inch long
-57	124-0089-00			1	STRIP, ceramic, 3/4 inch h, w/7 notches
				-	strip includes:
	355-0046-00			2	STUD, plastic
				-	mounting hardware: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-58	124-0090-00			7	STRIP, ceramic, 3/4 inch h, w/9 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
				-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-59	124-0091-00			10	STRIP, ceramic, 3/4 inch h, w/11 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
				-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-60	202-0015-00			1	COVER, relay
				-	mounting hardware: (not included w/cover)
-61	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch

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FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
4-62				1	RELAY
-63	211-0503-00			-	mounting hardware: (not included w/relay)
				2	SCREW, 6-32 x 3/16,, inch, PHS
-64	260-0208-00			1	SWITCH, thermal cutout
					mounting hardware: (not included w/switch)
-65	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-66	210-0006-00			2	LOCKWASHER, internal, #6
-67	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-68	386-0886-00			1	PLATE, rectifier mounting
-69	385-0096-00	20001	24879	1	ROD, plastic, 1 1/4 inches long
	385-0136-00	24880		1	ROD, plastic, 1 1/4 inches long
				-	mounting hardware: (not included w/rod)
-70	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
-71	385-0082-00	20001	24879	1	ROD, plastic, 2 1/4 inches long
	385-0137-00	24880		1	ROD, plastic, 2 1/4 inches long
				-	mounting hardware: (not included w/rod)
-72	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
-73	136-0015-00			1	SOCKET, tube, 9 pin, w/ground lugs
				-	mounting hardware: (not included w/socket)
-74	211-0033-00			2	SCREW, sems, 4-40 x 5/16 inch, PHS
-75	210-0004-00			2	LOCKWASHER, internal, #4
-76	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-77	343-0004-00			1	CLAMP, plastic, 5/16 inch
				-	mounting hardware: (not included w/clamp)
-78	214-0012-00			1	BOLT, spade, 6-32 x 3/8 inch
-79	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-80	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-81	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-82	210-0006-00			1	LOCKWASHER, internal, #6
-83	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-84	348-0006-00			1	GROMMET, rubber, 3/4 inch diameter
-85	337-0288-00			1	SHIELD, rectifier
				-	mounting hardware: (not included w/shield)
-86	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-87	166-0099-00			2	TUBE, spacing, 0.180 ID x 1/4 OD x 1 23/32 inches long
	211-0507-00			2	SCREW, 6-32 x 5/16, inch, PHS
-88	179-0298-00			1	CABLE HARNESS, rectifier
-89	179-0305-00			1	CABLE HARNESS, 110 volt rectifier

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FIG. 5 VERTICAL AMPLIFIER CHASSIS & PLUG-IN HOUSING

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
5-1	337-0066-00			1	SHIELD, top, plug-in housing
				-	mounting hardware: (not included w/shield)
-2	211-0101-00			2	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
-3	210-0851-00			2	WASHER, flat, 0.119 ID x 3/8 inch OD
-4	210-0004-00			2	LOCKWASHER, internal, #4
-5	210-0406-00			2	NUT, hex., 4-40 3/16 inch
-6	343-0042-00			2	CLAMP, plastic, half, 5/16 inch
				-	mounting hardware for each: (not included w/clamp)
-7	211-0507-00			1	SCREW, 6-32 x 5/6 inch, PHS
-8	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-9	210-0006-00			1	LOCKWASHER, internal, #6
-10	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-11	386-0355-00			1	PLATE, back, plug-in housing
				-	mounting hardware: (not included w/plate)
-12	212-0008-00			2	SCREW, 8-32 x 1/2 inch, PHS
-13	210-0804-00			4	WASHER, flat, 0.170 ID x 3/8, inch OD
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
-14	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-15	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-16	211-0538-00			1	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-17	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
-18	210-0202-00			1	LUG, solder, SE #6
-19	210-0006-00			4	LOCKWASHER, internal, #6
-20	210-0407-00			4	NUT, hex., 6-32x 1/4 inch
-21	131-0018-00			1	CONNECTOR, 16 contact
				-	mounting hardware: (not included w/connector)
-22	211-0016-00			2	SCREW, 4-40 x 5/8 inch, RHS
-23	166-0107-00	20001	33449	2	TUBE, spacer, 0.180 ID x 1/4 OD x 7/32 inch long
	166-0030-00	33450		2	TUBE, spacer, 0.180 ID x 1/4 OD x 3/16, inch long
-24	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-25	210-0202-00			1	LUG, solder, SE #6
				-	mounting hardware: (not included w/lug)
-26	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-27	337-0091-00			1	SHIELD, side, plug-in housing
				-	mounting hardware: (not included w/shield)
-28	211-0101-00			2	SCREW, 4-40 x 1/4 inch, 100° csk, FHS
-29	210-0851-00			2	WASHER, flat, 0.119 ID x 3/8 inch OD
-30	210-0004-00			2	LOCKWASHER, internal, #4
-31	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

Electrical Parts List-Type 535A

FIG. 5 VERTICAL AMPLIFIER CHASSIS & PLUG-IN HOUSING (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
5-32	386-0566-00	20001	31319	2	PLATE, side, plug-in housing
	386-0680-00	31320		2	PLATE, side, plug-in housing
				-	mounting hardware for each: (not included w/plate)
	211-0559-00			2	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
-33	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-34	406-0245-00			2	BRACKET, ground clip
-35				1	CAPACITOR
				-	mounting hardware: (not included w/capacitor)
-36	386-0255-00			1	PLATE, large capacitor
-37	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
-38	210-0006-00			2	LOCKWASHER, internal, #6
-39	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-40	200-0256-00			1	COVER, capacitor
-41				1	CAPACITOR
				-	mounting hardware: (not included w/capacitor)
-42	386-0252-00			1	PLATE, fiber, small capacitor
-43	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
-44	210-0006-00			2	LOCKWASHER, internal, #6
-45	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-46				1	RESISTOR, variable
				-	mounting hardware: (not included w/resistor)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-47	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-48	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-49				1	CAPACITOR
				-	mounting hardware: (not included w/capacitor)
-50	386-0253-00			1	PLATE, small capacitor
-51	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS
-52	210-0006-00			2	LOCKWASHER, internal, #6
-53	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
-54	385-0106-00	20001	30159	1	ROD, vertical amplifier support
	406-0827-00	30160		1	BRACKET, vertical amplifier support
				-	mounting hardware: (not included w/bracket)
	211 -052Z-30	20301	30159X	1	SCREW, 6-32 x 5/8 inch, 100° csk, FHS
-55	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-56	210-0457-00	X30160		1	NUT, keps, 6-32 x 5/16, inch
-57	348-0002-00			2	GROMMET, rubber, 1/4 inch diameter

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FIG. 5 VERTICAL AMPLIFIER CHASSIS & PLUG-IN HOUSING (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
5-58				4	COIL
-59	213-0054-00			- 1	mounting hardware for each: (not included w/coil) SCREW, thread cutting, 6-32 x 5/16 inch, PHS
-60	385-0076-00 385-0138-00	20001 24880	24879	1 1 -	ROD, plastic, 1 5/8 inches high ROD, plastic, 1 9/16 inches high mounting hardware: (not included w/rod)
-61	211-0507-00 213-0041-00	20001 24880	24879	1 1	SCREW, 6-32 x 5/16 inch, PHS SCREW, thread cutting, 6-32 x 3/8 inch, THS
-62	136-0015-00			8 -	SOCKET, tube, 9 pin, w/ground lugs mounting hardware for each: (not included w/socket)
-63	213-0044-00			2	SCREW, thread forming, 5-32x 3/16 inch, PHS
-64	441-0213-00			1 -	CHASSIS, vertical amplifier mounting hardware: (not included w/chassis)
-65	211-0507-00 210-0457-00			2 2	SCREW, 6-32 x 5/16 inch, PHS NUT, keps, 6-32 x 5/16 inch
-66	124-0087-00 355-0046-00 361-0009-00			3 - 1 - 1	STRIP, ceramic, 3/4, inch h, w/3 notches each strip includes: STUD, plastic mounting hardware for each: (not included w/strip) SPACER, plastic, 0.406 inch long
-67	124-0090-00 355-0046-00 361-0009-00			1 - 2 - 2	STRIP, ceramic, 3/4 inch h, w/9 notches strip includes: STUD, plastic mounting hardware: (not included w/strip) SPACER, plastic, 0.406 inch long
-68	124-0091-00 355-0046-00 361-0009-00			5 - 2 - 2	STRIP, ceramic, 3/4 inch h, w/11 notches each strip includes: STUD, plastic mounting hardware for each: (not included w/strip) SPACER, plastic, 0.406 inch long
-69	179-0248-00			1	CABLE HARNESS, vertical amplifier

Electrical Parts List-Type 535A

FIG. 6 CATHODE RAY TUBE SHIELD, FOCUS & INTENSITY CHASSIS

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
6-1	337-0088-00			1	SHIELD, CRT
				-	mounting hardware: (not included w/shield)
	211-0559-00			6	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
	210-0457-00			6	NUT, keps, 6-32 x 5/16 inch
-2	406-0239-00			2	BRACKET, CRT spring
-3	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-4	210-0006-00			1	LOCKWASHER, internal, #6
-5	385-0080-00			1	ROD, hex., 6-32 x 1/4 x 7/16 inch
-6	210-0811-00			2	WASHER, fiber, 0.140 ID x 5/16 inch OD
-7	124-0068-00			1	STRIP, felt
-8	134-0031-00			1	PLUG, CRT contact
-9	210-0914-00	X22899		1	WASHER, wavy, 0.320 ID x 0.492 inch OD
-10	200-0112-00			1	ASSEMBLY, CRT anode cover & plate
				-	assembly includes:
-11	200-0111-00			1	COVER, CRT anode
-12	386-0647-00			1	PLATE, CRT anode
-13	131-0086-00			1	ASSEMBLY, CRT anode connector
				-	assembly includes:
-14	131-0073-00			1	CONNECTOR, CRT anode
-15	200-0110-00			1	CAP, CRT anode
-16	136-0001-00			2	SOCKET, graticule lamp
					mounting hardware for each: (not included w/socket)
-17	211-0534-00			1	SCREW, sems, 6-32 x 5/16 inch, PHS
-18	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-19	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-20	343-0002-00			1	CLAMP, plastic, 3/16 inch
				-	mounting hardware: (not included w/clamp)
	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
-21	210-0803-00			1	WASHER, flat, 0.150 ID x 3/8 inch OD
-22	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-23	175-0587-00			1	WIRE, CRT lead, 0.500 foot, striped red
				-	wire includes:
	131-0049-00			1	CONNECTOR, CRT contact
	175-0588-00			1	WIRE, CRT lead, 0.833 foot, striped orange
				-	wire includes:
	131-0049-00			1	CONNECTOR, CRT contact
	175-0591-00			1	WIRE, CRT lead, 0.417 foot, striped green
				-	wire includes:
-24	131-0049-00			1	CONNECTOR, CRT contact
-25	406-0251-00			1	BRACKET, CRT support
				-	mounting hardware: (not included w/bracket)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00			2	WASHER, flat, 0.150 ID 3/8 inch OD
	212-0004-00			2	SCREW, 8-32 x 5/6 inch, PHS
	210-0804-00			1	WASHER, flat, 0.170 ID 3/8 inch OD

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FIG. 6 CATHODE RAY TUBE SHIELD, FOCUS & INTENSITY CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
6-26	354-0078-00	X21350	28840	1	RING, CRT securing
	354-0178-00	28841		1	RING, CRT securing
-27	355-0049-00	X21350		1	STUD, 10-32 x 31/4 inches
-28	366-0032-00	X21350		1	KNOB, red
	213-0004-00			-	knob includes:
				1	SCREW, set, 6-32 x 3/16 inch, HSS
-29	432-0022-00	X21350		1	BASE, CRT rotator
			-	-	mounting hardware: (not included w/base)
-30	211-0561-00			2	SCREW, 6-32 x 3/8 inch, hex. socket, FH cap
-31	210-0503-00			1	NUT, CRT rotator securing
-32	348-0002-00			11	GROMMET, rubber, 1/4 inch diameter
-33	343-0034-00	20001	21349	1	CLAMP, CRT
				-	mounting hardware: (not included w/clamp)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	354-0103-00	21350		1	RING, CRT clamping
				-	ring includes:
-34	210-0502-00			1	NUT, CRT rotator
-35	212-0536-00	20001	21349	1	SCREW, 10-24 x 7/8 inch, RHS
	211-0560-00	21350		1	SCREW, 6-32 x 1 inch, RHS
-36	210-0416-00	20001	21349	1	NUT, square, 10-24 x 3/8 inch
	210-0407-00	21350		1	NUT, hex., 6-32 x 1/4 inch
-37	354-0066-00	20001	21349X	1	RING, CRT rotating
-38	136-0019-00			1	SOCKET, CRT, 14 pin
-39	20001	33829		2	SCREW, 4-36 x 3/4 inch, RHS
	211-0017-00	33830		2	SCREW, 4-40 x 3/4 inch, RHS
		20001	33829	2	NUT, hex., 4-36 x 1/4 inch
	210-0586-00	33830		2	NUT, keps, 4-40x 1/4 inch
-40	348-0003-00			1	GROMMET, rubber, 5/16 inch diameter
-41	214-0210-00	X25220		1	ASSEMBLY, solder spool
				-	assembly includes:
	214-0209-00			1	SPOOL, w/o solder
				-	mounting hardware: (not included w/assembly)
	361-0007-00			1	SPACER, plastic, 0.188 inch long
-42	348-0005-00	X26906	33279	1	GROMMET, rubber, 1/2 inch diameter
	348-0063-00	33280		1	GROMMET, plastic, 1/2 inch diameter
-43	337-0148-00			1	SHIELD, focus & intensity
				-	mounting hardware: (not included w/shield)
-44	213-0054-00			1	SCREW, thread cutting, 6-32 x 5/16 inch, PHS
-45	211-0503-00			2	SCREW, 6-32 x 3/16 inch, PHS
-46	385-0090-00			1	ROD, plastic, 1 9/16 inches high
-47	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
	210-0005-00			1	LOCKWASHER, external, #6

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FIG. 6 CATHODE RAY TUBE SHIELD, FOCUS & INTENSITY CHASSIS (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
6-48	348-0005-00			1	GROMMET, rubber, 1/2 inch diameter
-49	210-0202-00			1	LUG, solder, SE #6
				-	mounting hardware: (not included w/lug)
-50	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-51	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
-52	385-0074-00	20001	24879	1	ROD, plastic, 1 inch high
	385-0135-00	24880		1	ROD, plastic, 15/16 inch high
				-	mounting hardware: (not included w/rod)
-53	211-0507-00	20001	24879	1	SCREW, 6-32 x 5/16 inch, PHS
	213-0041-00	24880		1	SCREW, thread cutting, 6-32 x 3/8 inch, THS
-54	441-0223-00			1	CHASSIS, focus & intensity
-55	179-0061-00			1	CABLE HARNESS, focus & intensity
-56	124-0089-00			1	STRIP, ceramic, 3/4 inch h, w/7 notches
				-	strip includes:
	355-0046-00			2	STUD, plastic
				-	mounting hardware: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-57	124-0091-00			3	STRIP, ceramic, 3/4 inch h, w/11 notches
				-	each strip includes:
	355-0046-00			2	STUD, plastic
				-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, plastic, 0.406 inch long
-58	124-0100-00			2	STRIP, ceramic, 3/4 inch h, w/1 notch
				-	each strip includes:
	355-0046-00			1	STUD, plastic
				-	mounting hardware for each: (not included w/strip)
	361-0008-00			1	SPACER, plastic, 0.281 inch long

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FIG. 7 CABINET & FRAME RAILS

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
7-1	386-0770-00	20001	22599	1	PLATE, cabinet, right side
	387-0076-00	22600		1	PLATE, cabinet, right side plate includes:
-2	214-0057-00			2	ASSEMBLY, cabinet latch fastener each assembly includes:
	210-0480-00			1	NUT, plastic, latch
	105-0007-00			1	STOP, 7/32 ID x 22/32 inch OD
	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
	213-0033-00			1	SCREW, fastening, 8-32 x 1/2 inch
-3	200-0118-00	20001	22599	1	COVER, manual tray
	200-0216-00	22600		1	COVER, manual tray
-4	384-0538-00			1	ROD, hinge
-5	166-0126-00	20001	29089	2	TUBE, spacing each tube includes:
	213-0048-00			1	SCREW, set, 4-40 x 1/8 inch, HSS
	354-0165-00	29090		1	RING, retaining
-6	214-0061-00			1	SPRING, cover
-7	214-0058-00	20001	29089	1	FASTENER, tray
	214-0234-00	29090		1	FASTENER, clip spring mounting hardware: (not included w/fastener)
-8	406-0312-00	20001	29089X	1	BRACKET, fastener
	211-0008-00	20001	29089	3	SCREW, 4-40 x 1/4 inch, PHS
	211-0007-00	29090		1	SCREW, 4-40 x 3/16 inch, PHS
-9	210-0004-00	20001	29089	3	LOCKWASHER, internal, #4
	210-0004-00	29090		1	LOCKWASHER, internal, #4
-10	210-0406-00	20001	29089	3	NUT, hex., 4-40 x 3/16 inch
	210-0406-00	29090		1	NUT, hex., 4-40 x 3/16 inch
-11	381-0121-00	20001	22599	1	ASSEMBLY, top bar & handle
	381-0149-00	22600	28599	1	ASSEMBLY, top bar & handle
	381-0204-00	28600		1	ASSEMBLY, top bar & handle assembly includes:
-12	367-0011-00			2	HANDLE
-13	343-0073-00			4	CLAMP, handle mounting hardware: (not included w/assembly)
	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
-14	381-0073-00			2	BAR, retaining
	386-0736-00	20001	22599	1	PLATE, cabinet, left side
-15	387-0077-00	22600		1	PLATE, cabinet, left side plate includes:
	134-0028-00			1	PLUG
-17	214-0057-00			2	ASSEMBLY, cabinet, latch fastener each assembly includes:
	210-0480-00			1	NUT, plastic, latch
	105-0007-00			1	STOP, 7/32 ID x 21/32 inch OD
	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
	213-0033-00			1	SCREW, fastening, 8-32 x 1/2 inch

Electrical Parts List-Type 535A

FIG. 7 CABINET & FRAME RAILS

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
7-18	122-0019-00			1	ANGLE, frame, top left mounting hardware: (not included w/angle)
	211-0559-00			4	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
-19	122-0051-00	20001	22599	1	ANGLE, frame, left bottom
	122-0070-00	22600	30159	1	ANGLE, frame, left bottom
	122-0105-00	30160	33899	1	ANGLE, frame, left bottom
	122-0138-00	33900		1	ANGLE, frame, bottom mounting hardware: (not included w/angle)
-20	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
-21	386-0597-00	20001	22599	1	PLATE, cabinet, bottom
	387-0061-00	22600	30159	1	PLATE, cabinet, bottom
	387-0478-00	30160		1	PLATE, cabinet, bottom plate includes:
-22	214-0057-00			4	ASSEMBLY, cabinet latch fastener each assembly includes:
-23	210-0480-00			1	NUT, plastic, latch
-24	105-0007-00			1	STOP, 7/32 ID x 21/32 inch OD
-25	210-0847-00			1	WASHER, plastic, 0.164 ID x 0.500 inch OD
-26	213-0033-00			1	SCREW, fastening, 8-32 x 1/2 inch
-27	122-0050-00	20001	22599	1	ANGLE, frame, right bottom
	122-0071-00	22600	30159	1	ANGLE, frame, right bottom
	122-0104-00	30160	33899	1	ANGLE, frame, right bottom
	122-0138-00	33900		1	ANGLE, frame, bottom mounting hardware: (not included w/angle)
-28	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch

APPENDIX A

REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, and Lubrication Orders.
DA Pam 310-7	U. S. Army Equipment Index of Modification Work Orders.
TB SIG 364	Field Instructions for Painting and Preserving Electronics Command Equipment.
TM 38-750	Army Equipment Record Procedures.

**APPENDIX C
MAINTENANCE ALLOCATION**

Section I. INTRODUCTION

C-1. General

This appendix provides a summary of the maintenance operations covered in the equipment literature for Oscilloscope AN/USM-182A. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

C-2. Explanation of Format for Maintenance Allocation Chart

- a. *Group Number.* Not used.
- b. *Component Assembly Nomenclature.* This column lists the item names of components units, assemblies, subassemblies, and modules on which maintenance is authorized.
- c. *Maintenance Function.* This column indicates the maintenance category at which performance of the specific maintenance function is authorized. Authorization to perform a function at any category also includes authorization to perform that function at higher categories. The codes used represent the various maintenance categories as follows:

<i>Code</i>	<i>Maintenance category</i>
C	Operator/crew.
O	Organizational maintenance.
F	Direct support maintenance.
H	General support maintenance.

D Depot maintenance.

d. *Tools and Equipment.* The numbers appearing in this column refer to specific tools and equipment which are identified by these numbers in section III.

e. *Remarks.* Self-explanatory.

C3. Explanation of Format for Tool and Test Equipment Requirements

The columns in the tool and test equipment requirements chart are as follows:

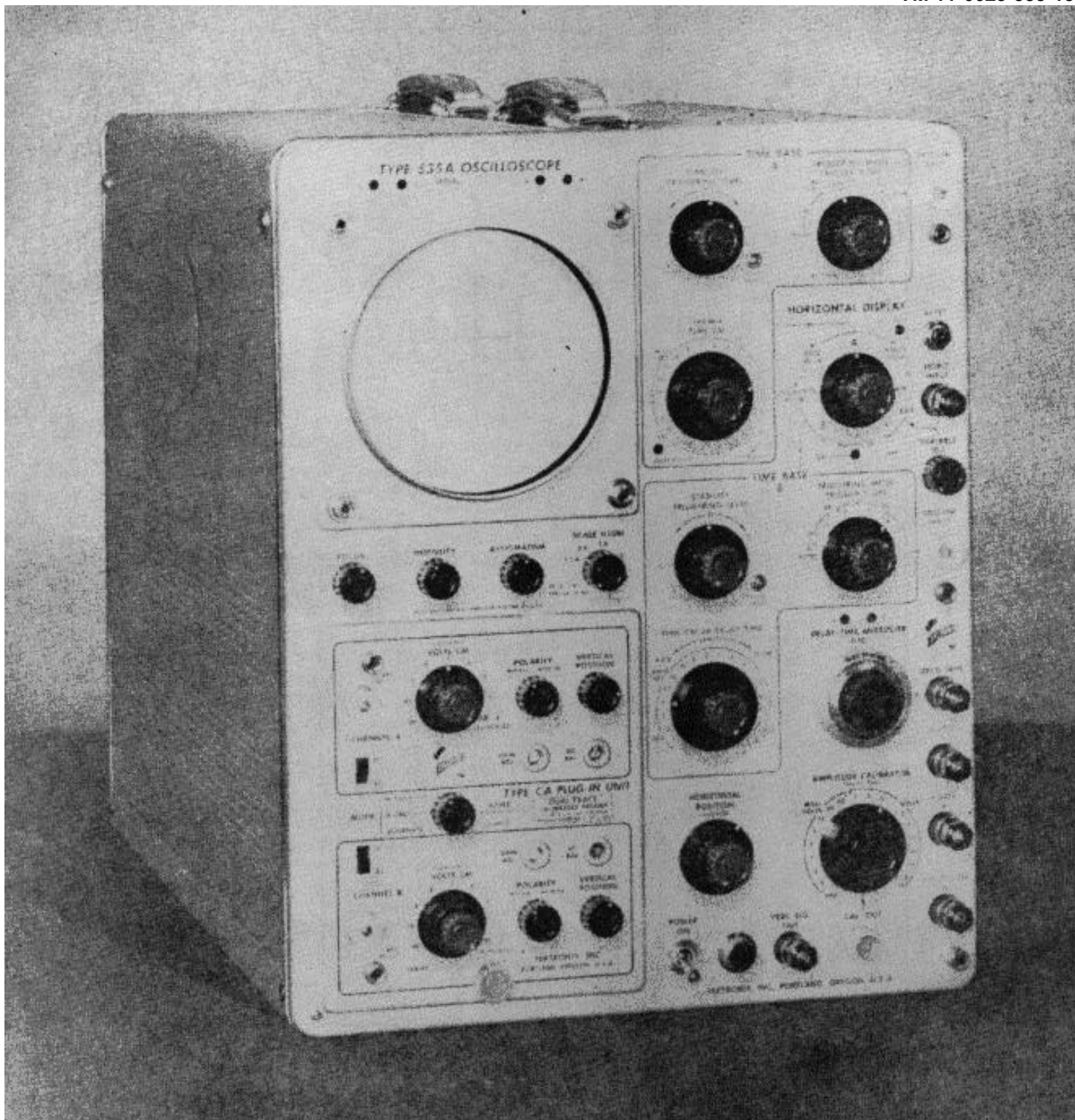
- a. *Tools and Equipment.* The numbers in this column coincide with the numbers used in the tools and equipment column of the MAC. The numbers indicate the appropriate tool for the maintenance function.
- b. *Maintenance Category.* The codes in this column indicate the maintenance category normally allocated the facility.
- c. *Nomenclature.* This column lists tools, test, and maintenance equipment required to perform the maintenance functions.
- d. *Federal Stock Number.* This column lists the Federal stock number.
- e. *Tool Number.* Not used.

Section II. MAINTENANCE ALLOCATION CHART

GROUP NUMBER	Component Assembly Nomenclature	Maintenance functions											Tools and equipment	Remarks
		I N S P E C T	T E S T	S E R V I C E	A D J U S T	A L I G N	C A L I B R A T E	I N S T A L L	R E P L A C E	R E P A I R	O V E R H A U R	R E B U I L D		
	<p>OSCILLOSCOPE AN/USM-182A</p> <p>LEAD, TEST</p>	0	H	0	H	H					H	D	1,2,4,5,6,8 10 1,2,4 1,2,4,5,6 1,2,3,4, 5,6, 7,8,9 1, 2,3,4, 5,6, 7,8,9 9	

Section III. TOOL AND TEST EQUIPMENT REQUIREMENTS

TOOLS AND EQUIPMENT	MAINTENANCE CATEGORY	NOMENCLATURE	FEDERAL STOCK NUMBER	TOOL NUMBER
1	H,D	AUDIO OSCILLATOR AN/URM-127	6625-783-5965	
2	H,D	FREQUENCY METER AN/USM-207	6625-911-6368	
3	H,D	GENERATOR, ELECTRONIC MARKER AN/USM-108	6625-987-9564	
4	H,D	MULTIJETER ME-26D/U	6625-360-2493	
5	H,D	OSCILLOSCOPE AN/USM-281	6625-053-3112	
6	H,D	GENERATOR, SIGNAL SG-299/U	6625-808-5584	
7	D	TEST SET, ELECTRON TUBE TV-2/U	6625-699-0263	
8	H	TESTER, TUBE TV-7/U	6625-820-0064	
9	H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-105/G	5180-610-8177	
10	O	TOOL AND TEST EQUIPMENT NORMALLY AVAILABLE TO THE REPAIRMAN USER BECAUSE OF HIS ASSIGNED MISSION		



Type 535A

By Order of the Secretary of the Army:

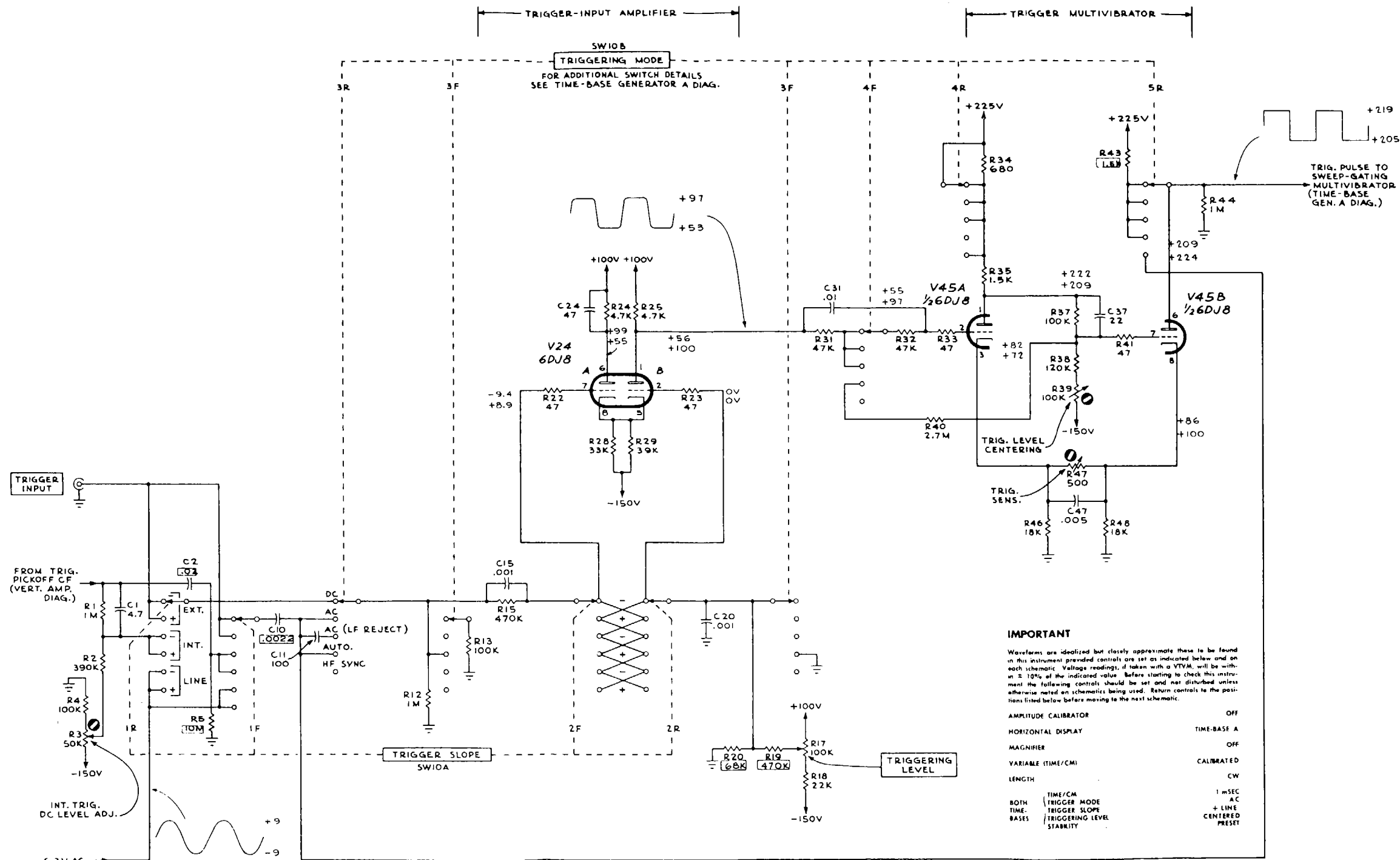
Official:

KENNETH G. WICKHAM,
*Major General, United States Army,
The Adjutant General.*

W. C. WESTMORELAND,
*General, United States Army,
Chief of Staff.*

Distribution:

To be distributed in accordance with DA Form 12-32, Organizational maintenance requirements for AN/FSA-25, AN/GSA-37, AN/GSG-5, AN/GSG-6, AN/MSQ-18, AN/MSQ-28, AN/MSQ-56 and AN/TSQ-38 systems.



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.

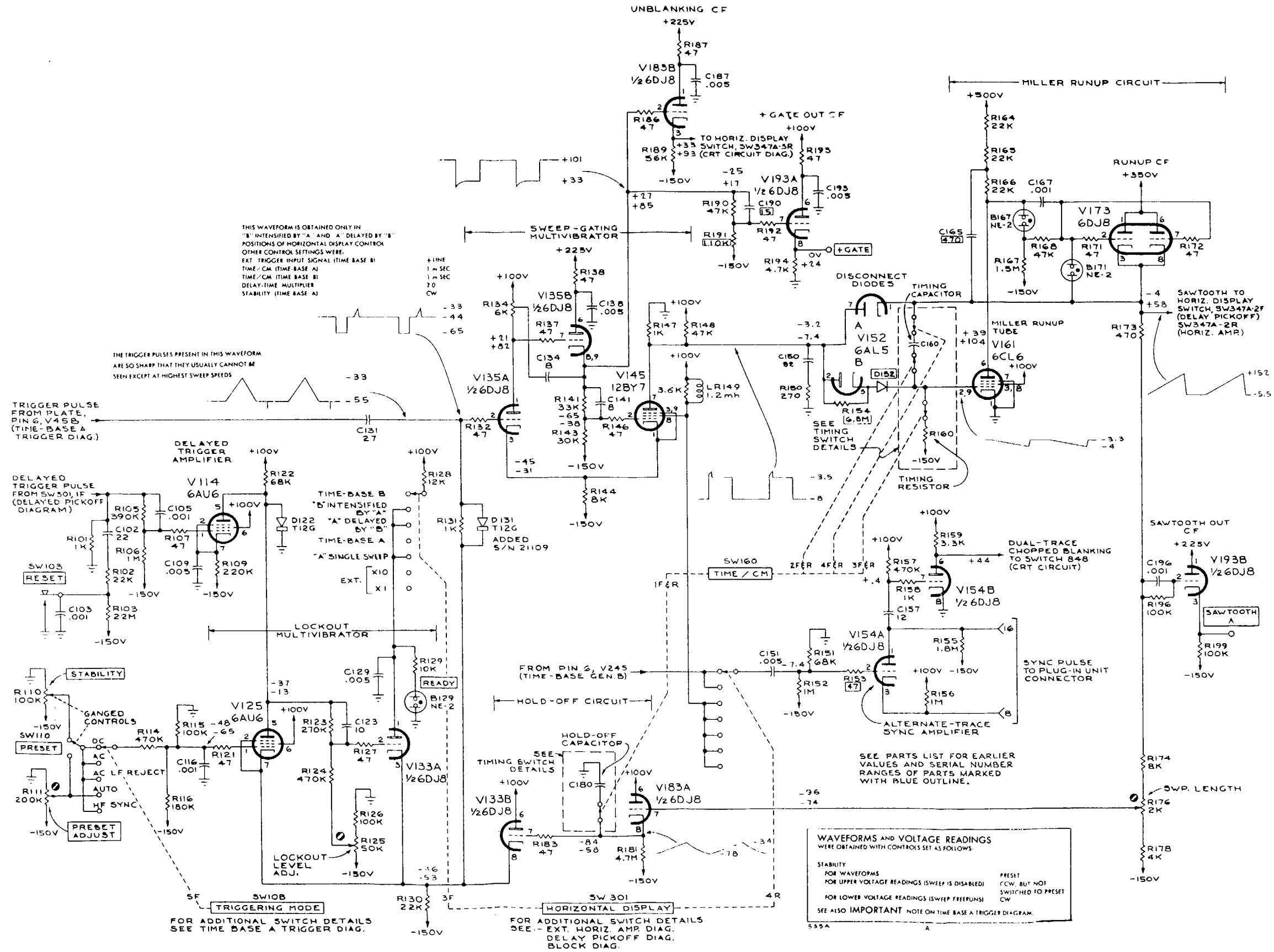
AMPLITUDE CALIBRATOR	OFF
HORIZONTAL DISPLAY	TIME-BASE A
MAGNIFIER	OFF
VARIABLE TIME/CM	CALIBRATED
LENGTH	CW
BOTH TIME/CM	1 mSEC
TIME TRIGGER MODE	AC
BASES TRIGGER SLOPE	+ LINE
TRIGGERING LEVEL	CENTERED
STABILITY	PRESET

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

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

TRIGGER SIGNAL	+ LINE
FOR WAVEFORMS	NONE
FOR VOLTAGES	NONE
TRIGGERING LEVEL	CENTERED
FOR WAVEFORMS	CW
FOR UPPER VOLTAGE READINGS	CW
FOR LOWER VOLTAGE READINGS	CW

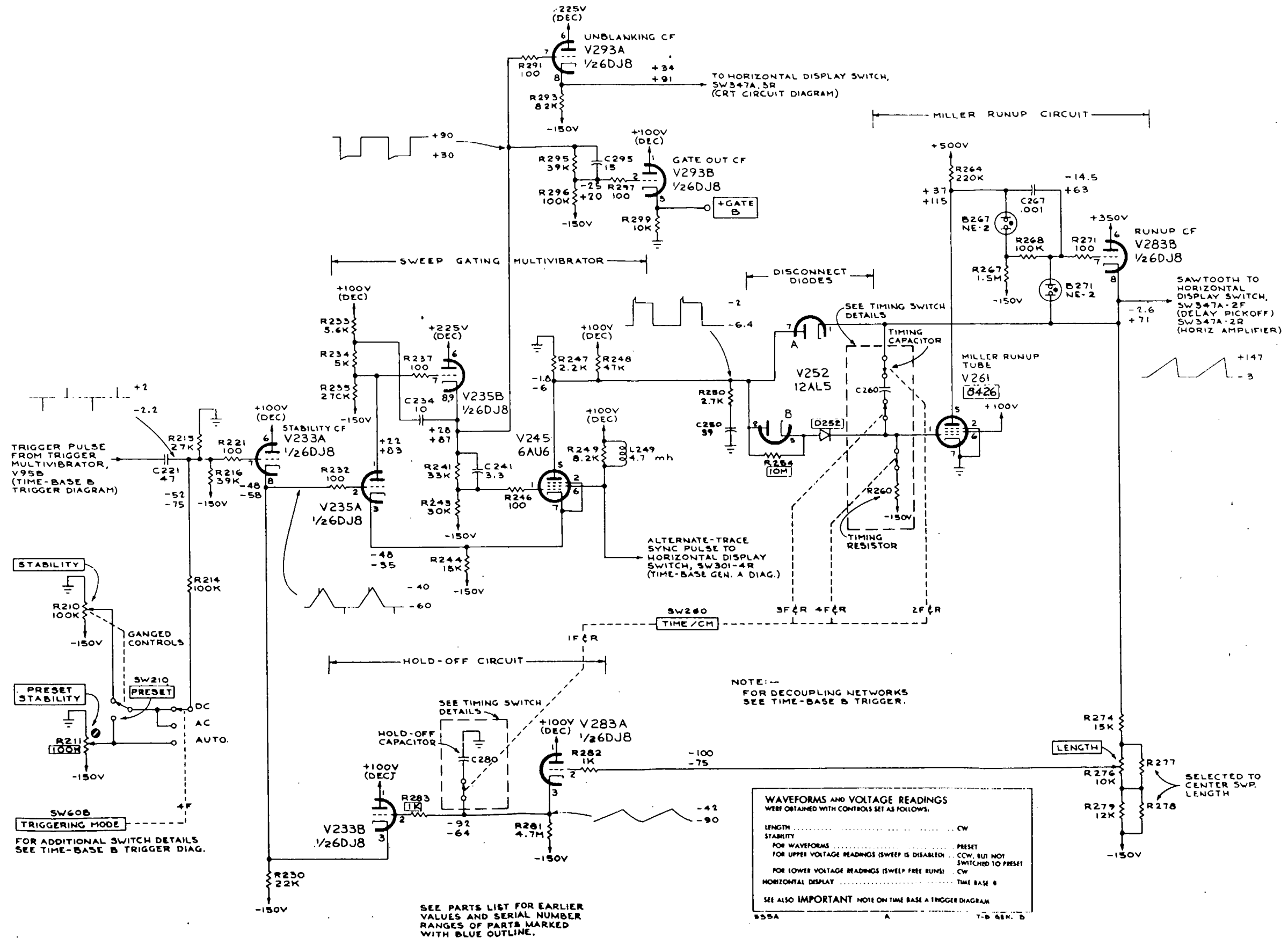
SEE ALSO IMPORTANT NOTE ON THIS DIAGRAM

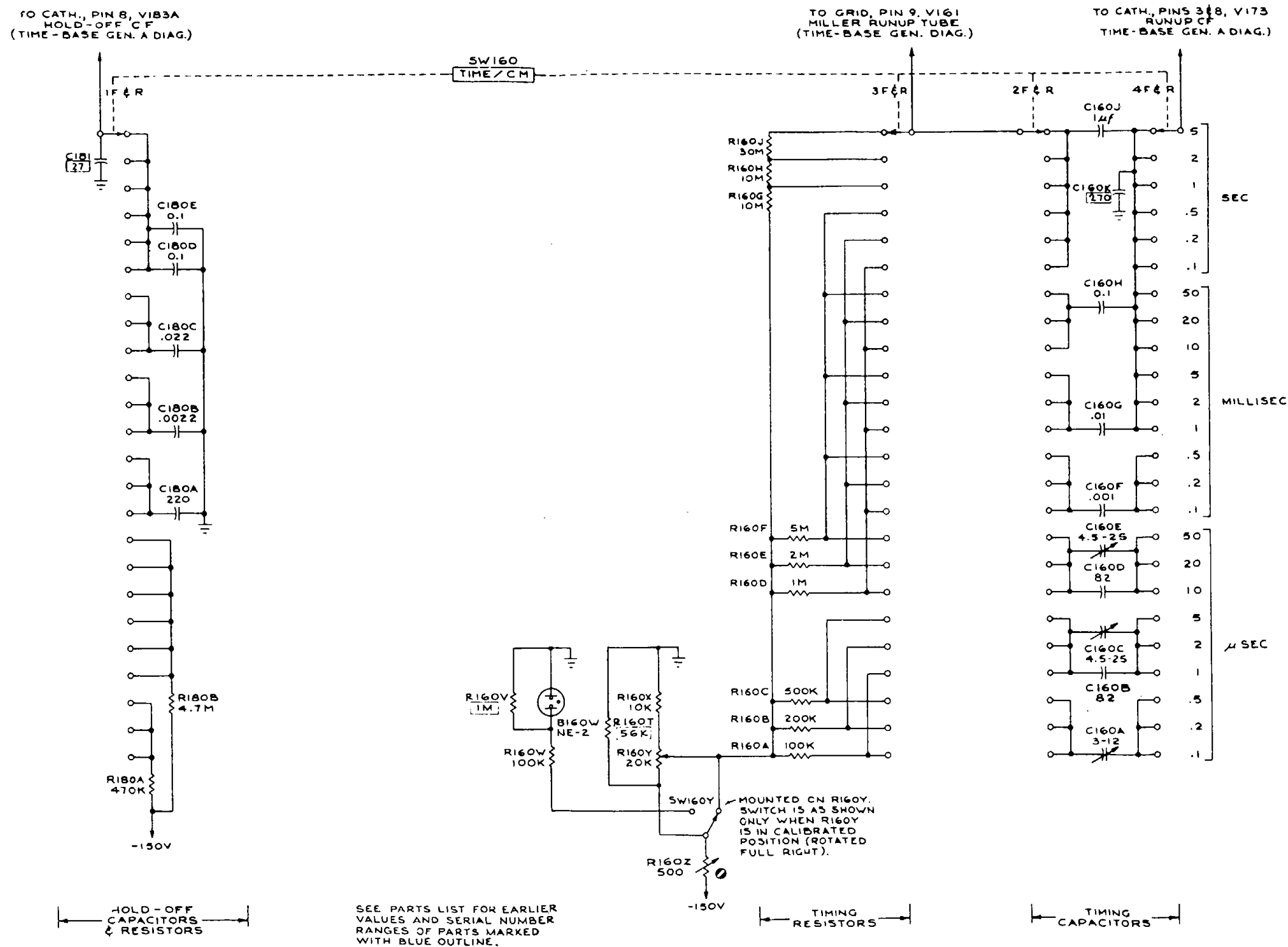


TYPE 535A OSCILLOSCOPE

CIRCUIT NUMBERS 100 THRU 199

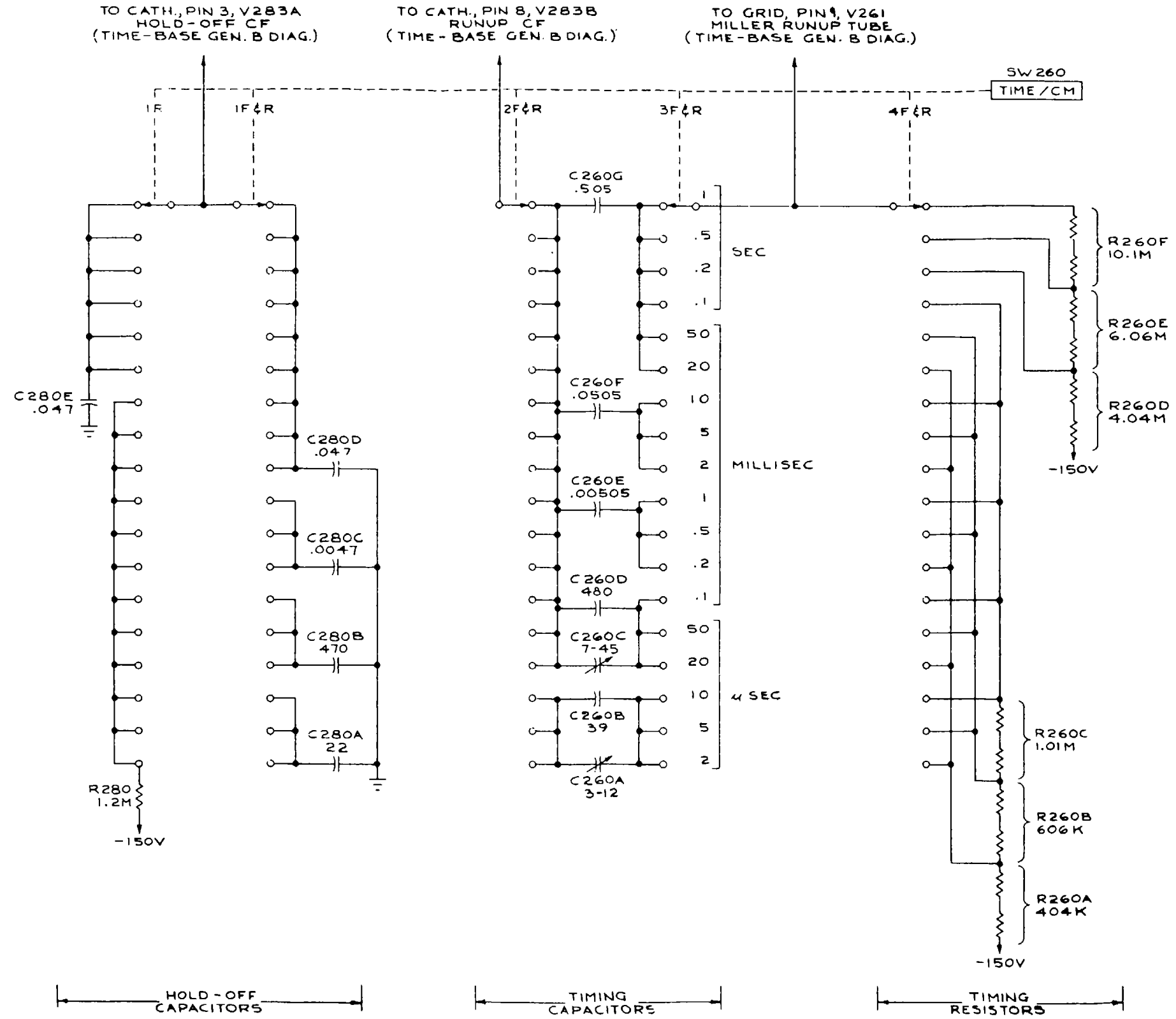
TIME - BASE A TRIGGER





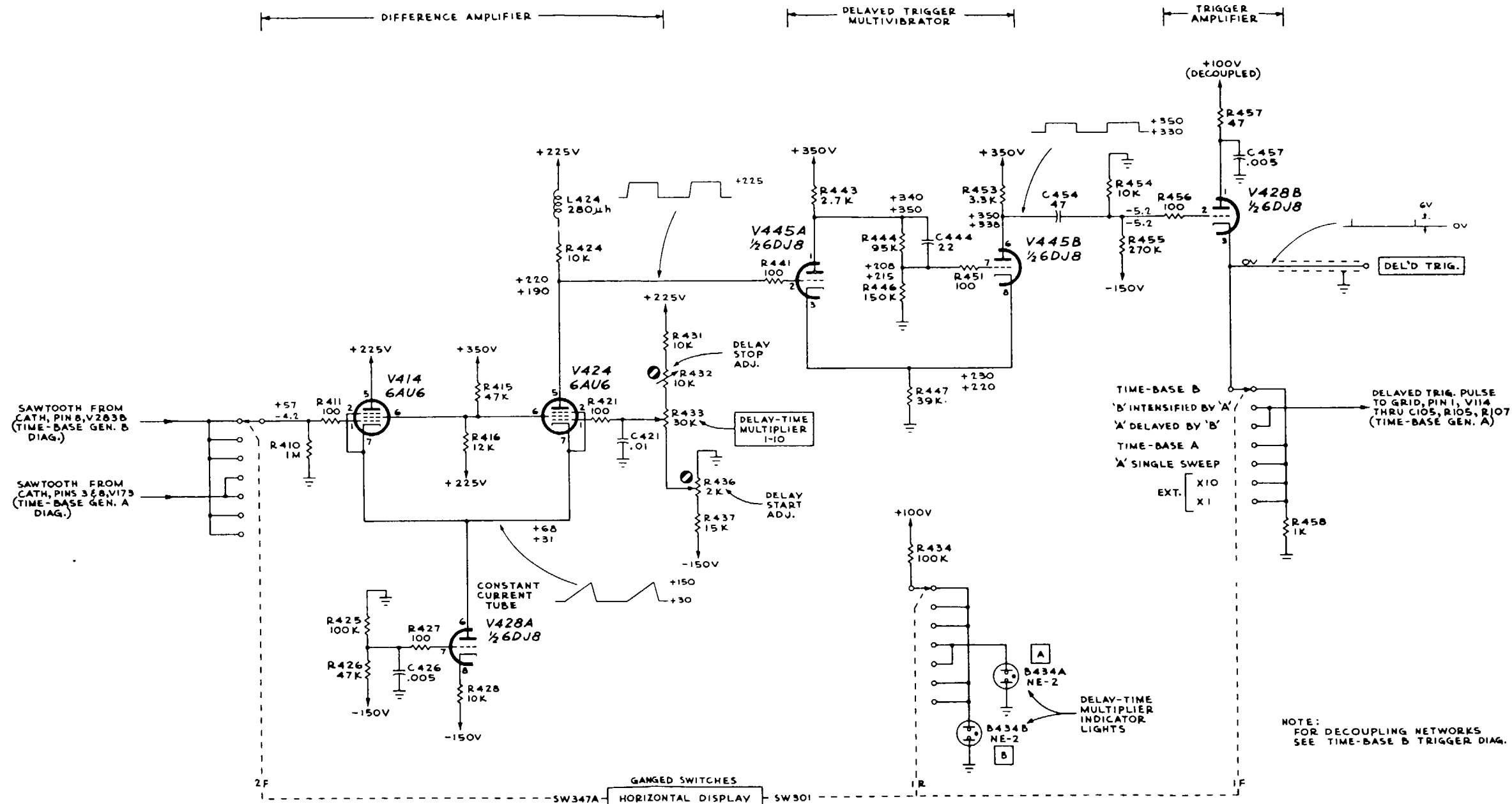
TYPE 535A OSCILLOSCOPE

TIME - BASE A TIMING SWITCH



TYPE 535A OSCILLOSCOPE

TIME - BASE B TIMING SWITCH



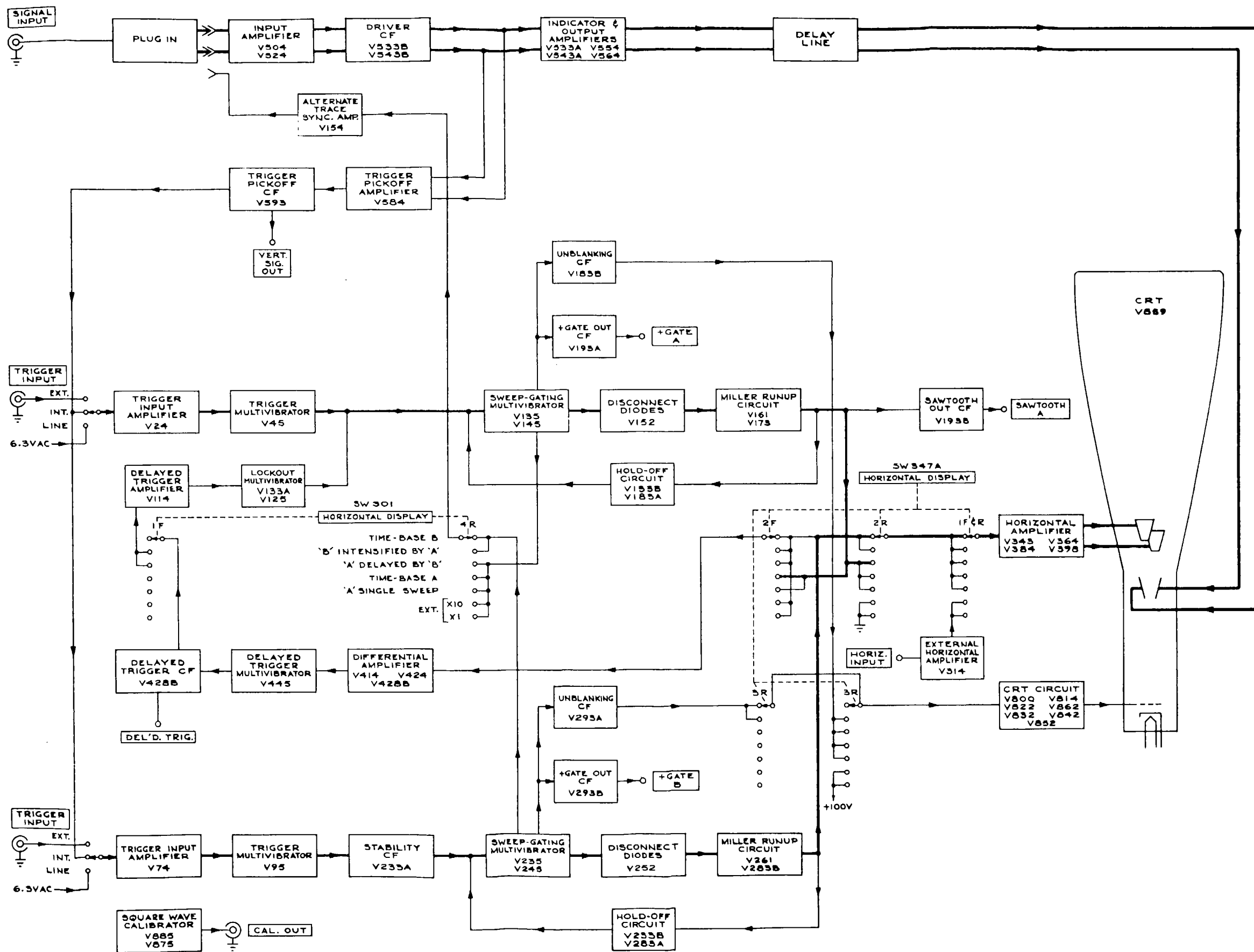
GANGED SWITCHES
 HORIZONTAL DISPLAY SW301
 FOR ADDITIONAL SWITCH DETAILS SEE:
 SW347A C.B.T. DIAG.
 HORIZ. AMP. DIAG.
 SW301 BLOCK DIAG.
 EXT. HORIZ. AMP. DIAG.
 TIME-BASE GEN. A DIAG.

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

TRIGGER INPUT SIGNAL (TIME-BASE A)	.....	+ LINE
HORIZONTAL DISPLAY	.....	TIME-BASE A
DELAY-TIME MULTIPLIER	.....	2.0
STABILITY (TIME-BASE A)	.....
FOR WAVEFORMS	.....	PRESET
FOR UPPER VOLTAGE READINGS	.....	CW
FOR LOWER VOLTAGE READINGS	.....	CW, BUT NOT SWITCHED TO PRESET

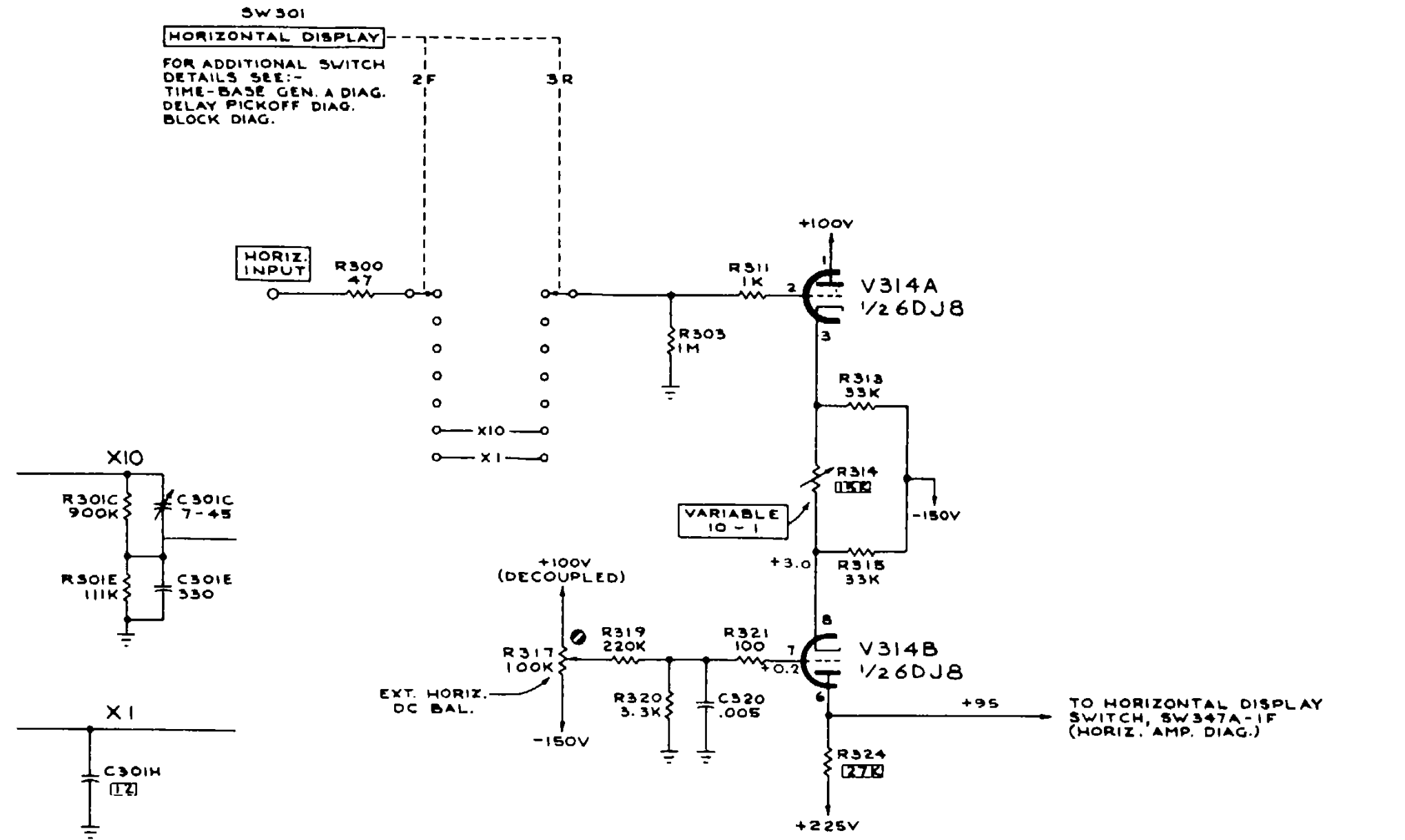
SEE ALSO IMPORTANT NOTE ON TIME-BASE A TRIGGER DIAGRAM.

535A A DELAY-PICKOFF



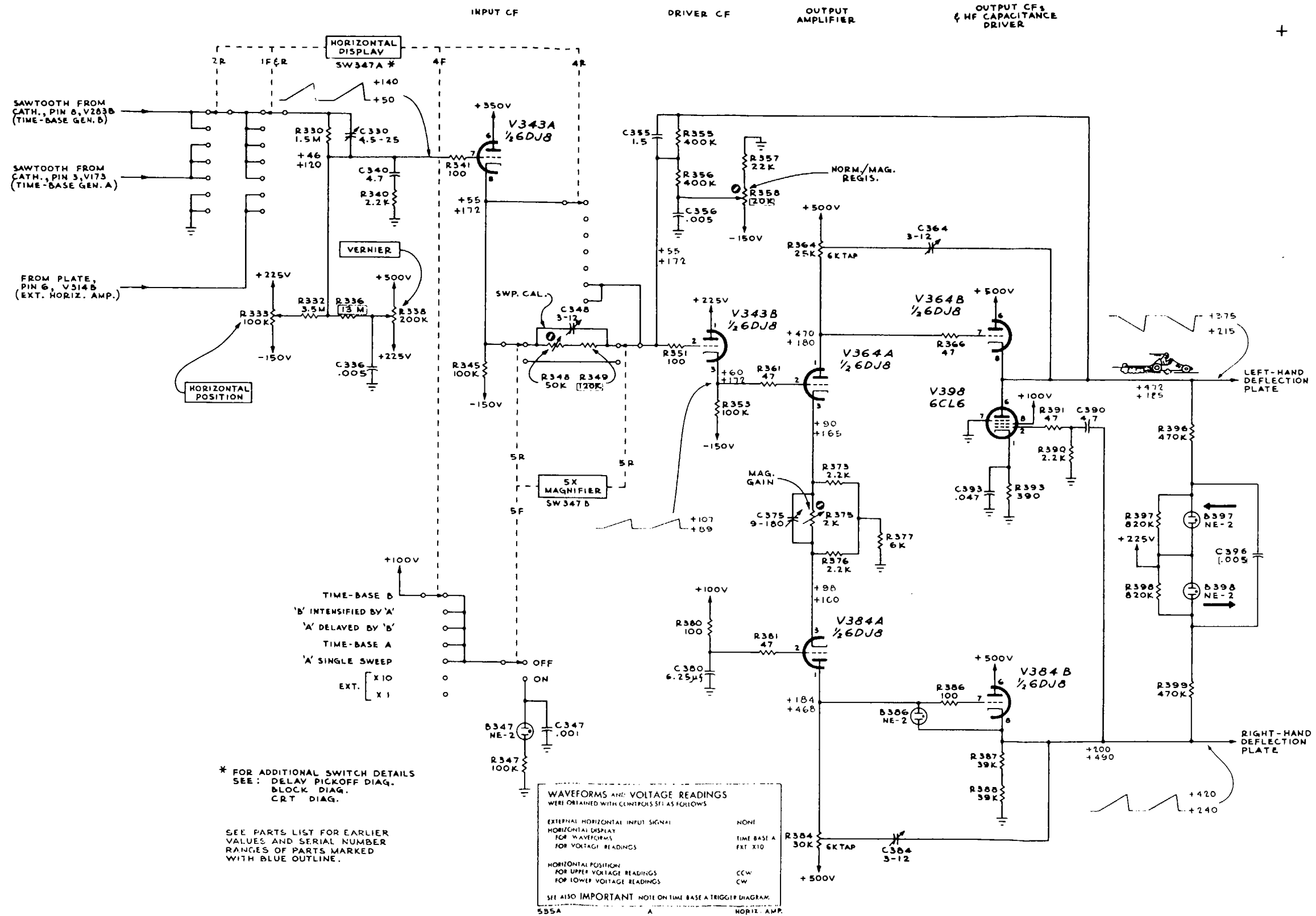
TYPE 535A OSCILLOSCOPE

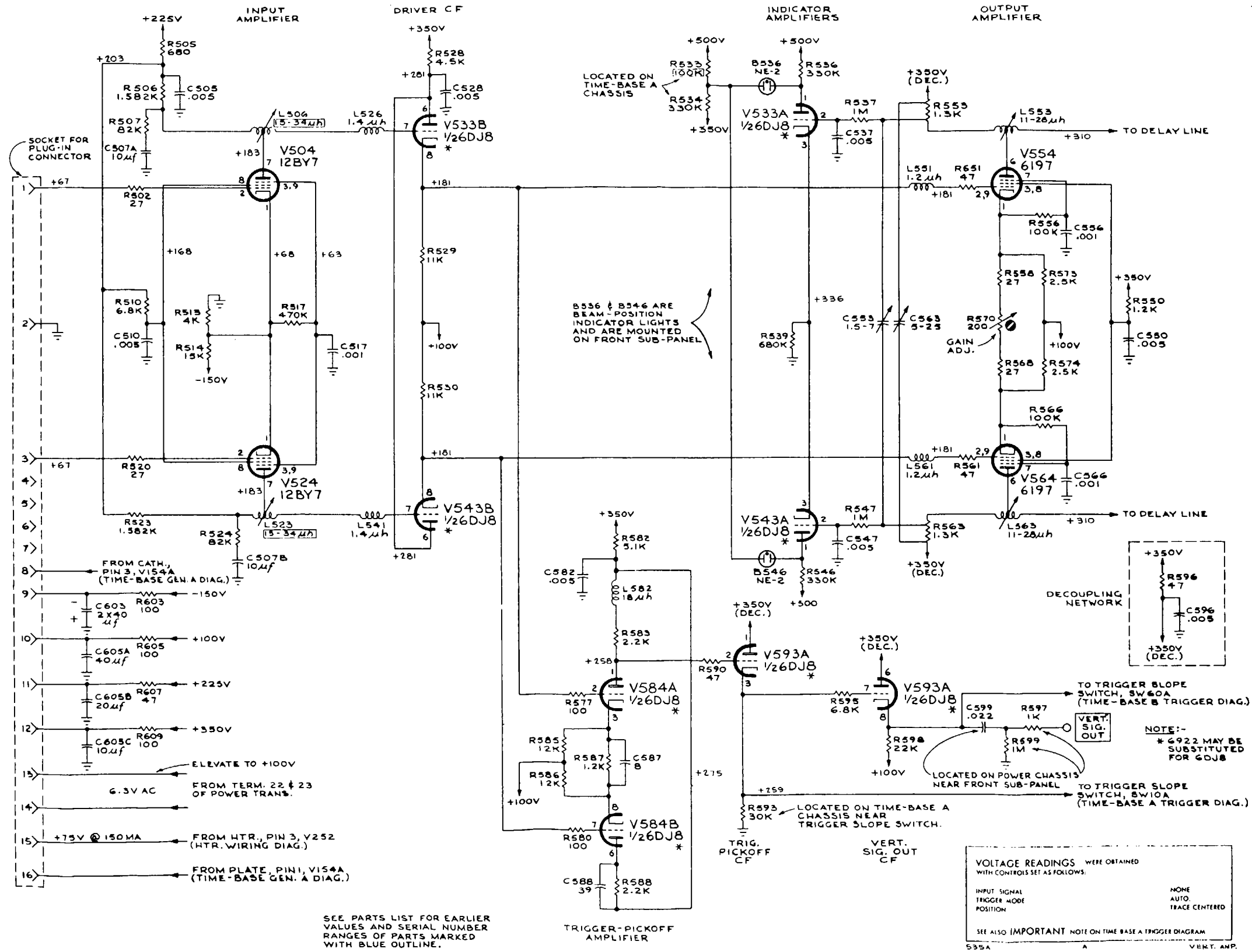
BLOCK DIAGRAM

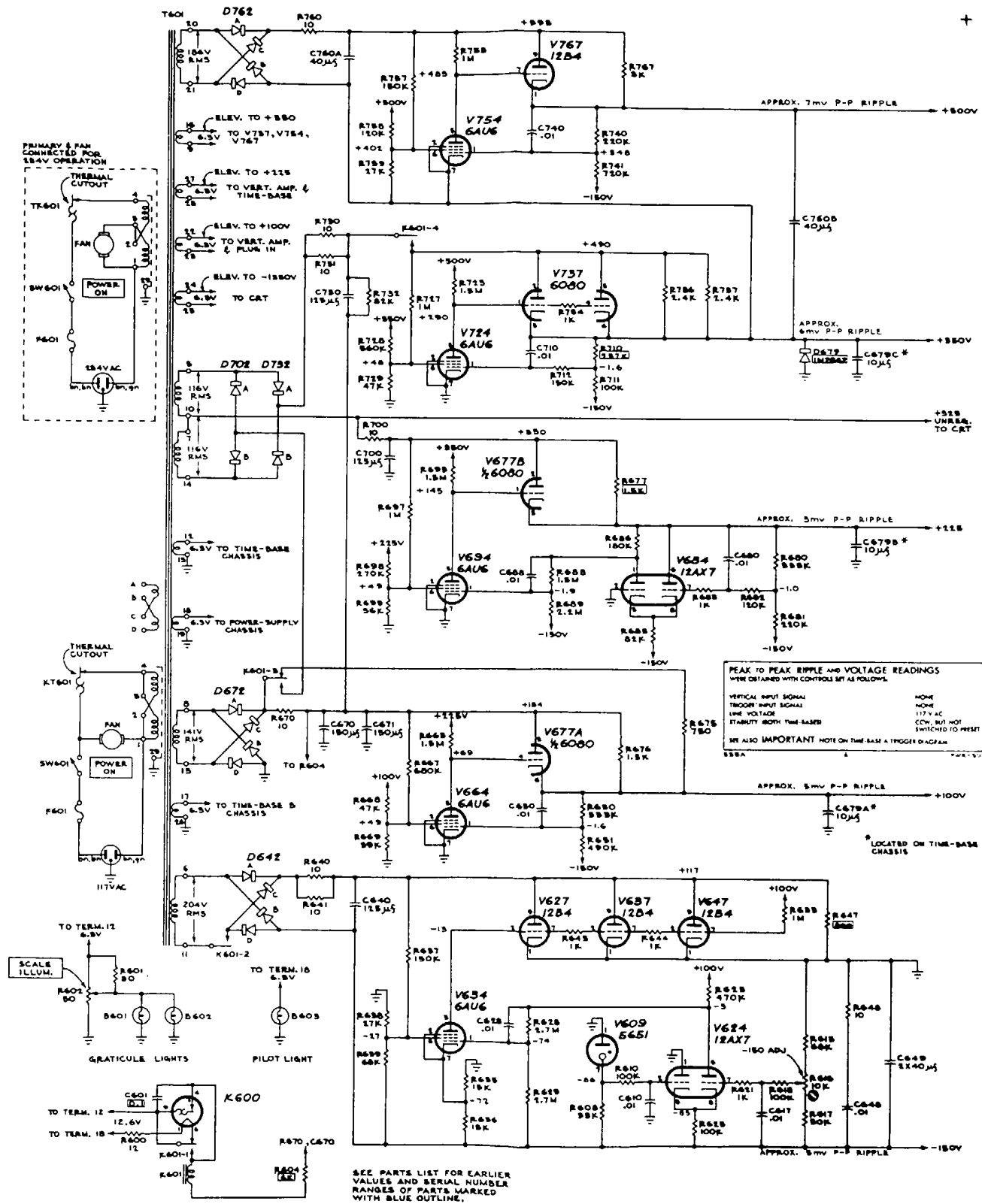
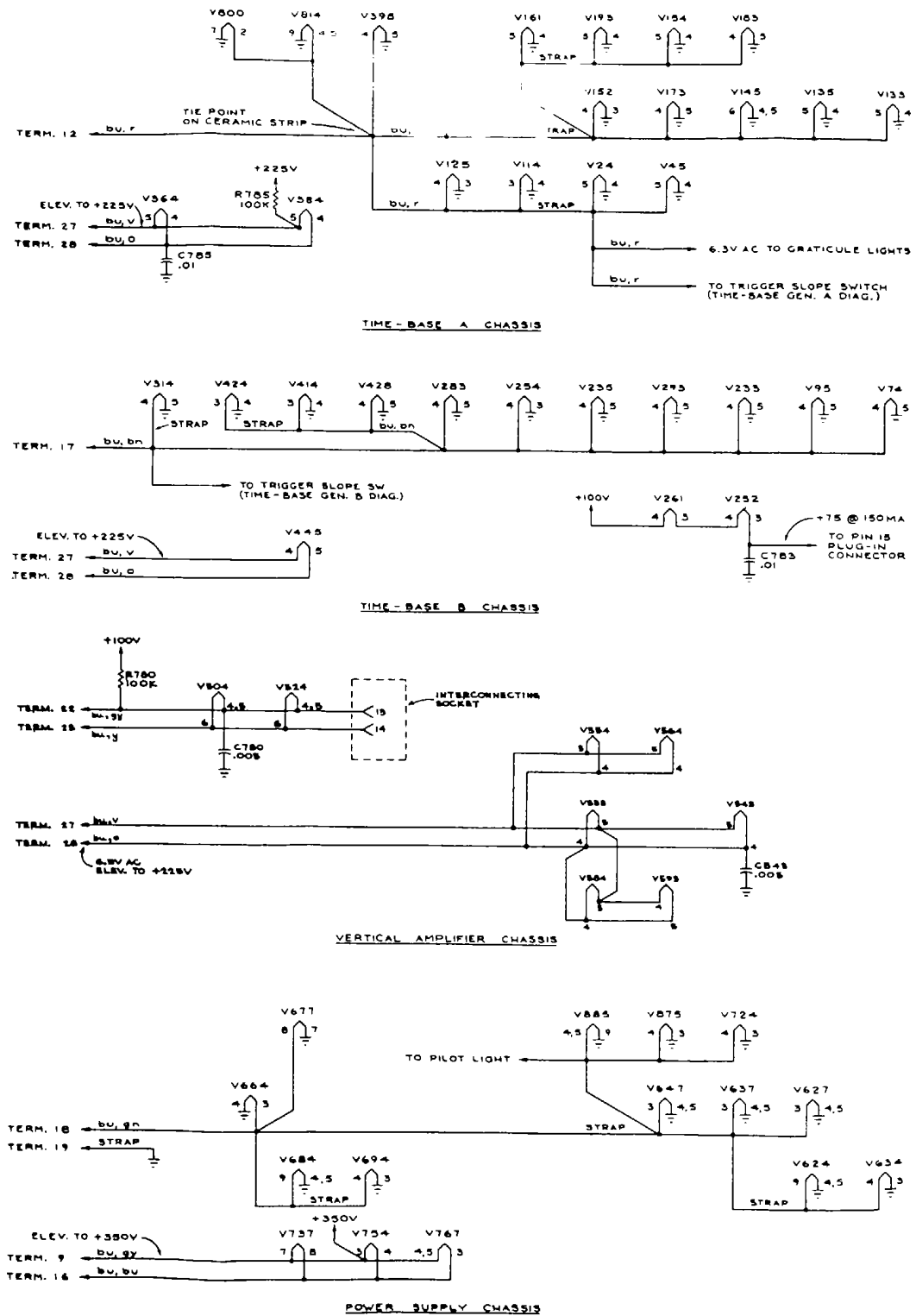


NOTE:-
FOR DECOUPLING NETWORKS SEE TIME-BASE B TRIGGER.
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:	
EXTERNAL HORIZONTAL INPUT SIGNAL	NONE
HORIZONTAL DISPLAY	EXT. X10
VARIABLE 10-1	CW
SEE ALSO IMPORTANT NOTE ON TIME-BASE A TRIGGER DIAGRAM.	



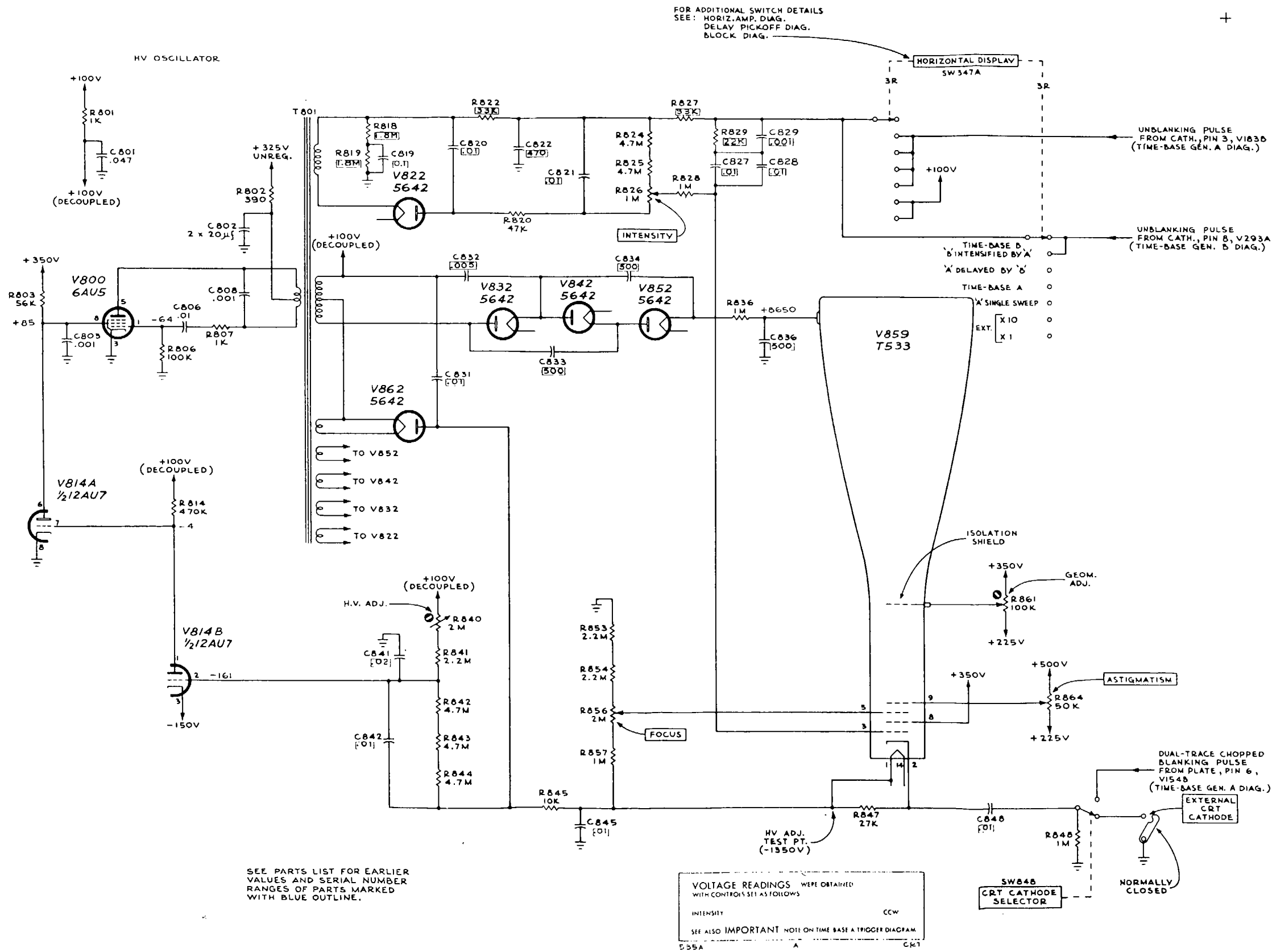




TYPE 535A OSCILLOSCOPE

HEATING WIRING DIAGRAM F₆
CIRCUIT NUMBERS 600 THRU 769

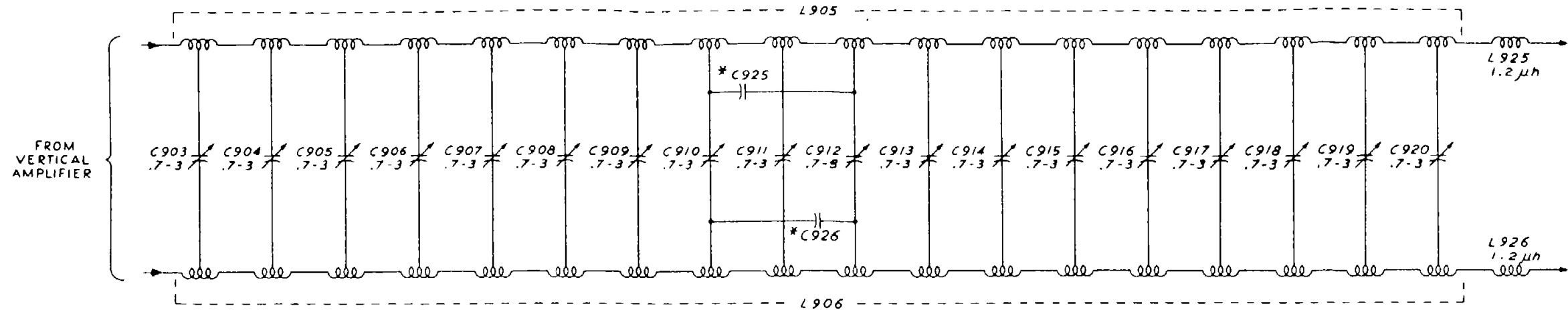
POWER SUPPLY



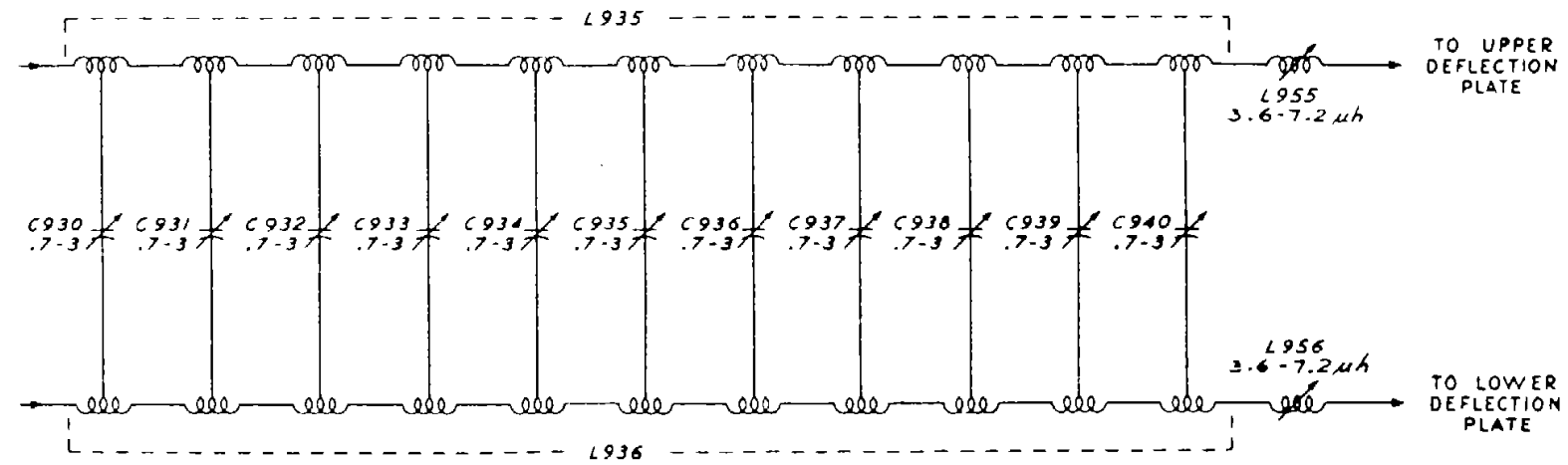
TYPE 535A OSCILLOSCOPE

I₂
CIRCUIT NUMBERS 800 THRU 865

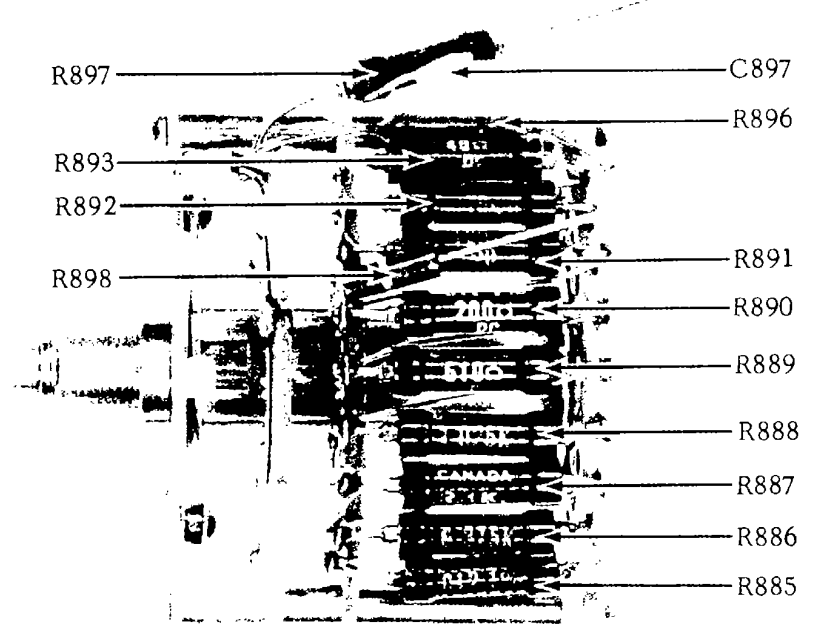
CRT CIRCUIT



* SEE PARTS LIST



SWITCH DETAIL

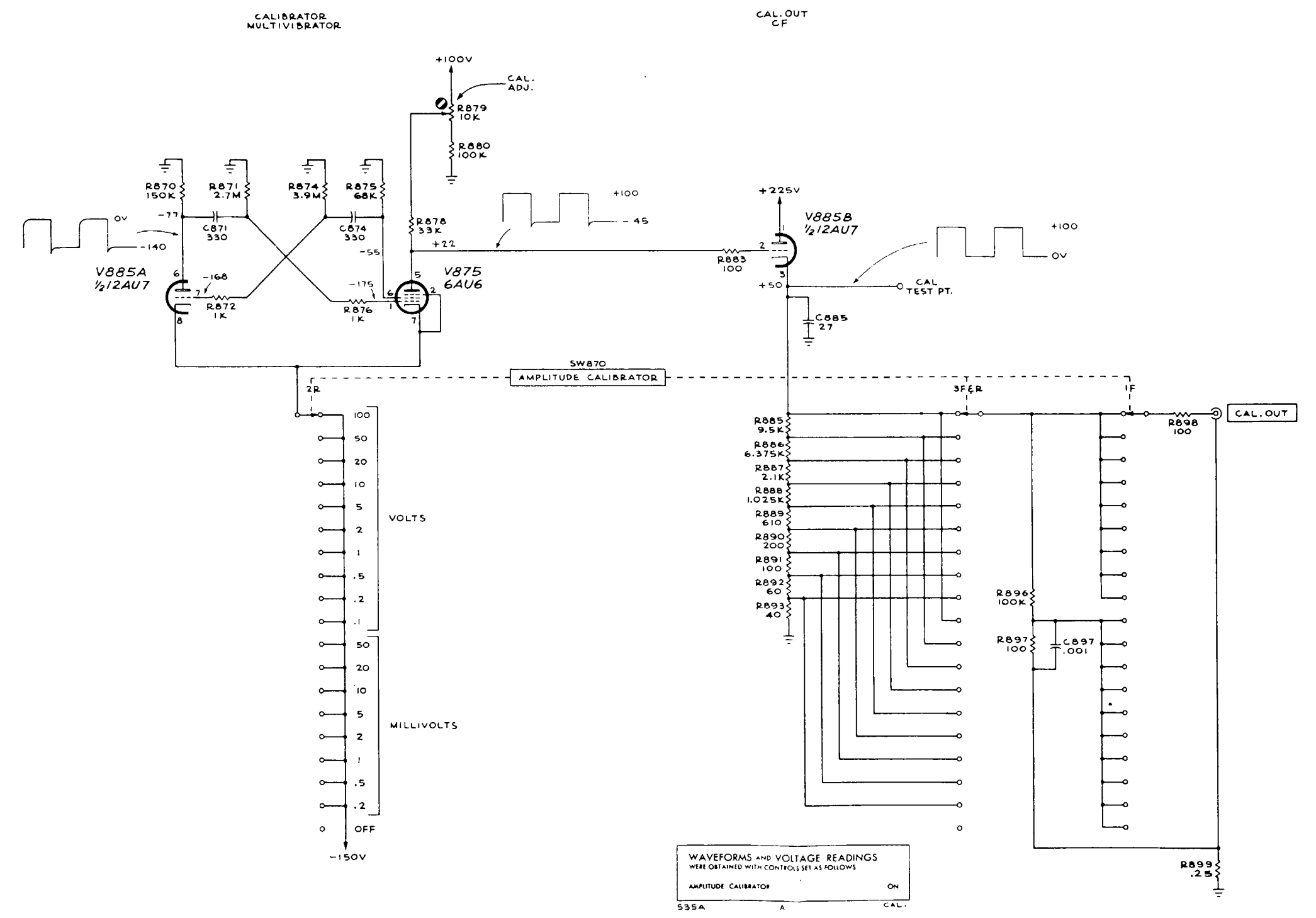


AMPLITUDE CALIBRATOR SWITCH
 Bottom View

535A

A

TYPE 535A OSCILLOSCOPE



CALIBRATOR MULTIVIBRATOR

CAL. OUT CF

VOLTS

MILLIVOLTS

WAVEFORMS AND VOLTAGE READINGS
 WERE OBTAINED WITH CONTROLS SET AS FOLLOWS
 AMPLITUDE CALIBRATOR ON

A₄
 CIRCUIT NUMBERS 300 THRU 325
 +

CALIBRATOR

+

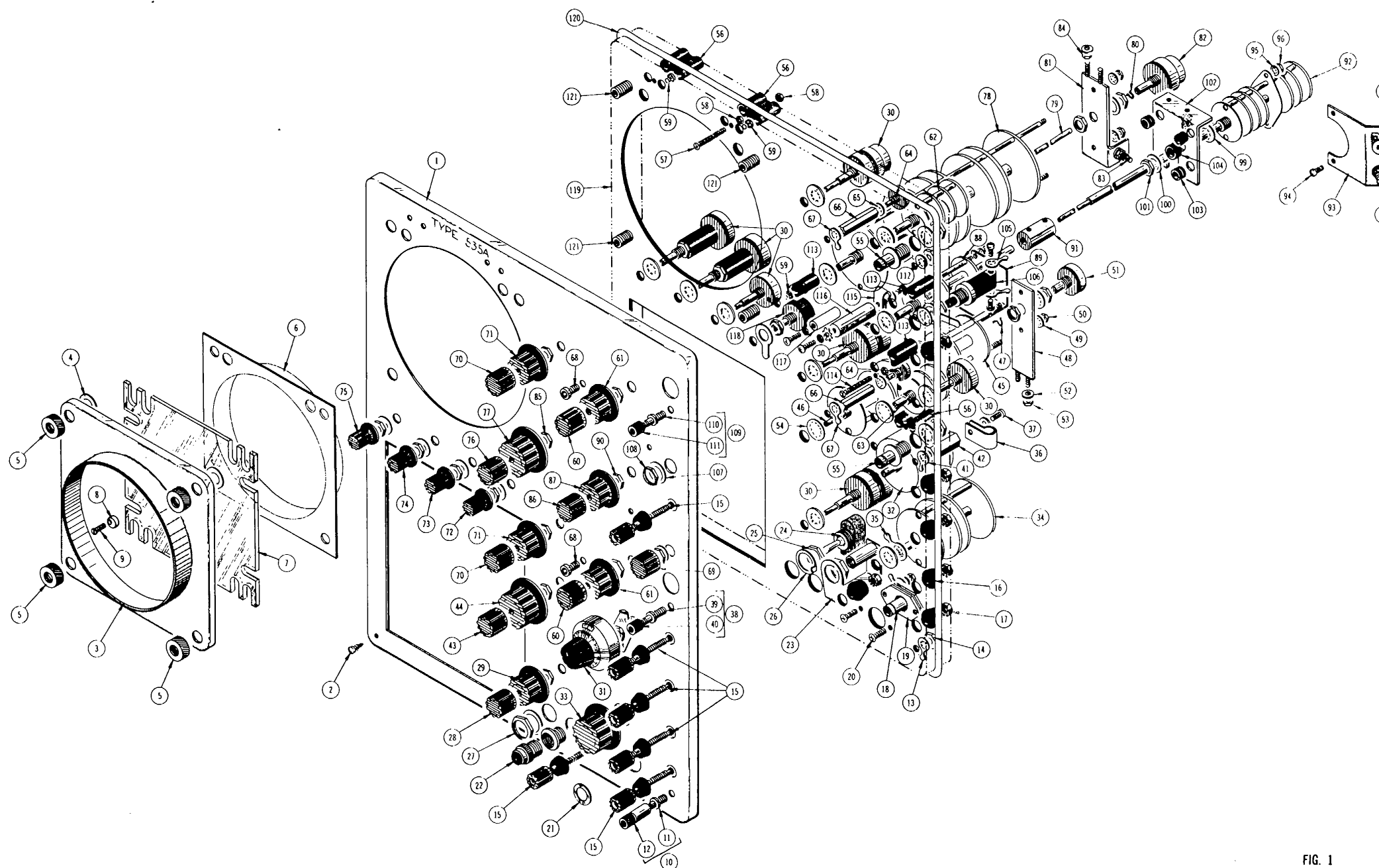


FIG. 1. FRONT & SWITCHES.

FIG. 1

TYPE 535A OSCILLOSCOPE

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TYPE 535A OSCILLOSCOPE

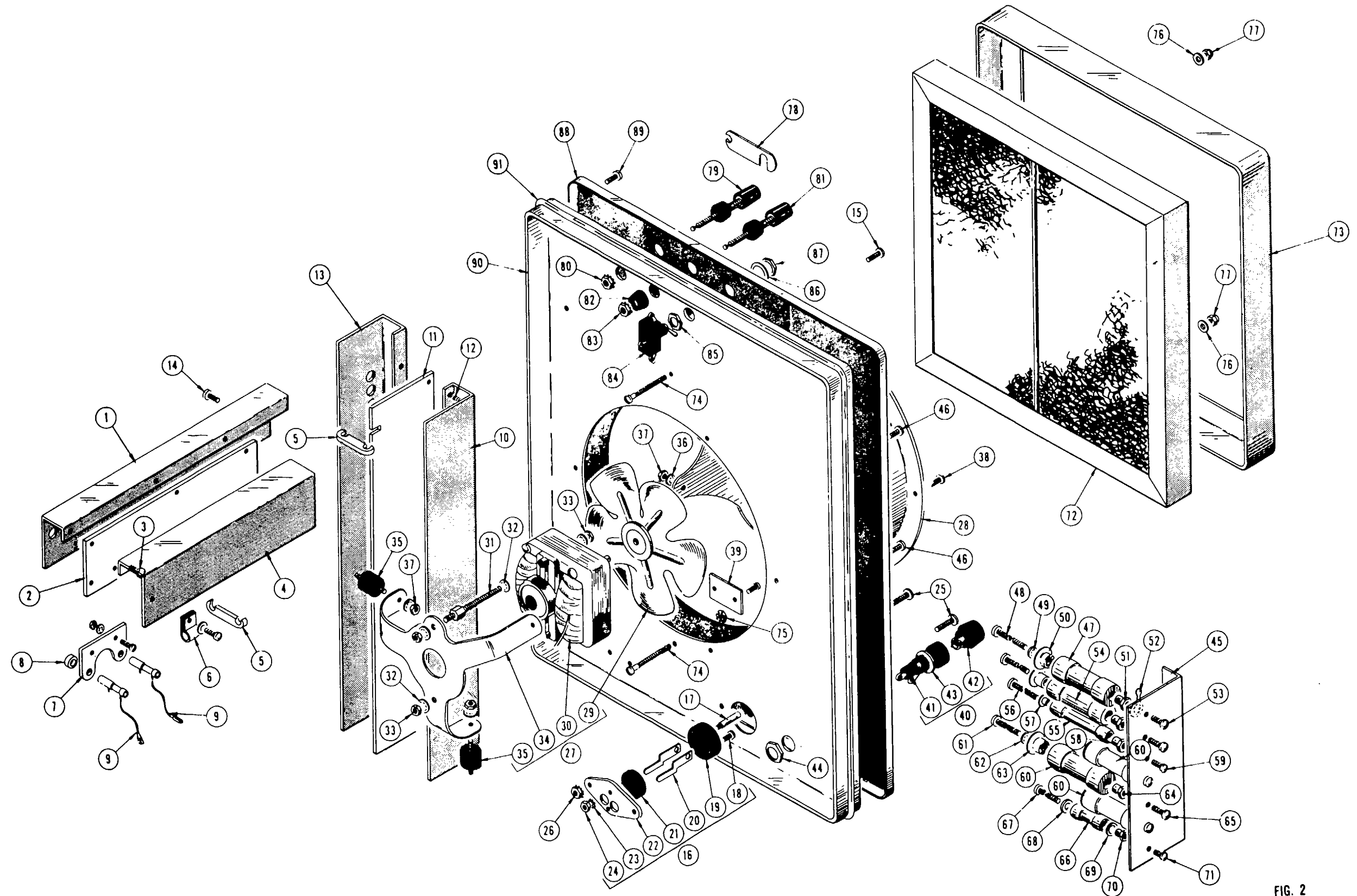


FIG. 2 REAR & DELAY LINE

FIG. 2
TYPE 535A OSCILLOSCOPE

{A}
+

+

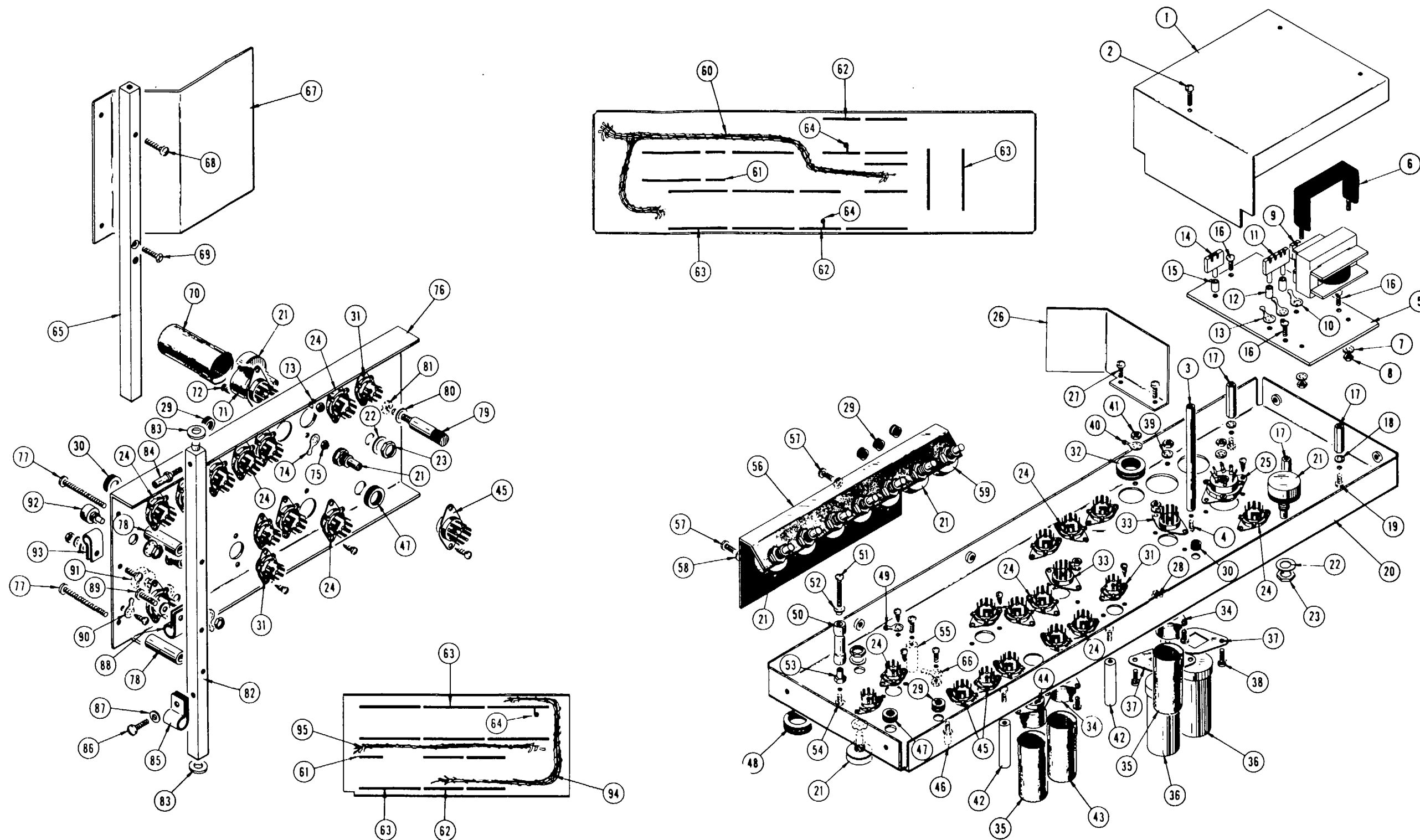


FIG. 3 SWEEP CHASSIS, HIGH VOLTAGE BOARD & DELAY SWEEP CHASSIS

TYPE 535A OSCILLOSCOPE

{A}

+

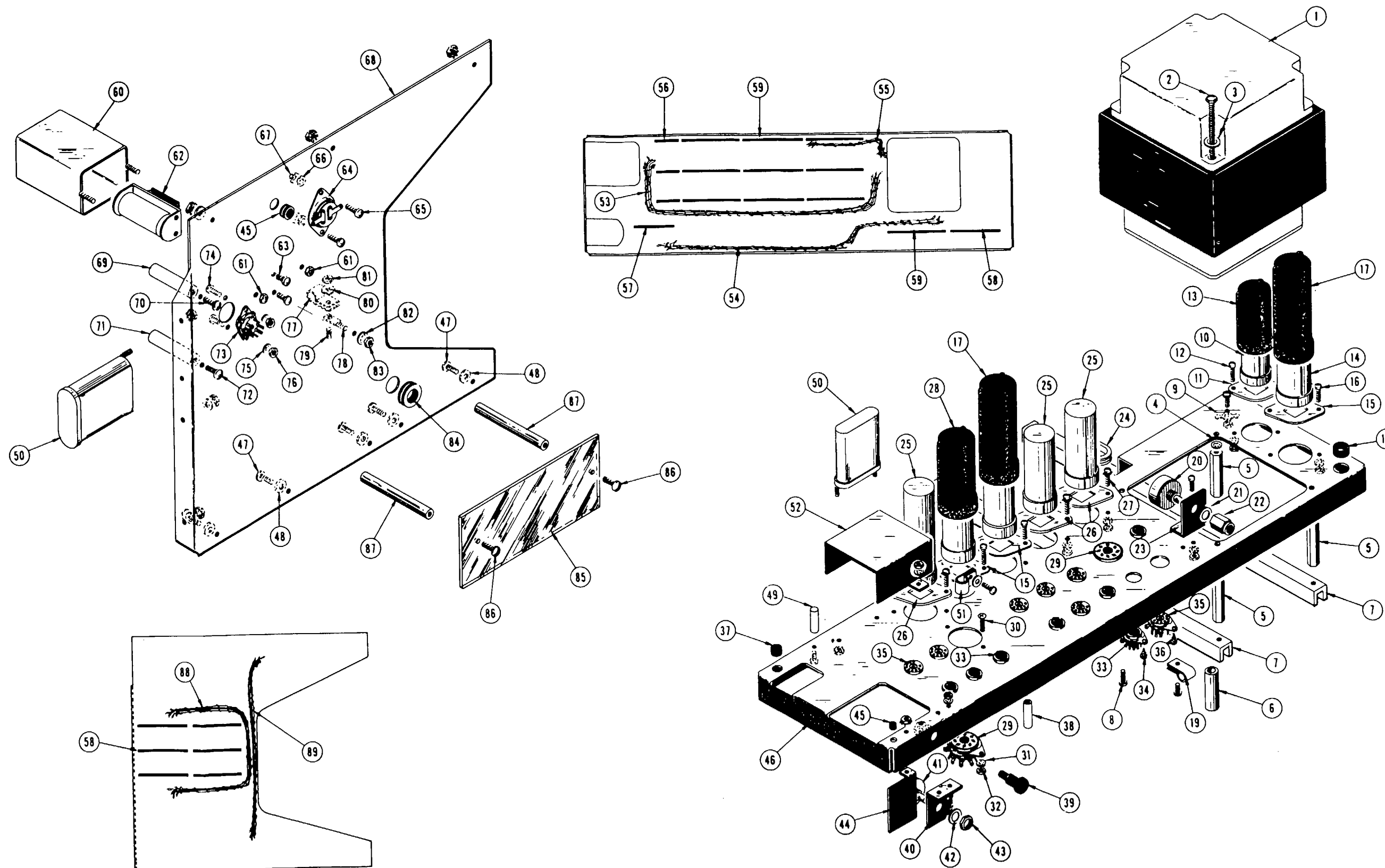
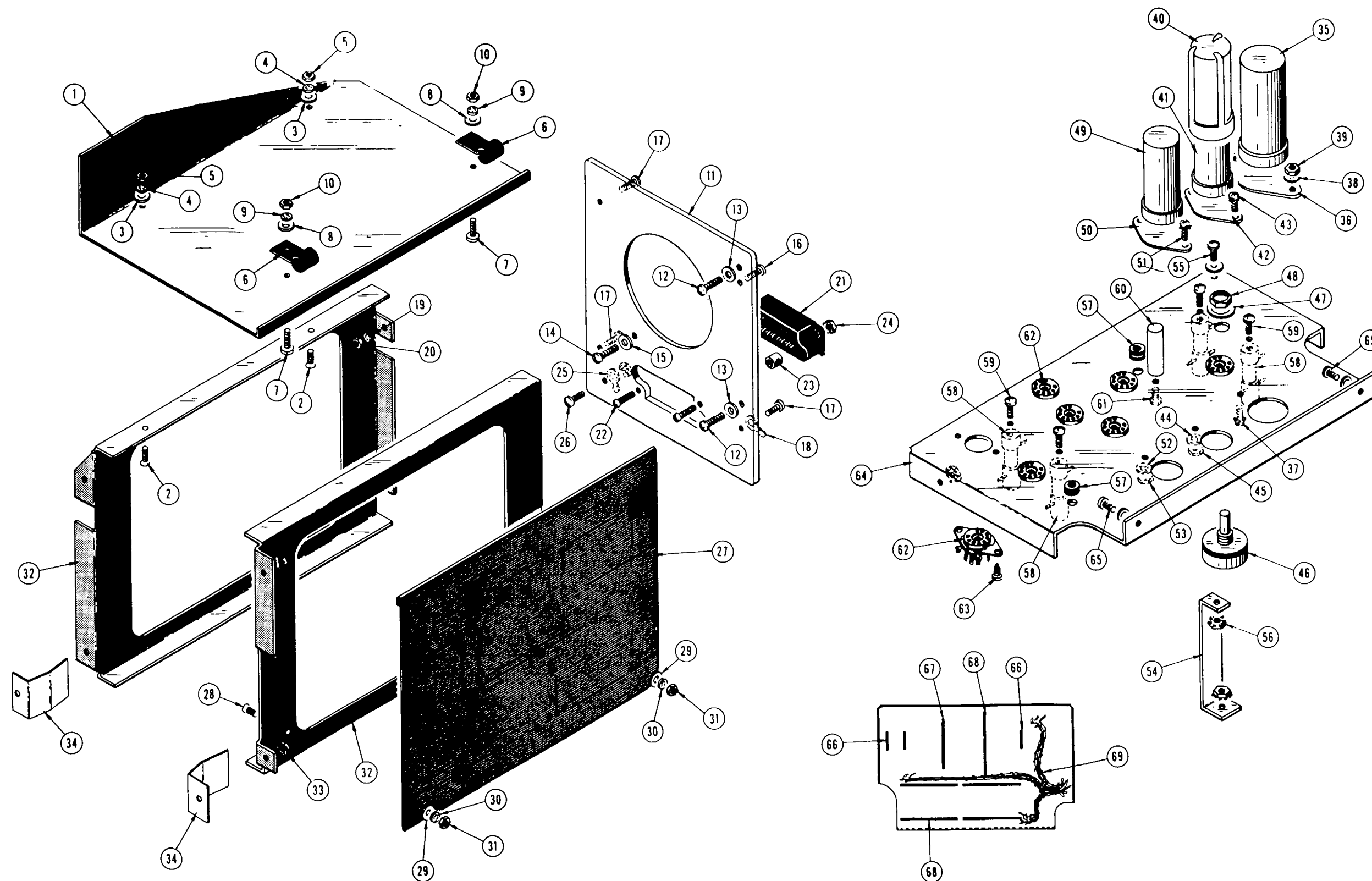


FIG. 4 POWER CHASSIS & RECTIFIER MOUNTING PLATE

FIG. 4
TYPE 535A OSCILLOSCOPE

{A}
+



{A}

+

FIG. 5 VERTICAL AMPLIFIER CHASSIS & PLUG-IN HOUSING

FIG. 5
TYPE 535A OSCILLOSCOPE

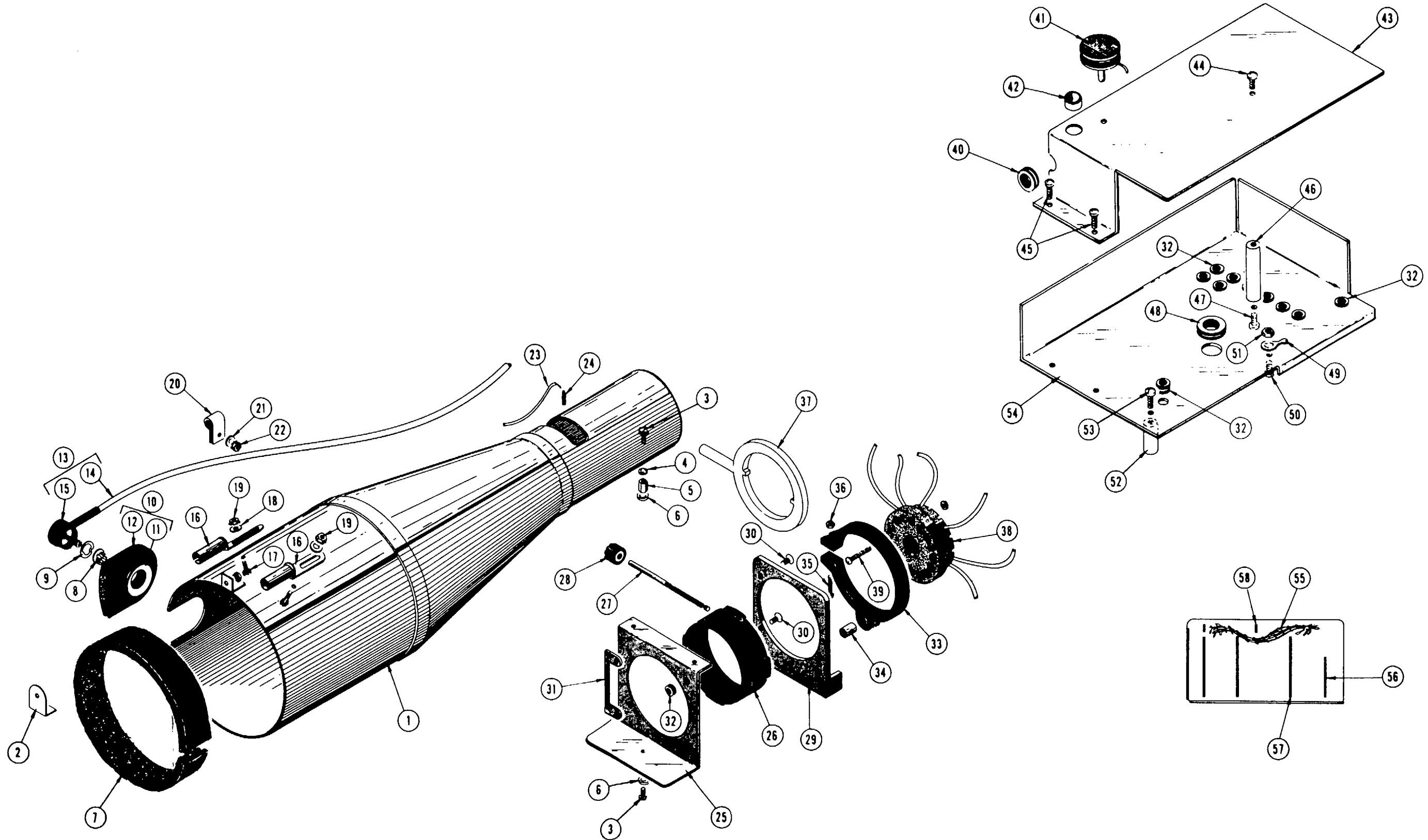


FIG. 6 CATHODE RAY TUBE SHIELD, FOCUS & INTENSITY CHASSIS

FIG. 6
TYPE 535A OSCILLOSCOPE

{A}
+

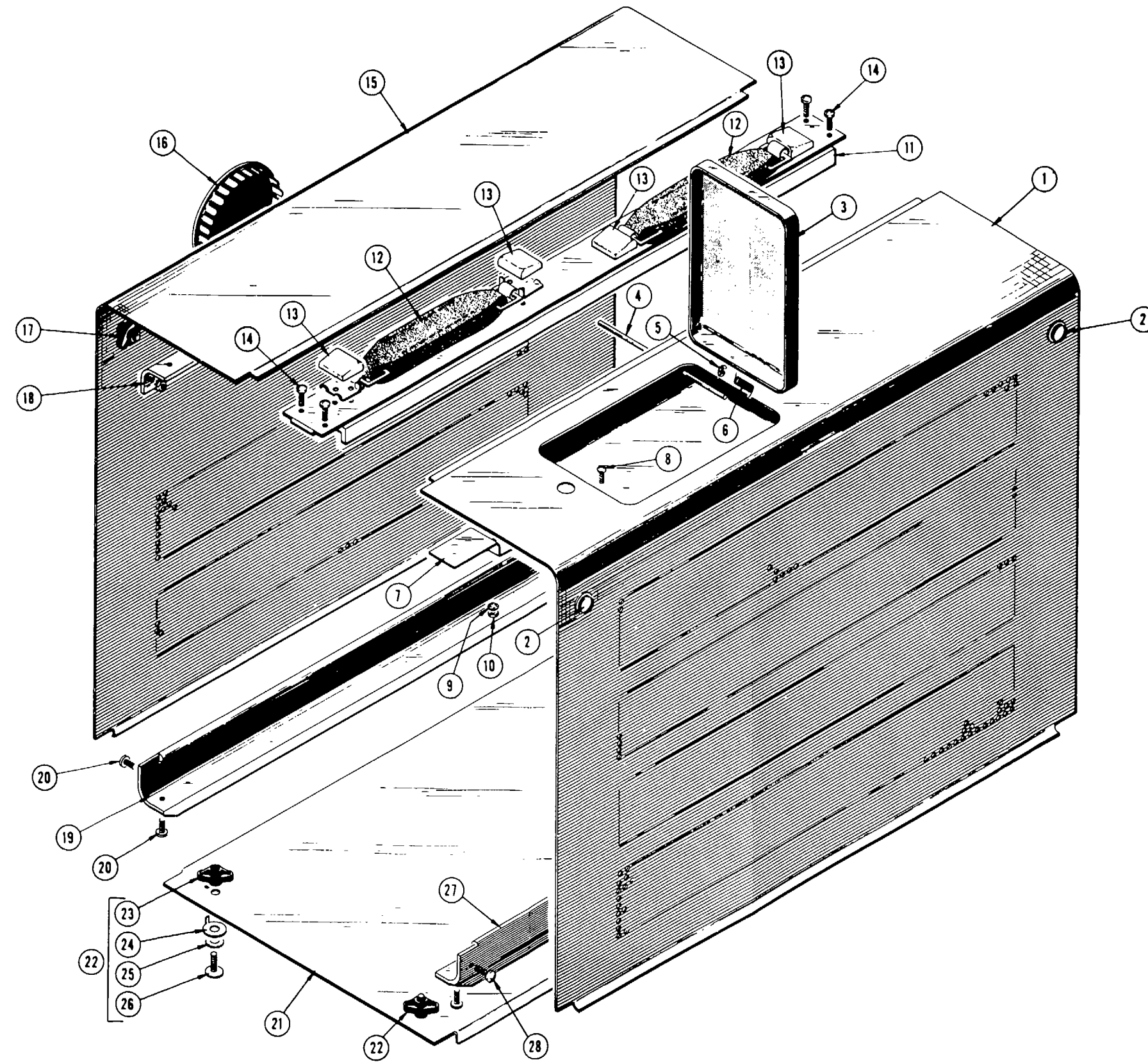


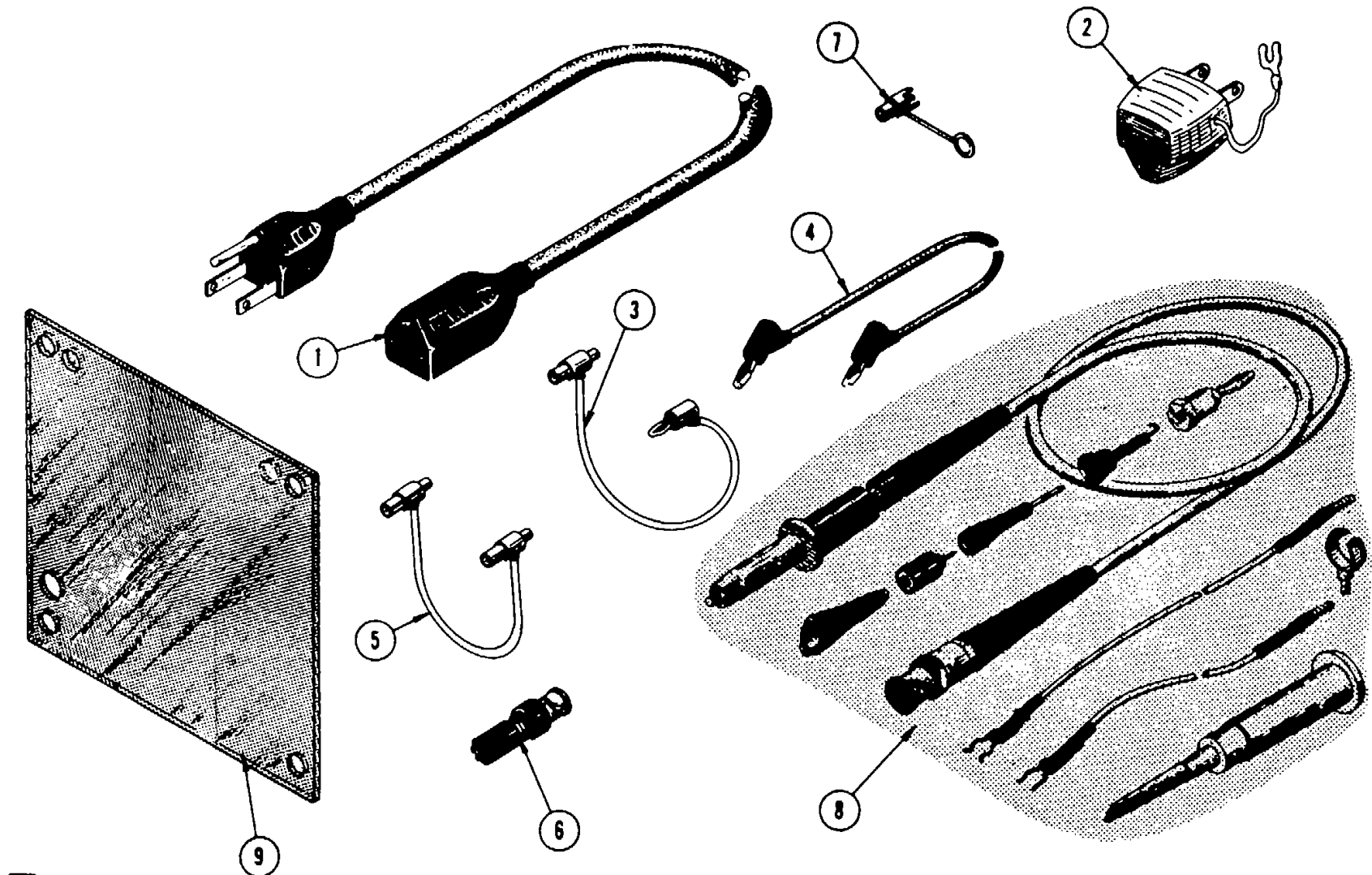
FIG. 7 CABINET & FRAME RAILS

FIG. 7
TYPE 535A OSCILLOSCOPE

+

FIG. 8 STANDARD ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Qty	Description
		Eff	Disc		
8-1	161-0010-00	20001	34599	1	CORD, power, 16 gauge, 8 foot, 3 wire
	161-0010-03	34600		1	CORD, power, 16 gauge, 8 foot, 3 wire
-2	103-0013-00			1	ADAPTER, power cord, 3 to 2 wire
-3	012-0091-00	x32970		1	CORD, patch, BNC to banana, red, 18 inches long
-4	012-0031-00	20001	32969	1	CORD, patch-banana, red, 18 inches long
-5	012-0087-00	32970		1	CORD, patch, BNC to BNC, red, 18 inches long
-6	013-0004-00	20001	31259	2	ADAPTER, binding post
	013-0033-00	31260	3269X	2	ADAPTER, BNC to binding post
-7	012-0092-00	X32970		1	JACK, BNC-POST
-8	010-0127-00			2	PROBE, P6006, 10 MEG, 10X, 42 inches, BNC
-9	378-0514-00	20001	33439	1	FILTER, light, plexiglass, 5 inches, green, w/cam hole
	378-0567-00	33440		1	FILTER, light, smoke gray
--	070-0145-01			2	MANUAL, instruction (not shown)




+ A

FIG. 8 STANDARD ACCESSORIES

FIG. 8 ACCESSORIES
TYPE 535A OSCILLOSCOPE

RECOMMENDED CHANGES TO EQUIPMENT TECHNICAL PUBLICATIONS

 <div style="border: 1px solid black; border-radius: 15px; padding: 5px; display: inline-block; margin-left: 10px;"> <p style="margin: 0;"><i>THEN...JOT DOWN THE DOPE ABOUT IT ON THIS FORM. CAREFULLY TEAR IT OUT, FOLD IT AND DROP IT IN THE MAIL.</i></p> </div>		SOMETHING WRONG WITH PUBLICATION	
		FROM: (PRINT YOUR UNIT'S COMPLETE ADDRESS)	
		DATE SENT	
PUBLICATION NUMBER		PUBLICATION DATE	PUBLICATION TITLE
IN THIS SPACE, TELL WHAT IS WRONG AND WHAT SHOULD BE DONE ABOUT IT.			
BE EXACT PIN-POINT WHERE IT IS			
PAGE NO.	PARA-GRAPH	FIGURE NO.	TABLE NO.
PRINTED NAME, GRADE OR TITLE AND TELEPHONE NUMBER		SIGN HERE	

The Metric System and Equivalents

Linear Measure

1 centimeter = 10 millimeters = .39 inch
 1 decimeter = 10 centimeters = 3.94 inches
 1 meter = 10 decimeters = 39.37 inches
 1 dekameter = 10 meters = 32.8 feet
 1 hectometer = 10 dekameters = 328.08 feet
 1 kilometer = 10 hectometers = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigrams = .035 ounce
 1 decagram = 10 grams = .35 ounce
 1 hectogram = 10 decagrams = 3.52 ounces
 1 kilogram = 10 hectograms = 2.2 pounds
 1 quintal = 100 kilograms = 220.46 pounds
 1 metric ton = 10 quintals = 1.1 short tons

Liquid Measure

1 centiliter = 10 milliliters = .34 fl. ounce
 1 deciliter = 10 centiliters = 3.38 fl. ounces
 1 liter = 10 deciliters = 33.81 fl. ounces
 1 dekaliter = 10 liters = 2.64 gallons
 1 hectoliter = 10 dekaliters = 26.42 gallons
 1 kiloliter = 10 hectoliters = 264.18 gallons

Square Measure

1 sq. centimeter = 100 sq. millimeters = .155 sq. inch
 1 sq. decimeter = 100 sq. centimeters = 15.5 sq. inches
 1 sq. meter (centare) = 100 sq. decimeters = 10.76 sq. feet
 1 sq. dekameter (are) = 100 sq. meters = 1,076.4 sq. feet
 1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
 1 sq. kilometer = 100 sq. hectometers = .386 sq. mile

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
 1 cu. decimeter = 1000 cu. centimeters = 61.02 cu. inches
 1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Approximate Conversion Factors

To change	To	Multiply by	To change	To	Multiply by
inches	centimeters	2.540	ounce-inches	Newton-meters	.007062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
square inches	square centimeters	6.451	kilometers	miles	.621
square feet	square meters	.093	square centimeters	square inches	.155
square yards	square meters	.836	square meters	square feet	10.764
square miles	square kilometers	2.590	square meters	square yards	1.196
acres	square hectometers	.405	square kilometers	square miles	.386
cubic feet	cubic meters	.028	square hectometers	acres	2.471
cubic yards	cubic meters	.765	cubic meters	cubic feet	35.315
fluid ounces	milliliters	29.573	cubic meters	cubic yards	1.308
pints	liters	.473	milliliters	fluid ounces	.034
quarts	liters	.946	liters	pints	2.113
gallons	liters	3.785	liters	quarts	1.057
ounces	grams	28.349	liters	gallons	.264
pounds	kilograms	.454	grams	ounces	.035
short tons	metric tons	.907	kilograms	pounds	2.205
pound-feet	Newton-meters	1.356	metric tons	short tons	1.102
pound-inches	Newton-meters	.11296			

Temperature (Exact)

°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C
----	------------------------	----------------------------	---------------------	----

PIN: 017291-000