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INSTRUCTION MANUAL

Serial Number 1408

TYPE 549
STORAGE
OSCILLOSCOPE

Tektronix, Inc.

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070-0508-00



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Abbreviations and symbols used in this manual are based on, or taken directly from, IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

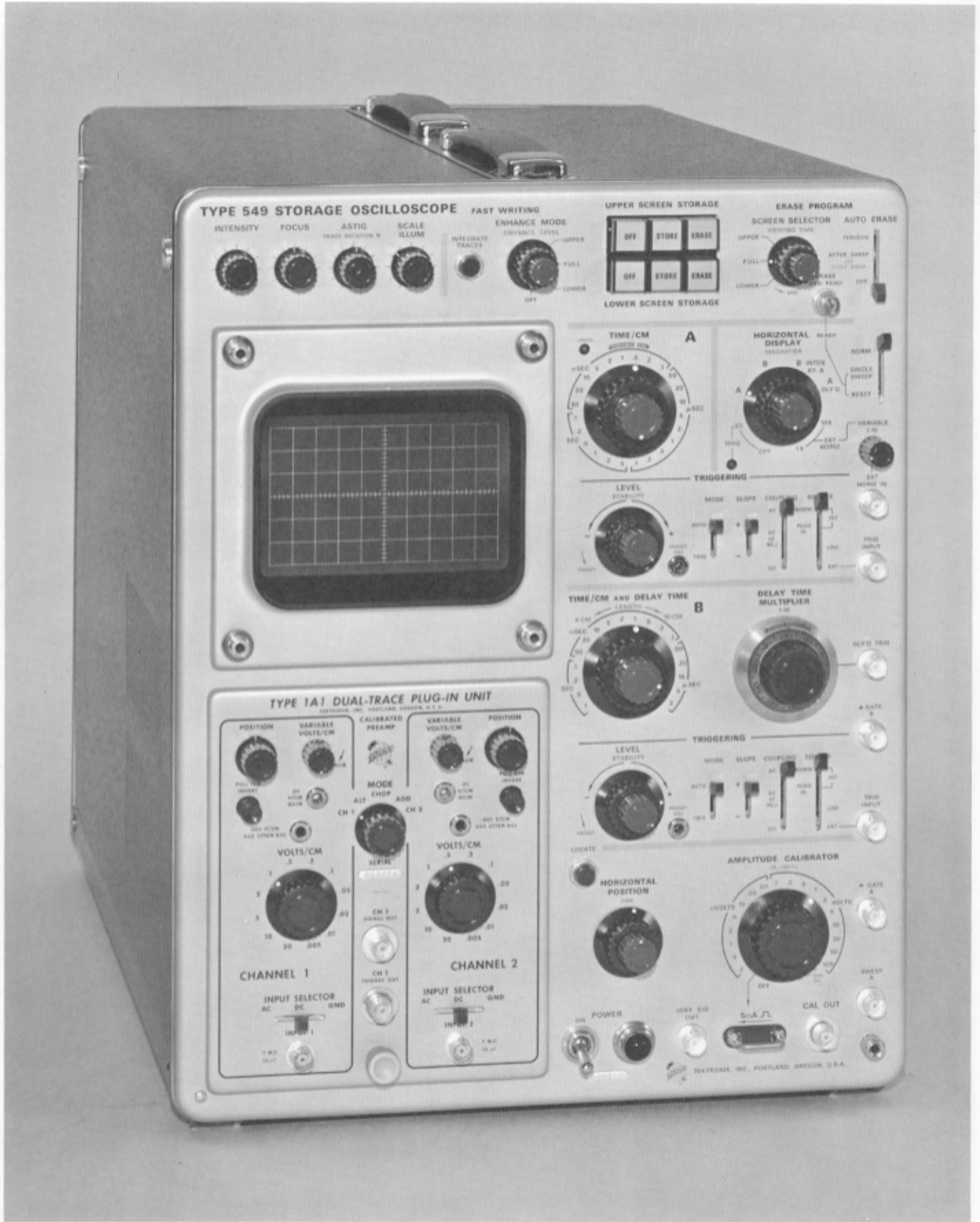


Fig. 1-1. The Type 549 Storage Oscilloscope.

SECTION 1

CHARACTERISTICS AND OPERATING FEATURES

Introduction

The Type 549 Storage Oscilloscope is a laboratory instrument designed to operate with all Tektronix letter-series or one-series plug-in units.

The cathode ray tube (T5490) used in the Type 549 is a direct view, bistable storage tube having a 6×10 cm display area, divided into two 3×10 cm targets. The targets are independently controlled for split screen applications. An additional area which does not store is provided to the left of the targets. This area functions as a locate zone in single sweep store mode.

This instrument will perform to specifications in laboratory environment with ambient temperature range between 0° C to 50° C except as indicated. Warm-up time for rated accuracies at $+25^{\circ}$ C $\pm 5^{\circ}$ C is 20 minutes. Adequate ventilation must be maintained, and a minimum two inch clearance around the instrument is recommended.

Statements related to measurement capabilities of the instrument with respect to voltage, time or frequency are characteristics and are printed in bold type. Other features are listed in regular type.

Characteristic or Feature	Requirement
----------------------------------	--------------------

VERTICAL DEFLECTION SYSTEM

Frequency Response	DC to 30 MHz or more (at -3 dB point). Equivalent to a risetime of 12 ns or less.
Input Deflection Factor	100 mV/cm $\pm 3\%$

HORIZONTAL DEFLECTION SYSTEM

Time Base A	
Sweep Rate	Accuracy within $\pm 3\%$ of indicated rate in all calibrated step positions.
Variable Range	Sweep rate continuously variable uncalibrated.
Time Base B	
Sweep Rate	Accuracy within $\pm 3\%$ of indicated rate in all calibrated step positions.
Sweep Length	Sweep length is adjustable from 4 cm or less to 10 cm or more.
$\times 5$ Magnified (Time Base A and B)	Accuracy is within $\pm 2\%$ of the sweep rate accuracy.

STORAGE PERFORMANCE

Writing Speed	Equal to or greater than 0.5 cm/μs.
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Characteristic or Feature

Requirement

Enhanced Writing Speed	Equal to or greater than 5 cm/μs.
Stored Resolution	Stored vertical resolution, 20 lines/cm.
Contrast Ratio	Contrast ratio at operating level is equal to or greater than 4:1.

VARIABLE TIME DELAY

Delay Time Accuracy	Accuracy is within $\pm 1\%$ of Time Base B sweep rate accuracy. (± 2.0 minor divisions of the DELAY TIME MULTIPLIER dial).
Multiplier Incremental Linearity	Incremental delay accuracy is $\pm 0.2\%$ of total range.
Variable Time Delay Jitter	1 part in 20,000 of the available delay interval. (10 times B TIME/CM setting).

NOTE

Stated accuracies apply only when the VARIABLE control is set to the CAL position.

AMPLITUDE CALIBRATOR

Voltage Output	Peak to peak amplitude accuracy is within $\pm 2\%$ of indicated amplitude when working into an impedance of 1 MΩ or higher. When working into a 50 Ω load, in the 0.2 to 200 mVOLT position, output amplitude is one-half the indicated amplitude $\pm 3\%$.
Current Output	5 mA $\pm 2\%$.
Current Signal Output	Provides a square wave of current or DC.
Frequency	1 kHz $\pm 25\%$, positive going square wave with zero volt baseline.
Rise Time	Equal to or less than 1 μ s.

EXTERNAL HORIZONTAL AMPLIFIER

Frequency Response	DC to 350 kHz at maximum gain (at -3 dB point).
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Characteristics—Type 549

Characteristic or Feature	Requirement	Remote Control Connector
Deflection Factor		
1×	0.2 V/cm maximum. (VARIABLE 1-10 control fully clockwise)	Remote Erase - Upper Screen Ground pin A. Lower Screen Ground pin B.
10×	2 V/cm maximum. VARIABLE 1-10 control provides variable attenuation of the input signal of at least 10:1.	Remote Erase and Reset Ground pin E. Remote Single Sweep Reset Ground pin F. Remote Save Ground pin C. Remote Store - Upper Screen Ground pin H. Lower Screen Ground pin J.

FRONT PANEL OUTPUT SIGNALS

VERT SIG OUT	Output is 1.5 volts per centimeter $\pm 20\%$ of displayed deflection on the CRT. Frequency response is DC to 700 kHz (at the -3 dB point). This is equivalent to a risetime of $1 \mu\text{s}$ or faster.
SWEEP A	150 volts ± 10 volts increasing to approximately 180 V ± 10 volts at the faster sweep speeds and having the same time duration as the A sweep. Recommended load resistance equal to or greater than 100 k Ω .
+ GATE A	Within the range of 20 to 40 volts. Positive going pulse with the baseline at zero volts. Time coincident with the A sweep. Recommended load resistance equal to or greater than 5 k Ω .
+ GATE B	Within the range of 20 to 40 volts. Positive going pulse, baseline at zero volts, time coincident with the B sweep.
DLY'D TRIG	A positive going pulse 7 V ± 2 V into a load equal to or greater than 10 k Ω . Pulse occurs at the end of the delay period.

EXTERNAL SIGNAL CONNECTORS

Z Axis Modulation

CRT GRID	An applied 20 volt peak-to-peak signal from DC to 1 MHz will blank or unblank the CRT. A 5 volt peak-to-peak signal will produce noticeable modulation. Negative portion of signal blanks CRT beam.
CRT CATHODE	An applied 20 volt peak-to-peak signal from 20 kHz to 1 MHz will blank or unblank the CRT. A 5 volt peak-to-peak signal will produce noticeable modulation. Positive portion of the signal blanks CRT beam.

A and B SWEEP GENERATOR

TRIGGERING FEATURES

Source	Internal (from trigger pickoff circuit in the vertical amplifier or from the plug-in unit), external and line.
Coupling	Direct (DC), capacitive (AC) or low-frequency rejection (AC LF REJ).
Slope	Trigger on positive going or negative going portion of trigger signal.
Mode	Automatic or Trig, adjustable stability at an adjustable level and free running sweep.

Triggering Performance¹

A Time Base

Source	Coupling	Condition
NORM (internal)	DC	Minimum 0.2 cm of deflection, DC to 10 MHz, increasing to 2.0 cm at 30 MHz.
	AC	Same amplitude as DC. 300 Hz to 30 MHz.
	AC LF REJ	Same amplitude as DC. 200 kHz to 30 MHz.
PLUG-IN (internal)		Triggering dependent on plug-in unit performance.
EXT	DC	Minimum 0.3 volt signal, DC to 10 MHz increasing to 3 volts at 30 MHz.
	AC	Same amplitude as DC, 300 Hz to 30 MHz.
	AC LF REJ	Same amplitude as DC, 200 kHz to 30 MHz.

¹ Upper and lower frequency triggering requirements for Time Base A are shown in Fig. 1-2.

B Time Base²

Source	Coupling	Condition
NORM (internal)	DC	Minimum 0.2 cm of deflection, DC to 1 MHz, increasing to 1 cm at 10 MHz.
	AC	Same amplitude as DC, 300 Hz to 10 MHz.
	AC LF REJ	Same amplitude as DC, 200 kHz to 10 MHz.
PLUG-IN (internal)		Triggering dependent on plug-in unit performance.
EXT	DC	Minimum 0.3 volt signal, DC to 1 MHz, increasing to 1.5 V at 10 MHz.
	AC	Same amplitude as DC, 300 Hz to 10 MHz.
	AC LF REJ	Same as DC, 200 kHz to 10 MHz.

Automatic Mode: Time Base A and Time Base B³

Source	Condition
NORM (internal)	Minimum 0.2 cm of deflection, 50 Hz to 10 kHz, increasing to 2 cm at 1 MHz.
EXT	Minimum 0.3 volt signal, 50 Hz to 10 kHz, increasing to 3 V at 1 MHz.

External Trigger Input characteristics:

Time Base A	1 megohm paralleled with 25 pF except the AC LF REJ coupling which is approximately 91 kilohms.
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² Upper and lower frequency triggering requirements are shown in Fig. 1-3.

³ The Automatic Mode triggering features shown in Fig. 1-2 and 1-3 are applicable only when using AC coupling.

Time Base B	1 megohm paralleled with 40 pF, except the AC LF REJ coupling which is approximately 91 kilohms.
Maximum External Input Voltage	50 volts, combined DC and AC peak.

POWER SUPPLY REQUIREMENTS AND FEATURES

Trans Pri Sel	A switch selects the center voltage of two operating ranges: 94 to 138 VAC or 187 to 279 VAC.
LINE RANGE Selector	LOW: 104 VAC $\pm 10\%$ or 208 VAC $\pm 10\%$. MED: 115 VAC $\pm 10\%$ or 230 VAC $\pm 10\%$. HIGH: 127 VAC $\pm 10\%$ or 254 VAC $\pm 10\%$.
Line Voltage Frequency	50 to 60 Hz.
Input Power (Maximum)	750 volt amperes, 650 watts.
Thermal Protection	Automatic resetting thermal cutout which interrupts instrument power if internal temperature exceeds a safe operating level.

MECHANICAL FEATURES

Construction	Aluminum alloy chassis. Anodized front panel. Blue vinyl coated cabinet.
Overall Dimensions	13 inches wide, 24 inches long and 17 inches high.

Standard accessories supplied with the instrument will be found on the last pull-out page at the back of the manual. For optional accessories see Tektronix, Inc. catalog.

TYPE 549 TIME-BASE A
TRIGGERING SIGNAL REQUIREMENTS

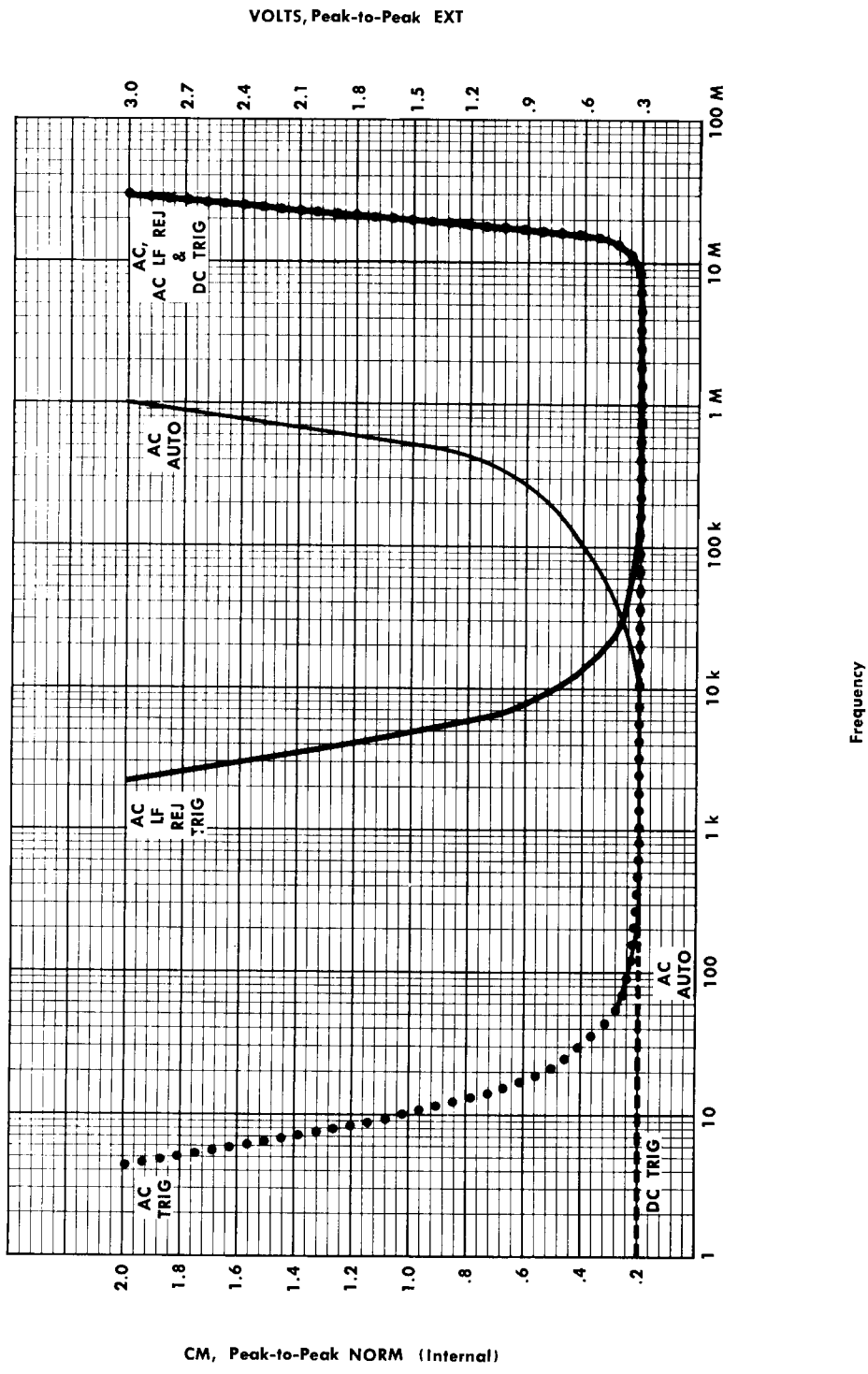


Fig. 1-2.

TYPE 549 TIME-BASE B
TRIGGERING SIGNAL REQUIREMENTS

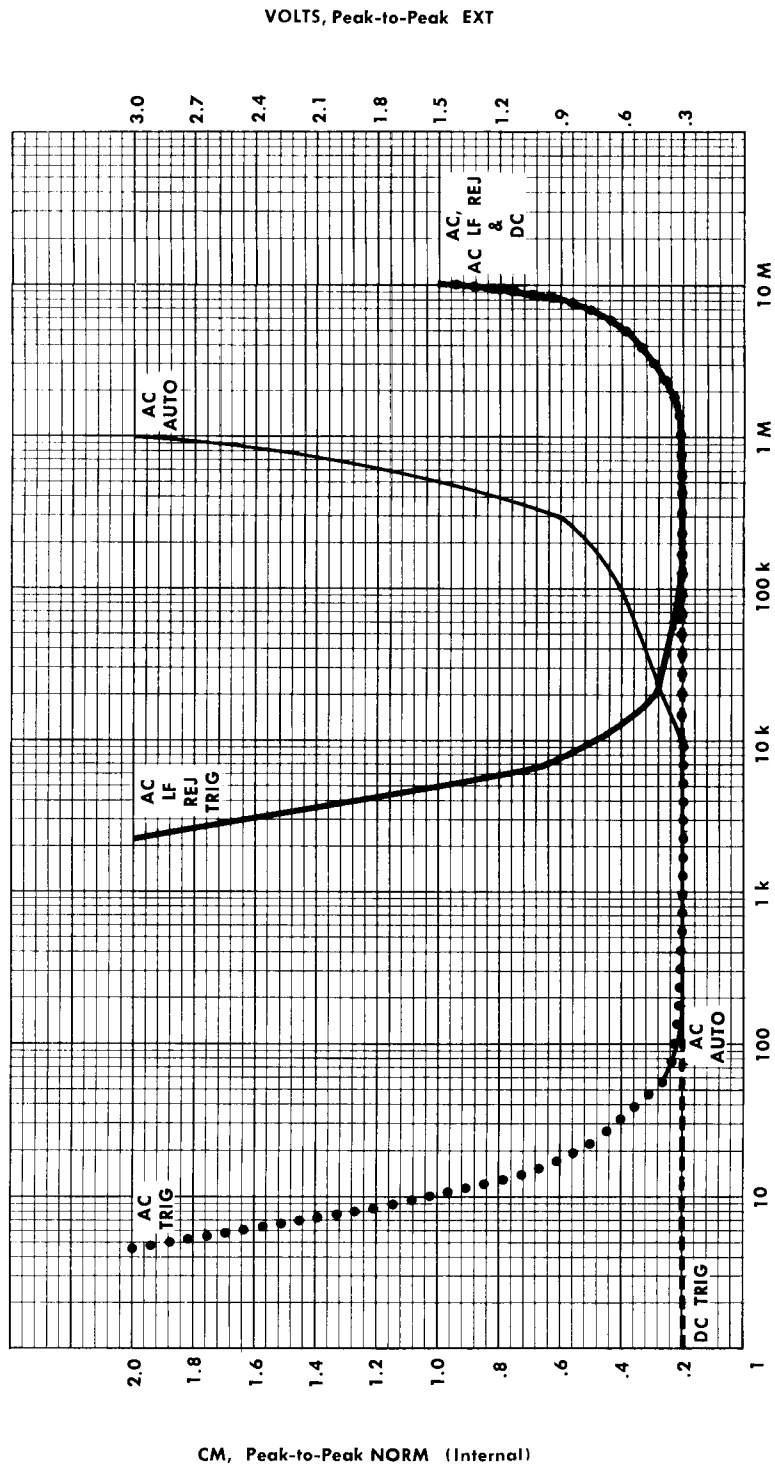


Fig. 1-3.

SECTION 2

OPERATING INSTRUCTIONS

Introduction

The Type 549 combines high speed storage with a general purpose laboratory oscilloscope. This section of the manual describes operation and applications of the instrument.

The description begins with the storage tube and its operational characteristics, then covers each front and rear panel control, switch and connector.

Circuit functions and modes of operation for the Type 549 are described next, with emphasis on storage and storage technique.

The section concludes with general oscilloscope measurement applications.

Storage Tubes

Terms and storage nomenclature used in this manual are defined at the start of the circuit description section. A brief discussion on storage tube principles is also presented.

The storage tube in the Type 549 is a relatively new tube, and can be more easily damaged than conventional CRT's. However with reasonable care they will provide very satisfactory service. The following precautions will prevent damage, increase tube life and maintain optimum performance.

Protective circuitry is incorporated to limit beam intensity. However, a repetitive sweep over the same area for extended periods may damage the storage target. Use only the intensity level required to write a well-defined display. Turn the INTENSITY control to its minimum setting during warm-up time and before changing to slower sweep speeds or switching the HORIZONTAL DISPLAY selector.

Turn the INTENSITY control counterclockwise and the POWER switch to OFF when changing plug-in units.

Avoid continued use of one target area. This causes differential aging of the storage target and may result in differential light emitting qualities over the target area.

Avoid leaving stored display on the screen longer than required. Operation in the ready-to-write (fully erased) state will give longer target life.

When store operation is no longer required, shift to conventional mode operation. Conventional operation does not deteriorate the storage screens; however, avoid prolonged display periods of a repetitive waveform or a free running sweep. These may cause a residual image of the display to appear in the store mode.

Readjustment of the focus and astigmatism is usually required after the beam intensity level is changed to maintain optimum writing speed.

Storage tube characteristics change with use more noticeably than characteristics of conventional tubes. Circuit calibration should, therefore, be checked frequently to ensure optimum operation. Operating levels for a new tube should be checked after the first 100 hours of operation. Progressively longer periods between checks may then be set.

Storage Target Phenomena

The storage screen may display unusual dark or bright areas which resemble previously written information. Three different types of residual images may be noted.

1. Negative residual image.

This appears in the ready-to-write state as a negative image of some previously stored display. It is caused by leaving a stored display on the target over an extended period. This type of image usually disappears within a few hours of operation.

2. Bright residual image.

This appears only in the enhanced mode as a bright image of some previously written display. The secondary emission characteristics of the affected target area have changed so that they fade positive when pulsed by the enhanced pulse while the remainder of the target area reacts normally.

These bright residual images are caused by stored displays for extended periods. They are not a problem if the enhance level is kept below the point the images appear and with time will fade away.

3. Dark Burn.

This is a spot or line across the screen which has a lower light level than the rest of the target when the target is fully written. If extreme, the dark burn area will not store.

Dark burn is caused by the destruction of the storage screen from a high intensity writing beam and is similar to phosphor burn in a conventional CRT.

This type of damage may remain indefinitely if the burn is extensive.

Generally, non-destructive type images will fade in about the same period of time it took to produce them. It is important to age the target area as uniformly as possible to maintain uniformity in writing speed and light level.

General Information

The Type 549 will operate in ambient temperatures up to 122° F (50° C). A minimum of two inches unobstructed clearance around the instrument is recommended for adequate ventilation. If the internal temperature becomes too high, a thermal cutout will open and disconnect power until the internal temperature has returned to approximately 115°F. If this occurs, check to see that air circulation and ventilation are adequate. Constant temperature is important for accurate operation of the instrument.

The instrument requires a minimum 20 minute warm-up period at ambient room temperature of +25° C ±5° C for rated accuracies.

Line Voltage Selection

115 or 230 volt line voltage is selected by means of an internal switch SW602. Three voltage ranges, LOW 104/208, MED 115/230 and HIGH 127/254 are selected by the LINE RANGE switch SW602 on the back panel. The instrument is normally shipped with these switches set for 115 V. Line frequency is 50 to 60 Hz.

CAUTION

Before applying power to the instrument, check that the 115 V/230 V internal selector switch (located at the rear of the vertical amplifier chassis) is positioned correctly for the power source voltage.

FUNCTION OF CONTROLS AND CONNECTORS

NOTE

The Time Base A and Time Base B controls serve identical functions with the exception of the LENGTH control.

TRIGGERING

LEVEL. Selects the amplitude point on the triggering signal where sweep triggering occurs.

STABILITY. Adjust the sweep triggering circuits for a stable display. The STABILITY control can generally be set to the PRESET position and left there. This PRESET position with the LEVEL control midrange, provides stable triggering for most displays.

MODE. AUTO position permits normal triggering on signals with repetition rates higher than about 50 Hz. With no trigger signal, or with a lower repetition rate, the time base circuit free runs to provide a reference trace. TRIG (triggered) position permits normal triggering on all triggering signals. No trace occurs when the triggering signal is removed.

SLOPE. Determines whether the time base is triggered on the negative (—) or positive (+) going slope of the signal.

COUPLING. AC position blocks the DC component of the triggering signal and allows triggering to occur only on the changing portion of the signal. With frequencies below about 30 Hz, use the DC position. AC LF REJ position attenuates trigger signal frequencies below about 17 kHz, allowing the trigger circuits to respond only to higher frequencies. DC position permits triggering on both high and low (to DC) frequency signals.

SOURCE. INT NORM position uses a portion of the signal applied to the vertical deflection plates of the CRT as a trigger signal. INT PLUG IN position applies to multitrace plug-in units that provide a single-channel trigger signal through pin 5 of the interconnecting plug (e.g. Tektronix Type 1A1 plug-in unit). LINE position uses a line-frequency signal as a trigger. EXT position permits external triggering on a signal applied to the TRIGGER INPUT connector.

Time Base Controls

TIME/CM. Selects the time-base sweep rate.

VARIABLE (Time Base A). Provides an uncalibrated sweep rate adjustment which will slow the sweep rate to at least 2.5 times the setting of the TIME/CM switch. An UNCALIBRATED lamp lights when the VARIABLE control is not in the CAL position.

LENGTH (Time Base B). Controls the length of the B sweep.

HORIZONTAL DISPLAY. A: Selects only Time Base A for display on the CRT screen. B: Selects only Time Base B for display on the CRT. B INTEN BY A: One of the delayed-sweep functions. In this position a portion of Time Base B is intensified during the time that Time Base A (the delayed sweep) is in operation. A DLY'D: Another delayed-sweep function. In this position, Time Base A is delayed at the end of each delay period as determined by the B, TIME/CM AND DELAY TIME switch setting and the DELAY-TIME MULTIPLIER 1:10 dial reading. EXT 1× and 10×: Permits an external signal to be applied to the horizontal deflection circuit. Sensitivity is continuously variable with the VARIABLE 1-10 control.

READY Lamp. Lights when time-base circuit is ready for triggering after being reset.

MAGNIFIER. Horizontally expands the portion of the sweep in the center of the graticule by 5 times at any setting of the TIME/CM switch.

NORM-SINGLE SWEEP (Sweep mode selector). Three-position switch selects NORMAL or SINGLE SWEEP operation for either time base. Switch is spring loaded at the RESET position. In the SINGLE SWEEP position, selected time base will sweep once upon receipt of trigger signal, then remain inactive until the circuit has been reset with the RESET switch or ERASE AND RESET button. Single sweep permits photographing or storage of nonrepetitive waveforms.

DELAY-TIME MULTIPLIER 1-10. Works in conjunction with the Time Base B TIME/CM AND DELAY TIME switch. Varies sweep delay from 0 to 10 times the rate indicated by the Time Base B TIME/CM AND DELAY TIME switch.

HORIZONTAL POSITION and FINE. Positions the display along the horizontal axis of the crt screen.

LOCATE button. When the Type 549 is operating as a conventional oscilloscope, the LOCATE button provides a trace finding mode. The gain of both the vertical and horizontal amplifiers is reduced so that regardless of the input signal, an on-screen display is presented. With either of the STORE buttons depressed the LOCATE button does not affect the horizontal or vertical gain, but the Horizontal Amplifier is DC offset and moves the beam to the left of the CRT screen. This places the beam in the locate zone of the target (a non-store area) and permits vertical positioning of the beam.

In either mode, the intensity is brought to a preset level when the LOCATE button is depressed.

Other Controls

AMPLITUDE CALIBRATOR. Determines the peak-to-peak voltage available at the CAL OUT connector.

5 mA Current Strap. Provides a calibrated source of square-wave current. The arrow indicates conventional current (i.e. positive to negative).

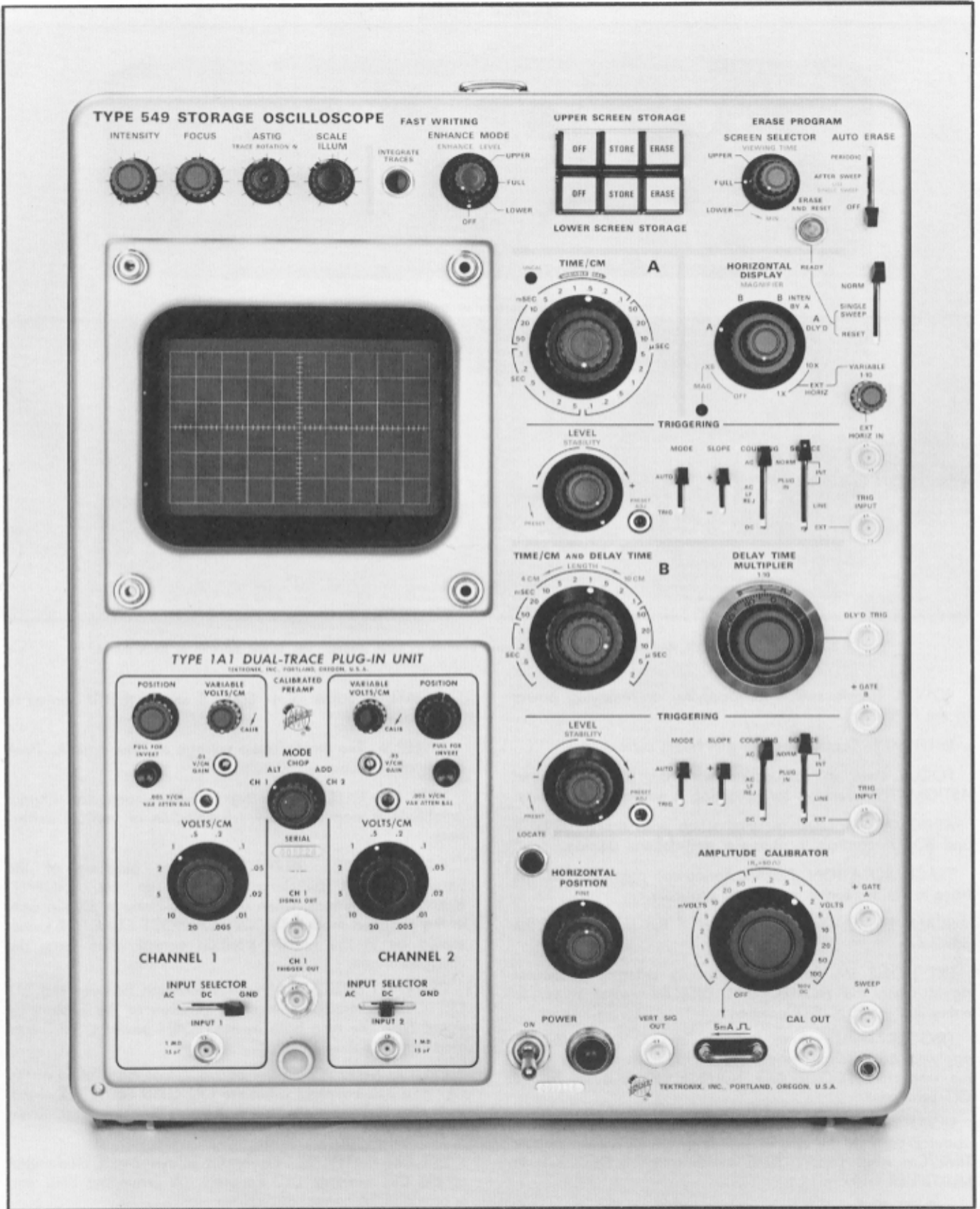


Fig. 2-1. Front panel controls and connectors.



Fig. 2-2. Rear panel controls and connectors. (A) Upper portion of back panel. (B) Lower portion of back panel.

POWER. Toggle switch for applying or removing power to the instrument.

INTENSITY. Controls writing gun beam current.

FOCUS. Used in conjunction with the INTENSITY and ASTIGMATISM controls for obtaining a well-defined display.

ASTIGMATISM. Used in conjunction with the INTENSITY and FOCUS controls to obtain a well-defined display.

TRACE ROTATION. Permits horizontal alignment of the trace to the horizontal lines of the graticule.

SCALE ILLUM. Varies illumination of the grid lines of the graticule.

EXT HORIZ IN. Connector to apply external horizontal signal when the HORIZONTAL DISPLAY switch is set to either 1× or 10× EXT position.

TRIGGER INPUT (Time Base A and B). Connector for applying an external trigger signal to the time base when the respective TRIGGERING SOURCE switch is set to the EXT position.

DLY'D TRIG. Supplies a positive-going trigger output of about 7 volts at the end of the delay period as set by the TIME/CM AND DELAY TIME switch and the DELAY TIME MULTIPLIER 1:10 dial.

+GATE B. Supplies an approximate 20 to 40-volt square-wave output pulse when Time Base B is operating. Pulse duration is same as the B sweep length.

+GATE A. Same as + GATE B except that it applies to Time Base A.

SWEEP A. The sweep ramp voltage of Time Base A. Peak amplitude is about +150 volts.

VERT SIG OUT. Vertical signal output connector. Output amplitude is approximately 1.5 volts/cm of vertical deflection.

CRT CATHODE SELECTOR. Provides blanking of the between-channel switching transients (in the CHOPPED BLANKING positions) when using multi-channel plug-in units in the chopped mode. The CRT CATHODE SELECTOR switch should be in the NORM position except when using the chopped mode.

CRT GRID SELECTOR. Provides selection between the EXT CRT GRID connector in the EXT position or the unblanking signal from the time base in the NORM position, for Z axis modulation to the CRT grid.

EXT CRT GRID. Connector allows Z-axis modulation of the CRT grid (DC coupled) when the CRT GRID SELECTOR switch is in the EXT position. Normal trace blanking is removed with the switch in the EXT position.

EXT CRT CATHODE. Connector allows Z-axis modulation of the CRT cathode (AC coupled). A grounding BNC cap is provided for normal operation.

REMOTE CONTROL INPUT. Provides remote operation of the single sweep reset functions, erasure of each target and

remote store function. These functions can be controlled by completing the circuit to ground. See the Characteristics section.

A remote Storage Oscilloscope Control Unit (Tektronix Part Number 012-0102-00) is available as an optional item. This unit contains upper and lower erase buttons and a sweep reset button. See Fig. 2-3.

Primary Voltage Range Switches. SW602 (Internal). A two position switch selects line voltages from 93.6 to 138.6 VAC, or 187.2 to 279.2 VAC depending on the position of the LINE RANGE switch SW603.

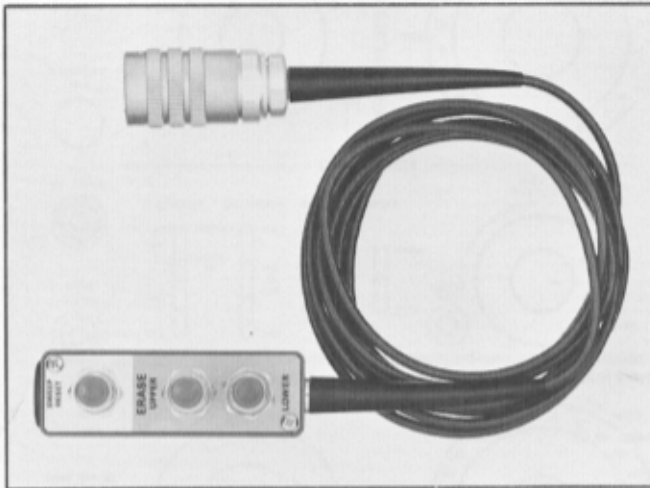


Fig. 2-3. Remote control unit.

LINE RANGE. Three position switch selects center line nominal value:

LOW	MED	HIGH
104 VAC	115 VAC	127 VAC
208 VAC	230 VAC	254 VAC

CAUTION

Be sure that the internal switch SW602 is in the 230 VAC position when the power cord is connected to a 230 VAC nominal supply source.

Store Controls

UPPER and LOWER SCREEN STORAGE: OFF-STORE-ERASE push buttons provide conventional or stored mode operation, with manual ERASE control to erase stored information.

ENHANCE MODE: Permits storage of high speed waveforms by momentarily changing CRT voltage operating levels to increase writing speed. A four position ENHANCE MODE switch permits UPPER Screen, FULL Screen or LOWER Screen enhancement.

ENHANCE LEVEL control permits adjustment for optimum enhancement.

INTEGRATE: Permits storage of very fast repetitive signals, by permitting the writing gun beam to accumulate charges on the target while the flood gun beams are turned off.

Erase Program

SCREEN SELECTOR: Selects UPPER, FULL or LOWER screen for the erase program.

VIEWING TIME: Variable control that selects display time between erasures when in the auto erase mode. Viewing time varies from approximately 0.5 to 5 seconds.

ERASE and RESET Button: Erases display and resets sweep circuit.

Auto Erase

PERIODIC: Erases the target automatically, independent of sweep operation, at a time period determined by the VIEWING TIME control setting.

AFTER SWEEP: Erases the display after the sweep has run. Viewing time is determined by the setting of the VIEWING TIME control. Resets the sweep circuit after erasure.

OFF: With erase program switch in the OFF position, display must be erased manually.

BASIC OSCILLOSCOPE OPERATION

Sweep Triggering

Proper sweep triggering is essential for a stable presentation of an input signal. The sweep must be triggered at the same time relative to the displayed signal. Thus, the sweep must be triggered by the input signal or by some external signal that has a fixed time relationship with the displayed signal. The external trigger signal must be the same frequency or a sub-multiple of the input signal.

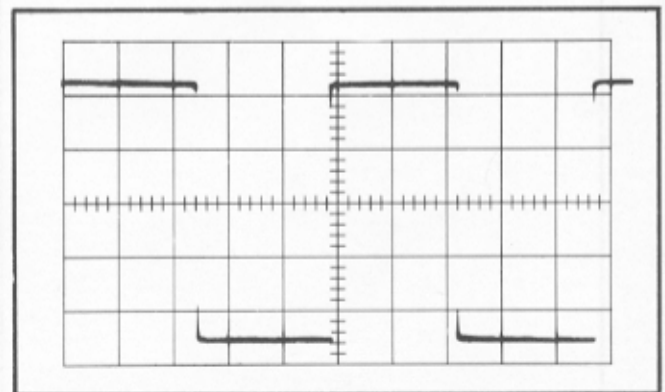


Fig. 2-4. AMPLITUDE CALIBRATOR, triggered waveform.

The SOURCE switch selects one of a variety of possible triggering signals. For most applications, the sweep can be triggered internally from the displayed signal. This occurs with the SOURCE switch set at NORM position.

The PLUG-IN position is used with plug-in units that supply a single-channel triggering signal through pin 5 of the interconnecting plug, such as the Tektronix Type 1A1

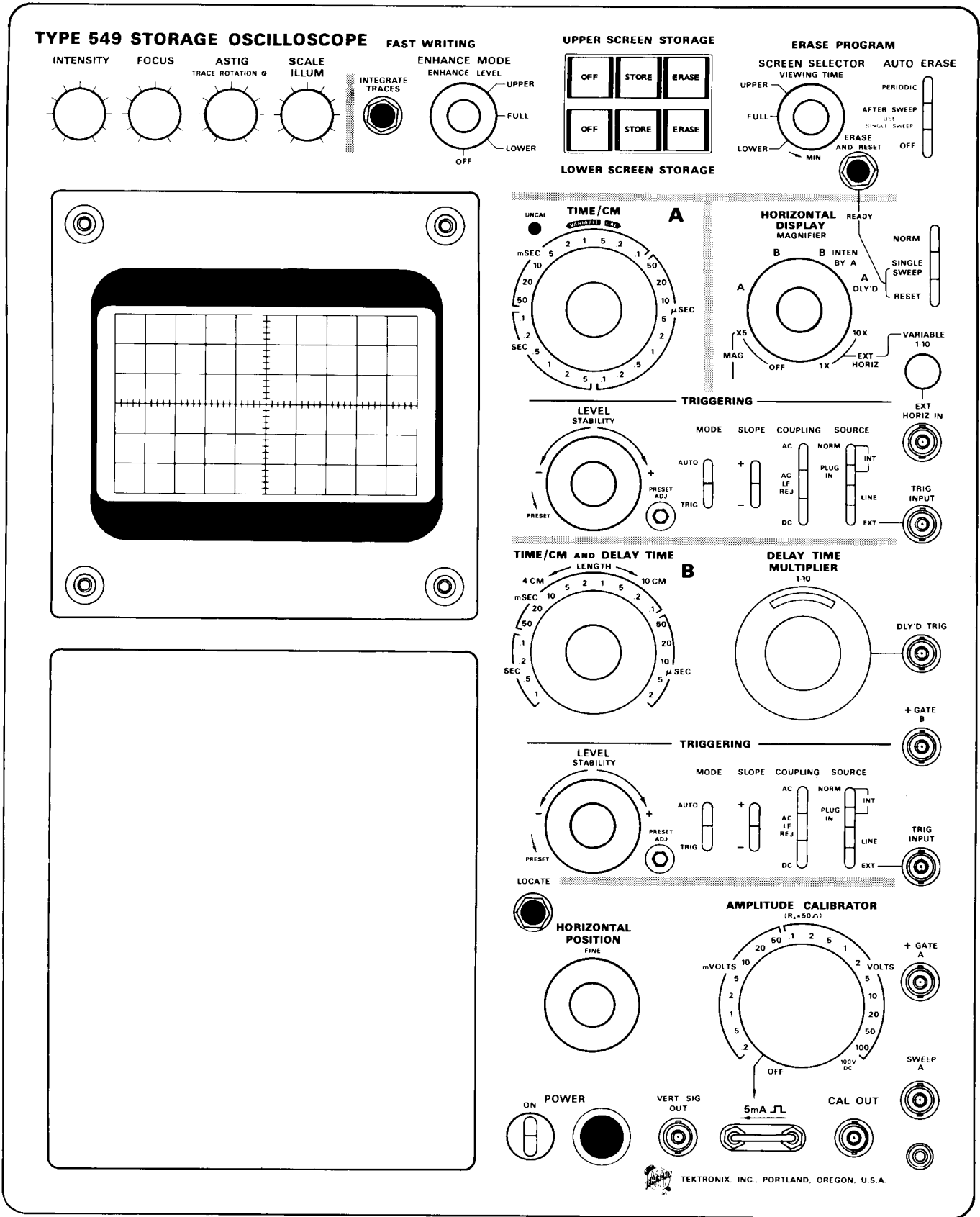


Fig. 2-5. Control setup chart.

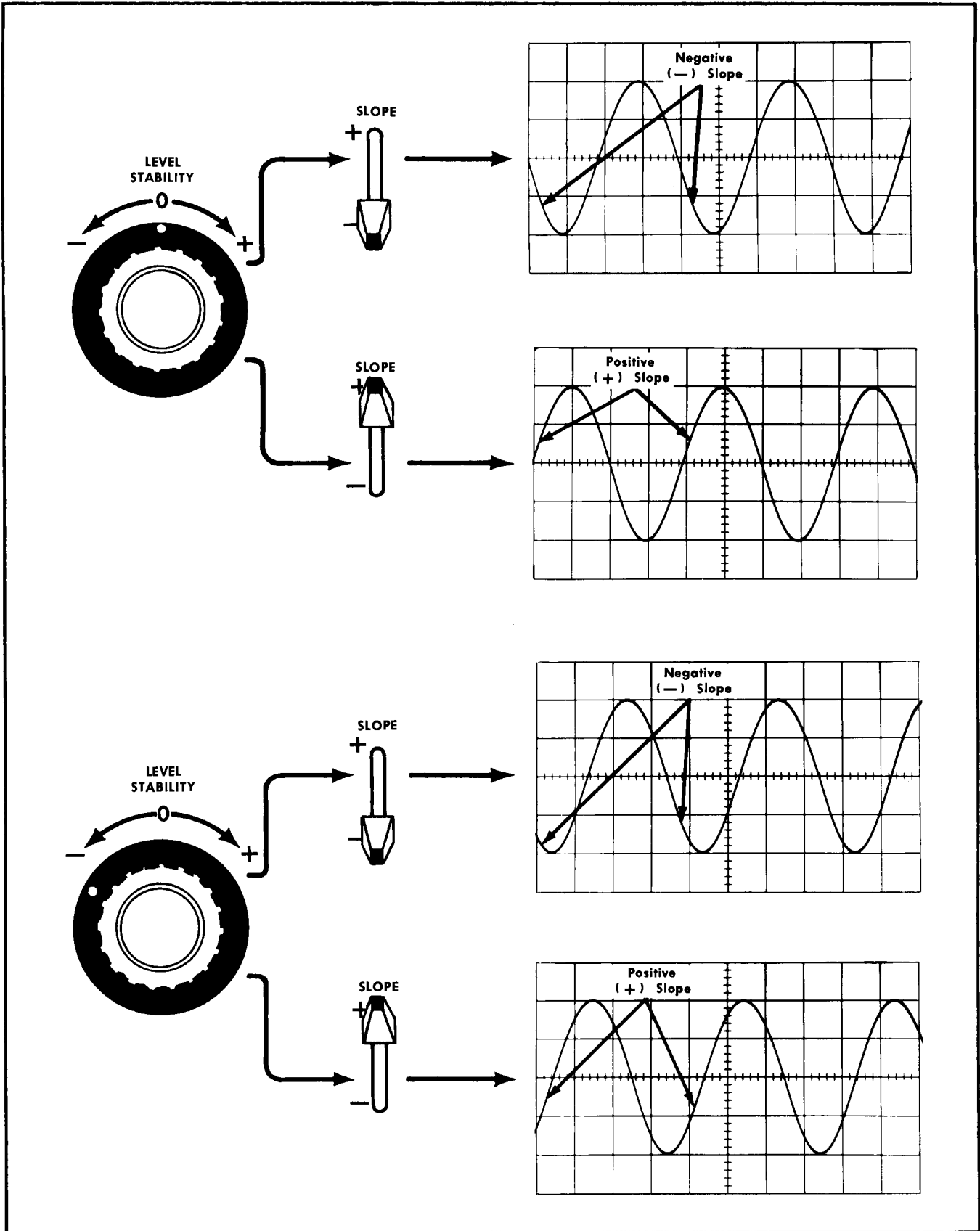


Fig. 2-6. Effects of the TRIGGERING LEVEL and SLOPE controls.

Operating Instructions—Type 549

Dual Trace Plug-In Unit. This position is useful when operating the plug-in unit in dual-trace chopped-mode operation, since the triggering signal is the same as the applied signal and is free from any between-channel switching transients.

External triggering is often used when signal tracing in amplifiers, phase-shift networks, and wave shaping circuits. The signal from a single point in the circuit can be used as the external trigger signal. With this arrangement, it is possible to observe the shaping and/or amplification of a signal at various points through the circuit without resetting the triggering controls for each new display.

In general, use AC coupling, unless it is necessary to use DC coupling for very low-frequency signals. When line-frequency hum is mixed with the triggering signal, use AC LF REJ coupling so that triggering takes place only on the desired signal (if the signal contains frequency components higher than 17 kHz).

The AC LF REJ position is also useful when triggering internally from multi-trace plug-in units operated in the alternate dual-trace mode (unless the plug-in unit is a Type 1A1 and the SOURCE switch is set to PLUG IN). AC LF REJ coupling has a faster recovery time when subjected to the alternate DC levels from the multi-trace plug-in unit.

Selecting Trigger Slope

The trigger SLOPE switch determines whether the triggering circuit operates on the rising (+ setting) or the falling (— setting) portion of the triggering signal. If a certain portion of a waveform is to be examined, the SLOPE switch will start the display on the desired slope of the input signal. Fig. 2-6 illustrates the effect of both the SLOPE and TRIGGERING LEVEL controls.

Selecting Trigger Mode

The automatic stability mode is more convenient in most cases. With the MODE switch set to AUTO, proper triggering takes place if the signal is faster than 50 Hz. When the triggering signal is removed, the time-base circuit automatically free runs and presents a reference display.

The TRIG position of the MODE switch should be used if the trigger signal has a low repetition rate (below about 50 Hz).

Setting Stability Control

In most triggering applications, satisfactory operation can be obtained with the STABILITY control in the PRESET (fully counterclockwise) position. If triggering becomes difficult with the STABILITY control at PRESET, it may be necessary to adjust the STABILITY control. To adjust, set the LEVEL and STABILITY control in the fully counterclockwise position, then turn the STABILITY control slowly clockwise until a trace appears on the CRT. The correct setting is obtained by turning the control counterclockwise three to five degrees from the point where the trace appears. The setting is just below a free running sweep.

Setting Triggering Level

The TRIGGERING LEVEL control determines the amplitude point on the signal where triggering occurs.

The trigger circuit is most sensitive to AC triggering signals with the TRIGGERING LEVEL control set near zero. Moving the TRIGGERING LEVEL control in the + direction causes the trigger circuit to operate at some higher positive amplitude on the triggering signal. Moving the TRIGGERING LEVEL control in the — direction causes the trigger circuit to operate at some higher negative amplitude on the triggering signal. See Fig. 2-6.

Selecting TIME/CM (Sweep Rate)

The TIME/CM and the MAGNIFIER switches determine sweep rate. The MAGNIFIER expands either time base sweep rate by a factor of 5.

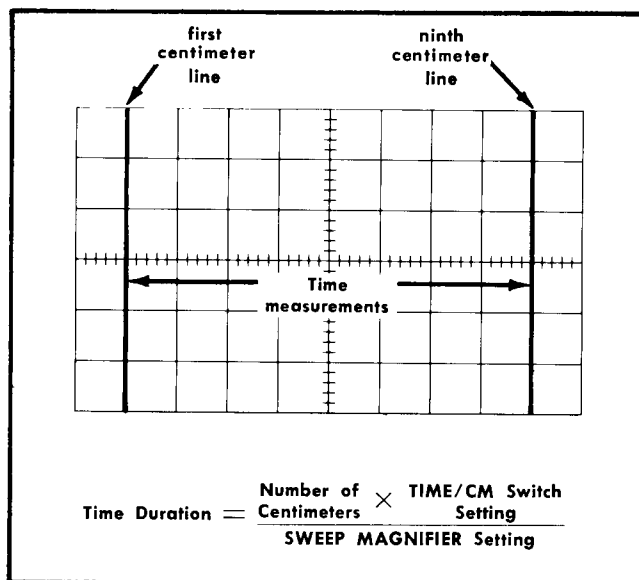


Fig. 2-7. Area of graticule used for accurate time measurements.

With the VARIABLE control in the CAL position the TIME/CM switch provides a wide selection of calibrated sweep rates. When making time measurements from the CRT graticule, be certain the VARIABLE (Time Base A) control is in the CAL position.

The VARIABLE control provides a continuously variable uncalibrated sweep rate. The UNCAL neon lights when the VARIABLE control is at other than the calibrated (detent) position.

When the MAGNIFIER switch is set to the OFF position the TIME/CM switch indicates sweep rate. With the MAGNIFIER switch set to the $\times 5$ position the setting of the TIME/CM switch must be divided by 5 to determine sweep rate. (i.e. If the TIME/CM switch is set to 1 mSEC the sweep rate would be 0.2 mSEC/CM.) When making time measurements from the graticule, the horizontal portion between the 1st and 9th centimeter lines is the most linear. See Fig. 2-7.

Single Sweep Operation

For applications where the displayed signal is not repetitive or varies in amplitude, shape or time, a photograph or storage of the display may be best achieved with the single sweep feature of this instrument.

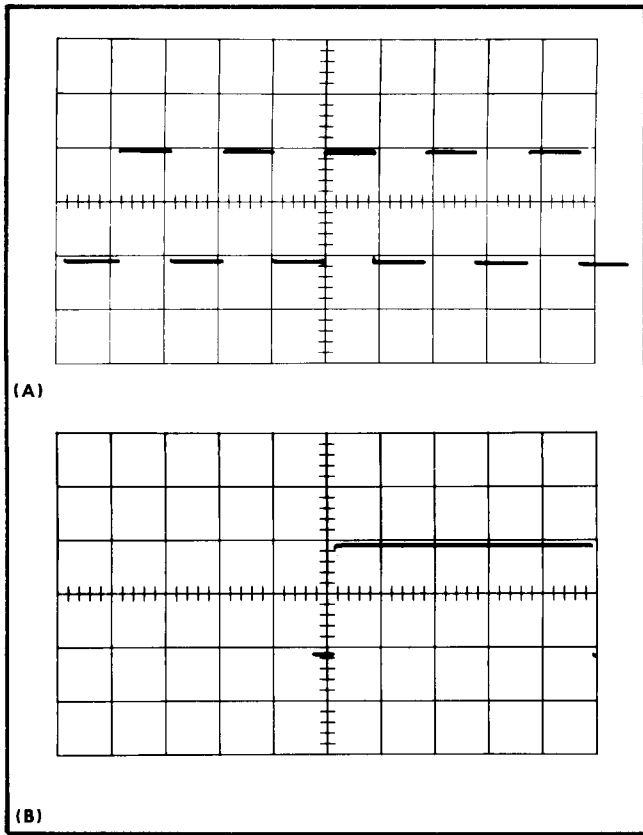


Fig. 2-8. Operation of sweep magnifier. (A) Waveform with MAGNIFIER in OFF position. (B) Magnified waveform. MAGNIFIER in $\times 5$ position.

To operate the single sweep feature, first make certain the trigger circuit will trigger on the event to be displayed.

With the HORIZONTAL DISPLAY switch set to the desired time base and the MODE switch set to TRIG position, adjust and set the TRIGGERING controls and switches for a triggered display.

Set the NORM-SINGLE SWEEP-RESET switch to the SINGLE SWEEP position.

Push the switch to the spring loaded RESET position and release, or push the ERASE and RESET button in the ERASE PROGRAM sector.

The ERASE AND RESET button should light and stay lit, indicating the trigger circuit is armed and ready for a trigger signal. When the circuit is triggered the sweep will run and the ERASE AND RESET ready-light will go out, indicating the circuit has been triggered.

To ready the circuit for another event, push the ERASE AND RESET button or the SINGLE SWEEP switch to the RESET position and release.

Delayed Sweep Operation

The start of the horizontal sweep can be delayed for a period of $1 \mu\text{s}$ to 10 s after the triggering signal is applied. This is accomplished in the Type 549 by the simultaneous use of both time bases. Control of the sweep delay is governed by the settings of the Time Base B TIME/CM AND DELAY TIME switch and the DELAY TIME MULTIPLIER 1-10 control. See Fig. 2-9.

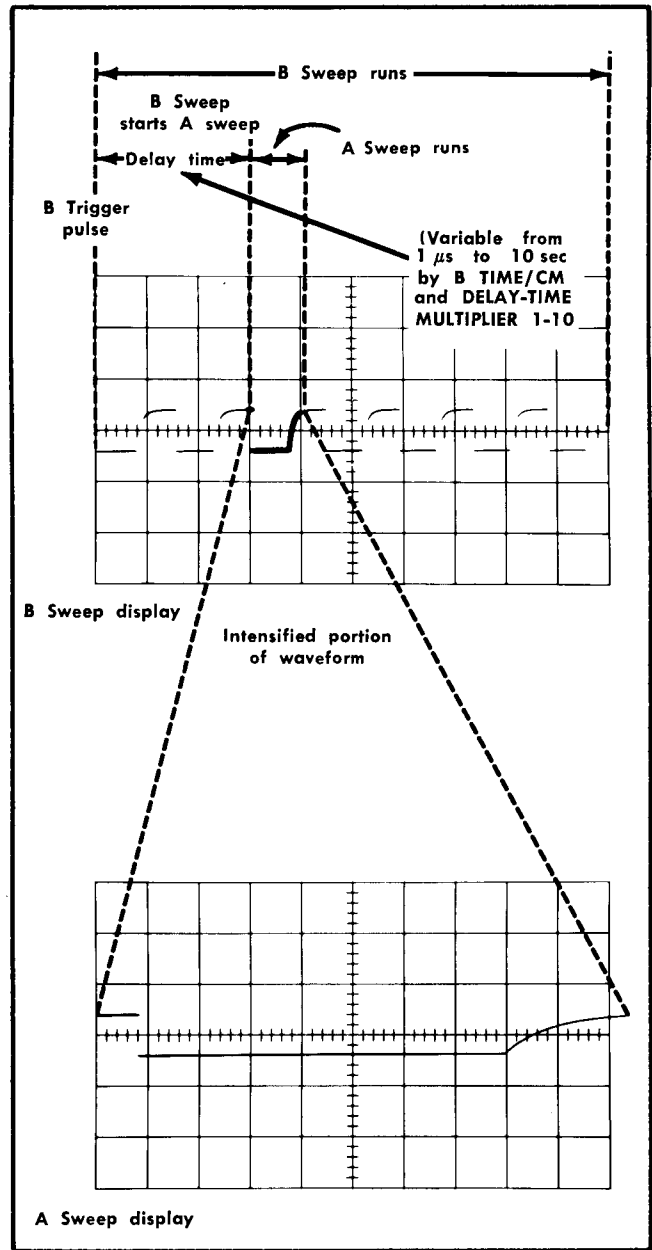


Fig. 2-9. Delayed sweep operation.

The delayed sweep feature is operable when the HORIZONTAL DISPLAY switch is in the A DLY'D position. The delay period is indicated by the settings of the B TIME/CM AND DELAY TIME switch multiplied by the setting of the DELAY TIME MULTIPLIER 1-10 vernier dial reading. For example: TIME/CM AND DELAY TIME switch is set to $10 \mu\text{SEC}$ position and the vernier of the DELAY TIME MULTIPLIER 1-10 dial indicates 6.75. The delay time equals $6.75 \times 10 \mu\text{SEC}$ or 67.5 microseconds. See Fig. 2-10.

With the HORIZONTAL DISPLAY switch in the B INTEN BY A position and all controls set for delayed sweep operation, a portion of the Time Base B sweep will be intensified by the Time Base A sweep. The length of the intensified portion is determined by the A TIME/CM switch setting. The position of the intensified portion is dependent on the DELAY TIME MULTIPLIER 1-10 control setting.

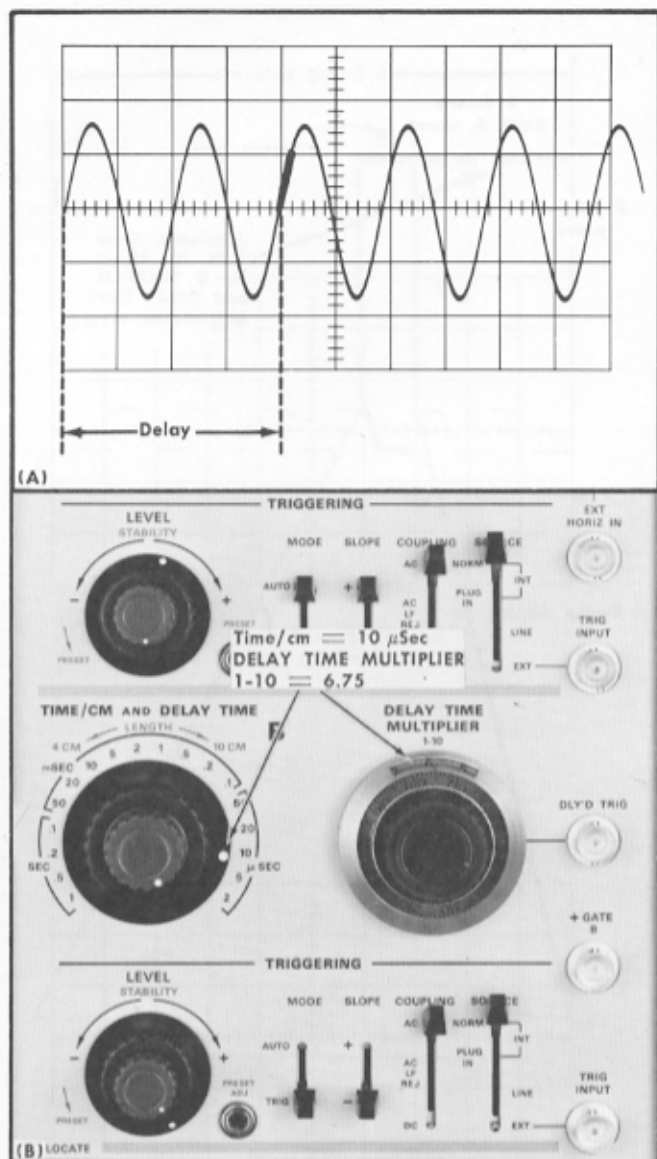


Fig. 2-10. Delay Time = B TIME/CM AND DELAY TIME setting (10 μSEC) multiplied by DELAY TIME MULTIPLIER 1-10 dial reading (6.75) or 67.5 μSEC delay.

To expand a portion of the Time Base B sweep presentation, adjust the DELAY TIME MULTIPLIER 1-10 and the A Time Base TIME/CM controls to include the portion of the waveform to be expanded in the intensified portion, then set the HORIZONTAL DISPLAY switch to the A DLY'D position. This expands the intensified portion to the full 10 cm graticule width. The amount of magnification is the ratio of Time Base B TIME/CM AND DELAY TIME setting to the Time Base A TIME/CM control setting. For example: Time Base B TIME/CM AND DELAY TIME switch is set to 1 mSEC position and Time Base A TIME/CM switch is set at 1 μSEC, and the brightened portion is magnified horizontally 1,000 times. Practical sweep magnifications up to approximately 10^4 are attainable.

When using the delayed sweep feature to obtain high magnification, the trace may become very dim because of

the low duty cycle. The intensity can often be increased through the use of the Time Base B LENGTH control. Set the HORIZONTAL DISPLAY switch to the B INTEN BY A position and adjust the LENGTH control until the sweep stops at a point just past the brightened portion of the trace. Then, return the HORIZONTAL DISPLAY switch to the A DLY'D position. Using this procedure, the maximum delayed sweep repetition rate will be obtained.

External Horizontal Deflection

In some applications, it may be desirable to display one signal versus another (X-Y) rather than against time (internal sweep). The EXT HORIZ position of the HORIZONTAL DISPLAY switch provides a means to apply an external signal to the horizontal amplifier and establish this type of display.

To use the External Horizontal Amplifier, connect the external waveform to the EXT HORIZ INPUT connector and place the HORIZONTAL DISPLAY switch in the 10X or 1X EXT HORIZ position. The horizontal deflection factor is continuously variable from approximately 0.15 to approximately 15 volts per centimeter with the VARIABLE 1-10 control and the 10X or 1X position of the HORIZONTAL DISPLAY switch. Remember when using this mode the horizontal deflection factor is uncalibrated.

Intensity Modulation

Intensity (Z axis) modulation can be used to relate further information to the displayed waveform, without changing the X-Y information. The intensity modulation can be applied to the rear panel EXT CRT GRID or the EXT CRT CATHODE connectors. If the modulation signal is applied to the EXT CRT GRID connector, place the CRT GRID SELECTOR switch to EXT position. In this position there is no blanking pulse applied, therefore retrace is visible. The modulating signal is DC coupled to the CRT grid.

If the modulation signal is applied to the EXT CRT CATHODE connector, the signal is AC coupled to the CRT cathode when the CRT CATHODE switch is in the NORMAL position. Only high frequency signals are applicable (above 20 kHz).

At normal intensity levels an approximate 20 volt signal will produce visible modulation.

Time markers applied to the connectors provide a direct time reference on the display. When using uncalibrated horizontal sweep or external horizontal deflection, the time-markers provide direct time display information to the waveform. If the markers are not time-related to the display, single sweep display should be used.

When Z axis modulation is not in use, keep the CRT GRID SELECTOR switch in the NORMAL position and the ground-ing cap installed on the EXT CRT CATHODE.

Amplitude Calibrator

The Calibrator provides a convenient source of square waves of known amplitude at a frequency of approximately 1 kHz. The voltage output from the Calibrator is adjustable through 18 steps from .2 mVOLTS to 100 VOLTS peak to peak. An additional step provides 100 volts DC. The source impedance of the .2 mVOLT to 0.2 VOLT range is $50 \Omega \pm 2\%$.

The current link provides 5 milliamp current signal, which can be used to check and calibrate current probe systems. This current signal is obtained by clipping the probe around the current loop. Current is available and constant through the loop when the AMPLITUDE CALIBRATOR switch is in the 100 VDC position. The arrow indicates conventional current (i.e. positive to negative).

Control and Circuit Functions

Control Setup Chart: Fig. 2-5 is a control setup chart of front panel controls which may be reproduced and used as a test setup record for special measurements, applications or procedures. It may also serve as a training aid device for familiarization with this instrument.

First Time Operation (Initial set-up)

Install a plug-in unit (such as Type 1A1 or 1A2) in the vertical compartment of the Type 549.

Check the position of the primary voltage range switches and switch to settings that correspond to available power source.

Set the front panel controls of the Type 549 as follows:

HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE	NORM
SWEEP-RESET	
A TIME/CM	1 mSEC
VARIABLE	CAL
TRIGGERING switches	Place all switches in up position
STABILITY	PRESET
LEVEL	Midrange

STORAGE Controls

ENHANCE MODE	OFF
UPPER and LOWER	
SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Midrange
AUTO ERASE	OFF

CRT Controls

INTENSITY	Fully Counterclockwise
FOCUS	Midrange
ASTIG	Midrange
AMPLITUDE CALIBRATOR	1 VOLT

Vertical Unit

Volts/Div	0.5
Input Selector	AC

Connect a coaxial cable between the CAL OUT connector and the vertical Input connector.

Connect the Type 549 to a suitable power source and turn the POWER switch to ON. Allow a few minutes for

the delay time relays to energize and the instrument to stabilize.

Push the LOCATE button and position the display to the center of the graticule area with the HORIZONTAL and Vertical POSITION controls. Note the preset intensity level.

Release the LOCATE button and adjust the INTENSITY, FOCUS and ASTIG controls for a well defined display of nominal brightness. See Fig. 2-4. The FOCUS control should be adjusted for the best vertical definition and the ASTIG control should be adjusted for equally focused horizontal and vertical segments of the displayed waveform.

Remove the signal cable between the CAL OUT connector and the vertical Input connector.

Trace Alignment

If the free running trace is not parallel with the horizontal graticule lines, adjust TRACE ROTATION so the trace is parallel with the horizontal graticule lines.

Locate Logic

When the Type 549 is operating in the conventional mode the LOCATE pushbutton provides a trace locating mode. The gain of both horizontal and vertical amplifiers is reduced so that regardless of the input signal, an on-screen display is presented.

With either of the STORE switches depressed the locate button does not affect the horizontal or vertical gain but the horizontal amplifier is DC offset and moves the beam to the left of the CRT screen. This places the beam in the locate zone of the target, which is a non-store area and permits vertical positioning of the beam. In either mode the intensity level is brought to a preset level when the LOCATE button is pushed.

Storage Controls And Operating Technique

This section covers primary control operation for storage and illustrates their function in storage technique. Fig. 2-11 illustrates the storage controls for the Type 549. The primary control is the UPPER and LOWER SCREEN STORAGE push-buttons. The OFF and STORE buttons are self-cancelling, so depressing one of the buttons returns the other to its cancelled position. The ERASE button is spring loaded and independent of the STORE and OFF button.

To the left of the pushbuttons are the FAST WRITING controls. The INTEGRATE TRACES pushbutton provides integrate mode operation and allows the storage targets to accumulate charges from a repetitive writing gun beam which is too fast for single trace writing. Integration is accomplished by opening the flood gun cathode lead to allow the writing beam to sum charges over the target area so that these areas shift into storage when the button is released. See storage tube principles in the Circuit Description section.

Integrate mode is most useful on very fast low repetition rate signals.

The ENHANCE MODE and the ENHANCE LEVEL provide extended capabilities for single event writing by target pulsing. This mode is effective for sweep rates of approxi-

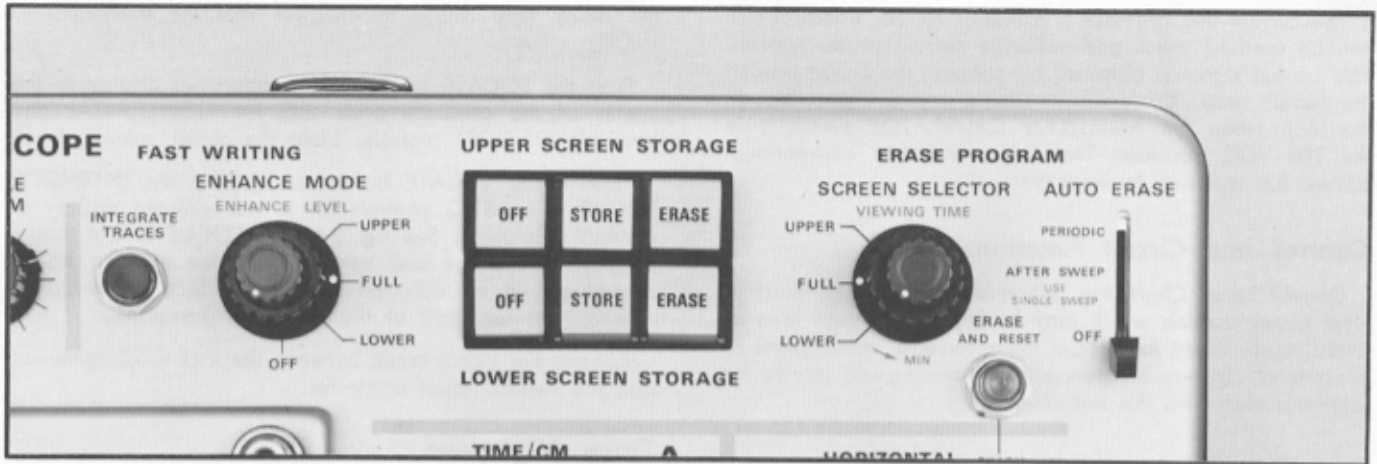


Fig. 2-11. Storage controls of the Type 549.

mately 0.5 mSEC/CM or faster. At high writing rates the writing beam charge will not shift the target all the way to the stored state and the flood beam current destroys the partial charge. To enhance the writing speed, an adjustable enhance pulse is applied to the target after the writing beam sweep. This pulse shifts the target near the crossover point so the writing beam can readily shift the target to the written or stored state.

The enhance pulse is generated by a monostable multivibrator after the sweep. Fig. 2-12 shows time relationship. The width is an internal adjustment and the amplitude is controlled by the ENHANCE LEVEL.

Either target may be selected so a fully enhanced event may be stored on one target for comparison while the other target is used in any desired mode.

The ERASE PROGRAM provides a variable viewing time followed by an erase cycle, sweep reset and then a repeat of the cycle. Special logic is incorporated to recognize which of the horizontal display modes is in use and also prevent a succeeding sweep until after the erase cycle. See Fig. 2-12.

The OFF position of the AUTO ERASE can be used to hold a stored waveform if switched to OFF position before the end of the view time. The OFF function may be remotely controlled so that remote logic may cause a unique display to be held for observation or photographing.

PERIODIC ERASE actuates the erase cycle without any time relationship to sweep or display. It is useful in both X-Y and repetitive sweep displays.

A manual ERASE AND RESET lighted pushbutton overrides the AUTO ERASE program in all modes. This action can both erase the full screen and reset the single sweep mode, thus simplifying storage scope operation.

A rear connector allows remote operation of single sweep reset function and erasure of each target. The functions are controlled by providing closures to ground through a remote switch.

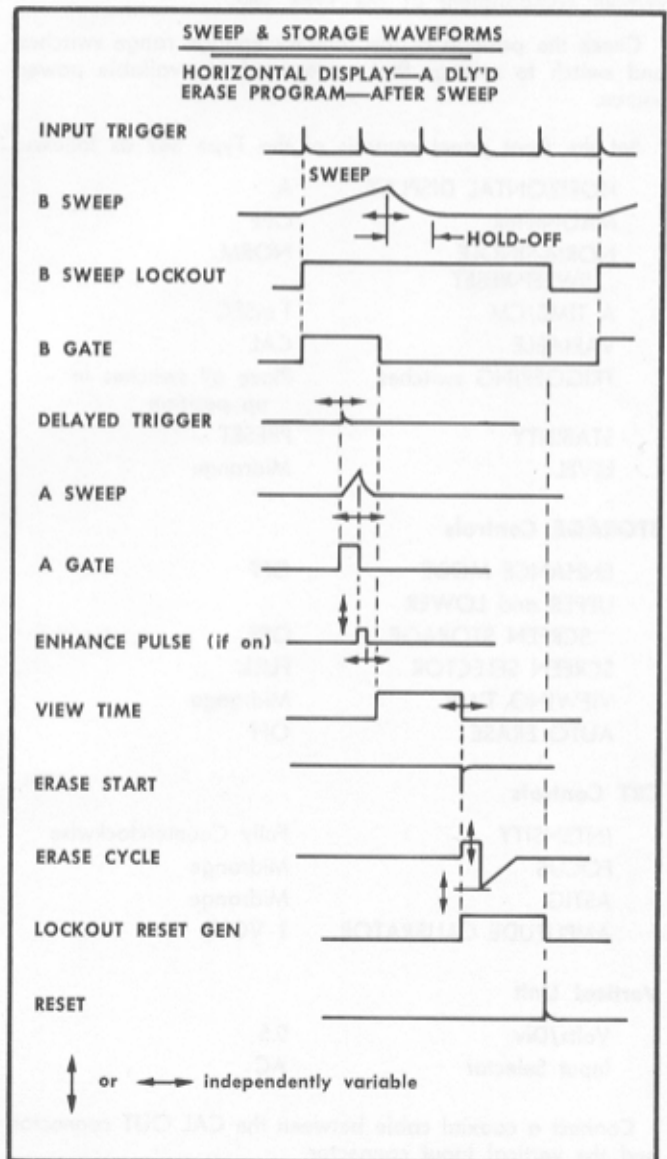


Fig. 2-12. The delayed A sweep is being viewed and the erase program is in AUTO ERASE—AFTER SWEEP mode.

Storage Technique

This demonstration illustrates the basic techniques for storing a repetitive waveform.

1. Install a vertical amplifier plug-in unit (such as 1A1 or 1A2) in the vertical compartment of the Type 549.

2. Set the Volts/Div switch to 0.5 and the Input Selector switch to AC.

3. Apply a 2 volt signal from the Amplitude Calibrator to the Input connector for the plug-in unit.

4. Set the Type 549 front panel controls as follows:

HORIZONTAL DISPLAY	A
NORM-SINGLE SWEEP	NORM
A TIME/CM	.2 mSEC
VARIABLE	CAL
TRIGGERING switches	Place in up position
STABILITY	PRESET
LEVEL	Midrange

Storage Controls

ENHANCE MODE	OFF
UPPER and LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Midrange
AUTO ERASE	AFTER SWEEP

5. Connect the Type 549 to a suitable power source and turn the POWER switch ON.

6. Push the LOCATE button and position the display to the center of the graticule area.

7. Adjust INTENSITY, FOCUS and ASTIG controls for a well-defined display with nominal brightness.

8. Switch the A TRIGGERING MODE switch to TRIG position and adjust the TRIGGERING LEVEL control for a triggered display.

9. Position the display vertically so that half of the Calibrator waveform is on the upper target and half on the lower target area.

10. Switch the sweep mode switch to SINGLE SWEEP position. A periodic display should occur. This feature provides automatic erase and trigger reset after a time period set by the VIEWING TIME controls.

11. Push both STORE buttons for the UPPER and LOWER SCREEN STORAGE. Note the stored waveform between sweep times.

12. Increase the A TIME/CM switch to a setting that produces only partial storage of the Calibrator waveform.

13. Adjust INTENSITY, FOCUS and ASTIG controls for optimum storage. Note the effect these controls have on writing speed. Focus and astigmatism have a direct effect on writing speed.

14. Save a stored display by switching the AUTO ERASE switch to the OFF position.

15. Push the UPPER SCREEN STORAGE ERASE button. Note that only the upper screen is erased.

16. Push the ERASE AND RESET button. Note that both storage screens erase, and the waveform is then stored again. This button overrides the AUTO ERASE feature.

17. Push the LOCATE button. Note the two spots in the locate zone at the left of the storage targets. Position the trace to the upper target area with the vertical position control.

18. Write a display by pushing the ERASE and RESET button.

19. Depress the LOCATE button, then position the trace to the lower target area. Depress the ERASE button for the LOWER SCREEN STORAGE to erase the lower screen, then push the OFF button for the LOWER SCREEN.

20. Switch the NORM-SINGLE SWEEP switch to the NORM position. A conventional display of the Calibrator waveform will now be displayed on the lower portion of the screen, and a comparison can be made with the stored display on the upper portion of the screen.

21. Erase the screen and switch to non-store operation by depressing both OFF buttons.

Fast Writing Technique

Writing speed can be increased through the use of the FAST WRITING controls. This demonstration illustrates these control functions.

Enhance Mode

1. Set the front-panel controls as per the previous demonstration setup and apply a 2 volt signal from the Amplitude Calibrator to the Input connector for the vertical plug-in unit.

2. Set the Volts/Div switch to 0.5 and the Input Selector switch to AC position.

3. Adjust the CRT positioning and triggering controls for a centered, well focused, triggered display.

4. Set the NORM-SINGLE SWEEP switch to the SINGLE SWEEP position.

5. Push both STORE buttons for the UPPER and LOWER SCREEN STORAGE. A periodic stored display with a viewing time dependent on the VIEWING TIME control setting should be observed.

6. Increase the sweep rate by advancing the A TIME/CM switch to a setting which produces only partial display storage. This is approximately 5 μ SEC, see Fig. 2-13B.

7. Increase intensity and readjust focus and astigmatism controls. Writing speed should increase and the display should again store. See Fig. 2-13C.

8. Increase the sweep rate until the display is again partially stored.

9. Turn the ENHANCE MODE switch to FULL and slowly turn the ENHANCE LEVEL control clockwise. Increased writing speed will be apparent (Fig. 2-14).

10. Increase the sweep rate and continue adjusting the ENHANCE LEVEL control to the position where background deterioration (light spots in the background) begins to splatter the storage screen (Fig. 2-15).

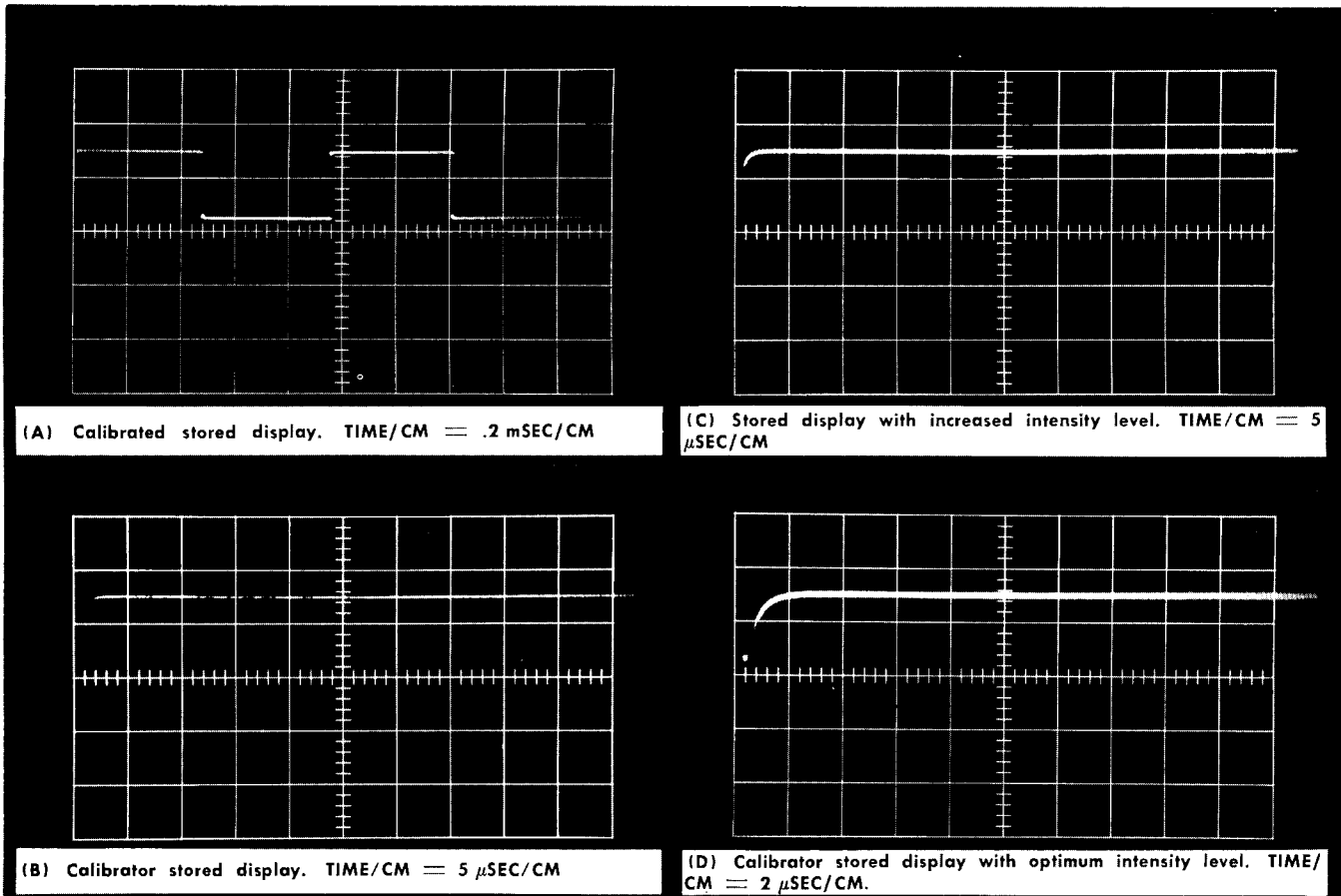


Fig. 2-13. Stored display writing speed increased by adjusting intensity level.

11. Try combinations of INTENSITY and ENHANCE LEVEL control settings. Remember the FOCUS and ASTIG controls must also be adjusted after each setting of the INTENSITY control.

12. Turn the ENHANCE MODE switch to OFF and switch to non-store operation by pushing both OFF buttons for the upper and lower screen storage switches.

Integrate Operation

Integrate trace operation is most effective on very fast low repetition rate signals.

1. Set the NORM-SINGLE SWEEP switch to NORM and the A TIME/CM switch to 50 μSEC position.

2. Switch the A TRIGGERING SOURCE switch to LINE and the MODE switch to TRIG position.

3. Set the STABILITY control to PRESET and adjust the LEVEL control for a triggered trace.

4. Turn the MAGNIFIER to $\times 5$ position. Increase the sweep rate to a TIME/CM setting where the trace is no longer discernible.

5. Switch the NORM-SINGLE SWEEP switch to SINGLE SWEEP position for single sweep operation.

6. Push both STORE buttons for storage operation and erase the screen by depressing both ERASE buttons.

7. Depress the INTEGRATE TRACES button and while the button is depressed, momentarily switch the sweep mode to the NORM position then back to the SINGLE SWEEP position. Release the INTEGRATE TRACES button. A stored trace should appear.

8. Erase the display, then change the sweep rate to a faster setting and repeat the integrating process. As the sweep speed increases, the integrate period must increase. Very fast repetitive events may be stored by integrating.

9. Erase the display, then switch to non-store operation by pushing both OFF buttons. Return the MAGNIFIER to OFF, A TIME/CM switch to 1 mSEC and the TRIGGERING switches to the up position.

NOTE

When using the integrate feature, portions of the stored display may blur or thicken, since the vertical and horizontal sensitivity shifts slightly when the button is depressed.

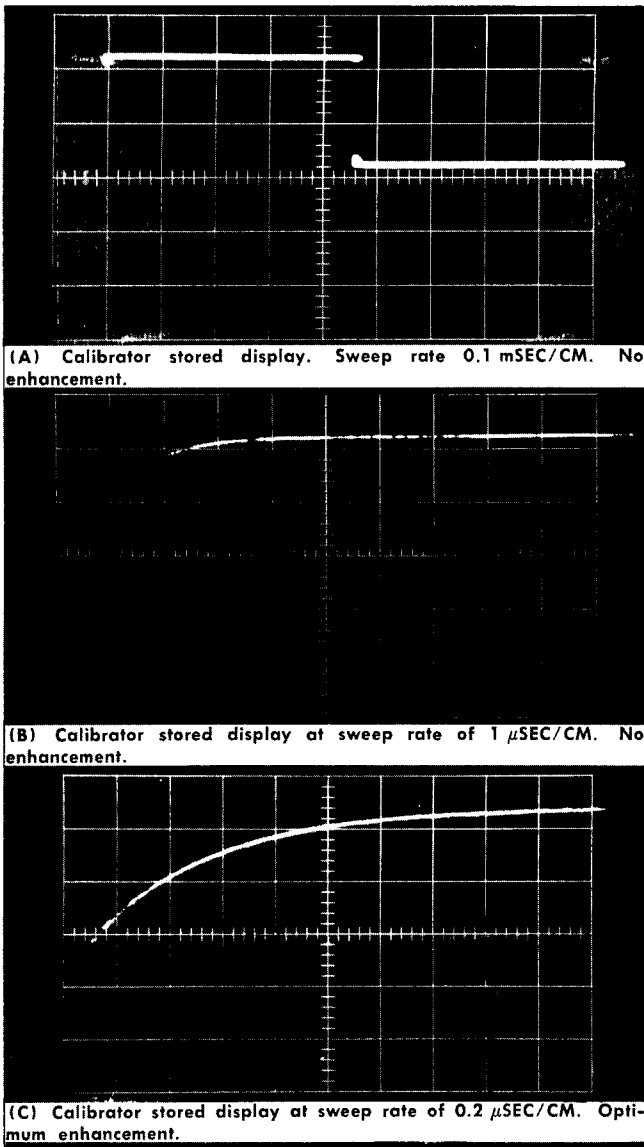


Fig. 2-14. Enhanced writing rate through the use of enhance mode.

CAUTION

Do not attempt to store extremely fast-rising or falling portions of waveforms viewed at relatively slow sweep rates. The high intensity level required to store fast events could damage the storage target.

Oscilloscope Measurement Application

The following applications describe the procedure and technique for making basic measurements with the Type 549 Oscilloscope. These applications are not described in detail but are designed to provide familiarization with the controls and basic operating technique.

AC Component Voltage Measurements

In oscilloscope measurements, the AC component of a waveform is usually measured in terms of its peak-to-peak or

peak-to-trough value. This type of measurement is most conveniently made by using the graticule to measure the vertical distance between peaks and multiplying this distance by the deflection factor of the oscilloscope. The figure obtained is the actual peak-to-peak voltage. In most cases, the AC component of a waveform can be measured with the Input Selector switch in either the AC or DC position. It may be necessary to use the AC position, however, in certain applications to prevent the DC component of the waveform from deflecting the trace off the screen. To prevent inaccuracies, the DC position should be used when low-frequency measurements are made.

To measure peak-to-peak voltage on the AC component of a waveform the following method can be used:

1. With the aid of the graticule, measure the vertical distance in centimeters from the positive peak to the negative peak.

NOTE

This technique may also be used to make measurements between two points on the waveform rather than peak to peak.

2. Multiply the distance measured by the Volts/Cm switch setting. Also include the attenuation factor of the probe, if any.

Example: Assume a peak-to-peak vertical deflection of 4.6 divisions (see Fig. 2-15) using a 10× attenuator probe and a Volts/Cm switch setting of .5.

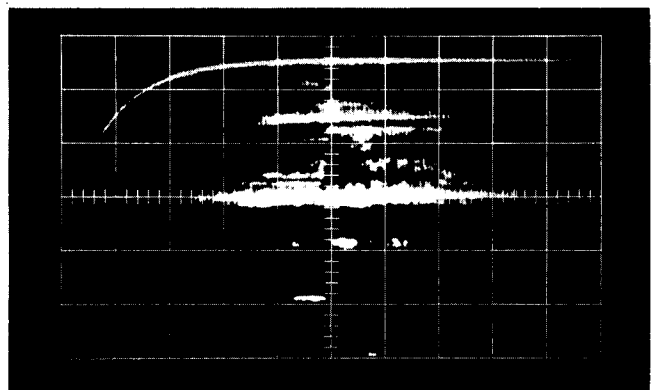


Fig. 2-15. Background deterioration as ENHANCE LEVEL is increased.

Using the formula,

$$\text{Volts peak to peak} = \text{vertical deflection (divisions)} \times \text{Volts/Cm setting} \times \text{probe attenuation factor}$$

Substituting the given values,

$$\text{Volts peak to peak} = 4.6 \times 0.5 \times 10$$

The peak-to-peak voltage is 23 volts.

Instantaneous Voltage Measurements

Instantaneous voltages are measured with respect to some reference voltage (normally ground). This reference level

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is first established along a graticule line, then the instantaneous voltage is applied and its amplitude measured in much the same way as AC peak-to-peak measurement, except that the measurement is made from the reference graticule line (reference voltage). Voltage measurements are then made with respect to this reference line. In this type of measurement, the Input Selector switch must be in the DC position. The method used to measure instantaneous voltages can be extended to measurements of the DC component of a waveform, since the average voltage of a waveform can be treated as an instantaneous voltage. The DC component of a waveform can therefore be measured if the average voltage can be determined.

In the following procedure, steps are given for establishing the voltage reference line as ground. The same general method may be used to measure voltage with respect to any other potential, if that potential is used to establish the reference line.

Measurement of an instantaneous voltage with respect to ground or other reference voltage is performed as follows:

1. To establish the voltage reference line, touch the probe tip to an oscilloscope ground terminal or the voltage reference. Adjust the oscilloscope controls for a free-running sweep. Vertically position the trace to a convenient point on the CRT. This point will depend on the polarity and amplitude of the input signal, but should be chosen so the trace lies along one of the major divisions of the graticule. If the trace is widened by stray interference, ground the probe body near the tip. The graticule line corresponding to the position of the trace is the voltage reference line and all voltage measurements are 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 or reference voltage and connect it to the signal source. Adjust the triggering controls for a stable display. The probe ground lead should be very short.

3. Using the graticule, measure the vertical distance in centimeters from the point to be measured to the voltage reference line.

4. Multiply the distance measured first by the Volts/Cm setting, then by the attenuation factor of the probe used.

Example: Assume that the vertical distance measured is 4.6 divisions (see Fig. 2-16), the waveform is above the reference line, using a $10\times$ attenuator probe and a Volts/Cm setting of 2.0.

Using the formula:

Instantaneous Voltage =

$$\begin{array}{ccccccc} \text{vertical} & & & \text{Volts/} & & \text{probe} & \\ \text{distance} & \times & \text{polarity} & \times & \text{Cm} & \times & \text{attenuation} \\ \text{(divisions)} & & & & \text{setting} & & \text{factor} \end{array}$$

Substituting the given values:

$$\text{Instantaneous Voltage} = 4.6 \times +1 \times 2 \times 10$$

The instantaneous voltage is +92 volts.

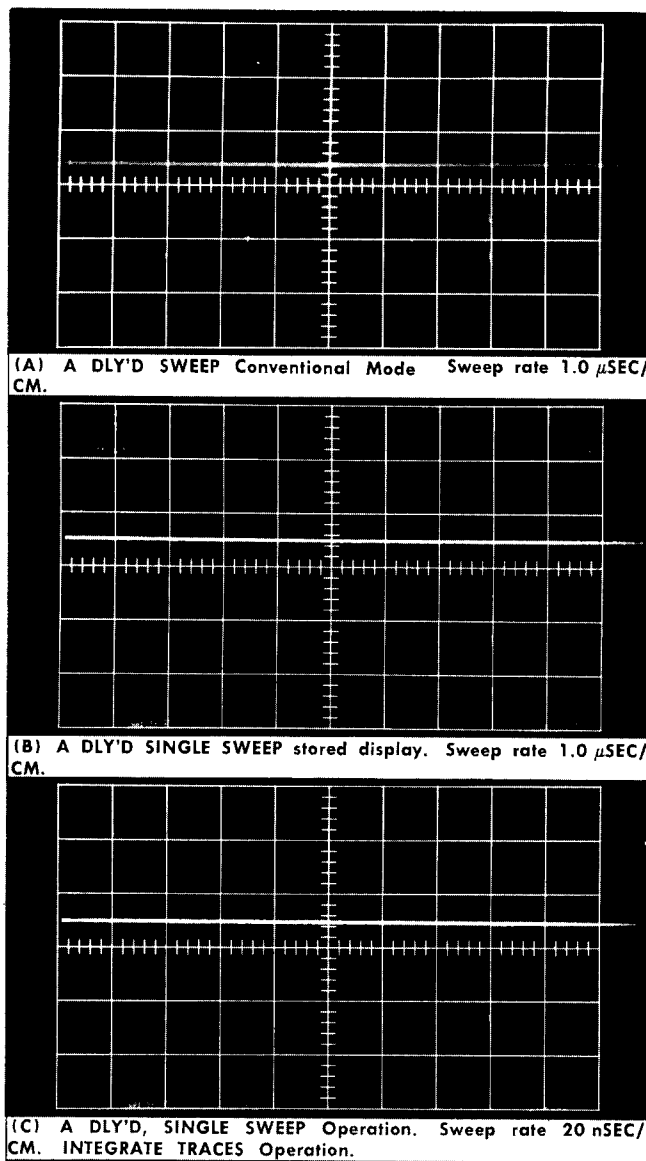


Fig. 2-16. Storage of a repetitive waveform illustrating integrate operation.

Voltage Comparison Measurements

In some applications it may be necessary to establish a set of deflection factors other than those indicated by the Volts/Cm switch. This is useful for comparing signals to a reference voltage amplitude. To establish a new set of deflection factors based upon a specific reference amplitude, proceed as follows:

1. Apply the reference signal of known amplitude to the Input connector. Using the Volts/Cm switch and the Variable control adjust the display amplitude for an exact number of divisions. Do not move the Variable Volts/Cm control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (volts) by the product of the deflection in divisions (established in step 1) and the Volts/Cm switch setting. This is the deflection conversion factor.

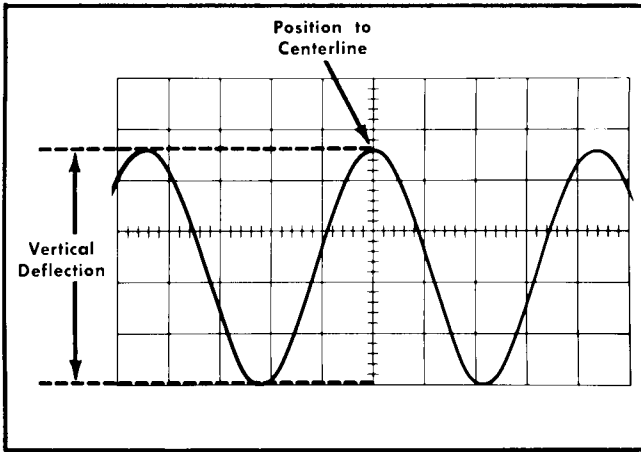


Fig. 2-17. Measuring peak-to-peak voltage.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{deflection (divisions)} \times \text{Volts/Cm setting}}$$

3. To establish an adjusted deflection factor at any setting of the Volts/Cm switch, multiply the Volts/Cm switch setting by the deflection conversion factor established.

$$\text{Adjusted Deflection Factor} = \text{Volts/Cm setting} \times \text{Deflection Conversion Factor}$$

4. To determine the peak-to-peak amplitude of a signal compared to a reference, disconnect the reference and apply the signal to the Input connector.

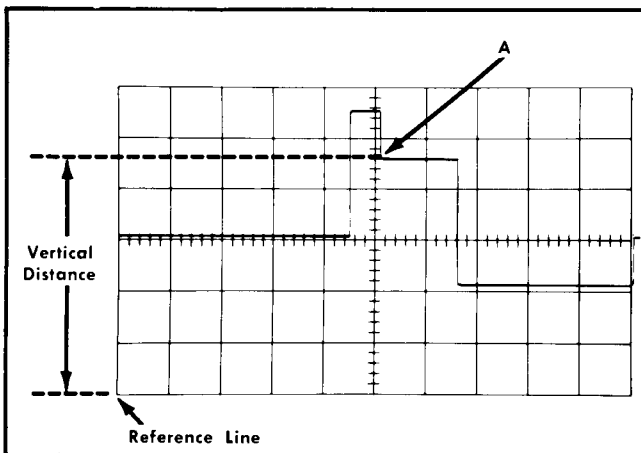


Fig. 2-18. Measuring instantaneous voltage with respect to a reference voltage.

5. Set the Volts/Cm switch to a setting that will provide sufficient deflection to make the measurement. Do not readjust the Variable Volts/Cm control.

6. Measure the Vertical deflection in divisions and determine the amplitude by the following formula:

$$\text{Signal Amplitude} = \text{Adjusted Deflection Factor} \times \text{deflection (divisions)}$$

Example: Assume a reference signal amplitude of 30 volts, a Volts/Cm setting of 5 and a deflection of 4 cm. Substituting these values in the Deflection Conversion Factor formula:

$$\text{Deflection Conversion Factor} = \frac{30}{4 \times 5} = 1.5$$

Then with a Volts/Cm switch setting of 10, the adjusted deflection factor would be:

$$\text{Adjusted Deflection Factor} = 10 \times 1.5 = 15 \text{ volts/cm}$$

Time Measurements

Both A and B Time Base sections are accurately calibrated, therefore any horizontal distance represents real time. Time intervals between two or more events can thus be measured directly on the graticule.

The following is a method of measurement which is accurate for most applications.

1. Using the graticule, measure the horizontal distance between the two displayed events.

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 CAL position.)

3. Divide the apparent time interval by the MAGNIFIER setting to obtain the actual time interval.

Example: Assume that the distance between the time measurement points is 4 divisions (see Fig. 2-19) and the TIME/CM switch to set to .1 μSEC with the magnifier on (×5).

Using the formula:

$$\text{Time Duration} = \frac{\text{horizontal distance (divisions)} \times \text{TIME/CM setting}}{\text{magnification}}$$

Substituting the given values:

$$\text{Time Duration} = \frac{4 \times 0.1 \mu\text{sec}}{5}$$

The time duration is 80 ns.

Increased Accuracy Time Measurements

A second method for measuring time intervals involves the use of the intensified sweep feature of the Type 549 oscilloscope. In this method the HORIZONTAL DISPLAY switch is placed in the B INTEN BY A position. The brightened portion of the trace is then used as a continuously variable time marker. The brightened portion of the trace and the DELAY TIME MULTIPLIER 1-10 control are used to make the time measurements. This method provides a high degree of accuracy if care is taken in making the measurements. The method is as follows:

1. Set the HORIZONTAL DISPLAY switch in the B INTEN BY A position and adjust the B triggering controls for a

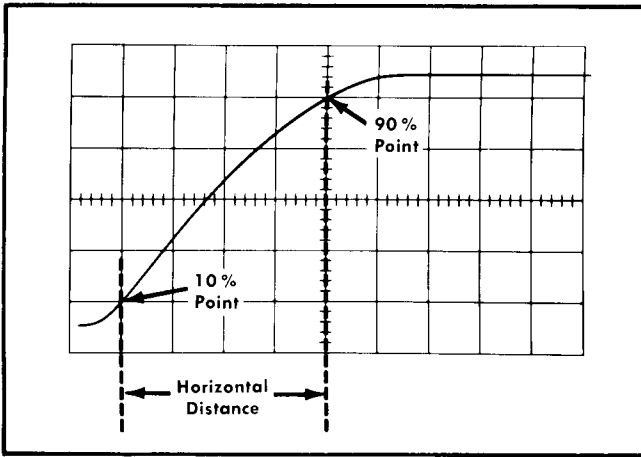


Fig. 2-19. Measuring risetime.

stable display. Set the A STABILITY control for free-running operation (fully clockwise).

2. Decrease the intensity until the brightened portion of the trace is easily distinguishable. Set the A TIME/CM switch setting so the brightened portion is a small segment of the trace.

3. With the DELAY TIME MULTIPLIER 1-10 control, position the start of the brightened portion to the start of the interval to be measured. Record the setting of the DELAY TIME MULTIPLIER 1-10 vernier dial.

4. Adjust the DELAY TIME MULTIPLIER 1-10 control to position the start of the brightened portion of the trace to the end of the interval to be measured. Again record the setting of the DELAY TIME MULTIPLIER 1-10 vernier dial.

5. Subtract the first DELAY TIME MULTIPLIER 1-10 dial reading from the second and multiply the difference by the setting of the B TIME/CM AND DELAY TIME switch. The answer obtained is the time interval between the two events. This figure accuracy is within $\pm 1\%$.

Maximum Accuracy Time Measurements

The maximum accuracy method of time measurement involves the delayed sweep feature of the Type 549. This method uses only the DELAY TIME MULTIPLIER 1-10 dial and accuracy to ± 2 minor dial divisions can be achieved. When this accuracy is desired the Time Base B calibration should be checked for the individual TIME/CM ranges to be used.

Establish the accuracy of the Time Base B TIME/CM ranges to be used, then proceed as follows:

1. Complete the time measurement as described in the previous section on Increased Accuracy Time Measurements. The A STABILITY control must be fully clockwise at free-run position.

2. Set the DELAY TIME MULTIPLIER 1-10 control so the intensified spot is at the beginning of the interval to be measured. Set the HORIZONTAL DISPLAY switch to A DLY'D. With the DELAY TIME MULTIPLIER 1-10 control,

position the beginning of the interval to be measured to the graticule centerline. (The graticule centerline is now the reference point of the CRT display for the following measurements.) Record the DELAY TIME MULTIPLIER 1-10 dial reading.

3. Set the HORIZONTAL DISPLAY switch to B INTEN BY A and rotate the DELAY TIME MULTIPLIER 1-10 control to position the intensified portion of the sweep to the end of the interval being measured. Set the HORIZONTAL DISPLAY switch to A DLY'D. With the DELAY-TIME MULTIPLIER 1-10 control, horizontally position the end of the interval to the graticule centerline. Record the DELAY-TIME MULTIPLIER 1-10 dial reading.

4. Take the difference of the two DELAY-TIME MULTIPLIER 1-10 dial readings and multiply the result by the setting of the Time Base B TIME/CM AND DELAY TIME switch. The figure obtained is accurate to within 0.2% plus the accuracy of the B sweep.

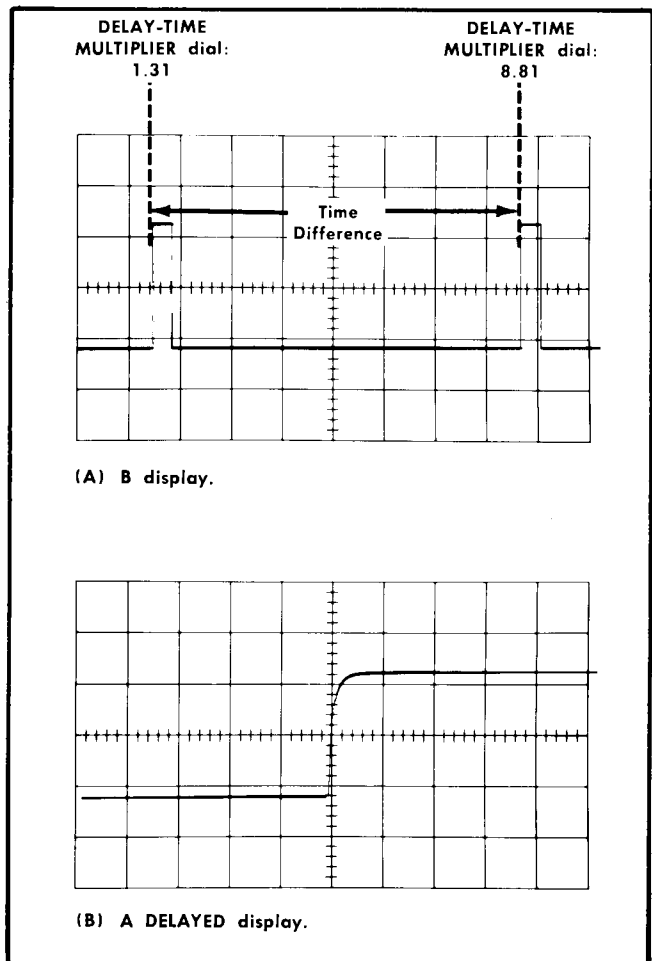


Fig. 2-20. Accurate time measurements using delayed sweep and DELAY-TIME MULTIPLIER dial readings.

Example: Assume the first dial reading is 1.31 and the second dial reading is 8.81 with the TIME/CM switch set to 0.2 microsecond (see Fig. 2-20).

Using the formula:

$$\text{Time Difference (delayed sweep)} = \left(\begin{array}{l} \text{second dial} \\ \text{reading} \end{array} - \begin{array}{l} \text{first dial} \\ \text{reading} \end{array} \right) \times \text{B TIME/CM setting}$$

Substituting the given values:

$$\text{Time Difference} = (8.81 - 1.31) \times 0.2 \mu\text{s.}$$

The time difference is 1.5 microseconds.

Frequency Measurements

By use of 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 be easily calculated, since frequency is the reciprocal of the time period. For example, if the period of a recurrent waveform is accurately measured and found to be 0.2 microseconds, the frequency is the reciprocal of 0.2 microsecond or 5 MHz.

Phase Measurements

Since a complete cycle of a sinusoidal waveform is 360 degrees, it is possible to calibrate the oscilloscope display directly in degrees per centimeter by means of the TIME/CM controls. For example if the TIME/CM controls are adjusted so one cycle of the input waveform covers 9 centimeters, (see Fig. 2-21) each centimeter then corresponds to 40 degrees. Under this condition the display is calibrated to 40 degrees per centimeter.

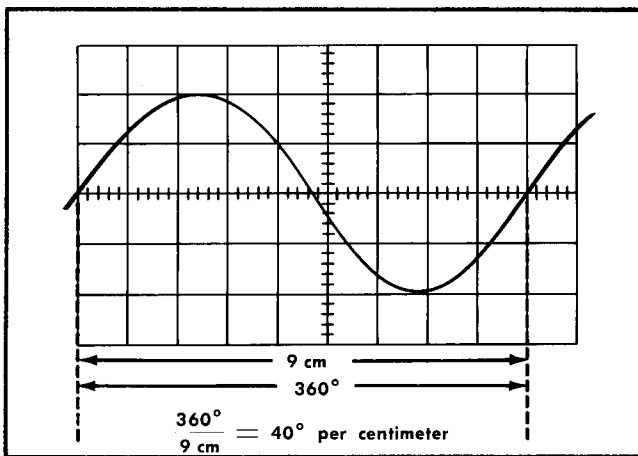


Fig. 2-21. A method of calibrating the displayed waveform in degrees/centimeter.

It is possible therefore to measure phase angles by: (1) calibrating the display in degrees per centimeter; (2) measuring the displacement between corresponding points on the two phases; and (3) multiplying the displacement by the number of degrees per centimeter. This method is illustrated in Figure 2-22. Note that the relative amplitude of the two

signals does not affect the phase measurement if the signals are both centered about the horizontal centerline. It is important to note that the two waveforms shown in the illustration do not appear simultaneously on the oscilloscope screen. The first waveform is displayed and positioned to a convenient reference point. The second waveform is then displayed and compared to this reference point.

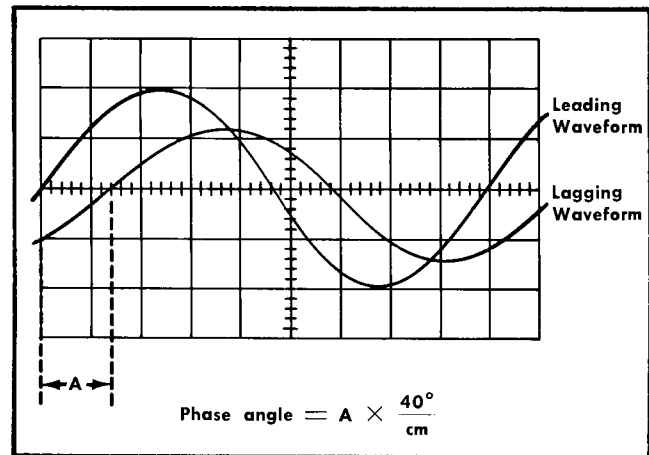


Fig. 2-22. Measurement of the phase angle between two waveforms. Note: the two displayed waveforms are not simultaneously on the screen.

With reference to Fig. 2-23 the phase angle between the two waveforms is $360^\circ \times A/B$. It is not necessary to calibrate the display in degrees per centimeter as long as it is possible to measure A and B accurately. It is particularly important to measure A accurately when the phase angle is less than 10° . The delayed sweep feature provides a means for accurate measurements. The phase angle can be found by: (1) measuring A; (2) measuring B; and (3) multiplying A/B by 360° . Here again the relative amplitude of the two waveforms is unimportant as long as the waveforms are centered about the horizontal centerline of the graticule.

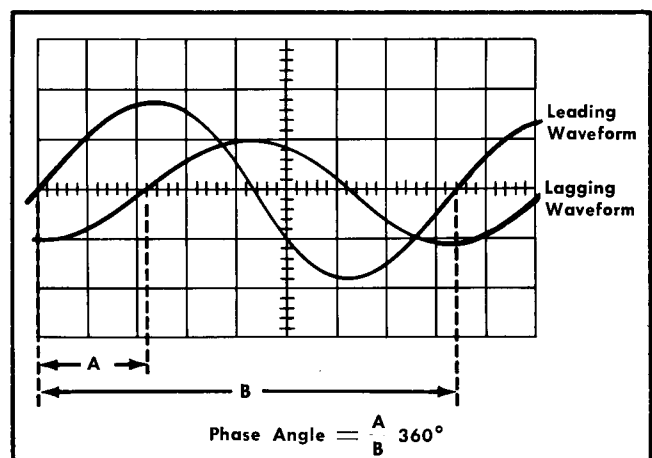


Fig. 2-23. An alternate method for measuring the phase angle between two signals.

Operating Instructions—Type 549

When using the Type 549 Oscilloscope for phase measurements, it is necessary to maintain a constant amplitude point on the input triggering signal because the two input signals are compared indirectly to this reference and directly to each other. The trigger signal must have sufficient amplitude to ensure stable triggering. The triggering signal must be related in frequency to the waveforms on which phase measurements are to be made; however, the actual phase of the triggering signal is not critical. It is essential that after triggering conditions have been established, there is no change during any phase measurement.

The amplitude of the display should be large to improve accuracy. Accuracy of the measurements also depends on keeping the waveforms centered about the horizontal center-line of the graticule. See Fig. 2-24.

Dual-Trace Chopped Blanking

A multi-channel plug-in unit provides two separate traces on the CRT and thus permits two functions to be displayed simultaneously. Detailed instructions for operating the multi-channel plug-in unit in conjunction with the Type 549 Oscilloscope are contained in the plug-in unit instruction manual.

When the multi-channel plug-in unit is operated in chopped mode to obtain a dual-trace presentation, switching transients will be displayed on the CRT. These switching transients can be reduced by placing the CRT CATHODE SELECTOR switch at the rear of the instrument in the CHOPPED BLANKING position.

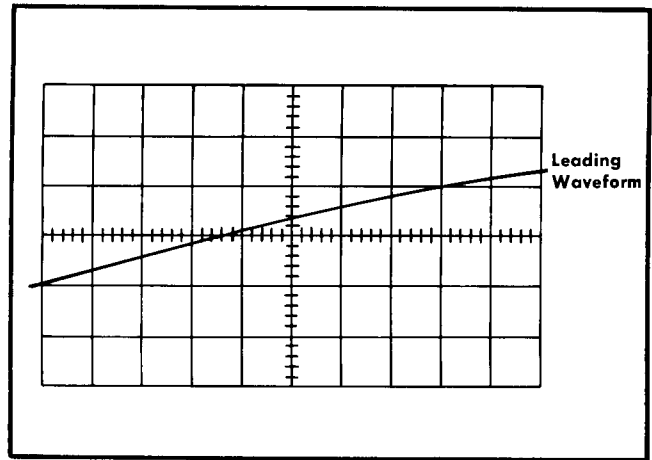


Fig. 2-24. Establishing the reference point with the leading waveform by using MAGNIFIER operation.

Light Filter

The light filter provided with the Type 549 minimizes undesirable reflections when viewing the display under high ambient light conditions. The filter may be left on when taking waveform photographs unless a high writing rate is required.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section describes storage techniques as employed in the Type 549, followed by block diagram analysis and basic circuit theory.

Glossary of Terms and Storage Tube Nomenclature

Storage technique and analysis involves the use of special terminology. The following glossary of terms should assist the reader in understanding their application when describing storage tubes and circuitry.

Background Light Level	The average brightness of the light emitted by the storage target when completely erased, with the backplate set at a given voltage.	Operating Level or Storage Level	The voltage between the flood gun cathode and backplate within the operating range.
Brightness Uniformity Ratio	The ratio of the brightest to the dimmest area when the target is fully stored.	Operating Range	The flood gun cathode to backplate voltage range within which information can be stored.
Collimation Lens	An electrostatic low-voltage lens used to adjust the trajectories of the flood gun electrons.	Ready-to-write State	The state of the storage target immediately after erase and before writing again.
Collimation Electrodes	Elements used in the collimation lens.	Rest Potential	Average equilibrium potential assumed by the unwritten areas of the target when it is operated in the storage mode.
Conventional Mode	A mode of operation such that written information cannot be stored, and the tube behaves as a conventional CRT.	Retention Threshold	The lowest flood gun cathode to backplate voltage at which previously written information will remain stored.
Enhance	A method of momentarily altering electrode potentials to increase writing speed.	Stable Range	The flood gun cathode to backplate voltage range within which information can be stored (fade positive minus retention threshold).
Erase	The operation of changing electrode potentials in such a manner that previously stored information is removed.	Storage Mode	A mode of operation such that written information is stored until intentionally erased.
Fade Positive	The flood gun cathode to backplate potential at which an unwritten area fades up as bright as an adjacent written area anywhere within the quality area, without writing a trace.	Storage Target	A surface having the ability to store information when bombarded by an electron beam.
Flood gun	A low-energy electron gun directing a large area flow of electrons toward the entire screen.	Stored Brightness	The brightness of stored information with the backplate set at a given voltage.
Integrate	A method of operation that interrupts flooding of the target and permits the writing gun electrons to sum over several sweeps.	Viewing	A method of holding written information for a period of time before automatic erasure.
Ion Repeller	An electrode that produces a potential barrier against ions.	Writing	The process of recording the information on the storage target.
Locate Zone	An area that does not store on the left-hand side of the graticule to permit pre-setting of the vertical position of the trace (in storage mode).	Writing Gun	A high-energy electron gun giving a narrow focused beam. This beam can be deflected and is used to write the information to be stored.
		Writing Rate	The time rate, i.e., sec/cm at which the writing beam will register stored information when scanning the storage target, under stated conditions of operation.
		Writing Speed	The speed, i.e., cm/sec at which the writing beam will register stored information when scanning the storage target, under stated conditions of operation.
		Writing Threshold	The lowest flood gun cathode to backplate voltage at which a signal of fixed writing speed can be stored.
		Upper Writing Limit	The flood gun cathode to backplate potential at which an unwritten area fades up as bright as an adjacent written area or the trace spreads after it is written on the screen.

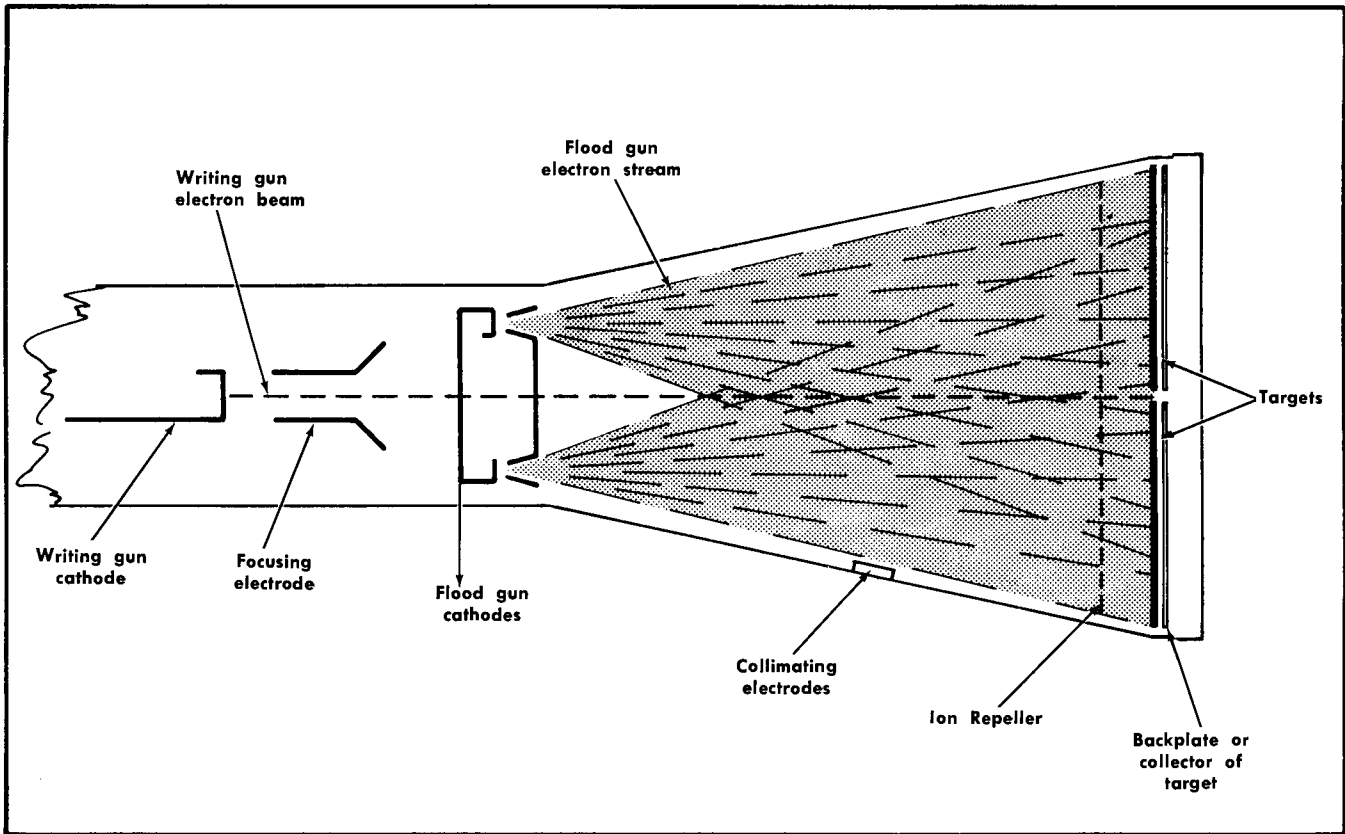


Fig. 3-1. Pictorial diagram of storage tube Type T5490.

Basic Operating Principles of the Storage Tube

The Tektronix T5490 CRT is a direct-view storage cathode ray tube with a split screen viewing area that can be individually operated for stored displays. The storage target stores electrical charges on an insulated surface by using the secondary emission properties of the surface. The stored charge is then used to control the flow of electrons to a phosphor screen to give visual output that corresponds to the location of the stored charge.

The storage cathode ray tube contains special storage elements in addition to the conventional writing gun elements. The operating mode of the tube depends primarily on the voltages applied to these storage electrodes. With one condition of applied potentials, the storage screen or target operates in the ready-to-write state; then, when it is bombarded with high energy writing beam current, it shifts to the stored mode to store a written display. With a different set of applied voltages the screen or target operates in the conventional mode, similar to a conventional cathode ray tube.

The storage screens contain a special coated surface which continues to emit light when bombarded by the flood gun electrons, provided the surface has been written by the writing gun beam and shifted to the stored state. The two targets are electrically isolated from each other, which allows simultaneous presentations of stored information on one half and non-store (conventional) information on the other half of the viewing area.

Fig. 3-1 illustrates the basic construction of the T5490 storage tube. The flood guns emit two cones of electrons which completely cover the storage targets. The ion repeller minimizes ion bombardment of the target surface. The collimation electrodes shape the flood beam. The operating level of the tube is the potential difference between the target backplate and the flood gun cathodes.

In the store mode the insulator surface of the target tends to charge down to a potential lower than the backplate potential, and towards the potential of the flood gun cathode. This is due to the ratio of primary current (flood gun beam) to target secondary emission current. The potential to which the target charges is called its rest potential. This potential is such that the flood gun electron landing energy is not enough to illuminate the phosphor in the target. The target is now ready to write. See Fig. 3-2.

In the writing process, the target is scanned by the writing gun electrons. These high energy electrons increase the target secondary emission over the area they scan, so that the ratio of primary current to secondary current becomes greater than one. When this ratio exceeds one, that part of the bombarded surface shifts to a new stable state. Writing has been accomplished and this segment of the target is now stored.

In the written state, the potential difference between the flood gun cathode and target becomes greater and the flood gun electrons now have a landing energy that is sufficient to provide a visual display due to the cathode lumi-

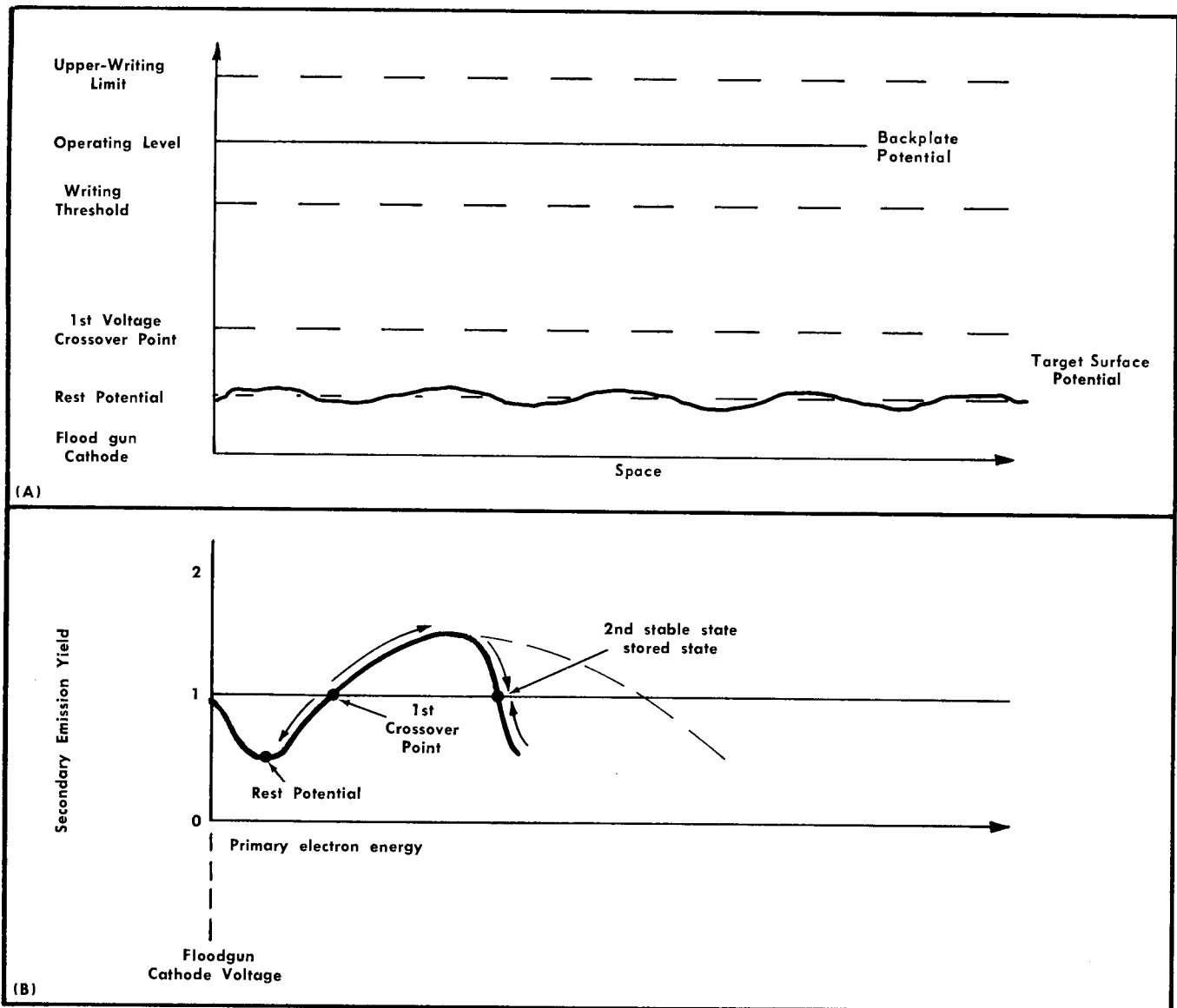


Fig. 3-2. (A) Storage electrode (target to flood gun cathode) operating potentials. (B) Secondary emission curve for insulator showing charging direction.

nescence of the phosphor-impregnated target. This visual display will continue as long as the flood gun beam covers the target.

At high sweep rates, the writing beam current is not adequate to bring the portion of the target scanned above the crossover point; therefore, the flood gun electrons when landing on the bombarded area will remove the charge developed by the writing gun electrons, and the target will discharge to its initial ready-to-write state without being written. Thus, complete writing is a function of writing beam current density.

When the stored display is no longer desired, the information is erased by a waveform as illustrated in Fig. 3-3. A positive-going pulse is first applied, to raise the backplate voltage above the writing threshold and write the entire target area with flood gun electrons. Next, the backplate voltage is pulled well below the rest potential, then as the

backplate voltage is gradually returned, the target is charged to the operating point and the target is now in the ready-to-write state.

Fast Writing Techniques

Writing speed is primarily a function of the writing gun beam current density and physical properties of the storage tube. At very fast sweep speeds, the writing beam does not charge the scanned portion of the target sufficiently to shift them to stored state, and the flood gun electrons discharge the small charge back down to rest potential before the next sweep.

Writing beyond the normal writing speed of the CRT is attained through the process of integration or enhancement. Integrate: The flood gun beam is momentarily interrupted. This allows the writing gun beam to sum small amounts of

Circuit Description—Type 549

charge for successive sweeps so that when the flood electrons are again turned on the scanned target area shifts to the stored state.

Enhance: An approximate 1 ms, variable amplitude pulse is applied to the target, which conditions the target so that less writing gun current is required to shift the scanned section to the stored state. A front panel control adjusts the enhance pulse amplitude.

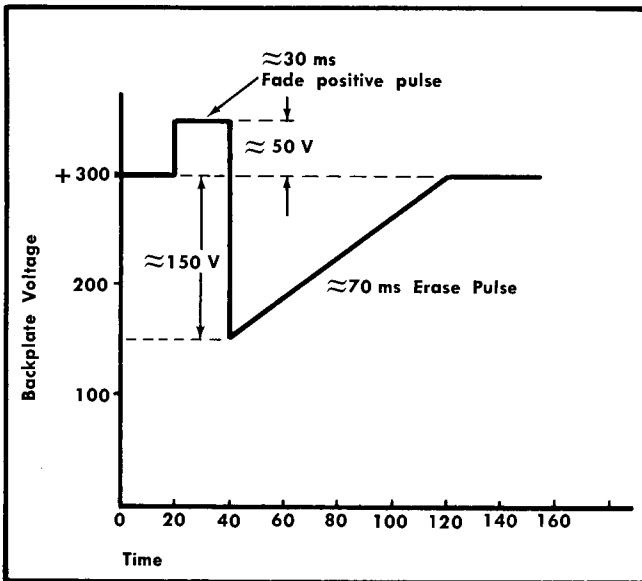


Fig. 3-3. Erase cycle waveform.

BLOCK DIAGRAM DESCRIPTION

Low Voltage Power Supply

The low voltage power supply produces all operating voltages for the oscilloscope with the exception of the CRT circuit. The low voltage supply provides regulated -12.4 , -150 , $+100$, $+225$, $+300$, $+350$ and $+500$ volts. It also provides heater voltages and an unregulated $+470$ volt output.

Vertical Plug-In Preamplifier

Any Tektronix letter or 1-series vertical plug-in preamplifier can be used with the Type 549. For a circuit description of the plug-in unit, refer to the plug-in unit instruction manual.

Vertical Input Amplifier

The vertical input amplifier is a balanced hybrid amplifier that amplifies the output of the plug-in vertical preamplifier and applies the amplified vertical signal to the trigger-pickoff circuit and the vertical output amplifier.

Delay Line

The push-pull output of the vertical input amplifier is applied through the balanced delay line to the vertical out-

put amplifier. The delay line is a specially braided $186\ \Omega$ line which delays the application of the vertical signal to the vertical output amplifier for 200 nsec. This provides time to unblank the CRT and start the horizontal sweep before the vertical signal reaches the deflection plates. The delay allows the leading edge of a single fast rising pulse to be displayed. Because of its precision construction, the delay line requires no adjustment.

Vertical Output Amplifier

The vertical output amplifier is a push-pull cascode amplifier that takes the output of the delay line and amplifies this output to a level sufficient to drive the vertical deflection plates of the CRT.

Trigger Pickoff Circuit

The trigger pickoff circuit applies a sample of the input waveform to the trigger circuits of both time bases. The pickoff is at the output of the vertical input amplifier. Internal plug-in trigger is also available at pins 4 and 5 of the blue ribbon connector J-11, which can be selected by the time base TRIGGERING SOURCE switch.

Time Base A Generator

The Time Base A Generator provides accurate ramp voltages for the horizontal deflection system, unblanking for the CRT and output waveforms to the + GATE and A SWEEP front panel connectors. The Time Base A Generator may be triggered by signals from either internal or external sources.

Time Base B Generator

The Time Base B Generator closely resembles the Time Base A Generator. Thus, the functions and the circuit description given for the Time Base A Generator, in most instances, apply also to the Time Base B Generator.

Delay Pickoff Circuit

The delay pickoff circuit compares the ramp-voltage output of the Time Base B Generator with a variable reference voltage and assuming identical characteristics in the two halves of the comparator, generates a trigger pulse when the two voltages are equal. The trigger output of the delay-pickoff circuit is used in the A DLY'D and B INT by A position of the HORIZONTAL DISPLAY switch, to arm or trigger Time Base A. The trigger output is also available at a front panel DLY'D TRIG connector.

B Unblanking

This circuit provides an unblanking pulse to the CRT circuit to unblank the CRT during sweep time and to the View Time Generator through the HORIZONTAL DISPLAY switch. The unblanking pulse is also available at the front panel as + Gate B.

A Unblanking

The circuit duplicates the operation of the B unblanking circuit for the A Time Base.

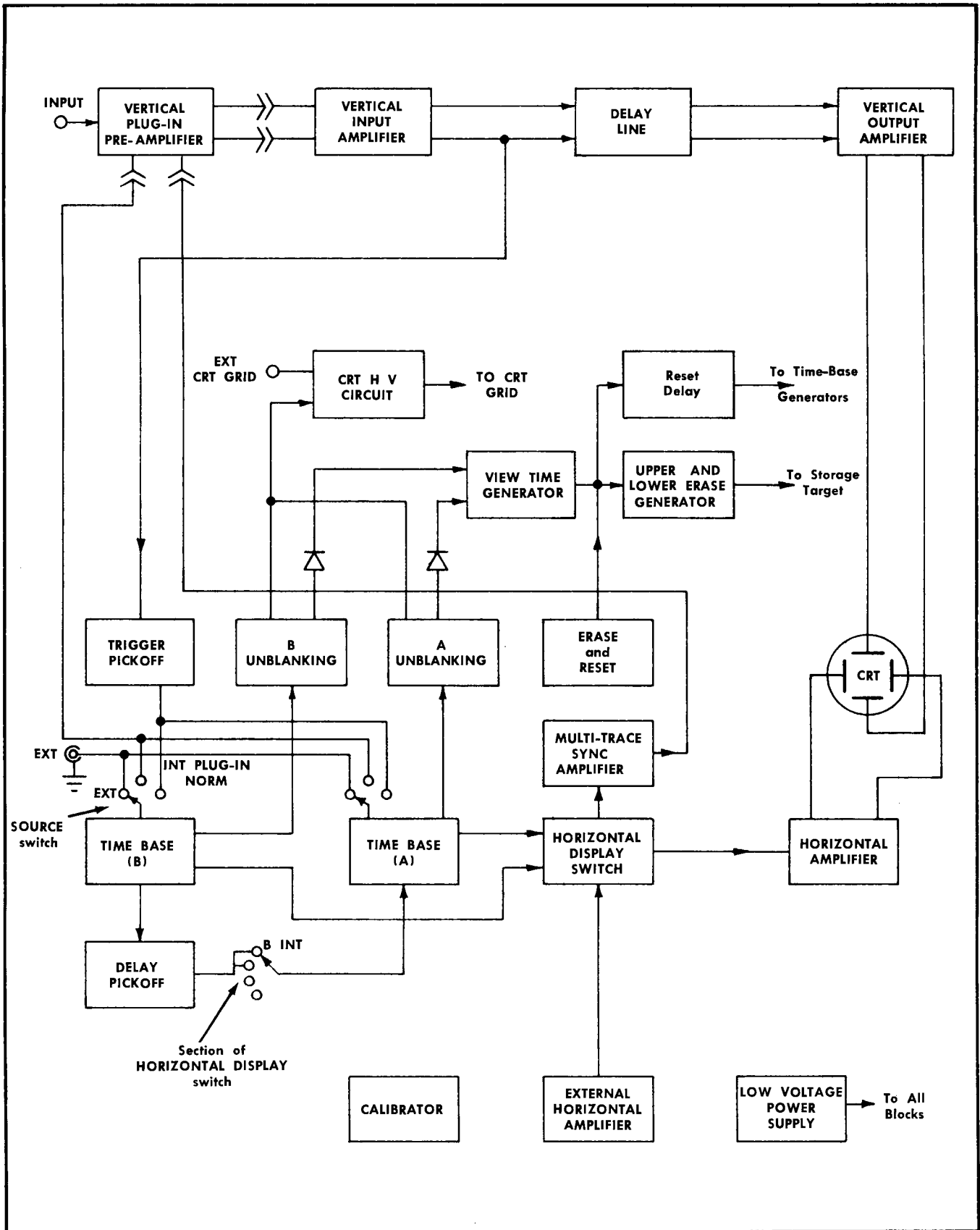


Fig. 3-4. Simplified Block Diagram.

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CRT Circuit

This circuit provides the high voltages required to operate the CRT, intensity modulation to unblank the CRT and multi-trace chopped blanking. A DC coupled external connection and switch provide the facility to externally modulate the CRT grid. An AC coupled external connection and switch provide the facility to externally modulate the CRT cathode.

View Time Generator

This circuit generates an erase trigger pulse for automatic erase after an adjustable delay which is set by the VIEWING TIME front panel control. This provides an adjustable viewing period of the stored information.

Erase and Reset

This circuit provides a manual control to erase written information and reset the sweep circuits.

Upper and Lower Erase Generator

These erase generators provide the erase pulse to erase stored information on either or both upper and lower sections of the CRT screen.

Horizontal Display Switch

Basically the switch performs the following functions:

1. Gates the ramp signals from the time base circuits and signals from the External Horizontal Amplifier into the Horizontal Amplifier.
2. Selects sync trigger to the Multi-Trace Sync Amplifier for dual-trace slaving pulses.
3. Provides $1\times$ and $10\times$ attenuation for the External Horizontal Amplifier.
4. Applies delayed trigger from Delay Pickoff circuit to the Time Base A Generator in the B INT by A and A DLY'D positions.
5. Selects proper unblanking pulse to trigger the View Time Generator and Enhance Generator.
6. Selects unblanking pulse to unblank CRT.
7. Steers the SINGLE SWEEP reset pulse to the appropriate time base generator.

Multi-trace Sync Amplifier

This amplifier provides the vertical plug-in unit with dual-trace slaving pulses.

Horizontal Amplifier

The input to the Horizontal Amplifier is selected from the outputs of the Time Base B Generator, Time Base A Generator, or the External Horizontal Amplifier. The selected input is split in phase and amplified to provide push-pull drive to the CRT horizontal deflection plates.

External Horizontal Amplifier

The External Horizontal Amplifier provides the necessary gain to drive the Horizontal Amplifier from external signals. An input attenuator and a gain control establishes horizontal deflection factors from about 0.2 to 15 volts/cm.

Calibrator

The Calibrator in the Type 549 is a multivibrator and cathode follower that provides a square-wave output with a maximum amplitude of 100 volts at a nominal 1 kHz. A step attenuator permits switching the output amplitude from the front panel.

CIRCUIT ANALYSIS

The following is a detailed discussion of the operation of each circuit in the Type 549. While reading the description of a particular circuit, refer to the proper schematic diagram in Section 9.

Low-Voltage Power Supply

The Low-Voltage Power Supply in the Type 549 (see Power Supply schematic diagram) consists of seven interrelated supplies that operate together as a system. This system delivers filtered and regulated voltages of -12.4 , -150 , $+100$, $+225$, $+300$, $+350$ and $+500$ volts as well as an unregulated DC voltage of 470 volts. A common power transformer, T601, supplies the input power to each of the supplies, as well as heater power to thermal time-delay relay K600 and the tubes in the oscilloscope.

Switches SW602 and SW603 are provided to accommodate a wide range of AC power line voltages by changing the power transformer primary-to-secondary turns ratio.

Switch SW602 connects the two primary windings of the transformer in parallel (115 V) or series (230 V).

Further switching of transformer taps with SW603 allows operation over a range from the nominal voltage set by SW602. With SW602 in the 115 V position, three positions of SW603 provide operation with line voltages of $104\text{ V} \pm 10\%$, $115\text{ V} \pm 10\%$ or $127\text{ V} \pm 10\%$. With SW602 in the 230 V position, the respective ranges are $208\text{ V} \pm 10\%$, $230\text{ V} \pm 10\%$ and $254\text{ V} \pm 10\%$.

The AC input power is applied to T601 through POWER switch SW601. Overload protection is provided by fuse F601 and F602. Thermal cutout TK601 in the primary circuit of T601 is a protective device that opens the transformer primary circuit if the temperature inside the oscilloscope rises above a safe level. TK601 resets automatically when temperature returns to normal. Thermal time-delay relay K600 provides a filament warm-up time of approximately 30 seconds before the DC power supplies are activated. The heater of K600 is connected to 6.3 volts on the T601 secondary winding. During heater warm-up time, contacts 4 and 9 of K600 remain open. At the end of heater warm-up time, contacts 4 and 9 close and apply power to relay K601. When K601 is energized, heater power is removed from thermal relay K600 and contact 1 of K601 is grounded, thus locking the relay in the holding mode. K601 now remains

energized until the power to the oscilloscope is switched off or otherwise interrupted. When K601 is energized, contacts K601-2, K601-3 and K601-4 are also closed and activate their respective DC supplies.

—150 Volt Supply

The —150 volt supply in the Type 549 is the reference voltage source for the other power supplies, therefore it must be very stable. The supply contains a high-gain electronic voltage regulator designed to provide the required regulation under all operating conditions. This regulator circuit contains three series regulator tubes, a gas voltage regulator tube for the reference source to the comparator and an error signal amplifier to control the series regulator.

Four silicon diodes D642 A, B, C and D form a bridge rectifier across pins 19 and 20 of transformer T601 and supply the voltage to the —150 volt regulator circuit when contacts of K601-2 close.

Current through the series regulator tubes V627, V637 and V647 is controlled by the output voltage of V634, the error voltage amplifier.

A portion of the —150 volt supply is applied through the DC voltage divider network R617, R616 and R615 to the grid of V624, the voltage comparator. This voltage is compared against the reference voltage established by V609 at the grid and cathode of V624 A and applied to the grid of V634 as an error signal.

V634 amplifies and inverts this error signal. Since the plate of V634 is connected through the grids of the series regulator tubes to its plate load resistor, this error signal effectively alters the bias of the regulators. Change in the bias will change the current through the tubes and maintain a stable —150 volt supply.

The screen grid of V634 is used as a signal grid for injecting any ripple or transient voltage present in the unregulated side of the —150 volt supply into the regulator circuit. The regulator thereby becomes a dynamic filter for ripple reduction. The ripple signal applied to the screen of V634 is amplified, inverted and applied to the grids of the series regulator tubes V627, V637 and V647. This amplified and inverted ripple signal at the regulator grids is of proper amplitude and phase to cancel the ripple appearing at the plates of the regulator tubes. R640 and R641 are current limiting resistors, while C649 suppresses sudden load changes that fall outside of the bandwidth of the regulator circuit.

—12.4 Volt Supply

The input to the —12.4 volt regulator is the full wave rectified output of diodes D772 and D782. The reference voltage source is the regulated —150 volt supply which sets the base voltage of the comparator Q774, through the voltage divider R774 and R775. The —12.4 volt supply is compared to the reference voltage and any difference is amplified by Q774. Q784 sets the bias of the regulator transistor Q787 so current through the regulator is determined by the demands of the load.

During the warm-up period, the —12.4 volt supply is referenced to an unregulated voltage obtained from the —150 volt supply rectifier circuit through R773. It supplies approximately —11 volts to the flood gun heaters. When K601-2 closes and the —150 volt supply is energized, the —12.4 volt supply becomes referenced to the —150 volt supply through D773.

+100-Volt Supply

The input source to the +100-volt supply is the output of the secondary winding (pins 21 & 22) of transformer T601 and silicon diode bridge D672. In addition to its other loads, the +100-volt supply is required to supply current to a series filament string at all times. When the Type 549 is first turned on, relay K601 contacts are open and all the regulated supplies are inoperative. During this time, the series filaments are supplied by the unregulated side of the +100-volt supply through relay contacts of K601-3 and R675. By the time thermal relay K600 activates K601, the series filaments have reached operating temperature. When activated by K600, K601-3 switches the series filaments to the regulated output of the +100-volt supply.

The reference voltage source is the regulated output of the —150-volt supply. V664 is an error amplifier, and V667A is the series regulator tube in shunt with R676.

The regulator circuit can never completely compensate for a change in output voltage because there must be an error input for the circuit to operate. However, any error in output is reduced by a factor equal to the loop gain of the regulator circuit.

The screen grid of V664 is used as a signal grid for injecting a sample of any ripple or transient voltage present in the unregulated side of the +100-volt supply into the regulator circuit. The regulator circuit thereby becomes a dynamic filter for ripple reduction. The ripple signal applied to the screen of V664 is amplified, inverted and applied to the grid of V677A. The amplified and inverted ripple at the grid of V677A is of proper amplitude and phase to cancel the ripple appearing at its plate.

+300-Volt Supply

Zener diode D704 sets the base potential of Q703 to approximately +75 volts above the reference voltage of +225. The output voltage at the emitter of Q703 is therefore maintained at an approximate +300 volts. This voltage is used for the collimation electrode flood gun anode and the ion repeller screen of the CRT.

+225-Volt Supply

The voltage source for the regulated +225-volt supply is pin 17 of the secondary winding of transformer T601 which is elevated by the +100-volt supply source. This regulator circuit is similar to the —150-volt regulator. The main difference is the source of the reference voltage for the comparator.

Any voltage error signal from the comparator side of V684 is cathode coupled to the amplifier section. The amplified error signal is applied to the grid of V694 which again amplifies and DC couples the inverted error signal as bias to the grids of the series regulator tubes V737A and V737B. The bias of the series regulator tubes sets the current through the power supply and the voltage output.

Here again, the screen of the error amplifier is acting as an injection grid for ripple reduction. A sample of the unregulated supply ripple is applied to the screen of V694. V694 amplifies the ripple, inverts it and applies it to the

Circuit Description—Type 549

grids of series regulators V737A and V737B. The result is that the same ripple appears simultaneously on the grids and plates of V737, but 180° out of phase; thus the ripple is effectively reduced in amplitude.

+350-Volt Supply

The input to the +350-volt supply is the full voltage output of the center-tapped bridge (+290 volts unregulated, see Fig. 3-5) added to the unregulated side of the +100-volt supply (+180 V) giving a total output of +470 V unregulated. The operation of the regulator circuit is very similar to the operation of the +100-volt regulator except for different component values.

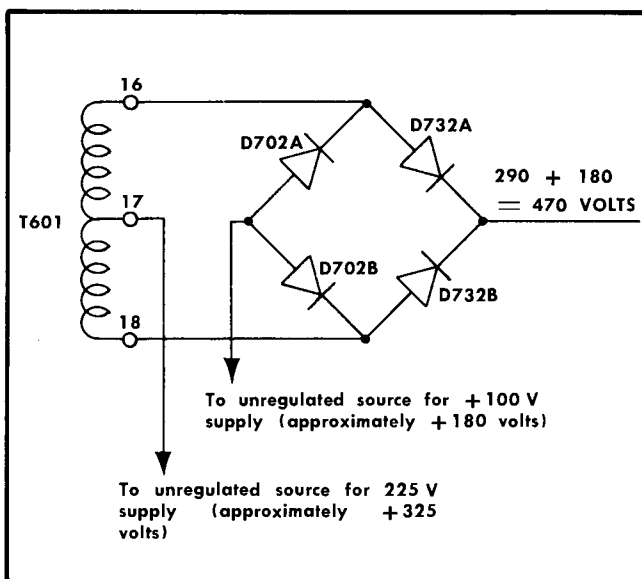


Fig. 3-5. Simplified diagram of +470-volt unregulated supply.

+500-Volt Supply

Rectified voltage from terminals 23 and 24 of T601 via the bridge rectifier D762, is added to the regulated voltage of the +350-volt supply to provide the +500-volt supply. The operation of the regulator circuit is similar to that of the +100-volt regulator except for different component values.

Unregulated +470-Volt Supply

The voltage source for the unregulated +470-volt supply differs somewhat from the voltage sources for the -150 and +100-volt supplies. The secondary winding of T601, D702 and D732 comprise a center-tapped bridge rectifier circuit. The negative side of this rectifier is connected to ground through the rectifier circuit of the +100-volt supply; this elevates the output of the bridge rectifier circuit to the unregulated output voltage of the +100-volt rectifier circuit, which is approximately +180 volts.

The unregulated output of the center-tapped bridge rectifier circuit is about +290 volts. Since the output of this circuit is elevated by the +180 volts, the total output

is an unregulated +470 volts. (This is the unregulated source for the regulated +300-volt supply.)

Vertical Amplifier

Contains a push-pull cathode follower stage driving a push-pull cascode amplifier, which in turn drives an output cascode amplifier through approximately a 200 ns delay line.

The push-pull output of the vertical plug-in preamplifier with a fixed DC level of approximately +67.5 volts is applied to the input of the vertical amplifier through terminals 1 and 3 of the plug-in connector.

R491 and R498 in series with the grids of the push-pull cathode follower stage, as well as with T500, are parasitic suppressors. DC balance of the input amplifier is set by the DC BAL adjustment R495. It is adjusted to place the trace at the CRT vertical center with a differential input voltage of zero across input terminals 1 and 3 of the plug-in connector J-11.

The DC Shift adjustment R502 is part of a voltage divider network which sets the grid voltage of V514A and V514B. This voltage is approximately 7 to 11 volts higher than the 67.5 volt output level from the plug-in units. This allows the voltage at the grids to nearly follow the cathode voltage of V494A and V494B, so the adjustment will correct when plug-in units with different output DC levels are used.

This DC Shift adjustment sets the operating point of the circuit transistors Q514 and Q524. The operating point is set so that thermal changes in amplifier gain are minimized.

The input cascode amplifier provides constant gain over a wide frequency range and matches the impedance of the delay line L552. Gain of the stage is set by Gain adjustment R520 which controls the amount of degeneration between the emitter circuits of transistors Q514 and Q524. C520 is a frequency compensation adjustment that must be set each time R520 is adjusted.

Voltage divider R512 and R513 set the base potential of Q513 and Q523, thus transistors Q513 and Q523 appear as a constant voltage source to the plate circuit of V514A and V514B and also provide reverse termination for the delay line L552.

The impedance looking into the emitter circuit of Q513 or Q523 is approximately 3 ohms. This impedance, with the impedance of R511 or R526, terminates the input to the delay line at 186 ohms or 93 ohms per side.

Since the dynamic plate impedance of V514 is very high, the terminating impedance is not affected by the operation of the cascode amplifier. The collector of Q523 drives the Trigger Pickoff circuit.

The vertical output cascode amplifier terminates the delay line and provides the stability and current to drive the CRT deflection plates over a wide frequency band.

Input impedance to the output amplifier is 93 ohms per side which properly terminates the delay line. High frequency compensation and proper delay line termination is set by adjusting L554, L560 and C568. A phase balancing transformer, T553, attenuates high frequency common mode signals.

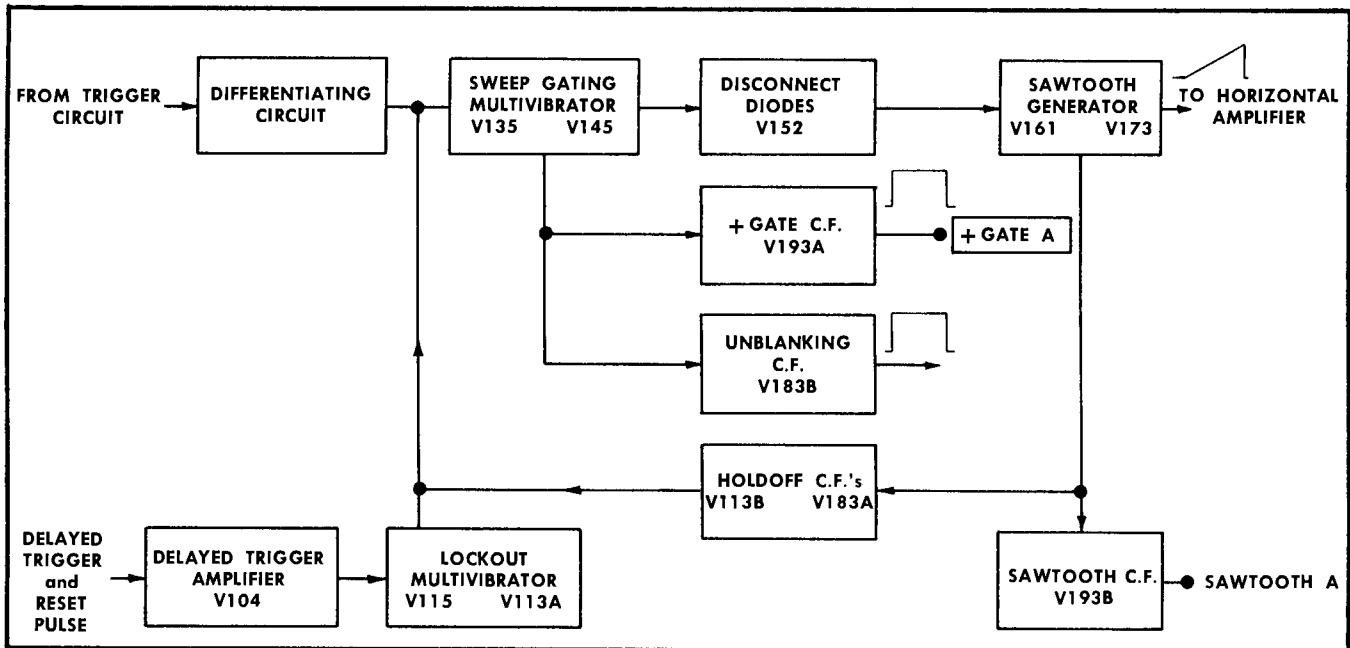


Fig. 3-6. Time-Base A block diagram.

Q584 and Q594 are emitter coupled amplifiers driving grounded grid amplifiers V584 and V594. DC offset for the grids of the output tubes is provided by R570 and R569. Setting grid voltage at this point sets the collector voltage of transistors Q584 and Q594 to the required level.

High frequency peaking and compensation in the output circuit is set by the adjustment of R580 and C578 in the emitter coupling circuit, L598 and L588 in the plate circuit of V584 and V594. The output to the deflection plates of the CRT is 'T' coil coupled and matched to the deflection plate impedance by adjusting L599 and L589.

Switch contacts of SW553 when closed provide vertical trace location by reducing the signal output amplitude from the delay line. Diodes D553 and D554 establish the window width of this reduced signal.

Trigger Pickoff Circuit

The trigger pickoff circuit provides isolation from the delay line matching network as well as a low impedance source for the trigger circuits located in both time bases.

Q533 is connected as an emitter follower with its emitter connected to a DC voltage dropping circuit consisting of R534, diodes D555-D552, R553, R535 and the long tailed constant current source Q534. Current through Q534 is set by the Int Trig DC Level adjustment R539 and is adjusted so the bias of the complementary transistors Q543 and Q553 establishes a DC output level of zero volts at the VERT SIG OUT connector and the trigger take off point to SW5 and SW55.

Forward bias for the transistors Q543 and Q553 is established by the voltage across diodes D555, D552, and R553. This bias is approximately 1 volt and effectively shifts the DC trigger level at the emitter of Q533 from +200 V to 0 V with very little attenuation of the AC signal amplitude.

Input DC level changes due to different plug-in units will change the current level through the input cascode amplifier, which will also shift the emitter DC level of Q533. To stabi-

lize the DC level of Q543 and Q553, a sample of the input DC level is directly coupled through R518 to the emitter of Q534.

If the input DC level increases, this will cause more current to be diverted from the constant current source through R518 to the vertical input amplifier. This reduces the current through R535, R553, D552, D555 and R534 and offsets the voltage drop at the emitter of Q533 to maintain a nearly constant output level at the VERT SIG OUT connector and the A and B trigger takeoff.

Time Base A Trigger and Sweep Circuits

The Time Base A consists of a Sweep Trigger and Sweep Generator circuit. The trigger circuit consists of a long-tailed, cathode-coupled comparator (Level Amplifier) that generates a pulse which is coupled through a trigger shaper to drive a hybrid Schmitt multivibrator. The Schmitt multi provides the trigger pulse to the Sweep Generator circuit. The sweep circuit is basically a Miller run-up circuit which generates the linear voltage ramp required for the horizontal deflection system. The Sweep Generator also provides alternate trace sync pulses, unblanking pulses and a gate pulse to the front panel + GATE A connector.

Time Base A Trigger

The input signal to the trigger generator is selected by the SOURCE switch SW6. SOURCE switch selections are: NORM (the signal from the trigger pickoff circuit in the Vertical Amplifier); PLUG-IN (the signal from the vertical plug-in unit); LINE (a 6.3 volt AC signal from a winding on the power transformer) and EXT (the signal from the front panel connector).

This input trigger is then AC or DC coupled by the setting of the COUPLING switch SW5 to the SLOPE switch.

Circuit Description—Type 549

The AC LF REJ position of the switch attenuates frequencies below approximately 17 kHz.

Slope (the polarity of the signal to which the trigger circuit is sensitive) is determined by the SLOPE switch SW15 setting. The Level Amplifier V24 is a cathode coupled comparator which compares the voltage level set by the Triggering LEVEL control on one side with the selected input trigger on the other side. The SLOPE switch determines which section of V24 receives the trigger signal or the DC reference voltage. The trigger circuit provides a negative-going trigger output pulse when the plate of V24B swings in a positive direction. The Schmitt circuit resets when the plate of V24B swings negative and returns to quiescent state.

Both V24A and V24B share the current through cathode resistor R27 at the balanced current point. With the TRIGGERING LEVEL control centered (0 volts on the grid), the Trig Level Centering is adjusted to set the plate voltage of V24B at 100 volts with currents balanced between the two sections. The balance point is the only point where the SLOPE switch can be switched from + to - without changing the current division through the tubes.

D29, R29 and D30 limit the amplitude of signal coupled to the base of the operational amplifier Q34. When the plate of V24B is below 100 volts, D29 is conducting and holding D30 reverse biased. Current flow through D29 is approximately 2 mA. The base of Q34 is anchored at approximately 100 volts and will change very little over the range of input current.

When the plate of V24B shifts positive through 100 volts, D29 is reverse biased and D30 turns on. The 2 mA of current now flows through the base circuit of Q34 and steps the voltage on the collector of Q34 down approximately 6 volts. Thus a relatively constant signal swing is assured to the input of the Schmitt trigger circuit Q35 and Q45.

Q35 and Q45 are connected as a transistorized Schmitt multivibrator circuit. Zener diode D43 allows direct low impedance coupling to the base of Q45 while maintaining the 10 volts offset between collector and base of the two transistors.

LR45 provides countdown for the Schmitt trigger circuit. With signal from the operational amplifier Q34 on the base of Q35, the transistor switches to the off state. Current change through LR45 develops a positive voltage spike on the base of Q45 that decays at the LR time rate of LR45. This positive voltage spike is applied to the emitter of Q35 through the common emitter load resistor R46, thus preventing any input signals from turning Q35 back on. When Q35 does turn on, a generated negative voltage spike holds Q45 off for the decay time. D46 and D47 prevent reverse voltage breakdown across the base emitter junction of the transistors from dissipating the voltage spike and spoiling the countdown.

When AUTO mode is selected, the collector of Q45 charges and discharges C49 through R49. This voltage is fed back to the base of Q34 and supplies an input signal to the trigger generator. This automatically operates the circuit at an approximate 40 Hz rate. Trigger signals from the input are mixed with the automatic feedback voltage and take over to operate the Schmitt circuit in the normal manner.

Time Base A Generator

The output trigger pulses from the Time Base A trigger circuit are applied to the grid of V135A, the input of a Schmitt gating circuit acting as an electronic switch for the Time Base Generator circuit. The input negative trigger pulse switches the sweep-gating multivibrator and cuts off the disconnect diodes V152A and V152B. This starts the operation of the Miller run-up circuit, generating an output ramp for the horizontal sweep circuit.

A positive going square-wave output of the sweep gating multivibrator is taken from the cathode of V135B and connected through the cathode follower V183B to the CRT as an unblanking pulse. The positive going square-wave output is also applied through cathode follower V193A to the + GATE connector on the front panel.

The ramp voltage or sawtooth waveform from the Miller run-up circuit is applied through cathode follower V193B and made available at the front panel SWEEP A connector.

The sweep-gating multivibrator is a bistable circuit. In the quiescent state V135A is conducting. This holds the grid of V145 about 12 volts more negative than its cathode potential of approximately -50 volts. Disconnect diodes V152A and B are turned on and the current flow through R137 and R138 sets the plate potential of V145 at approximately -3 volts.

If the STABILITY and Triggering LEVEL controls are adjusted for triggered operation, a negative trigger pulse drives the grid of V135A below cutoff and switches the sweep-gating multivibrator to its other state. Diode D129 and R129 hold the plate of V135A solidly at +100 volts. This provides a sharp corner on the unblanking waveform and eliminates any overshoot on the output waveform.

When V145 turns on, its plate voltage drops to about -7.5 volts and disconnects diodes V152A and B. Any spiking that may occur during this transition is attenuated by the network C156-R156. With the disconnect diodes turned off the action of the Miller run-up circuit is initiated.

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 run-up cathode follower V173 and opposes any attempt of the grid to swing 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 the DC network formed by neon lamp B167, the run-up cathode follower and the disconnect 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 or over the linear region of its characteristic curve.

The grid of Miller tube V161 is returned to the -150-volt supply through timing resistor R160. During 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 B section of the disconnect diode. When the disconnect 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 run-up cathode follower V173 with it. The voltage at the grids of V173 is maintained at a constant difference with respect to the Miller tube plate voltage by the voltage drop across neon bulb B167. C167 and R168 form a network connected around B167 to improve the risetime.

Bootstrap capacitor C165 is connected between a tap on the Miller tube plate load and the cathode of V173. This bootstrap capacitor increases the charging rate for the stray capacitances in the Miller tube plate circuit. Its action is most important in the generation of fast sweep rates.

The cathode of V173 closely follows the action of the grids which results in a linear rise in the voltage at the output end of timing capacitor C160. Since the charge on the capacitor cannot change instantaneously, this voltage is coupled to the grid of the Miller tube and opposes the tendency of the grid to swing negative.

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 on the disconnect diodes to the point where they begin to conduct.

The positive-going voltage at the cathode of V173 is coupled back to the input of the sweep gating multivibrator, causing 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.

The holdoff circuit allows a finite time for the time base circuits to reach a steady state after the completion of a sweep.

During the trace portion of the sweep, 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 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 sets the voltage at the cathode of V183A. This is coupled through V113B to the grid of V135A and determines when V135A comes out of cutoff and starts to conduct. This is the action that initiates the retrace.

At the start of the retrace interval, C180 starts discharging through the holdoff resistor R181. The long time constant of this circuit is such that during the retrace interval and for a short period after the completion of the retrace, the charge of C180 holds the grid of V135A positive enough to prevent re-triggering. When C180 has discharged to the point at which V113B is cut off, it loses control of the grid of V135A and the grid returns to the level set by the STABILITY control. The holdoff time required is determined by the size of the timing capacitor. For this reason, the TIME/CM switch changes the time constant of the holdoff circuit simultaneously with the change of timing capacitors. In the μ SEC positions of the TIME/CM switch, R181 is shunted

by either R180A or R180B, shown on the Timing Switch diagram.

A Unblanking Circuit

In the quiescent state of the Time Base Generator the CRT beam is cut off. The voltage rise at the cathode of V135B in the Time Base Generator is used to drive cathode follower V183B. The signal on the cathode of V183B unblanks the CRT beam during the time a sawtooth is being 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.

Trigger Mode

With the Triggering MODE switch in the TRIG position, operational mode of the Time Base Generator is determined by the setting of the STABILITY control R106. With the MODE switch in the AUTO position trigger stability is switched to A PRESET ADJ, R105.

These controls, through the cathode follower action of V115, regulate the grid potential of V135A. The STABILITY control is usually adjusted so the grid of V135A is just high enough to prevent the sweep-gating multivibrator from free running. With this setting, a sweep is only initiated when the multi receives an incoming trigger pulse. Moving the STABILITY control toward ground raises the grid level of V135A. A higher amplitude trigger signal will then be required to trigger the sweep-gating multivibrator. Moving the STABILITY control arm towards -150 volts drops the grid potential of V135A to the point where the discharge of the holdoff capacitor C180 will switch the multi so it free runs.

When the STABILITY control is turned full counterclockwise to the A PRESET ADJ position, R106 is switched out of the circuit and R105 is switched in. R105 is a front panel screw-driver adjustment that presets a DC voltage for the grid of V135A. When properly adjusted, the PRESET position of the STABILITY control can be used for most triggering applications. When triggering becomes difficult, the STABILITY control R106 should be manually adjusted for optimum trigger stability.

Sweep Mode and Lockout Multivibrator Operation

With the Sweep Mode selector switch SW125 in the NORM position the lockout multivibrator operates only when the HORIZONTAL DISPLAY switch is in either of two positions, B INTEN BY A or A DLY'D. With the Sweep Mode switch in either SINGLE SWEEP or RESET positions the lockout multivibrator operates in all positions of the HORIZONTAL DISPLAY switch except the two EXT positions.

The operation of the lockout circuit is described with the circuit in SINGLE SWEEP mode, the A sweep displayed and the AUTO ERASE switch in the OFF position. The other modes are variations of this description.

1. A Single Sweep—When the HORIZONTAL DISPLAY switch is in the A position and the sweep mode selector is set to SINGLE SWEEP, plate voltage is applied to V113A, which then operates in conjunction with V115 as a bistable lockout multivibrator.

Circuit Description—Type 549

In the first stable state that exists after the completion of a sweep, V115 is cut off and V113A is conducting. In this state the divider between the plate of V115 and the grid of V113A sets the cathode voltage of the lockout multivibrator, and consequently the grid voltage of V135A. The A Lockout Level R115 is adjusted to set the grid of V135A positive enough so the sweep-gating multivibrator cannot be triggered. This locks out the sweep.

A reset positive pulse from the Auto Erase circuit is applied through the HORIZONTAL DISPLAY switch and inverted by the delayed trigger amplifier V104. The resultant negative going pulse from V104 switches the lockout multivibrator to its other state, with V113A cut off and V115 conducting. The READY neon light connected through R125 to the plate circuit of V113A will light, due to the increase of V113A plate voltage.

With V115 conducting, the STABILITY control now controls 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 fully clockwise, the grid of V135A will be pulled down, causing the sweep-gating multivibrator to switch to its other state and initiate a sweep. Or, if the STABILITY control is adjusted for triggered operation, the sweep will be initiated by the first negative trigger pulse to arrive at the grid of V135A.

As the sweep begins, the rising sawtooth voltage pulls up the cathode of V113B by the holdoff action previously described. As the cathode of the lockout multivibrator follows the cathode of V113B up, V115 cuts off and V113A conducts. As the cathodes continue to rise (following the rise in the sawtooth sweep voltage) V113A cuts off again. Both tubes are then held cut off for the remainder of the sweep and the READY lamp stays on. When the grid of V135A rises to the point at which the sweep gating multivibrator reverts, the sweep is terminated.

As holdoff capacitor C180 discharges, the cathode voltage of the lockout multivibrator starts to decrease. V113A conducts before V115 and the READY neon goes out. V115 is held below cutoff by V113A. A new sweep cannot be initiated until another reset pulse resets the circuit.

2. A DLY'D—With the HORIZONTAL DISPLAY switch in this position, the lockout multivibrator V115 and V113A operation is the same as with HORIZONTAL DISPLAY switch in the A position and the Sweep Mode switch in the SINGLE SWEEP position. The reset pulse for the circuit is now applied to the grid of V104 from the Delay Pickoff circuit. A positive pulse is applied each time the Time Base B circuit generates a sweep. Time Base A Generator will operate only during a sweep of Time Base B Generator. It will operate after a time set by the Time Base B TIME/CM AND DELAY TIME control setting, multiplied by the DELAY-TIME MULTIPLIER 1-10 dial reading. The CRT sweep is that of the Time Base A Generator.

3. B INTEN BY A—With the HORIZONTAL DISPLAY switch in the B INTEN BY A position, the operation of the lockout multivibrator is almost identical to the operation in A DLY'D position. The horizontal amplifier, however, receives the Time Base B sweep. Time Base A Generator provides only the unblanking signal to the CRT for the intensified portion of the display when the delayed action of Time Base A occurs (see Fig. 3-7).

Dual-Trace Sync Pulse and Chopped Blanking Circuitry

Synchronizing pulses for dual-trace plug-in preamplifiers are supplied by V144A. When multivibrator V145 cuts off, a sharp differentiated positive pulse is developed at its screen. This pulse coupled to the grid of V144A, produces a negative trigger at the plate of V144A. This trigger then switches the multivibrator, for alternate sweeps in the dual-trace plug-in unit.

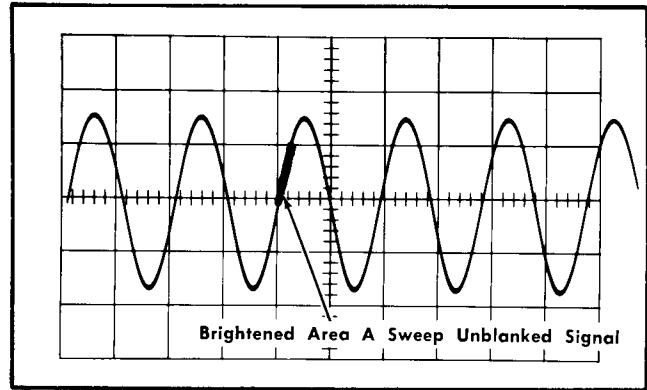


Fig. 3-7. B INT by A Operation.

When the dual-trace multivibrator is connected to free-run for chopped sweep operation, a negative pulse is coupled from the multivibrator to the grid of V144B. The resultant positive output pulse at the plate of V144B is then applied to the CRT circuit to blank the beam during switching. Refer to the dual-trace plug-in unit instruction manual for a detailed description of the switching operation.

The function of the AUTO ERASE switch is described with the circuit description for the Auto Erase Circuit.

Time Base B

Time Base B is functionally the same as the Time Base A circuitry. The trigger circuit does not contain the operational amplifier and the sweep generating circuit does not have the cathode follower for the sweep output connector. Since the fastest sweep rate is $2\mu\text{s}$ the bootstrap capacitor is not required.

Time Base B Trigger

The input trigger signal selection is identical to the Time Base A circuitry. The trigger input or level amplifier provides a negative going pulse to drive the Schmitt multivibrator.

Slope or polarity of the triggering signal is set by the SLOPE switch SW65. The level amplifier V74 is a cathode coupled comparator that compares the level of voltage set by the Triggering LEVEL control for one section with the level of the input trigger signal on the other section. The Trig Level Centering R82 is adjusted in the same manner as it was in the Time Base A Trigger circuit.

Switching diodes D78 and D79 across the cathodes of V74 switch all of the current to the on side of the amplifier to help generate a sharp negative pulse of constant amplitude to trigger the Schmitt circuit.

The Schmitt multivibrator is similar to the Schmitt circuit in Time Base A. LR84 in the collector circuit of Q85 limits the recovery time of the multivibrator and provides the countdown if the input trigger frequency becomes too high for the Schmitt circuit time constants.

D81 and D82 in series with C81, limit high frequency peaking in the plate circuit of V74B.

The trigger and automatic modes operate as follows: with the MODE switch SW85 in the TRIG position, 100 volts is connected to the junction of R95 and R93 and isolates the rest of the circuit from the collector of Q95. In the AUTO position the Schmitt trigger generator will free run at approximately 40 Hz. Assume that Q95 has turned on. Increased current demands discharge C90 and the current available from C90 through R90 to the base of Q95 will decrease and turn Q95 off. The emitter coupling of the multi in turn causes Q85 to turn on and the Schmitt multivibrator to flip to its other state. C90 will now start to charge towards +225 volts. When the charge is sufficient, Q95 turns on and the cycle repeats.

Time Base B Generator

Time Base B linearity tolerance is such that more gain is required from the Miller run-up tube than in the Time Base A circuit. The increased gain is obtained through the use of a higher-value plate load resistor for V261.

The output sawtooth voltage of Time Base B Generator is directly coupled to the HORIZONTAL DISPLAY switch. Synchronizing pulses for alternate-trace plug-in preamplifiers are supplied from the screen grid circuit of V245. As the plate current of V245 increases or decreases the screen voltage also varies across LR249. The output pulse is connected to the plug-in interconnecting plug through the HORIZONTAL DISPLAY switch only when the switch is in the B or B INTEN BY A positions.

Delay Pickoff Circuit

A sawtooth waveform from Time Base B Generator is applied to the input of a difference amplifier. This circuit compares the voltage level of the input sawtooth against a reference voltage set by the DELAY TIME MULTIPLIER 1-10 control. When the voltage level of the input sawtooth waveform reaches the set level, as determined by the setting of the DELAY TIME MULTIPLIER 1-10 control, an output signal from the difference amplifier triggers the delayed trigger multivibrator V445. The delayed trigger multivibrator then initiates the delayed trigger, which is applied through a differentiating circuit to the delayed trigger cathode follower V428B. Output from the delayed trigger cathode follower is applied to the DLY'D TRIG output connector on the front panel and to the HORIZONTAL DISPLAY switch.

Difference Amplifier: The difference amplifier provides a time selection of any rate sawtooth voltage. The time selection is based upon the position of the DELAY TIME MULTIPLIER 1-10 dial, which establishes a voltage on the grid of V424. A voltage comparison becomes a time selection because the sawtooth voltage is changing at a definite rate. Assume the sawtooth input rate of change is 15 volts per

millisecond. If the DELAY TIME MULTIPLIER 1-10 dial were set to 2.0 (2.0 is equal to 30 volts of a 150 volt ramp), the delay pickoff would generate a delayed trigger 2 milliseconds after the sawtooth started.

Constant Current Tube: To permit the difference amplifier to have a dynamic range of 150 volts grid signal, it is necessary to establish a constant cathode current. A constant cathode current also permits the output voltage to vary between the same limits regardless of which portion of the sawtooth is amplified.

V428A grid voltage is stabilized at approximately -100 volts and the cathode is long-tailed to the -150 volt supply. R428 sets the cathode current of V428A at a constant 5 milliamps. Thus, the plate can move over a wide voltage range without appreciable current change in the circuit. The plate resistance changes as the plate-to-cathode voltage changes, thus assuring a constant current cathode circuit for the difference amplifier.

Delayed Trigger Multivibrator: This multivibrator receives a DC coupled signal from the difference amplifier. V445A turns on when its grid voltage rises to the upper hysteresis point and the multivibrator flips. The output waveform from the plate of V445B is differentiated and applied to the grid of cathode follower V428B.

V428B is biased at or near cutoff; therefore, only the positive portion of the differentiated multivibrator pulse appears at the output DLY'D TRIG connector and the HORIZONTAL DISPLAY switch. Fig. 3-8 illustrates the waveform sequence of operation for a complete sawtooth input signal.

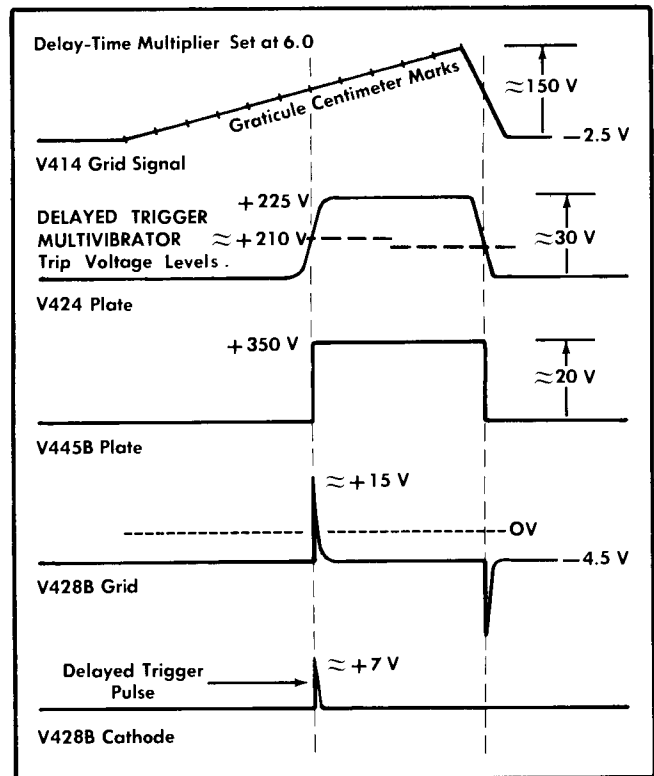


Fig. 3-8. Waveform ladder diagram of the Delay Pickoff circuit operation.

Horizontal Amplifier

The Horizontal Amplifier converts the single-ended sawtooth output of the Time Base Generators into a push-pull signal suitable for driving the horizontal deflection plates of the CRT.

The gain of the amplifier may be varied by a factor of five with the MAGNIFIER switch. Controls are also provided for horizontal positioning.

The sawtooth waveform from the Time Base Generator is coupled to the input cathode follower through a RC network. This network attenuates the input signal and provides means to compensate the input circuitry for optimum frequency response.

The HORIZONTAL POSITION and FINE controls vary the DC level on the grid of V343A. This alters the DC level on the signal path through the amplifier and changes the DC voltage applied to the CRT horizontal deflection plates which shifts the horizontal position of the trace.

Possible damage to the target area during initial turn on time is prevented by pulling the beam to the left and off the CRT screen. C335 couples a negative pulse through diode D334 and R334 to the grid of V343A when the -150 volt supply turns on which charges C340. This charge decays at an RC time rate and provides ample time for all voltages to stabilize before the beam is allowed to return to the CRT screen area.

Coupling between the input cathode follower and the driver cathode follower is made through the MAGNIFIER switch. With the MAGNIFIER switch in the OFF position, the signal from the input cathode follower is attenuated by a factor of five through the network of C348, in parallel with the series combination of R348 and R349. Variable potentiometer R348 adjusts the length of the sweep by varying the amplitude of the sawtooth applied to the grid of V343B. Variable capacitor C348 is adjusted to provide optimum linearity of the sweep. To provide magnification of the sweep, the network is removed when the MAGNIFIER switch is turned to the $\times 5$ position.

The gain of the Horizontal Amplifier is controlled by a negative-feedback circuit. A portion of the signal at the left-hand deflection plate is fed back to the input of driver cathode follower V343B. Norm/Mag Regis R358 establishes the DC voltage applied to the feedback loop.

By changing the DC voltage at this point, the starting position of the unmagnified sweep can be adjusted so it will correspond with the starting position of the magnified sweep in the center of the graticule.

The cathodes of the output amplifier tubes V364A and V384A are connected through a degenerative network which includes the Mag Gain adjustment. The Mag Gain R375, is adjusted when the MAGNIFIER switch is in the $\times 5$ position. C375 in parallel with the Mag Gain is a linearity adjustment for very fast sweep speeds.

The output signal from the paraphase amplifier (output amplifier) drives the output cathode followers. Cathode followers are used to provide the current drive for the capacitance of the horizontal deflection plates and stray circuit capacitance. To help supply the high current required at high sweep rates, V398 is connected in a cascode con-

figuration with V364B. Plate current of a pentode remains fairly constant even when the plate voltage decreases. A flat topped pulse, derived by differentiating the positive going sawtooth from the cathode of V384B through C390 and R390, is applied to the grid of V398 to boost current output during the sweep or trace period. The amplitude of this flat-topped pulse is proportional to the sweep rate; therefore, more current boost is provided as the sweep rate is increased.

Bootstrap capacitors C364 and C384 are used to help supply the charging current for the plate circuits of V364A and V384A respectively at fast sweep rates.

When the LOCATE button SW380 is depressed, power is applied to both L362 and L553 provided both OFF switches of the UPPER and LOWER SCREEN STORAGE selector switches are closed (pushed in). With power applied to L362 and L553, both reed switches SW362 and SW553 close. This decreases both the horizontal sweep and the vertical signal deflection amplitudes. SW380 also sets the intensity in the CRT circuit to a preset level.

With either of the two STORE buttons pushed in, the corresponding OFF switch is opened and L362 or L553 will not energize with the closure of the LOCATE switch. The LOCATE switch does, however, shift the DC level slightly positive on the grid of V384A. This results in a beam shift to the left of the CRT graticule area or to the locate zone. With single sweep operation, the beam can therefore be positioned vertically without affecting stored information.

Storage System

The basic operation of the storage CRT was described earlier in this section. The electrodes of the CRT and circuits peculiar to the storage feature of the Type 549 are shown in the storage circuit diagrams in the schematic section.

The storage circuits contain the following: Voltage divider and operational amplifiers which set the voltage levels of the CRT storage electrodes; erase pulse generating circuits with an optional automatic erase feature to erase written information; enhance pulse generator circuit to provide a controlled amount of enhancement to the CRT storage target; and integrate circuitry to sum writing beam current of a repetitive signal.

The operating voltage levels of the target backplates are stabilized by operational amplifiers. These provide a constant voltage source to these electrodes.

V1064A and B operates as a cathode follower operational amplifier for the upper target backplate and sets the operating level for the upper backplate. V1164A and B sets the operating level for the lower backplate.

Backplate Level adjustment R1055 establishes the operating level of the target backplate and sets the current output of the operational amplifier when the CRT is shifted to the ready-to-write state (STORED switch pushed in). Adjustment R1050 sets the DC balance of the two target backplates.

The voltage that is applied to each backplate depends on the position of the corresponding STORE switch (SW1005 and SW1105). In the conventional mode the backplate voltage is set by the Non Storage Level adjustment R1169.

When either STORE switch is pushed in, the respective backplate voltage is increased to a level determined by the setting of R1055. The CRT is now ready to write and store information.

The operating voltage for the flood gun cathodes is set by a voltage regulating circuit. This operating level is set by the FG Cath Level adjustment R1185. The potential difference between the flood gun cathode and the +300 volt supply is 175 volts. See Calibration section.

As the screen becomes increasingly written (stored), the backplate current will increase slightly but the voltage remains stable because of the operational amplifiers.

Collimation Electrodes

The operating voltage level for the collimation electrodes is established by emitter follower Q1073. This voltage is adjusted by R1070 and set to collimate (render parallel) the flood gun electron beam, to provide optimum light uniformity and maximum brightness over the storage target.

The ion repeller voltage is set for optimum operation by voltage divider R1080 and R1081.

Erase Generator

Both erase generating circuits are identical; therefore, only the upper erase circuit will be described.

Input current to the operational level amplifier V1064 is supplied from the erase generating circuit or the enhance level circuit. The erase waveform to the back plate is shown in Fig. 3-9.

This waveform is generated as follows: A negative pulse from the Auto Erase circuit or the pulse generated when either the ERASE switch SW1001, or the STORE switch SW1005 is closed, is applied to the base of Q1015.

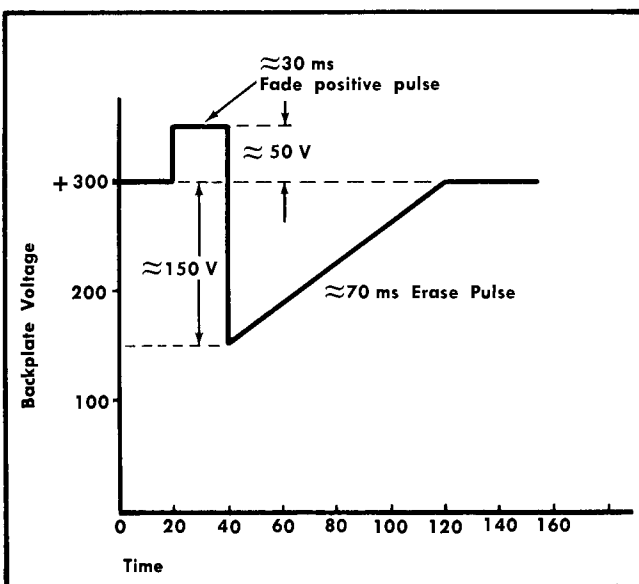


Fig. 3-9. Erase cycle waveform.

Q1015, Q1025 and associated circuitry comprise a monostable multivibrator. The output signal from this multivibrator is an approximate 30 ms negative-going pulse, with an amplitude that is limited at the junction of R1025 and R1060, by the limiting action of Q1033. The limiting level is set by the Erase Positive adjustment R1033 to the minimum amplitude required to fade up the target.

The negative-going output pulse from the erase multivibrator also charges C1028 through D1027, to an amplitude set by the limiter Q1043. At the end of the negative pulse (erase multivibrator returns to quiescent state), the charge on C1028 generates a negative going ramp across R1028, which is clamped to ground by diode D1029. The amplitude of this negative portion of the waveform is set by Erase Negative adjustment R1043. These two waveforms are added together at the junction of R1029 and R1060 and the sum current is applied to the grid of V1064A.

Remote erase function is provided through J925. A remote switch connected to pin A or B generates a negative trigger when grounded, which is applied to the erase multivibrator. Diode D1009 isolates the -12 volt trigger pulse from the internal wiring to the remote erase switch.

Enhance Circuit

The enhance circuit generates an approximate 1 ms negative-going pulse which is applied to the summing point (grid of V1064A). This conditions the target so that less writing gun current is required to write the target.

Q1135, Q1145 and associated circuitry form a monostable multivibrator. In quiescent state, Q1135 is on and Q1145 off. The negative-going portion of the input unblanking waveform triggers the enhance multivibrator. A negative output pulse is generated at the collector of Q1145. The duration or width of this pulse is set by the Enhance Width adjustment R1132.

When the ENHANCE MODE switch SW1145 is in any position other than OFF, the related backplate DC operating voltage is lowered slightly by the Enhance Target Level adjustment R1140. This provides a DC operating level for optimum enhance operation.

Integrate Switch

With the INTEGRATE TRACES button SW1196 in its normal position, the flood gun cathodes potential is set by the operational amplifier. Pressing the INTEGRATE TRACES button disconnects the flood gun cathodes from their current source and permits repetitive traces to sum their charge, so the target will shift to the written state when the INTEGRATE TRACES button is released.

The INTEGRATE TRACES button also connects a high voltage divider to +300-volt supply (in the CRT circuit) and shifts the high voltage slightly to correct for the deflection sensitivity changes that occur when the flood gun cathodes are turned off.

Auto Erase

The auto erase circuit provides a repetitive trigger pulse to the erase multivibrator. The trigger period can be varied

Circuit Description—Type 549

from approximately 0.5 to 5 seconds with the AUTO ERASE switch in the PERIODIC position. When the AUTO ERASE switch is in the AFTER SWEEP position, the trigger is generated after each sweep. A reset pulse generator is also triggered which resets Time Base A or B.

Assume that the AUTO ERASE switch SW930 is in the AFTER SWEEP position. The input unblanking signal from Time Base A or Time Base B is differentiated and clamped to ground by C901, R902 and D902. After sweep time the negative going trigger pulse triggers the Schmitt multivibrator V915A and V915B. The output signal on the plate of V915A is a positive pulse with a time duration that is dependent on the setting of the VIEWING TIME control R910.

This positive pulse is AC coupled through C921 and clamped to ground by diode D921. This provides an approximate 12 volt negative-going trigger pulse from the Schmitt multivibrator at the end of the pulse time. See Fig. 3-10. This trigger is applied through the ERASE SELECTOR switch SW929, to the erase multivibrators for the upper and lower storage circuit.

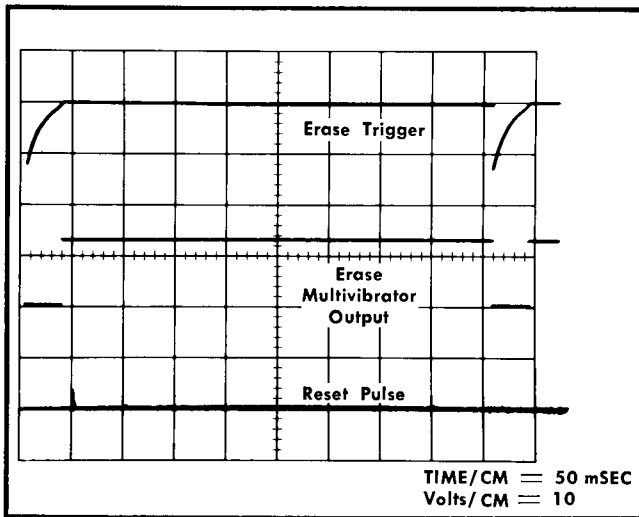


Fig. 3-10. Sequence of AUTO ERASE CIRCUIT; trigger pulse, erase multivibrator output and reset pulse.

Q935 and Q945 are part of a monostable multivibrator that generates the reset pulse for the Time Base Generators. The output auto erase signal is applied to the base of Q935 when the AUTO ERASE switch is in the AFTER SWEEP position. This negative-going erase pulse turns Q935 off and Q945 on. Feedback current through D945, D947 and R932 generates a negative gate at the junction of R932 and D932 which disconnects diode D932. Q935 returns to its quiescent (on) state and turns Q945 off, which develops a positive-going output pulse. This pulse is applied to Time Base B Generator and through the HORIZONTAL DISPLAY switch to Time Base A Generator as a reset pulse.

An erase and reset Trigger pulse is generated by closing ERASE AND RESET switch SW925, or grounding pin E of J925.

Diodes D930 and D927 isolate the generated erase trigger pulse from the wiring to the remote input connector and to

the ERASE AND RESET switch SW925. This reduces stray electromagnetic fields in the oscilloscope wiring.

When the AUTO ERASE switch is in the PERIODIC position, diodes D906 and D902 limit the differentiated input signal to approximately ± 0.5 volts and the erase multivibrator free runs at a rate that is adjustable with the VIEWING TIME control.

CRT (Writing Gun) Circuit

The CRT circuit contains the high voltage supply and the writing gun control circuits.

High Voltage

The accelerating potential applied to the writing gun beam is approximately 4 kV, developed by the -3700 volts on the cathode and $+300$ volts on the deflection and flood gun structures.

A Hartley oscillator consisting of V800, the primary of T801 and the winding and circuit capacitance oscillates at a frequency of approximately 50 kHz. The oscillator provides the energy through the transformer T801 for the high voltage rectifiers D826 and D836.

The output of one secondary winding is rectified by D826, to provide the -3700 volts for the writing gun cathode and a voltage range (dependent on the FOCUS control setting) of approximately -2850 to -3100 volts at the focus anode. The CRT 6.3 volt AC heater supply is elevated to the cathode potential through R864.

A sample of the -3700 -volt regulated supply is fed from R855 (High Voltage) to the grid of a comparator V814B, which compares the sampled portion of the -3700 -volt supply with the -150 -volt supply on its cathode. The error is DC coupled to the grid of V814A, which amplifies any error and adjusts the screen potential of the Hartley oscillator to regulate the high voltage. R855 is adjusted to set the high voltage to -3700 volts.

The output of the other secondary winding of T801 is rectified by D836. This voltage (ranging from about -3700 to about -3850 volts) is applied to the writing gun control grid. It is dependent on the INTENSITY control setting, the amplitude of the unblanking pulse or the modulation signal applied to the EXT CRT GRID connector J840.

Neon bulbs B865, B866 and B867 limit the grid-to-cathode voltage to less than 200 volts. Normally the neon bulbs are not conducting.

Intensity Control

Q824 and Q823 are part of an operational amplifier circuit that controls the CRT beam current and thus the intensity. The output voltage of the operational amplifier is set by both the INTENSITY control R818 and the Intensity Range adjustment R815.

The output voltage level of the operational amplifier is applied to one side of the secondary winding of T801. The other side of the winding is stabilized at -3700 volts by the regulator circuit. Therefore, the output voltage of the

intensity operational amplifier sets or adjusts the voltage across C826 and, through the action of the HV regulator and transformer, raises or lowers the voltage across the winding for the grid supply voltage. Thus, the CRT grid potential is indirectly controlled by the INTENSITY control circuit.

Focus and Astigmatism

The FOCUS control R860 and ASTIG control R847 operate in conjunction with each other to establish optimum focus for the writing gun beam.

Trace Rotation

TRACE ROTATION adjustment R849 sets the DC current through the beam rotation coil L859 to align the display with the screen split and to the graticule.

Geometry

Internal Geometry control R846 adjusts the isolation shield voltage in the CRT and is set to minimize bowing or tilting of the display.

When the Type 549 is used with a multi-channel vertical plug-in preamplifier that provides dual-trace chopped blanking pulses, the blanking pulses are applied through rear panel CRT CATHODE SELECTOR switch SW875. With the vertical plug-in preamplifier operating in the chopped mode and SW875 set to the CHOPPED BLANKING position, a positive pulse of approximately 20 volts amplitude is applied through C865 to the cathode of the CRT. At normal intensity levels, this pulse is sufficient to cut the CRT beam off during the time the amplifier channels in the vertical plug-in preamplifier are switched.

Two input connectors on the rear panel of the Type 549 provide means to externally modulate the CRT beam. With the CRT GRID SELECTOR switch SW840 in the EXT position, signals connected to the EXT CRT GRID connector J840 are DC coupled to the CRT grid. AC coupling to the CRT cathode is provided through J869, when the CRT CATHODE SELECTOR switch SW875 is in the NORM position. Effective cathode modulation is possible at frequencies above 20 kHz.

External Horizontal Amplifier

When HORIZONTAL DISPLAY switch SW301 is in either the EXT 1× or 10× position, an external signal can be fed through the EXT HORIZ IN connector to an auxiliary amplifier whose output is then fed to the Horizontal Amplifier.

External signals are applied to the grid of V314A directly or through a 10× attenuator. The signal applied to the grid of V314A is then cathode coupled to V314B. The amp-

lifier gain can be adjusted by varying VARIABLE 1-10 control R314, which determines the amount of cathode coupling. Cathode DC balance is set by adjusting Ext Horiz DC Bal R317. This prevents a change in the cathode DC level when the resistance of the VARIABLE 1-10 control is changed.

Signal output from V314B is connected to input cathode follower V343A in the Horizontal Amplifier when the HORIZONTAL DISPLAY switch is in either of the EXT positions.

Amplitude Calibrator

The Amplitude Calibrator in the Type 549 is a 1-kHz square-wave generator (see Amplitude Calibrator schematic) that provides both voltage and a 5-mA current output to the front panel connectors. The voltage output is taken from the CAL OUT connector on the front panel, where either a selectable-amplitude square wave, or a steady +100-volt DC reference voltage is available. By turning the AMPLITUDE CALIBRATOR switch, the amplitude of the square-wave output may be varied from 0.2 mV to 100 volts peak to peak. When the AMPLITUDE CALIBRATOR switch is in the 100 V DC or the 5 mA position, 5 mA of current is supplied to the external link. With the switch in 100 V DC position, the current is DC; with the switch in the 5 mA position, the output is a 1 kHz square wave of current. The arrow indicates conventional current.

CAUTION

The link is designed for use with a snap-on current probe and does not unplug.

The square wave generator is an astable multivibrator direct coupled to a cathode follower. V885A and V875 are the tubes of the multivibrator. The screen of V875 serves as the anode for the multivibrator section while the output is taken from the plate. Different time constants in the grid circuits of the tubes compensate for the difference in tube characteristics.

When the AMPLITUDE CALIBRATOR is turned on, the multivibrator cathodes are returned directly to the -150 volt supply through a resistor, R873. The plate load and grid resistors are grounded, therefore, the supply voltage of the multivibrator is 150 volts. The maximum positive swing of the plate of V875 is determined by the setting of the CAL AMPL control and is adjusted so that the voltage at the cathode of V885B swings from 0 to +100 volts.

The cathode load for V885B is essentially the series of precision resistors from R885 through R893. The resistance taps on the precision divider are connected through the AMPLITUDE CALIBRATOR switch to the CAL OUT connector and provides 18 voltage selections from .2 mV to 100 volts in multiples of 1, 2 and 5. The 0.2 mV to 200 mV range source impedance is 50 Ω.

SECTION 4

MAINTENANCE

Introduction

This section of the manual contains preventive and corrective maintenance information for the Type 549. The Type 549 is a stable instrument which will provide many trouble free hours of operation; however, periodic checks and calibration will assure measurement accuracy and help detect minor troubles in the instrument.

Preventive Maintenance

Preventive maintenance consists of periodic inspection, cleaning and lubrication at regular intervals. The Type 549 should be checked approximately every 500 hours of operation or every 6 months, whichever occurs first. If the instrument is subjected to adverse environmental conditions such as excessive dust, high temperature or high humidity the frequency of the checks should be increased.

Panel Removal

The side and bottom panels of the Type 549 are held in place with coin-slotted fasteners. To remove the panels, turn each fastener a quarter-turn counterclockwise. Replace the panels as indicated on the inside to insure proper air flow throughout the instrument.

Cleaning

Clean the instrument often enough to prevent accumulation of dirt. Dirt on the components acts as a thermal insulating blanket preventing efficient heat dissipation and it may provide electrical conducting paths. Dirt in the air filter chokes the flow of cooling air and may result in excessive operating temperature.

The air filter should be visually checked every few weeks and cleaned when dirty by washing it in mild detergent solution. Rinse the filter thoroughly and let dry; then coat with air filter adhesive available from air-conditioner suppliers or from Tektronix, Inc. (Part No. 006-0058-00). Let the adhesive dry thoroughly before re-installing the filter.

Clean the instrument by loosening the accumulated dust with a dry, soft paint brush. Remove the loosened dust by vacuum and/or dry low pressure compressed air. High velocity air can damage certain components and its use should be avoided. Hardened dirt or grease may be removed with a cotton-tipped swab or a soft cloth dampened with water and a mild detergent solution (such as Kelite or Spray White). Abrasive cleaners should not be used.

The high-voltage circuits including parts located under the high-voltage shield should receive special attention. Excessive dust and dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

CAUTION

Do not allow water to get inside controls or shaft bushings. Avoid the use of chemicals which may damage the plastics used in this instrument. Avoid chemicals such as benzene, toluene, xylene, acetone or similar solvents.

Lubrication

The fan motor bearings should be lubricated every four or five months with a few drops of light machine oil (see Fig. 4-1). Failure to lubricate the fan bearings properly may cause the fan to slow and eventually fail.

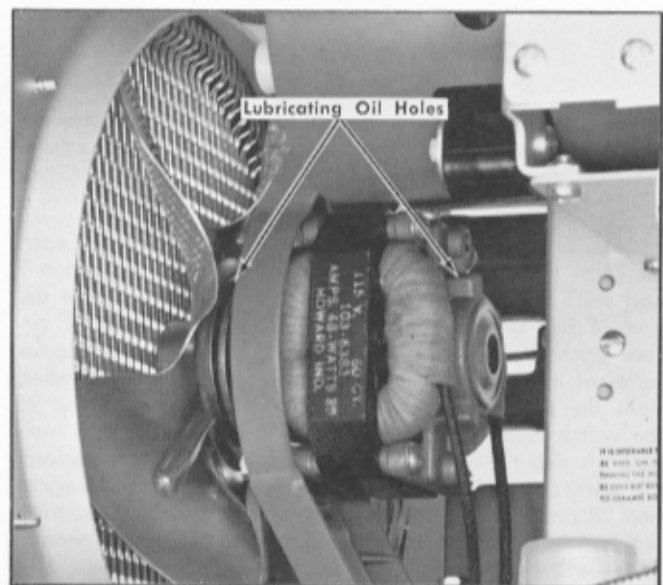


Fig. 4-1. Fan motor lubrication points.

The life of potentiometers and selector switches is lengthened if these components are kept properly lubricated. Use a cleaning type lubricant (such as Cramoline) on shaft bushings and switch contacts. Lubricate the switch detents with a heavier grease (Beacon grease No. 325 or equivalent). Do not over-lubricate. The necessary materials and instructions for proper lubrication of Tektronix instruments are contained in a component lubrication kit which may be ordered from your local Tektronix Field Office. Tektronix Part No. 003-0342-00.

After cleaning, the instrument should be carefully inspected for such defects as poor connections, damaged parts and improperly seated transistors. The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, determine the cause of overheating before the damage parts are replaced. Otherwise the damage may be repeated.

Tube and Transistor Checks

Periodic preventive maintenance checks on the tubes and transistors used in the instrument are not recommended. The circuits within the instrument generally provide the most satisfactory means of checking tube or transistor usability. Performance of the circuits is thoroughly checked during recalibration so that substandard tubes and transistors will usually be detected at that time.

Recalibration

To insure accurate measurements, the instrument calibration should be checked after each 500 hours of operation or every six months if used intermittently.

The calibration procedure can be helpful in isolating major troubles in the instrument. Moreover, minor troubles not apparent during regular operation may be revealed and corrected during calibration.

CORRECTIVE MAINTENANCE

Corrective maintenance consists of component replacement and instrument repair. Special techniques or procedures required to replace components in this instrument are described here.

Component Identification. The circuit number of each electrical part is shown on the circuit diagrams in Section 9 and on the pictorial diagrams of the circuit boards at the end of this section. Note that a functional group of circuits (such as the vertical amplifier) is assigned a particular series of numbers. Switch wafers are identified by counting from the first wafer located behind the detent section of the switch towards the last wafer. The letters F and R indicate whether the front or rear of the wafer is used to perform the particular switching function. For example, the designation 2R printed by a switch section on a schematic identifies the switch section as being on the rear side of the second wafer when counting back from the detent section.

Parts Replacement. Most of the electronic components in the Type 549 are standard items available locally. The remainder of the electronic components and most of the mechanical parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured for Tektronix to our specifications. However, all parts are obtainable through your Tektronix Field Office or Engineer. Before purchasing or ordering, consult the Parts List (Section 7 and 8) to determine the value, tolerance, and rating required. See "Parts Ordering Information" and "Special Notes and Symbols" on the first page of Section 7.

NOTE

When selecting the replacement parts, it is important to remember that the physical size and shape of a component may affect its performance in the circuit. Parts orientation and lead dress should duplicate those of the original part, since many of the components are mounted in a particular way to reduce or control stray capacitance and inductance. After repair, portions of the instrument may require recalibration.

Replacing Components on Etched Circuit Boards

It is best to remove the board from the instrument unless the back of the board is accessible. Use electronic grade 60/40 solder and a 15 watt pencil soldering iron with a $\frac{1}{16}$ inch wide chisel tip. The tip of the iron should be clean and properly tinned for best heat transfer in a short time to a soldered connection. A higher wattage soldering iron, if applied for too long a period, ruins the bond between the etched wiring and the base material by charring the glass epoxy laminate.

The following technique is recommended to replace a component on an etched circuit board.

1. Remove the component by cutting the leads near the body. This frees the leads for individual unsoldering.

2. Grip the lead with needle-nose pliers. Apply the tip of the soldering iron to the connection at the back of the board, then pull gently to remove the lead.

3. When the lead comes out of the board it should leave a clean hole; if not, the hole should be cleaned by reheating the solder and placing a sharp object such as a toothpick or enameled wire into the hole to clean out the old solder.

4. Clean the leads on the new component and bend them to the correct shape to fit into the holes. Insert the leads, making certain the component seats exactly the same as the original. If it does not, reheat the connection and gently press the component into place.

5. Apply the iron to the connection at the back of the board and apply only the amount of solder required to form a good electrical connection.

6. Check the front, or component side of the board to insure that the solder has wicked through the plated hole. In some instances the component may require soldering to an etched lead on the top of the board. If this is required, apply the tip of the iron to the connection and apply the required amount of solder to form a good electrical connection.

NOTE

Some components can be damaged by heat. If this is the case, connect a heat sink such as a pair of needle-nose pliers between the component and the connection before applying the soldering iron.

7. Clip the excess lead that protrudes through the hole in the board.

8. If necessary clean the area around the soldered connection with a flux-remover solvent to maintain good environmental characteristics.

Soldering Metal Terminals

When soldering metal terminals (e.g. switch terminals, potentiometers, etc.) ordinary 60/40 solder is satisfactory. The soldering iron should have a 40 to 75 watt rating with a narrow ($\frac{1}{8}$ inch wide) chisel tip.

1. Apply only enough heat to make the solder flow freely and only enough solder to form a good electrical connection. (Excess solder may impair the operation of the circuit or cover a cold joint.)

2. Clip off excess wire that may extend past the solder connection and clean with flux-remover solvent.

Ceramic Strip Soldering

Many of the components in your Tektronix instrument are mounted on ceramic terminal strips. The notches in these stripes are lined with a silver alloy. Application of excessive heat or repeated use of ordinary 60/40 tin-lead solder will break the silver-to-ceramic bond. Occasional use of ordinary solder is permissible, but for general repair work on Tektronix instruments solder containing about 3% silver should be used. Silver-bearing solder is available locally from electronics distributors or may be purchased in 1-pound rolls through your Tektronix Field Office. Order by Tektronix part number 251-0514-00.

When removing or installing a part mounted on ceramic terminal strips:

1. Use a 50 to 75-watt soldering iron with a thin wedge-shaped tip.

2. Tin the tip of the iron with silver-bearing solder.

3. Apply heat by touching one corner of the soldering iron tip to the base of the notch. See Fig. 4-2. Do not force the tip of the iron into terminal notch, as this may chip or break the ceramic strip.

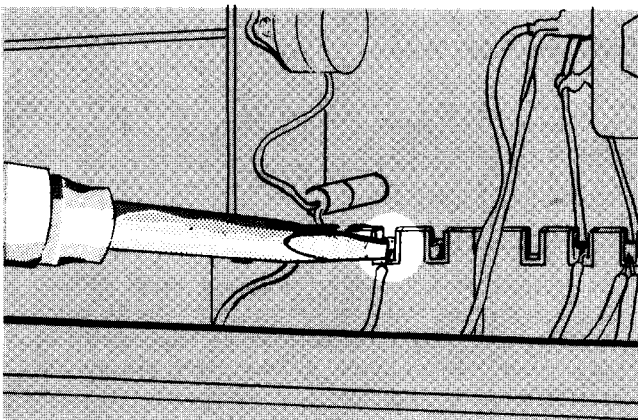


Fig. 4-2. Correct application of soldering iron when soldering to a ceramic terminal strip.

4. Use the minimum amount of heat required to make the solder flow freely.

5. Apply only enough solder to form a good bond. Do not attempt to fill the notch with solder.

Other Soldering Considerations

When soldering to a rotary switch, do not let the solder flow around and beyond the rivet on the switch terminal.

The spring tension of the switch contact may be destroyed by excess solder and the switch will need to be replaced.

When soldering or unsoldering any short-lead small component, observe the following precautions:

1. Use long-nosed pliers to act as a heat shunt between the soldering point and the component. See Fig. 4-3.

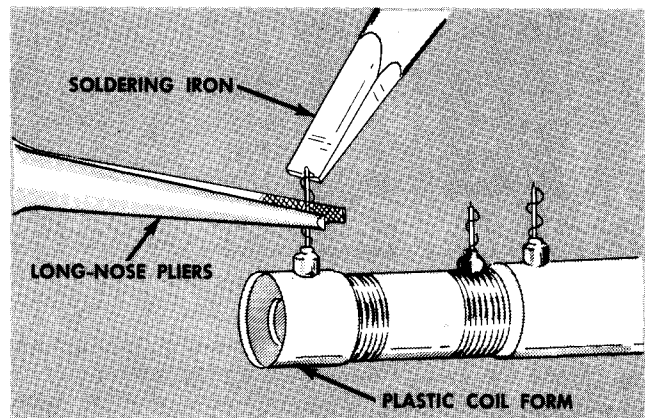


Fig. 4-3. Heat sink application when soldering to small or short lead components.

2. Use a moderately hot iron for a short period of time.

3. Manipulate your tools with care to avoid damage to small components.

If it is necessary to hold a bare wire in place while soldering, a handy tool for this purpose can be made by tapering a $\frac{1}{4}$ -inch wooden dowel or thermostat plastic rod into a wedge shape at one end.

After soldering any connection, clip off the excess length of the soldered leads. Be sure that these ends are not dropped into the instrument where they could cause electrical shorting.

Ceramic Strip Replacement

To replace a damaged ceramic terminal strip, first unsolder all connections, then pry the mounting studs out of the chassis. The strips may also be removed by tapping the studs out from the reverse side of the chassis or by cutting off one side of each stud with diagonal cutters.

If the nylon spacers do not come out with the studs, they may be left in the chassis or pulled out separately. If undamaged, the spacers can be used with the new ceramic strip assembly. Since mounting studs are attached to replacement ceramic strips, it is not necessary to salvage the old studs.

When the damaged strip assembly has been removed, place the spacers into the mounting holes in the chassis and press the mounting studs of the new assembly into the spacers. It may be necessary to tap lightly to make the studs seat all the way down on the spacers. To avoid damage to the terminal strip, use a soft-tipped tool for tapping and apply the force directly above the mounting studs. Fig. 4-4 shows the assembled terminal strip.

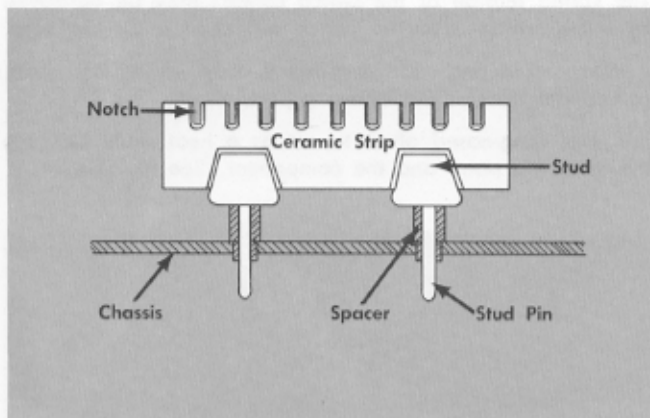


Fig. 4-4. The assembled ceramic terminal strip.

Cut off the excess length of the mounting studs extending beyond the ends of the spacers on the reverse side of the chassis. Resolder all components and wires in place (see Ceramic Strip Soldering suggestion given above.)

Power Transformer Replacement

If a complete check of the instrument shows that the power transformer requires replacement, notify your local Tektronix Field Office. The Tektronix Field Engineer will verify the transformer failure for a warranty replacement. (See the warranty note in the front of this manual.)

Be sure to use only the correct replacement for a power transformer. Tag the leads with the terminal numbers as they are unsoldered from the transformer to aid in connecting the new transformer. After replacing the power transformer, check the power supply (to ground) resistance given in Table 4-1, then check the calibration of the entire instrument.

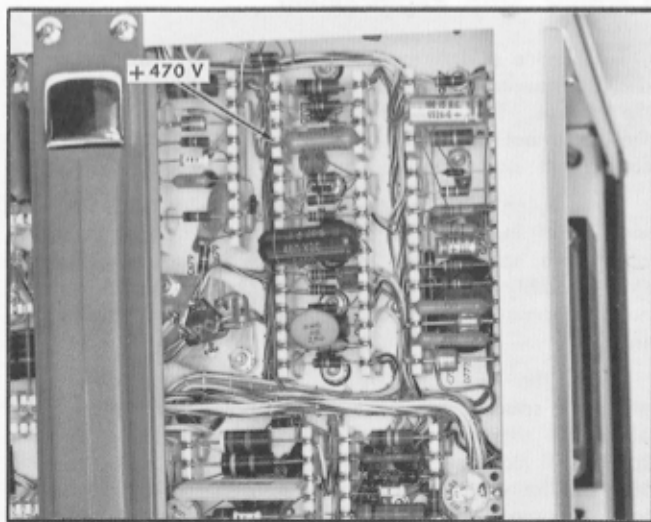


Fig. 4-5. +470-volt unregulated supply check point.

Replacement of Rotary Switches

When a rotary switch is removed, tag the leads and the switch contacts with corresponding identification tags, then use the old switch as a model for wiring the new one. The entire switch should be replaced if one section is defective. Order the switch either with or without associated components wired in place. The appropriate part numbers are given in the Parts List.

TABLE 4-1

Power Supply Resistance Checks
(Power line disconnected, plug-in units removed)

Supply	Approximate Resistance
Primary T601 (P601 to ground)	Infinite
-150 volt	*2.5 k Ω to 8 k Ω
-12.4	*5 Ω to 10 Ω
+100	2.5 k Ω to 10 k Ω
+225	3 k Ω to 10 k Ω
+300	6 k Ω to 15 k Ω
+350	1.5 k Ω to 5 k Ω
+500	20 k Ω to 50 k Ω
+470 unregulated (see Fig. 4-5)	7 k Ω to 10 k Ω

*Positive lead connected to ground.

Cathode Ray Tube

To remove and replace the cathode-ray tube, use the following procedure.

CAUTION

Be careful when handling the CRT. Avoid striking it on any object that may cause the tube to crack and implode. Flying glass from an imploding CRT can cause serious injury. Use safety glasses for protection.

1. Remove CRT bezel nuts, bezel and plastic graticule.
2. Disconnect both upper and lower, left and right deflection pin connectors. Pull connector straight off.
3. Disconnect CRT base socket by gently pulling the plastic handle straight back.
4. Loosen the CRT base clamp with a $\frac{7}{64}$ allen wrench. See Fig. 4-6.
5. Grasp the face of the CRT with the right hand. Push the CRT carefully toward the front of the Type 549 with the left hand. Be careful not to bend the neck pins or the deflection plate pins. Remove the CRT through the front of the oscilloscope.



Fig. 4-6. Location of CRT base clamp and positioning cams.

6. Carefully insert the new tube into the shield and the tube base clamp. The tube should be oriented so the deflection plate pins are correctly positioned and the wall bands are aligned with the metal contact fingers in the tube shield.

7. Reconnect the CRT socket to the tube base and the deflection plate leads to the vertical and horizontal deflection plate pins (observe color code).

NOTE

If the CRT face is not aligned with the front of the instrument, use an allen wrench to loosen the two mounting screws that fasten the base clamp to the mounting bracket (see Fig. 4-6). Move the base clamp and CRT radially to align the face of the CRT with the front panel of the instrument. (A straight edge across the front of the face plate will provide an alignment reference.)

8. Install the CRT graticule and align the storage screen split to the center line of the graticule by rotating the CRT and adjusting the vertical position of the graticule by rotating the nylon cam (see Fig. 4-7).

9. Tighten the CRT base clamp.

10. Install the bezel.

11. Turn on the oscilloscope power and obtain a free running trace on the CRT.

12. Recalibrate all circuits except the low voltage power supplies. See Calibration section.

NOTE

If the wall bands on the CRT are not making electrical contact with the contact fingers, the tube may fade positive or not store. If this condition occurs, try reseating the CRT.

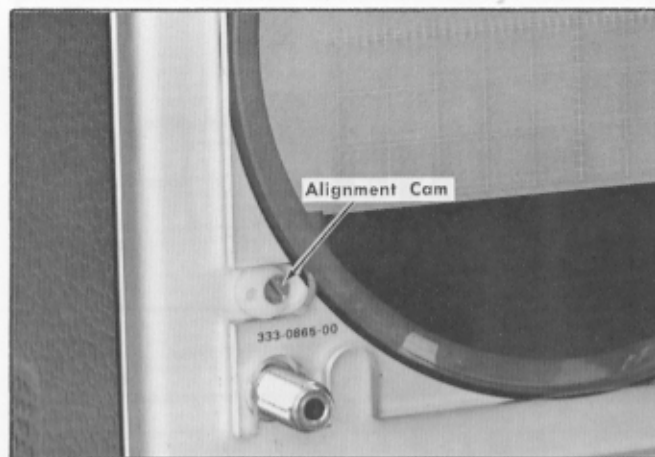


Fig. 4-7. CRT graticule alignment.

Tubes and Transistors

Tubes and transistors should not be replaced unless actually defective. Temporary substitution however, is an effective way to detect defective tubes or transistors. Before making substitutions the circuit conditions should be checked to be certain that a replacement tube or transistor will not be damaged. In some cases, these checks will also show if the tube or transistor is at fault.

When circuit conditions have been checked, install a tube or transistor which is good and of the same type, check for proper operation. If the original tube or transistor is thus proved satisfactory, return it to its original socket to avoid unnecessary recalibration.

Troubleshooting Aids

This manual and the instrument contain many features intended to speed and simplify maintenance. A block diagram which provides an overall picture of the instrument operation is included with the schematic diagrams. The schematic diagrams give the circuit reference number of each electrical component as well as important operating voltages, signals and conditions for the measurements.

The instrument contains a number of stable metal-film resistors identified by their gray background color and color coding. If a resistor has three significant figures and a multiplier, it will be EIA color coded. If it has four significant figures and a multiplier, the value will be printed on the resistor. For example, a 333 k resistor will be color coded, but a 333.5 k resistor will have its value printed on the resistor body. The color coding sequence is shown in Fig. 4-8.

Fig. 4-9 identifies the polarity of the various diode types used in Tektronix instruments.

In-circuit diode checks may be performed with a voltmeter. A comparison check of the voltages on each side of the diode with the typical voltages listed on the diagram will help determine if the diode is faulty. Forward to back resistance ratios can be checked by referring to the sche-

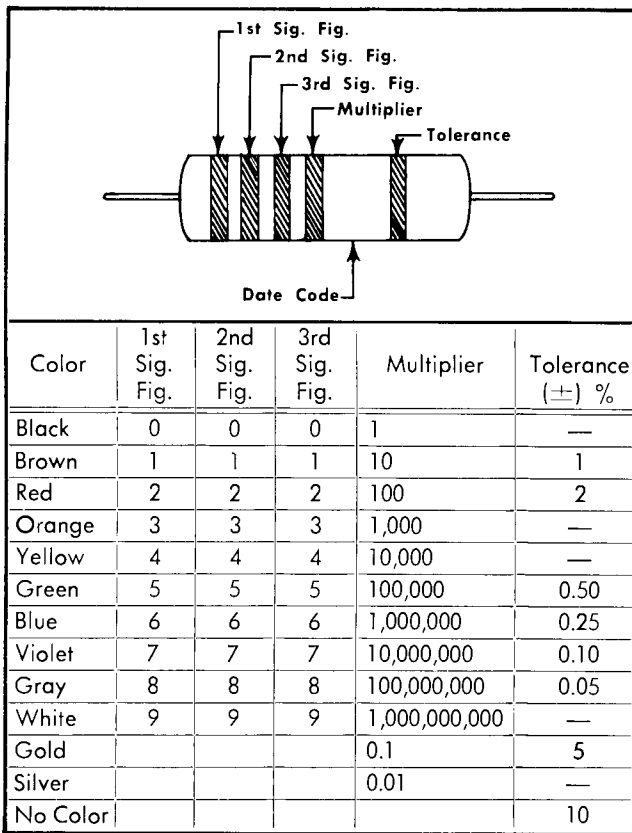


Fig. 4-8. Standard EIA color code for metal-film resistors.

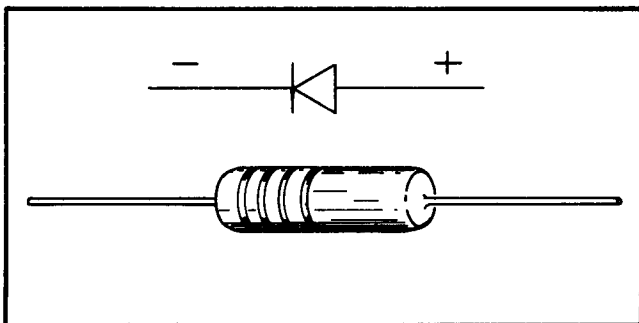


Fig. 4-9. Diode polarities and color code of glass diodes used in Type 549.

matic and pulling appropriate tubes or transistors to remove low resistance loops around the diode.

General Troubleshooting

Attempt to isolate the trouble to a circuit by an operational and visual check. Verify that the apparent trouble is actually a malfunction within the Type 549 and not improper control settings or a malfunction of associated equipment.

Operate the front-panel controls and note what effect they have on the trouble symptoms. Normal or abnormal operation of each control helps to establish the nature of the trouble. Refer to the Operating Instructions for the normal function of each control.

If the trouble cannot be isolated by front-panel checks, remove the side panel from the Type 549 oscilloscope.

Troubles may occur due to a failure in one of the low voltage power supplies. Circuitry in the Type 549 is such that an incorrect voltage may affect some circuits more than others. Power supply trouble could be the source of virtually any type of failure within the instrument. Check the regulated output and ripple of any suspected supply before proceeding with more detailed troubleshooting procedure. If the voltage and ripple of the regulator supply are correct, that supply can be assumed to be operating correctly.

Check circuit voltages and waveforms with those shown on the schematic in Section 9. Use an accurate 20,000 ohm/volt, DC voltmeter to measure these voltages and a recommended oscilloscope to check the waveforms. Test points are labeled and accessible on the circuit board assembly and throughout the instrument.

NOTE

Use extreme care when measuring voltages and checking waveforms. The small size and high density of components used in this instrument establishes a situation such that an inadvertent movement of the test probe or the use of oversized probes may short circuit between components. Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments.

Table 4-2 relates certain specific trouble symptoms to their probable causes, and indicates some of the components that might be defective. This table should be used primarily as a guide for troubleshooting, since it does not include all possible troubles that might occur, nor all possible causes for the given symptoms. The schematic diagram, used in conjunction with the circuit description, will suggest other checks that can be made.

Circuit Troubleshooting

When the trouble has been isolated to one circuit, perform a complete visual check of that circuit. Look for broken connections, improperly seated components, stray foreign matter, etc. Check tubes and transistors that are used in the circuit by direct replacement with known good ones. Be certain to return any tubes or transistors found to be good to their original sockets.

Refer to the Circuit Description in Section 3 for a description of the normal circuit operation. Check the components in the circuit (i.e. tolerance of resistor values, faulty capacitors etc.).

Repair and Readjust the Circuit

Refer to the replacement procedures and suggestions given under "Corrective Maintenance" (earlier in this section) when repairing any trouble found in the instrument. Be sure to check the calibration of any circuit that has been repaired or has had tubes or transistors replaced.

TABLE 4-2
Troubleshooting

CRT Writing Gun Circuit	
Symptoms	Checks
1. Abnormal operation of writing gun circuit.	<p>Preliminary: Set SCREEN STORAGE switches to OFF, to protect the storage target.</p> <p>a. Check line voltage and low voltage supplies. See Calibration procedure.</p> <p>b. Check B865, B866 and B867. If glowing brightly, D826 or D836 may be defective. Check CRT cathode and grid voltages. See schematic diagram. Check high voltage filter capacitors C837, C838, C842, C826.</p> <p>c. Check High Voltage adjustment R855. See Calibration procedure.</p> <p>d. Check V800 and V814 for heater glow and then by substitution. Install new tubes and recalibrate high voltage if new tubes correct trouble.</p> <p>e. If trouble still exists, check for additional symptoms as in following checks.</p>
2. No intensity.	<p>a. Check INTENSITY control setting.</p> <p>b. Make certain spot or trace is not positioned off screen area by the POSITION controls. Push LOCATE button. Spot should appear on screen.</p> <p>c. Check unblanking circuit. (Blanking voltage is applied except during sweep time.)</p>
3. Low or high intensity.	<p>a. Check INTENSITY control setting.</p> <p>b. Check setting of Intensity Range adjustment R815.</p> <p>c. Check and insure CRT GRID SELECTOR switch is in the NORM position.</p> <p>d. Check by direct replacement Q824 and Q823.</p> <p>e. Perform checks 1a through 1d.</p> <p>f. With power off, check high voltage divider R854 through R861.</p>

Symptoms	Checks
4. Poor astigmatism and/or focus.	<p>a. Check ASTIG and FOCUS control settings.</p> <p>b. Perform checks 1a and 1c.</p> <p>c. Check voltage at pin 8 of CRT. Should change from +350 to +225 volts as ASTIG control is rotated.</p> <p>d. Check voltage at center arm of FOCUS control should change approximately 150 volts above and below approximately 3000 volts.</p>
5. Blooming (increase in display size and intensity).	<p>a. Check high voltage.</p>

Storage Circuit

6. Any incorrect operation of storage functions.	<p>Preliminary: Set STORAGE switches to STORE to establish operating voltages. Turn ENHANCE MODE to OFF.</p> <p>a. Check CRT seating and position. Wall bands may not be making contact with spring contact fingers. Remove CRT bezel and graticule, then wiggle the CRT within the tube shield.</p> <p>b. Check upper and lower storage level voltages. (See calibration procedure.)</p> <p>c. Check low voltage supplies.</p> <p>d. Check voltage with those shown on the storage system schematic diagram.</p> <p>e. Check for additional symptoms as given in the following steps.</p>
7. Flood guns inoperative.	<p>a. Check flood gun heater for continuity, with power off and base disconnected.</p> <p>b. Check flood gun voltage. (Pin 6 to ground.)</p> <p>c. Perform checks 6b, 6d.</p> <p>d. Check by direct replacement Q1194 and Q1193.</p>
8. Screen will not store.	<p>a. Perform checks 6a through 6d.</p>
9. Screen does not store single sweep displays.	<p>a. Check INTENSITY and MODE control settings (see Operating Instructions).</p> <p>b. Check sweep speed to insure speed does not exceed writing speed of CRT.</p> <p>c. Storage screen may have deteriorated. Install new CRT.</p>
10. Screen does not erase.	<p>a. Perform check 6a.</p> <p>b. Check for erase pulse on the target upper or lower test point.</p>

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Symptoms	Checks
	c. Check operation and voltages for erase generator circuit.
11. Image can not be completely erased.	a. See CRT operating precautions given in the Operation Section. Care of Storage Screens. b. Check Erase Positive and Erase Negative adjustments. See Calibration procedure.
12. Screen has poor contrast.	a. Perform checks 6b and 6d. b. Check setting of ENHANCE MODE LEVEL control. c. Recheck Calibration procedure to set operating level.
13. Background brightens after storage.	a. Perform check 6b. b. Turn ENHANCE MODE control to OFF. c. Check Collimation electrode adjustment.
14. INTEGRATE in-operative.	a. Check voltage at junction of R1196 and SW1196. Should be approximately +150 volts normally, and increase when the INTEGRATE button is depressed.
15. Enhance mode in-operative.	a. Perform checks 6b and 6d. b. Check for negative trigger pulse approximately 8 volts in amplitude and 1 μ s wide at pin AB of etched circuit board with Q1135 and Q1145 removed from socket. (Sweep should be free-

Symptoms	Checks
	running at 1 μ SEC/CM). c. Check operation of Q1135 and Q1145 by direct replacement. Reset Enhance width adjustment (see Calibration procedure) if the transistors are replaced.
16. Erase Program in-operative.	a. Perform step 10 and check 6c. b. Check voltages and waveforms with those shown on schematic diagrams. c. With sweep free-running at 1 μ SEC/CM, check for an unblanking pulse at pin AD of circuit board assembly. d. With sweep free-running check for negative trigger pulses approximately 8 volts in amplitude at the junction of R902 and D902. e. Check Auto Erase multivibrator operation by observing waveform with test oscilloscope at pin E of circuit board assembly.
17. Will not cycle with the AUTO ERASE switch in AFTER SWEEP position.	a. Check for reset pulse with test oscilloscope at pin X of circuit board assembly when the ERASE AND RESET button is depressed. b. Check operation of Q935 and Q945 by direct replacement. c. Perform check 6c. d. Check voltages against those shown on the Auto Erase circuit diagram.

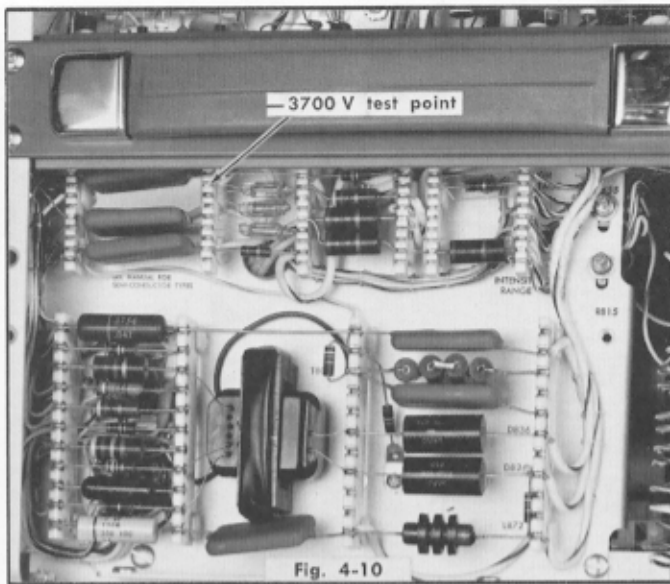


Fig. 4-10

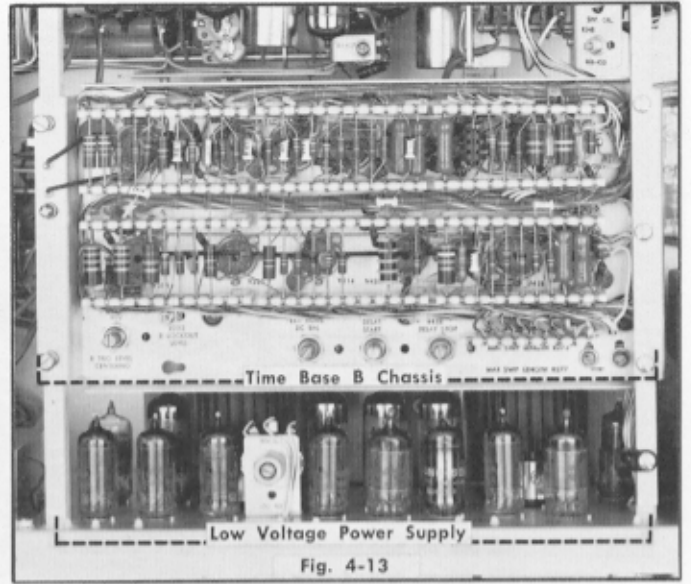


Fig. 4-13

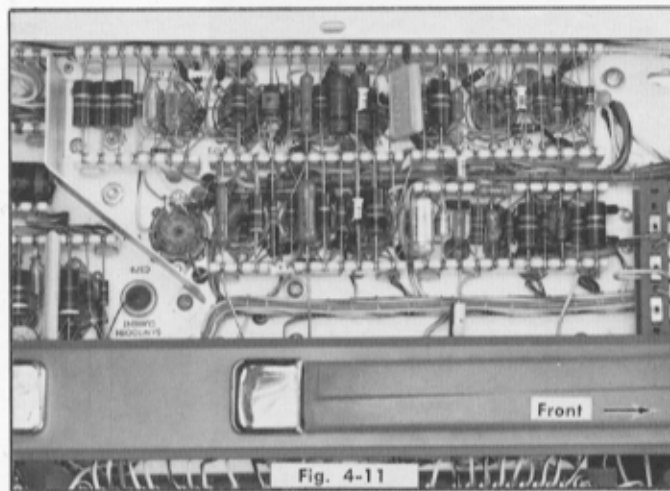


Fig. 4-11

Fig. 4-10. High Voltage Chassis.

Fig. 4-11. Time Base A Chassis.

Fig. 4-12. Horizontal sweep, -12.2 Volt, +300-Volt Supply, Intensity control circuit and Storage Operating Level Amplifier.

Fig. 4-13. Time Base B, Delay Pickoff and Low Voltage Power Supply Chassis.

Fig. 4-14. Vertical Amplifier Chassis.

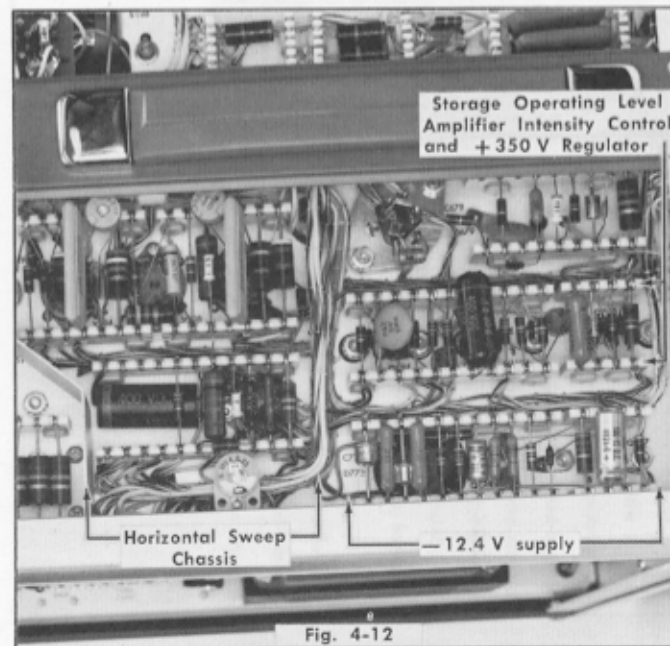


Fig. 4-12

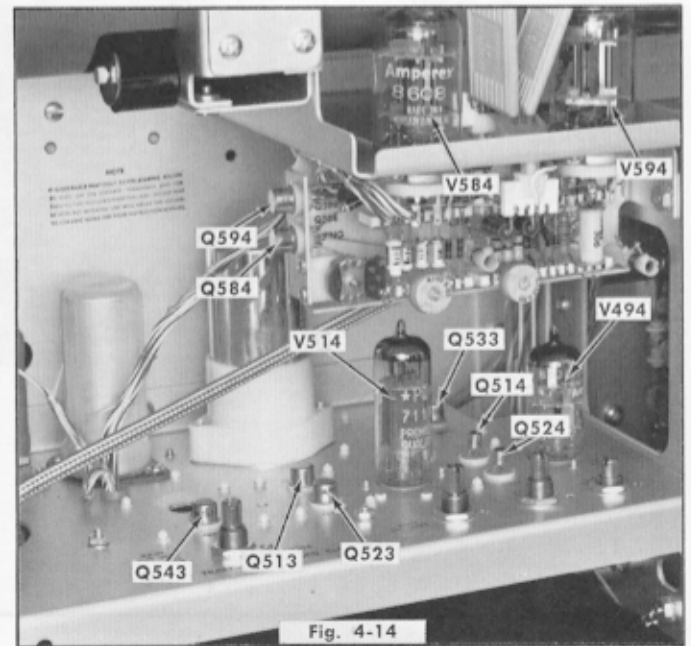


Fig. 4-14

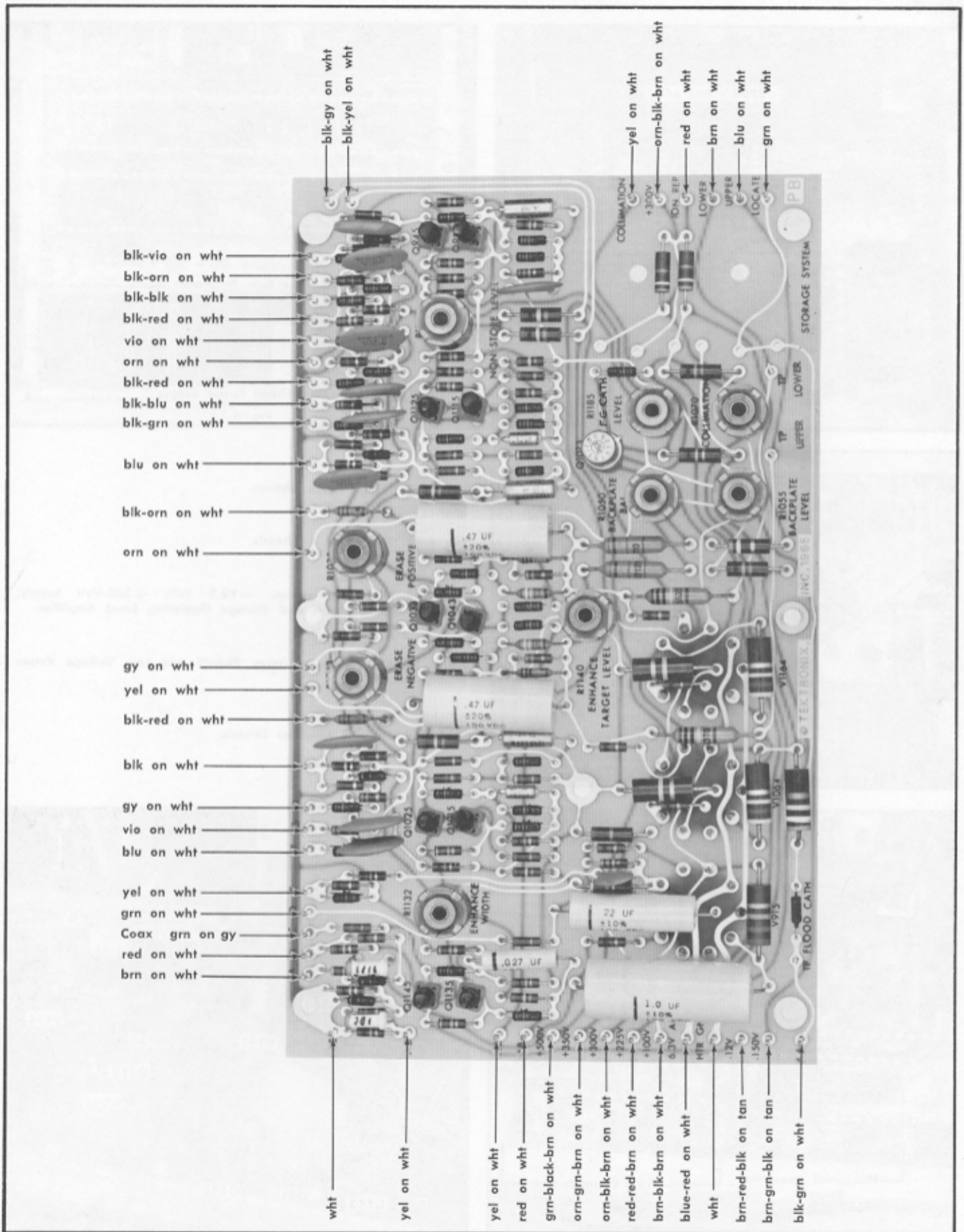


Fig. 4-15. Storage Circuit Board Assembly.

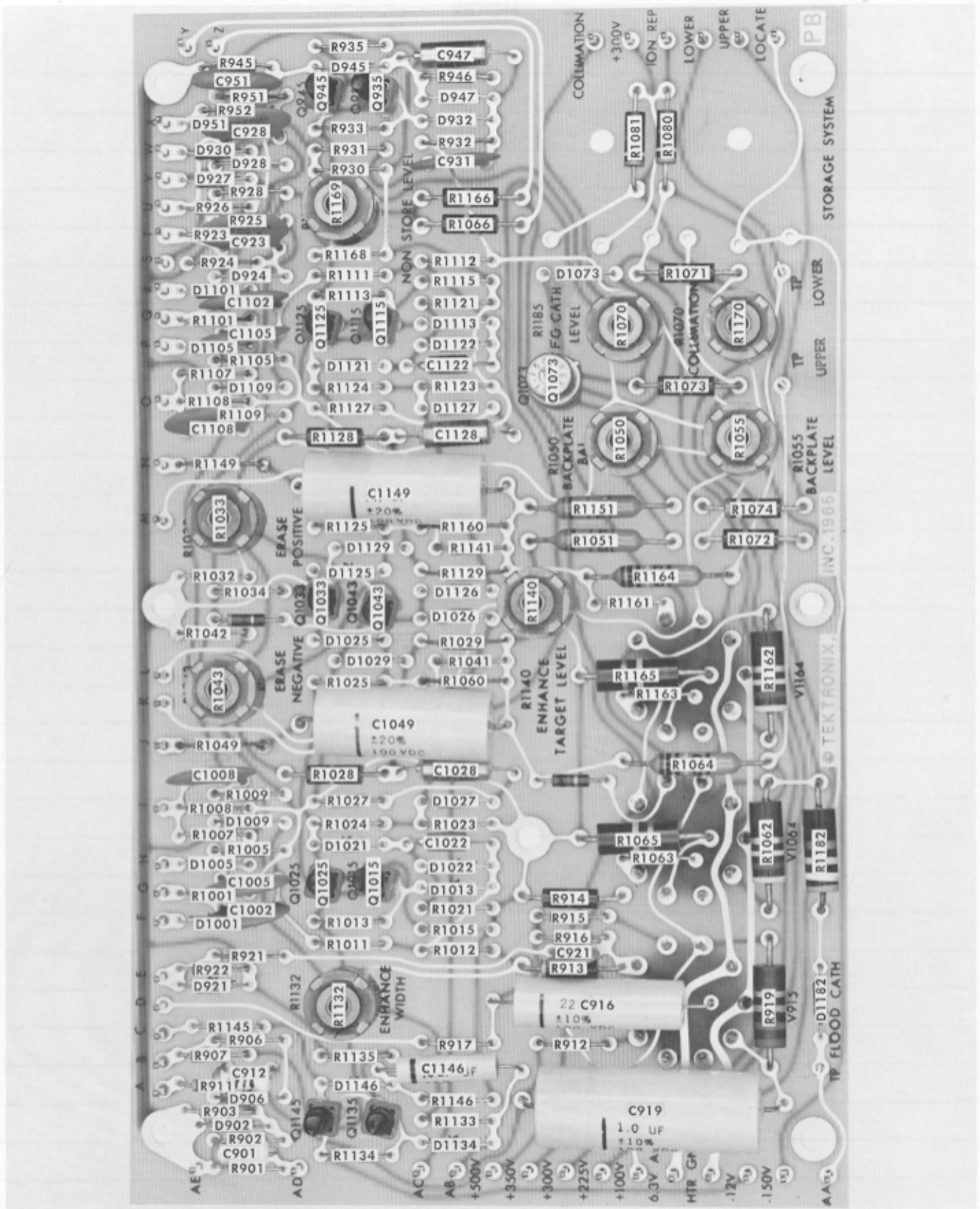


Fig. 4-16. Storage circuit board assembly with component call out.

SECTION 5

PERFORMANCE CHECK

Introduction

This performance check procedure is provided to check the operation of the Type 549 without removing the side panels. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Test oscilloscope: Risetime 20 ns or less, minimum deflection factor .05 volts/cm. Tektronix 540-series with a Type K Plug-In Unit or equivalent.

2. 10× attenuator probe: Tektronix P6006, or equivalent.

3. High gain DC Differential Amplifier plug-in unit: Sensitivity 1 mV/cm to 50 V/cm, frequency response DC to 300 kHz. Tektronix Type D unit or equivalent.

4. Test Load/Pulsar Plug-In Unit. Tektronix calibration fixture 067-0521-00.

5. Tektronix 1-series plug-in amplifier unit: Sensitivity 50 mV/cm or higher. Tektronix Type 1A1, 1A2 or equivalent.

6. Current probe: Sensitivity of 1 mA/cm. Tektronix P6019 Current Probe with a Type 134 Amplifier, Part No. 015-0067-00.

7. Time-Mark Generator: Marker Outputs 5 s to .1 μs, sine-wave output of 50 MHz (20 ns), accuracy 0.001%. Tektronix Type 184 Time-Mark Generator.

8. Standard Amplitude Calibrator: Amplitude accuracy within 0.25%, signal amplitude range 100 mV to 100 volts, frequency output 1 kHz, —DC and +DC with mixed display feature. Tektronix calibration fixture 067-0502-00.

9. Constant Amplitude Signal Generator: Frequency range 50 kHz to above 30 MHz. Tektronix Type 191 Constant Amplitude Signal Generator.

10. Termination, 50 ohm with BNC connectors. Tektronix Part No. 011-0049-00.

11. Three 50 ohm coaxial cables: Length 42 inches, with BNC connectors. Tektronix Part No. 012-0057-00.

12. T connector: BNC. Tektronix Part No. 013-0030-00.

13. Adapter GR to BNC female. Tektronix Part No. 017-0063-00.

14. Viewing Hood: Rectangular viewer. Tektronix Part No. 016-0039-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure uses the equipment listed under Recommended Equipment. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary Procedure

1. Install test plug-in load/pulsar unit in the vertical compartment of the Type 549, then connect the Type 549 to a power supply source within the regulating range of its power supplies.

2. Set the front panel controls as follows:

Type 549

CRT controls

INTENSITY	Counterclockwise
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
DELAY TIME MULTIPLIER	1.00
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC
LENGTH	Clockwise

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TRIGGERING controls (both A and B)	
LEVEL	Clockwise
STABILITY	Clockwise
Lever Controls	All in up position
HORIZONTAL POSITION	Midrange
FINE	Midrange
AMPLITUDE CALIBRATOR	OFF
Rear-panel switches	
CRT CATHODE SELECTOR	NORMAL
CRT GRID SELECTOR	NORMAL
LINE RANGE	MED
CRT CATHODE CONNECTOR	CAP installed

Test Load-Pulsar Unit

Test Function	Low Load
Variable	Counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

3. Set the POWER switch to ON. The pilot light should light and the delay relay for the power supply should operate with an audible click within a period of 15 seconds to 1 minute. Allow a minimum 20 minute warm-up period at an ambient temperature of $+25^{\circ}\text{C}$, $\pm 5^{\circ}\text{C}$ for stabilizing before checking the instrument to the given accuracy.

1. Check Graticule Scale Illumination

a. Requirement—Graticule scale illumination must vary smoothly from maximum to no illumination as the SCALE ILLUM control is rotated through its range.

b. Rotate the SCALE ILLUM control clockwise and counterclockwise.

c. Check—Maximum brightness with the control fully clockwise and no illumination with the control fully counterclockwise with smooth operation between extremes.

2. Check Intensity Range

a. Requirement—Spot just visible at maximum intensity when sweep is inoperative.

b. Set the INTENSITY control for a visible trace.

c. Position the start of the trace at the left edge of the graticule with the HORIZONTAL POSITION control.

d. Set the NORM-SINGLE SWEEP switch to SINGLE SWEEP.

e. Turn the INTENSITY control fully clockwise.

f. Check—Spot is just visible at the start of the graticule area.

3. Check Trace Rotation

a. Requirement—Trace parallel to horizontal graticule lines.

- b. Change the following control settings:
- | | |
|-------------------|--------------------|
| NORM-SINGLE SWEEP | NORM |
| INTENSITY | Nominal brightness |
- c. Position the trace to the horizontal centerline with the Test Load/Pulsar Vertical Position control.
- d. Check—Trace parallel to the horizontal graticule line.
- e. If necessary, adjust the TRACE ROTATION adjustment to align the trace to the horizontal graticule line.

4. Check Operation of LOCATE Button

a. Requirement—With the LOCATE button depressed and the Type 549 set for conventional operation, the sweep must compress and remain within the graticule area at extreme settings of the Vertical and HORIZONTAL POSITION controls. With the Type 549 in STORE mode and SINGLE SWEEP operation the beam must unblank and appear in the locate zone of the graticule area, provided the start of the trace has been positioned on the extreme left graticule line. Beam intensity must increase to a preset level.

b. Push the LOCATE button with the Type 549 in conventional (non-storage) mode of operation.

c. Check—The sweep must compress and remain in the graticule area at extreme settings of the Vertical and HORIZONTAL POSITION controls.

d. Position the trace horizontally so the sweep starts at the left edge of the graticule.

e. Set the NORM-SINGLE SWEEP switch to SINGLE SWEEP and both UPPER and LOWER SCREEN STORAGE to STORE.

f. Push the LOCATE button.

g. Check—The beam must unblank and appear to the left of the graticule in the locate zone.

h. Depress both UPPER and LOWER SCREEN STORAGE OFF buttons and set the NORM-SINGLE SWEEP switch to NORM.

5. Check Graticule-CRT Registration

a. Requirement—Horizontal graticule center line aligned with the slit in the center of the target surface.

b. Check—Center horizontal graticule line is positioned as required.

6. Check Geometry

a. Requirement—Linearity and alignment of time markers with the vertical graticule lines (within ± 2.0 mm).

b. Turn the POWER switch to OFF, replace the Test Load/Pulsar plug-in unit with a 1-series (Type 1A1, 1A2 or similar) plug-in unit, then turn the POWER switch to ON.

c. Apply 1.0 ms markers from the Time-Mark Generator to the Type 1A1 input connector through a 50 ohm coaxial cable and 50 ohm termination.

d. Set the Vertical Position control to position the display baseline below the graticule area and set the Volts/cm sensitivity so the markers over-scan the viewing area.

e. Check—Bowing and tilt of markers over entire display area, not to exceed 2.0 mm. See Fig. 5-1.

f. Turn the power switch to OFF, disconnect all test equipment, remove the Type 1A1 and install the Test Load/Pulser unit. Turn the POWER switch to ON.

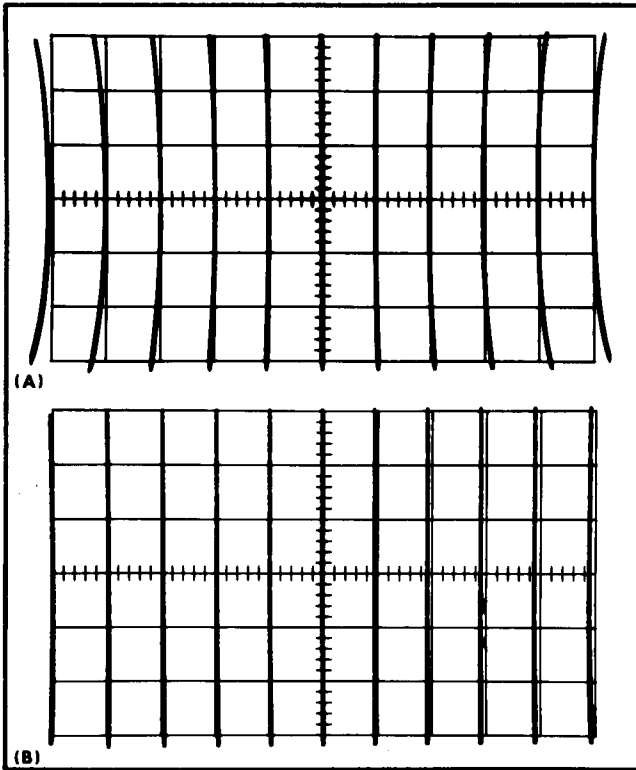


Fig. 5-1. (A) Typical CRT display showing incorrect geometry. (B) Typical CRT display showing correct geometry.

7. Check Alternate Trace Operation

a. Requirement—Alternate trace operation at all settings of the A TIME/CM switch and the B TIME/CM AND DELAY TIME switch.

b. Set the Test Load/Pulser Test Function switch to Alternate.

c. Apply the Standard Amplitude Calibrator output to the Test Load/Pulser Ext Input connector through 50 Ω coaxial cable and set the calibrator for a 20 volt signal.

d. Check—Alternate trace operation at all settings of the A TIME/CM switch. (At the slow sweep rates, alternate traces will consist of a single spot for one sweep, then two spots vertically separated in amplitude proportional to the amplitude of the input signal from the amplitude calibrator.)

e. Set the HORIZONTAL DISPLAY switch to B.

f. Check—Alternate trace operation at all settings of the B TIME/CM AND DELAY TIME switch.

g. Disconnect the Standard Amplitude Calibrator signal from the Test Load/Pulser Input connector.

8. Check Chopped Operation

a. Requirement—Complete blanking of switching transients (vertical lines) between chopped segments.

b. Set the Test Load/Pulser Test Function switch to Chopped position.

c. Set the B TIME/CM AND DELAY TIME switch to 5 μ SEC.

d. Set the CRT CATHODE SELECTOR switch (rear panel) to CHOPPED BLANKING.

e. Check—CRT display for blanking of switching transients (vertical lines) between chopped segments.

f. Return the CRT CATHODE SELECTOR switch to the NORMAL position.

g. Set the B TIME/CM AND DELAY TIME switch to the 1 mSEC position and the Test Function switch to Low Load position.

9. Check A and B Sweep Length

a. Requirement—A sweep length must be equal to or more than 10 cm; the B sweep length must vary between 4 cm or less to 10 cm or more.

b. Apply 1 mS and 0.1 mS markers from the Time-Mark Generator to the Ext Input connector of the Test Load/Pulser unit.

c. Set the B Triggering MODE switch to TRIG and adjust the STABILITY and LEVEL controls for a stable display.

d. Check—B sweep length must be 10 cm or more.

e. Rotate the LENGTH control fully counterclockwise.

f. Check—Smoothness of electrical operation of the LENGTH control; decreasing of the sweep length to 4 cm or less.

g. Return the B LENGTH control to full clockwise position and change the HORIZONTAL DISPLAY switch to A position.

h. Set the A MODE switch to TRIG and adjust the STABILITY and LEVEL controls for a stable display.

i. Check—A sweep length is 10 cm or more.

10. Check Sweep Magnifier Registration

a. Requirement—Normal to magnified sweep registration must be equal to or less than ± 0.5 cm.

b. Turn the MAGNIFIER to $\times 5$ and check that the MAG neon lights.

c. Position the start of the trace to the center vertical graticule line with the HORIZONTAL POSITION control.

d. Turn the MAGNIFIER switch to OFF and note the distance that the start of the trace shifts.

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- e. Check—Trace shift equal to or less than ± 0.5 cm.
- f. Set the A TIME/CM switch to $.1 \mu\text{SEC}$.

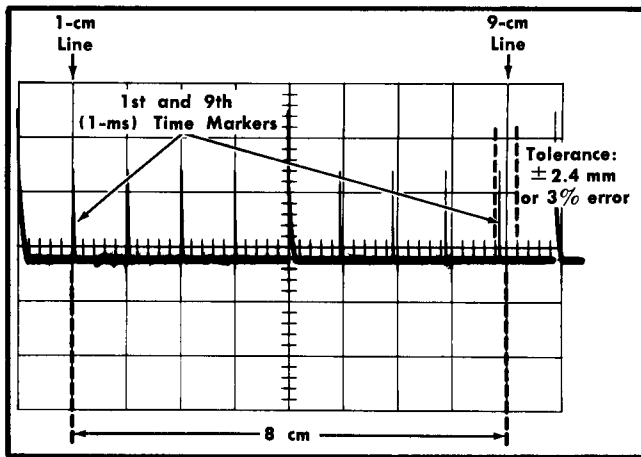


Fig. 5-2. Determining sweep rate accuracy.

TABLE 5-1

A TIME/CM Switch Setting	Time-Mark Generator Marker Selector	CRT Display Markers/CM
.1 μSEC	.1 μS	1
.2 μSEC	.1 μS	2
.5 μSEC	.5 μS	1
1 μSEC	1 μS	1
2 μSEC	1 μS	2
5 μSEC	5 μS	1
10 μSEC	10 μS	1
20 μSEC	10 μS	2
50 μSEC	50 μS	1
.1 mSEC	.1 mS	1
.2 mSEC	.1 mS	2
.5 mSEC	.5 mS	1
1 mSEC	1 mS	1
2 mSEC	1 mS	2
5 mSEC	5 mS	1
10 mSEC	10 mS	1
20 mSEC	10 mS	2
50 mSEC	50 mS	1
.1 SEC	.1 S	1
.2 SEC	.1 S	2
.5 SEC	.5 S	1
1 SEC	1 S	1
2 SEC	1 S	2
5 SEC	5 S	1

CHECK A AND B SWEEP TIMING

11. Check A Sweep Timing

- a. Requirement—Sweep timing accuracy within $\pm 3\%$ of TIME/CM indicated position.

- b. Check—A sweep timing as indicated in Table 5-1. Timing checked within the center 8 cm of the graticule area and must be within $\pm 3\%$. See Fig. 5-2.

12. Check Magnifier Timing Accuracy

- a. Requirement—Within $\pm 5\%$ of magnified sweep rate.
- b. Set the A TIME/CM switch to $.1 \mu\text{SEC}$.
- c. Set the MAGNIFIER to $\times 5$ position.
- d. Set the Time-Mark Generator marker selector to 20 ns (50 MHz). Slowly turn the A Triggering LEVEL control to the point the display stabilizes.
- e. Check—1 cycle/cm ± 4 mm (5%) between the first and ninth vertical graticule lines.
- f. Turn the MAGNIFIER switch to OFF and set the A TIME/CM switch to 1 mSEC position.

13. Check A Time Base Variable Control Range

- a. Requirement—Range equal to or greater than 2.5:1 decrease of the indicated sweep rate.
- b. Set the Time-Mark Generator marker selector to 1 mS.
- c. Set the TRIGGERING MODE switch to AUTO position.
- d. Rotate the VARIABLE control fully counterclockwise.
- e. Check—5 or more time-marks per 2 cm of display (2.5:1 range). Smooth electrical operation. UNCAL neon must light when the VARIABLE control is out of the CAL switch position.
- f. Return the VARIABLE control to the CAL position.

14. Check B Sweep Timing Accuracy

- a. Requirement—Sweep timing accuracy within $\pm 3\%$ of indicated sweep rate.
- b. Check—B sweep timing as indicated in Table 5-2. Timing checked within center 8 cm of graticule area and must check within $\pm 3\%$.

CHECK DELAY TIME MULTIPLIER

15. Check Linearity and Range Accuracy

- a. Requirement—Delay time multiplier range accuracy is within $\pm 1\%$ with an incremental linearity of $\pm 0.2\%$.
- b. Set the HORIZONTAL DISPLAY switch to B INTEN BY A position.
- c. Set the A TIME/CM switch to $5 \mu\text{SEC}$ and the B TIME/CM and DELAY TIME switch to 1 mSEC.
- d. Set the Time-Mark Generator selector switch for 1 mS markers.

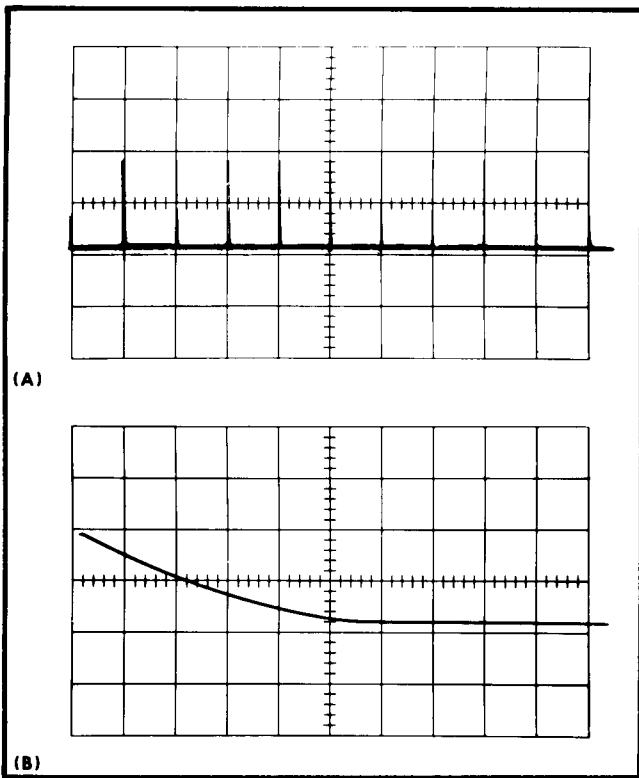


Fig. 5-3. (A) Intensified portion positioned to the 1st time marker. (B) Start of time marker positioned at the left graticule line.

e. Adjust the display intensity level with the INTENSITY control so the intensified portion of the display is visible, then position the intensified portion with the DELAY TIME MULTIPLIER 1-10 dial to the first time mark (see Fig. 5-3).

f. Set the HORIZONTAL DISPLAY switch to A DLY'D position.

g. Adjust the HORIZONTAL POSITION control to align the start of the trace with the extreme left graticule line.

h. Adjust the DELAY TIME MULTIPLIER 1-10 dial to position the beginning or rising portion of the 1st time marker to the left graticule line.

i. Record the dial reading (it should be very close to 1.00).

j. Turn the DELAY TIME MULTIPLIER 1-10 dial to position the 2nd time marker to the left graticule line and record this reading.

k. Continue taking readings of each time mark through the ninth time marker.

l. Check—Difference between dial readings at the first time mark and the ninth time mark must be between 7.92 and 8.08 ($\pm 1\%$). Difference between each recorded interval must be 1 major division ± 1.6 minor divisions.

16. Check Variable Time Delay Jitter

a. Requirement—Jitter not to exceed 1 part in 20,000 of the available delay interval (10 times B TIME/CM setting).

b. Change the following control settings:

A TIME/CM 1 μ SEC
VARIABLE CAL

c. Set the DELAY-TIME MULTIPLIER 1-10 dial to about 1.00 so a marker is displayed at center screen.

d. Check—Jitter on leading edge of marker not to exceed 0.5 division (1 part in 20,000); see Fig. 5-4. Ignore slow drift.

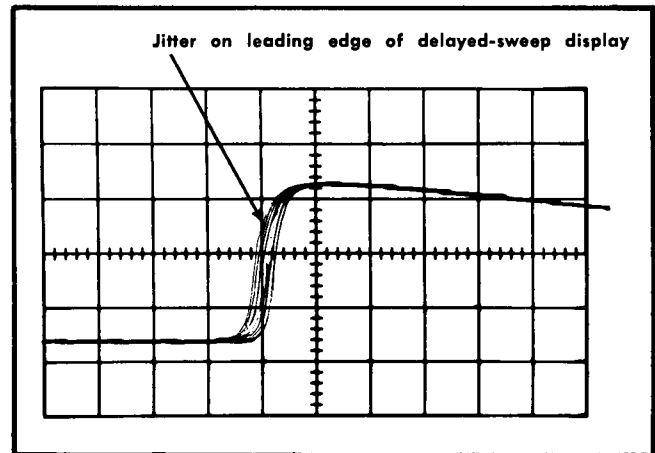


Fig. 5-4. Typical CRT display showing acceptable delay-time jitter.

TABLE 5-2

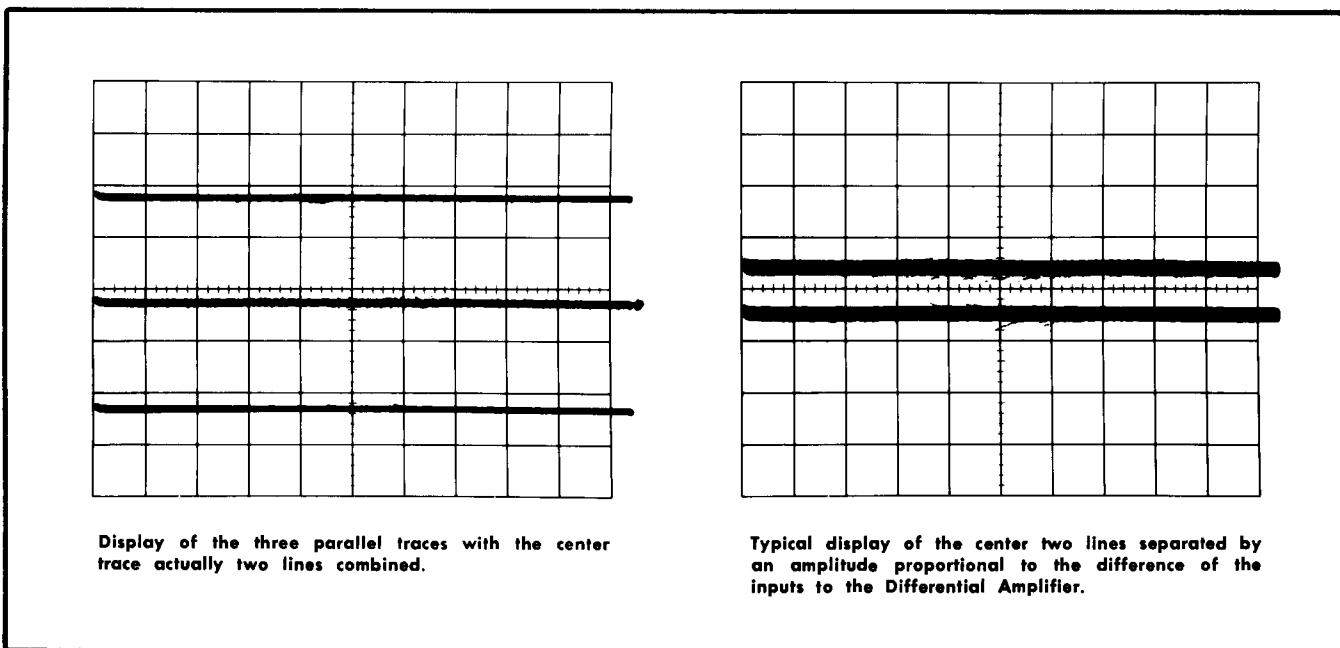
B TIME/CM and DELAY TIME Switch Setting	Time-Mark Generator Marker Selector	CRT Display Markers/Cm
2 μ SEC	1 μ S	2
5 μ SEC	5 μ S	1
10 μ SEC	10 μ S	1
20 μ SEC	10 μ S	2
50 μ SEC	50 μ S	1
.1 mSEC	.1 mS	1
.2 mSEC	.1 mS	2
.5 mSEC	.5 mS	1
1 mSEC	1 mS	1
2 mSEC	1 mS	2
5 mSEC	5 mS	1
10 mSEC	10 mS	1
20 mSEC	10 mS	2
50 mSEC	50 mS	1
.1 SEC	.1 S	1
.2 SEC	.1 S	2
.5 SEC	.5 S	1
1 SEC	1 S	1

CHECK AMPLITUDE CALIBRATOR

17. Check Amplitude Calibrator Voltage Accuracy

a. Requirement—Voltage accuracy $\pm 2\%$ of indicated setting.

b. Install a differential amplifier plug-in unit (Type D) in the test oscilloscope and set the front panel controls as follows:



Display of the three parallel traces with the center trace actually two lines combined.

Typical display of the center two lines separated by an amplitude proportional to the difference of the inputs to the Differential Amplifier.

Fig. 5-5. Checking AMPLITUDE CALIBRATOR accuracy.

Test Oscilloscope

Triggering controls, for a free running trace

Level	Clockwise
Stability	Clockwise
Time/cm	10 μ SEC

Differential Amplifier (Type D)

Millivolts/cm	1000
Variable	Calibrated
Multiplier	1
Input Selector	A-B, DC
Position	Centered

With no signal input, adjust the Fine and Preamp Balance controls until there is no vertical trace movement when the Variable control is varied.

c. Connect the output signal of a Standard Amplitude Calibrator to Input B of the Differential Amplifier.

d. Connect a 50 Ω coaxial cable between the Type 549 CAL OUT connector and Input A of the Differential Amplifier.

e. Set both the Standard Amplitude Calibrator and the Type 549 AMPLITUDE CALIBRATOR output to 2 volts.

f. Check—There should be 3 or 4 parallel lines on the test oscilloscope with the center line or lines showing the difference in amplitude of the two signals that are applied to the A and B inputs of the Differential Amplifier. See Fig. 5-5.

g. Set both the Standard Amplitude Calibrator and the Type 549 AMPLITUDE CALIBRATOR to 100 volts.

h. Check—Amplitude tolerance of the Type 549 AMPLITUDE CALIBRATOR as specified in Table 5-3. A single line indicates no difference of voltage, while two lines indicate there is a potential difference which is proportional to the separation between the lines.

TABLE 5-3

STANDARD and TYPE 549 AMPLITUDE CALIBRATORS	Differential Amplifier MILLIVOLTS/CM	Allowable Error in CM
100 volts	1000	2
50 volts	1000	1
20 volts	1000	0.4
10 volts	100	2
5 volts	100	1
2 volts	100	0.4
1 volt	10	2
.5 volt	10	1
.2 volt	10	0.4
.1 volt	1	2
50 mvolt	1	1

18. Check Amplitude Calibrator Repetition Rate

a. Requirement—Repetition rate 1 kHz \pm 25%.

b. Change the test oscilloscope and Type D controls as follows:

Time/cm	1 mSEC
Triggering controls	
Slope	+INT
Millivolts/cm	100
Input Selector	A, DC

c. Adjust test oscilloscope triggering controls for a stable display.

d. Check—Test oscilloscope display is between 7.5 and 12.5 cycles in 10 divisions (repetition rate of 1 kHz \pm 25%).

19. Check Amplitude Calibrator Symmetry and Risetime

a. Requirement—Symmetry within \pm 10% (duty cycle); risetime approximately 1 μ S.

- b. Change the test oscilloscope Time/cm switch and Variable Time/cm control to display one complete cycle in 10 cm of graticule area.
- c. Check—First half cycle (duty cycle) is between 4 and 6 cm.
- d. Set the test oscilloscope Time/cm switch to 1 μ SEC and set the Variable to the Calibrated position.
- e. Adjust the Triggering Level control so the leading edge of the signal is displayed.
- f. Use the Horizontal Position control to center the display then measure the risetime from the 10% to 90% points.
- g. Check—Risetime is typically 1 μ S or less.
- h. Disconnect all test equipment.

20. Check Amplitude Calibrator 5 mA Switch Position.

- a. Requirement—Output current is 5 mA \pm 2%. Accuracy checked in step 17.
- b. Change the switch settings as follows:

Test Oscilloscope	
Time/cm	1 mSEC
Type D	
Millivolts/cm	1
Mv/Cm Multiplier	50
- c. Set the Type 134 Current/Div to 2 mA.
- d. Connect the current probe assembly to A input connector of the Differential Amplifier (Type D) unit.
- e. Connect the P6019 current probe to the 5 mA current loop on the Type 549 and set the Type 549 Amplitude Calibrator switch to the 5 mA position.

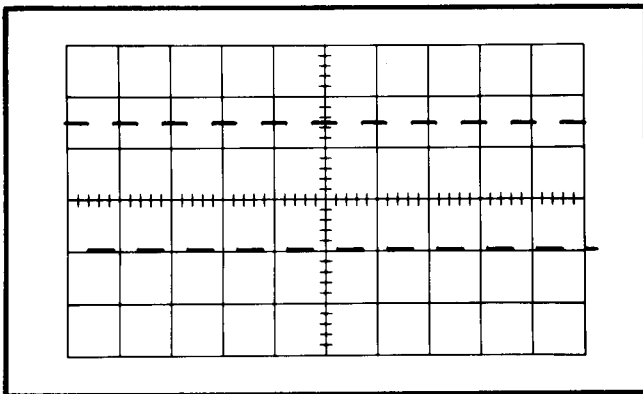


Fig. 5-6. Current waveform from AMPLITUDE CALIBRATOR.

- f. Check—Test oscilloscope display for a square wave with an amplitude of approximately 2.5 cm.
- g. Disconnect all test equipment, replace the Differential Amplifier (Type D) with the Fast-Rise Amplifier (Type K).

CHECK FRONT PANEL OUTPUT WAVEFORM AND HOLDOFF TIME

21. Check SWEEP A

- a. Requirement—Sawtooth waveform with an amplitude of 150 volts \pm 10 volts increasing approximately 30 volts at the faster sweep rates.

- b. Connect the 10 \times probe from the test oscilloscope and the plug-in unit to the SWEEP A connector on the Type 549.
- c. Set the controls as follows:

Type 549	
HORIZONTAL DISPLAY	A
A TIME/CM	.1 mSEC
A TRIGGERING MODE	TRIG
STABILITY AND LEVEL	Fully clockwise for a free running A sweep

Test Oscilloscope

Volts/cm	5
Time/cm	1 mSEC

- d. Adjust test oscilloscope triggering controls for a stable display.
- e. Check—Type 549 SWEEP A output. Should be 150 volt sawtooth \pm 10 volts.

22. Check +Gate A and Time Base A Hold-off Time

- a. Requirement—Gate amplitude within 20 to 40 volts, holdoff time within the time specified in Table 5-4.
- b. Connect the 10 \times probe from the test oscilloscope to the +GATE A connector.
- c. Change the test oscilloscope Volts/cm switch to 1 and the Time/cm switch to 1 μ SEC.
- d. Check—Waveform amplitude of 20 to 40 volts and holdoff time (lower portion of the square-wave display) as specified in Table 5-4. See Fig. 5-7.

TABLE 5-4

TYPE 549 A TIME/CM Setting	Test Oscilloscope Time/cm Setting	Holdoff Time
.1 to .5 μ SEC	1 μ SEC	4-9 μ s
1 to 50 μ SEC	5 μ SEC	15-40 μ s
.1 to .5 mSEC	50 μ SEC	150-400 μ s
1 to 5 mSEC	.5 mSEC	1.5-4 ms
10 to 50 mSEC	5 mSEC	15-40 ms
.1 to 5 SEC	50 mSEC	150-400 ms

23. Check +Gate B and Time Base B Hold-off Time

- a. Requirement—Gate amplitude is within 20 to 40 volts, holdoff time within the time specified in Table 5-5.
- b. Connect the 10 \times probe from the test oscilloscope to the +Gate B connector.
- c. Set HORIZONTAL DISPLAY to B and B TIME/CM AND DELAY TIME to 2 μ SEC position.
- d. Check—Waveform amplitude and holdoff time. See Fig. 5-7.

TABLE 5-5

TYPE 549 B TIME/CM AND DELAY TIME	Test Oscilloscope Time/cm Setting	Holdoff Time
2 to 10 μ SEC	5 μ SEC	15-40 μ s
20 μ SEC to .1 mSEC	50 μ SEC	150-400 μ s
.2 to 1 mSEC	.5 mSEC	1.5-4 ms
2 to 10 mSEC	5 mSEC	15-40 ms
20 mSEC to 1 SEC	50 mSEC	150-400 ms

Performance Check—Type 549

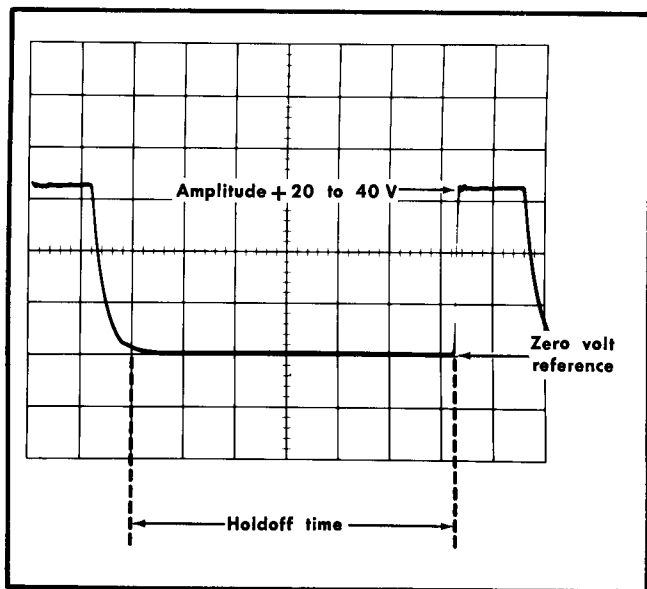


Fig. 5-7. Typical test oscilloscope display showing correct operation of the +GATE A and +GATE B circuits.

24. Check Dly'd Trig

- Requirement—Delayed trigger amplitude equal to 7 V \pm 2 volts.
- Connect the 10X probe to the center conductor of the DLY'D TRIG connector.
- Set the front panel controls as follows:

Type 549

HORIZONTAL DISPLAY	B INTEN BY A
A TIME/CM	.5 mSEC
B TIME/CM AND DELAY TIME	1 mSEC

Test Oscilloscope

Volts/cm	.2
Time/cm	2 μ SEC
Trigger Slope	+ INT
Trigger Mode	Auto

- Check—Delayed trigger pulse. Positive going pulse with an amplitude of 7 V \pm 2 volts.

CHECK VERTICAL AMPLIFIER

25. Check Vertical Amplifier DC Balance

- Requirement—Trace must be within \pm 1 cm of the graticule center line with the Test Load/Pulser unit, Test Function switch in Common Mode.
- Set the HORIZONTAL DISPLAY switch to A and the STABILITY control fully clockwise for a free running sweep.
- Set the Test Load/Pulser Function selector to the Common Mode position.

- Check—Trace must be within \pm 1 cm of the center horizontal graticule line.

26. Check Input Deflection Factor

- Requirement—Input deflection factor must be within \pm 3% at 100 mV/cm.
- Set the Test Load/Pulser Test Function switch to Gain Set position.
- Apply a 100-volt signal from the Standard Amplitude Calibrator to the Ext Input connector of the Test Load/Pulser.
- Set the Type 549 A TIME/CM switch to 2 mSEC position and the A TRIGGERING MODE switch to AUTO position.
- Check—Vertical amplitude of the square-wave display must be 4 cm \pm 1.2 mm.

27. Check Vert Sig Out

- Requirement—Vertical signal out must be between 1.2 and 1.8 volts (1.5 V \pm 20%) for each centimeter of deflection on the CRT of the Type 549.
- Set the Standard Amplitude Calibrator output selector to 50 V position.
- Connect the 10X probe from the test oscilloscope to the Type 549 VERT SIG OUT connector and set the controls on the test oscilloscope as follows:

Time/cm	2 μ sec
Stability	Full Clockwise
Volts/Cm	.1
- Check—Test oscilloscope display for signal amplitude between 2.4 and 3.6 cm (1.5 V/cm of deflection \pm 20%).
- Disconnect all test equipment.

28. Check Vertical Amplifier Transient Response

- Requirement—Maximum overshoot, rounding, ringing or tilt of a square wave is \pm 2.0%.
- Set the Test Load/Pulser Test Function switch to +Pulse position and the Repetition Rate switch to Low.
- Set the Type 549 A TIME/CM switch to 50 μ SEC and the A MODE switch to TRIG.
- Set the A STABILITY control to PRESET and adjust the A LEVEL control for a stable display.
- Adjust the Test Load/Pulser Amplitude control for a 4 cm display amplitude.
- Check—Tilt at the top and bottom of the waveform must be less than 1.0 mm (2.0%). See Fig. 5-8A.
- Set the Type 549 A TIME/CM switch to .1 μ SEC and the Test Load/Pulser Repetition Rate switch to High.
- Center the display with the POSITION controls and adjust signal amplitude for 4 cm display.

- i. Check—Overshoot and ringing. Must be less than ± 1.0 mm.

29. Check Vertical Amplifier Risetime

- a. Requirement—Risetime must be equal to or less than 12 ns.
- b. Adjust the Test Load/Pulser Amplitude control for a 5 cm display amplitude.
- c. Turn the MAGNIFIER to $\times 5$ and center the display within the graticule area. (Sweep rate is now 20 ns/cm.)
- d. Measure the risetime of the square-wave from the 10% to the 90% amplitude points. See Fig. 5-8B.

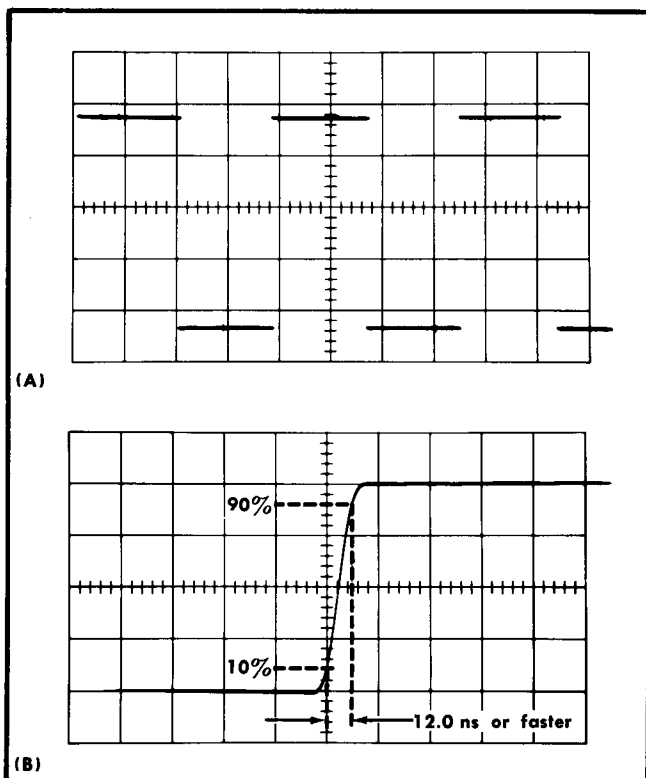


Fig. 5-8. (A) Typical CRT display of vertical amplifier transient response. (B) Measuring the risetime of a normal waveform; sweep rate is 20 ns/cm.

- e. Check—Risetime must be equal to or less than 12 ns.
- f. Change the Test Load/Pulser Test Function switch to —Pulse and the Type 549 A TRIGGERING SLOPE switch to — position.
- g. Reposition the negative-going waveform and again measure the risetime.
- h. Check—Risetime must be 12 ns or less.

30. Check Vertical Amplifier Frequency Response

- a. Requirement—Sensitivity not more than -3 dB at 30 MHz.
- b. Remove the Test Load/Pulser and install a 1-series plug-in unit, (Type 1A1 or equivalent).
- c. Change the Type 549 control settings as follows:

MAGNIFIER	OFF
A TIME/CM	.2 mSEC
A TRIGGERING MODE	TRIG
A TRIGGERING LEVEL	Clockwise
A STABILITY	Clockwise

1-Series Plug-In Unit

Volts/cm	.05
Input Selector	DC

- d. Connect the output of the Constant Amplitude Signal Generator through a GR to BNC adapter, a 50 ohm coaxial cable and a 50 ohm termination to the 1-series plug-in unit input connector.
- e. Set the Constant Amplitude Signal Generator frequency to 50 kHz and adjust the output amplitude control for a display amplitude of 4 cm.

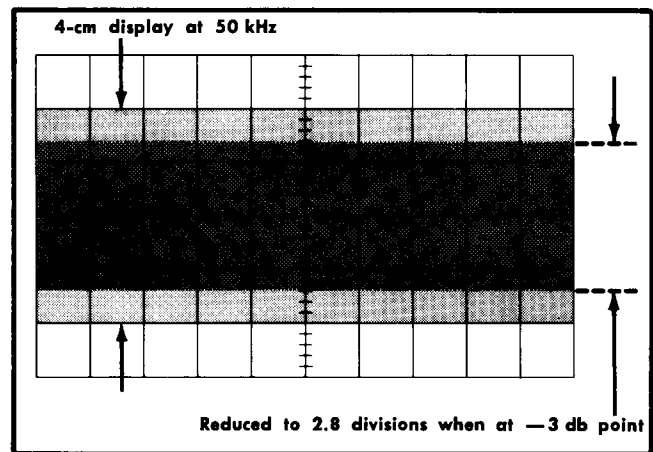


Fig. 5-9. Typical CRT display when checking vertical amplifier frequency response.

- f. Change the frequency to 30 MHz.
- g. Check—Amplitude of display must be 2.8 cm or more (-3 dB point). See Fig. 5-9.

31. Check VERT SIG OUT Frequency Response

- a. Requirement—Sensitivity not more than -3 dB at 700 kHz.
- b. Connect the $10\times$ probe from the test oscilloscope to the Type 549 VERT SIG OUT connector.
- c. Set the Constant Amplitude Signal Generator to 50 kHz and adjust the test oscilloscope sensitivity for a display amplitude of 4 cm on the test oscilloscope CRT.

TABLE 5-6

Triggering Switches			Input Trigger Signal		Other Conditions
SOURCE	MODE	COUPLING	Frequency	Amplitude	
NORM (Internal)	TRIG AUTO	AC	300 Hz	0.2 cm	Must not trigger with COUPLING switch in AC LF REJ
	AUTO	AC, DC, AC LF REJ	10 kHz	0.2 cm	
	TRIG	AC, AC LF REJ, DC	10 MHz	0.2 cm	Check also with STABILITY in PRE-SET position.
EXT	AUTO	AC, DC, AC LF REJ	10 kHz	0.3 volt	
	TRIG	AC, DC, AC LF REJ	10 MHz	0.3 volt	
	TRIG	AC, DC, AC LF REJ	30 MHz	3 volt	

d. Change the Constant Amplitude Signal Generator frequency to 700 kHz.

e. Check—Amplitude of test oscilloscope display must be 2.8 cm or more (−3 dB point).

e. Set SOURCE switch to PLUG-IN position and apply a 2 cm signal at a frequency of 5 MHz. Check for stable triggering with COUPLING switch in DC position and MODE switch in TRIG.

TRIGGERING CHECK

32. Check A Triggering Sensitivity

a. Requirement—Stable triggering with source, coupling, frequency and amplitude of trigger signals as specified in Table 5-6.

b. Apply the output signal of the Constant Amplitude Signal Generator or an audio signal generator (depending upon the trigger signal frequency listed in Table 5-6) through a 50 Ω coaxial cable, a 50 Ω termination and a BNC T connector to the Input connector of the vertical plug-in unit.

c. Connect a 50 Ω coaxial cable between the other end of the T connector and the A TRIG INPUT connector of the Type 549.

d. Check—The triggering must be stable with the SLOPE switch in either + or − position in accordance with the sensitivity specifications listed in Table 5-6.

With the MODE switch in the TRIG position the STABILITY and LEVEL controls must be adjusted as follows:

1. Adjust the STABILITY control 2 to 3 degrees past the position at which the trace no longer free runs.
2. Adjust the LEVEL control for a stable triggered display. The LEVEL control may need readjusting when the SLOPE switch position is changed.
3. With the SOURCE switch in EXT position, monitor the external trigger signal for the Type 549 with a test oscilloscope. If the frequencies are above the capabilities of the test oscilloscope, adjust the Constant Amplitude Signal Generator for the specified amplitude at a lower frequency and then set the signal generator to the frequency specified.

33. Check B Triggering Sensitivity

a. Requirement—Stable triggering with conditions as specified in Table 5-7.

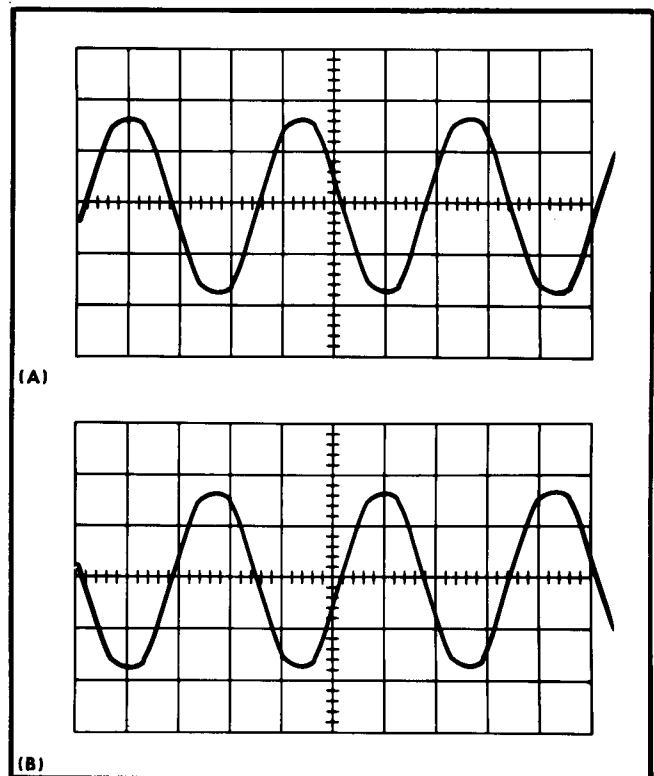


Fig. 5-10. Typical CRT display showing correct operation of the SLOPE switch. (A) SLOPE switch set to +, (B) SLOPE switch set to − position.

TABLE 5-7

Triggering Switches			Input Trigger Signal		Other Conditions
SOURCE	MODE	COUPLING	Frequency	Amplitude	
NORM	TRIG AUTO	AC	300 Hz	0.2 cm	Must not trigger in AC LF REJ
NORM	TRIG AUTO	AC, DC AC LF REJ	10 kHz	0.2 cm	
	TRIG	AC, DC AC LF REJ	10 MHz	1.0 cm	Check also with STABILITY in PRE- SET position
EXT	TRIG AUTO	AC, DC AC LF REJ	10 kHz	0.3 volt	
	TRIG	AC AC LF REJ	10 MHz	1.5 volt	

- b. Disconnect the coaxial cable from the A TRIG INPUT connector and connect it to the B TRIG INPUT connector.
- c. Set the HORIZONTAL DISPLAY switch to B position.
- d. Check—Triggering must be stable with either + or — position of the SLOPE switch. Adjust the STABILITY and LEVEL controls as directed in step 32.
- e. Repeat the procedure outlined in a through d.
- f. Disconnect test equipment and cables.

34. Check Line Triggering

- a. Requirement—Line triggering must produce a stable display of correct polarity.
- b. Set the controls of both A and B Time Bases as follows:

TIME/CM	5 mSEC
Triggering	
MODE	TRIG
COUPLING	AC
SOURCE	LINE
- c. Connect a 10× probe from the 1-series plug-in unit (1A1 or 1A2) Input connector to the high side of the Type 549 line voltage source.
- d. Adjust the STABILITY and LEVEL controls for a stable triggered display.
- e. Change the B SLOPE switch from — to +.
- f. Check—Slope of the display must correspond to the + and — settings of the SLOPE switch (see Fig. 5-10).
- g. Set the B MODE switch to AUTO and repeat check.
- h. Set the HORIZONTAL DISPLAY switch to A and repeat the checks for both TRIG and AUTO settings of the A MODE switch.
- i. Disconnect the 10× probe.

35. Check Single Sweep Operation

- a. Requirement—Triggering signal must generate a sweep each time the NORM-SINGLE SWEEP switch is depressed to

RESET or the ERASE AND RESET button is depressed. The READY neon must light and stay lit until the triggering signal activates the sweep.

- b. Set the controls as follows:

HORIZONTAL DISPLAY	B INTEN BY A
A TIME/CM	.2 mSEC
B TIME/CM	.5 mSEC
A and B Triggering	
MODE	TRIG
STABILITY and LEVEL	
control	Fully clockwise
AMPLITUDE CALIBRATOR	20 mVolts

- c. Apply the OUTPUT from the CAL OUT connector through a 50 ohm coaxial cable to the Input connector of the 1-series plug-in unit (1A1 or 1A2).
- d. Adjust the vertical plug-in unit Volts/Cm and Variable control for a display amplitude of 2 mm.
- e. Adjust the B LEVEL and STABILITY controls for a triggered intensified sweep.
- f. Set the 1-series Input Selector to Gnd and change the NORM-SINGLE SWEEP switch to SINGLE SWEEP position.
- g. Push the NORM-SINGLE SWEEP switch to RESET.
- h. Check—READY neon is lit.
- i. Change the 1-series Input Selector to DC position.
- j. Check—A single intensified sweep must occur and the READY neon must extinguish.
- k. Repeat the check using the ERASE RESET button to reset the single sweep.
- l. Set the NORM-SINGLE SWEEP switch to NORM and remove coaxial cable.

- m. Turn POWER switch to OFF. Remove the 1-series plug-in unit and install the Test Load/Pulser. Turn POWER switch to ON.

EXTERNAL HORIZONTAL AMPLIFIER

36. Check External Horizontal Amplifier DC Balance

- Requirement—DC shift less than or equal to 1.0 cm.
- Turn the INTENSITY control fully counterclockwise.
- Set the HORIZONTAL DISPLAY switch too EXT 1× position.
- Adjust the INTENSITY control clockwise until a spot is visible, then position the spot to the graticule center area with the POSITION CONTROLS.
- Rotate the VARIABLE 1-10 control and note the amount of horizontal movement of the spot.
- Check—Spot movement must be more than 1.0 cm.

37. Check External Horizontal Amplifier Deflection Factor

- Requirement—Deflection factor, 1× less than or equal to 0.2 V/CM, 10× less than or equal to 2 V/CM, VARIABLE 10:1 attenuates display by a factor of at least 10.
- Connect the OUTPUT from the SWEEP A connector to the Test Load/Pulser Ext Input connector through 50 Ω coaxial cable, then connect the OUTPUT from the AMPLITUDE CALIBRATOR through a T connector and 50 Ω cables to the EXT HORIZ IN connector and the A TRIG INPUT connector.
- Set the Type 549 controls as follows:

A TIME/CM	.5 mSEC
A TRIGGERING SOURCE	EXT
A TRIGGERING MODE	TRIG
AMPLITUDE CALIBRATOR	1 VOLT
- Set the VARIABLE 1-10 control fully clockwise.
- Check—Horizontal amplitude of display is 5 cm or more.
- Change HORIZONTAL DISPLAY to 10× position and the AMPLITUDE CALIBRATOR to 10 VOLTS.
- Check—Horizontal amplitude of display is 5 cm or more.
- Change the HORIZONTAL DISPLAY switch to 1× position and turn the VARIABLE 1-10 control fully counterclockwise.
- Check—Horizontal deflection amplitude must be equal to or less than the amplitude noted in step g.
- Set the AMPLITUDE CALIBRATOR switch to the 1 VOLT position, the VARIABLE 1-10 control fully clockwise and the HORIZONTAL DISPLAY switch to 1× position.
- Set the A STABILITY control to PRESET and adjust the LEVEL control for a stable display.
- Note the display signal amplitude and aberrations.

m. Change the HORIZONTAL DISPLAY switch to 10× position and the AMPLITUDE CALIBRATOR to 10 VOLT position.

n. Check and compare the display amplitude and wave shape with the display of step 1. Amplitude must be within ±3% and aberrations in both the 1× and 10× positions must be less than ±5%.

o. Disconnect the AMPLITUDE CALIBRATOR signal cable.

38. Check External Horizontal Amplifier Bandwidth

- Requirement—Amplifier bandwidth equal to or higher than 350 kHz (at the -3 dB point).
- Set the A STABILITY and LEVEL controls fully clockwise and the HORIZONTAL DISPLAY switch to 1× position.
- Apply the output from a Constant Amplitude Signal Generator to the EXT HORIZ IN connector through a 50 Ω coaxial cable.
- With the frequency of the Constant Amplitude Signal Generator set to 50 kHz, adjust its amplitude control for a horizontal display amplitude of 6 cm.

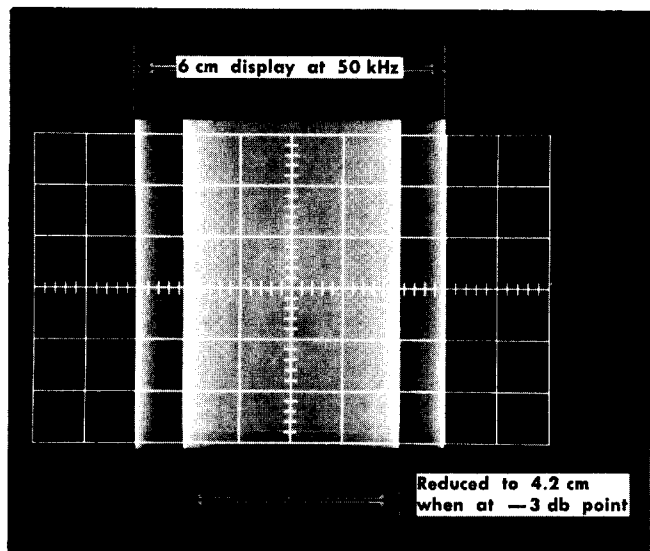


Fig. 5-11. Typical CRT display when checking horizontal amplifier frequency response.

- Change the signal generator frequency to 350 kHz.
- Check—Horizontal amplitude of the display must be 4.2 cm or more (see Fig 5-11).
- Disconnect the Constant Amplitude Signal Generator signal and the SWEEP A cable to the vertical input connector.

CHECK STORAGE SYSTEM

39. Check Collimation

- a. Requirement—The intensity level on a fully written screen must be uniform and free of bright spots.
- b. Reset the front panel controls as follows:

Type 549

CRT controls

INTENSITY	Normal intensity
FOCUS	Adjust for well-defined trace
ASTIG	Adjust for well-defined trace
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Counterclockwise
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM

Time Base A

TIME/CM	.2 mSEC
VARIABLE	CAL

Triggering controls

LEVEL	Fully clockwise
STABILITY	Fully clockwise
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM

Time Base B

TIME/CM AND DELAY

TIME	.5 mSEC
LENGTH	10 CM

Triggering controls

LEVEL	Clockwise
STABILITY	PRESET
Lever Switches	All in Up position
DELAY TIME MULTIPLIER	
1-10	1.00
HORIZONTAL POSITION	Midrange

FINE	Midrange
AMPLITUDE CALIBRATOR	.1 VOLT

Test Load/Pulser Unit

Test Function	Low Load
Variable	Fully counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

c. Position the trace off the graticule area with the Vertical Position control.

d. Depress both STORE buttons for the UPPER and LOWER SCREEN STORAGE.

e. Write the entire CRT screen by slowly positioning the trace through the graticule area with the Vertical Position control.

f. Check—Uniform brightness, absence of two bright spots within the graticule area.

g. Erase the screen by depressing both ERASE buttons for the UPPER and LOWER SCREEN STORAGE.

40. Check Non-Store Level

a. Requirement—Screen must erase promptly when a fully written screen is switched from STORE to OFF.

b. Write the entire screen area by slowly positioning the trace over the screen with the Vertical Position control.

c. Change the UPPER and LOWER SCREEN STORAGE to OFF.

d. Check—Stored screen erasure must be complete and prompt.

41. Check Erase Program Viewing Time

a. Requirement—Viewing time between erasures should be approximately 0.5 seconds to about 5 seconds.

b. Set the AUTO ERASE lever switch to the PERIODIC position, the A TIME/CM switch to 1 SEC and depress both STORE buttons for the UPPER and LOWER SCREEN STORAGE.

c. Check—With the VIEWING TIME control fully counterclockwise, the time between erasures should be approximately 0.5 seconds. With the VIEWING TIME control fully clockwise the time between erasures should be approximately 5 seconds or more.

42. Check After Sweep Automatic Erase

a. Requirement—Screen must automatically erase at the end of a sweep and the sweep must automatically reset and start over.

b. Change the A TIME/CM switch to .1 SEC, the AUTO ERASE lever switch to AFTER SWEEP position and NORM-SINGLE SWEEP switch to SINGLE SWEEP position.

Performance Check—Type 549

c. Check—The screen automatically erases after the sweep, at a time determined by the VIEWING TIME control setting, then the sweep automatically resets and starts over.

43. Check Operation of Screen Selector

a. Requirement—SCREEN SELECTOR switch must select either or both upper and lower screen for the erase program.

b. Change the SCREEN SELECTOR switch to LOWER position.

c. Check—The lower screen must erase in accordance with the program set by the ERASE PROGRAM AUTO ERASE switch and VIEWING TIME control.

d. Change the SCREEN SELECTOR switch to the UPPER position.

e. Check—The upper screen must erase in accordance with the ERASE PROGRAM, AUTO ERASE switch and VIEWING TIME control.

44. Check Writing Speed

a. Requirement—Writing speed is equal to or greater than $0.5 \text{ cm}/\mu\text{s}$.

b. Set the A TIME/CM switch to $20 \mu\text{SEC}$ position, the AUTO ERASE switch to AFTER SWEEP and the VIEWING TIME control midrange. Set the SCREEN SELECTOR switch to FULL position.

c. Apply an approximate 50 kHz sine-wave signal from the signal generator to the vertical plug-in unit and adjust the output signal amplitude control for a display amplitude of 3.2 cm.

d. Set the STABILITY control to PRESET and adjust the A LEVEL control for a stable display.

e. Carefully adjust the INTENSITY, FOCUS and ASTIG controls for optimum display storage. See Fig. 5-12A.

f. Increase the input frequency from the signal generator and adjust the TIME/CM switch setting and VARIABLE control to maintain slightly more than 15 cycles per 10 cm until the stored display shows breaks greater than 0.025 inches. See Fig. 5-12B. (Maintain optimum storage by adjusting the INTENSITY, FOCUS and ASTIG controls.)

g. Check—The frequency of the sine wave generator must be 50 kHz or higher. Writing speed in $\text{cm}/\mu\text{s} = \text{Frequency in MHz} \times 10$ (when the signal amplitude is 3.2 cm and a display of 15 cycles/10 cm is maintained).

45. Check Enhance Mode Operation

a. Requirement—Enhance mode operation must enhance the writing speed to $5 \text{ cm}/\mu\text{s}$ or greater.

b. Change the ENHANCE MODE switch to FULL position and adjust the ENHANCE LEVEL control for optimum storage. Increase the input signal generator frequency and adjust for optimum storage as in step 44, until breaks of approximately 0.025 inches are noted.

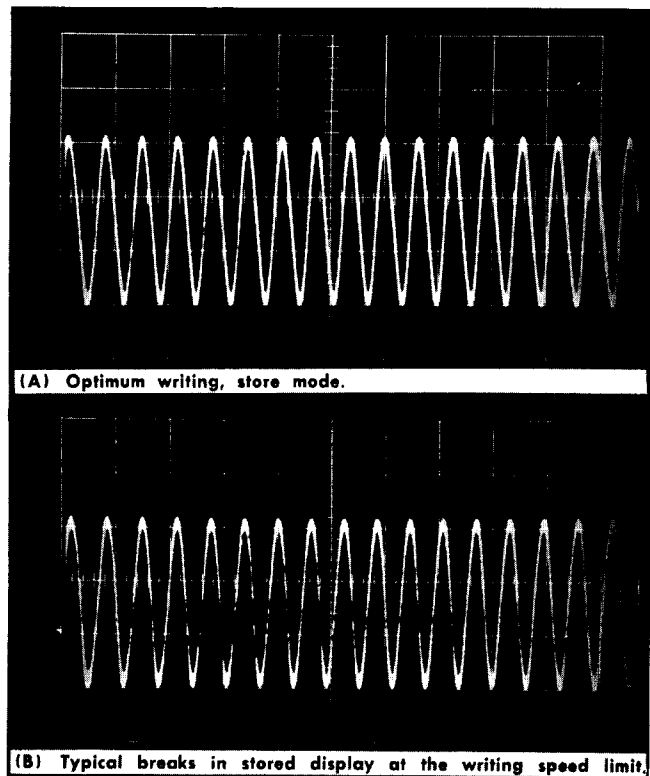


Fig. 5-12. Typical display when measuring writing speed.

c. Check—Frequency of the input signal. Enhanced writing speed in $\text{cm}/\mu\text{s} = \text{sine wave frequency in MHz} \times 10$, and should equal $5 \text{ cm}/\mu\text{s}$ or more.

d. Set the ENHANCE MODE switch to the UPPER and then LOWER position, checking enhance operation for each indicated switch position.

e. Turn the ENHANCE MODE switch to OFF position.

46. Check Integrate Traces Operation

a. Requirement—Depressing the INTEGRATE TRACES button must interrupt flood gun beam current and permit the integrating of writing beam traces.

b. Set the A TIME/CM switch to .1 mSEC, INTENSITY control fully counterclockwise, NORM-SINGLE SWEEP switch to SINGLE SWEEP position and AUTO ERASE to OFF position.

c. Depress both ERASE buttons to erase the storage area then depress the INTEGRATE TRACES button for 2 seconds.

d. Check—There must be no indication of fade positive after the INTEGRATE button is released.

e. Increase the intensity level by turning the INTENSITY control clockwise, and depress the ERASE AND RESET button to trigger the sweep until a complete trace is stored.

f. Depress the INTEGRATE TRACES button.

g. Check—The stored trace should disappear with the

button depressed and return when the INTEGRATE TRACES button is released.

47. Check Remote Control Input Operation

a. Requirement—Grounding each pin on the Remote Control Input connector (J925) must provide the operation indicated in Table 5-8.

b. Set the AMPLITUDE CALIBRATOR to 1 VOLT, center the display and set the NORM-SINGLE SWEEP switch to SINGLE SWEEP position.

c. Connect a jumper lead (meter test lead) between the ground post on the front panel and each pin of J925 as indicated in Table 5-8, checking for indicated operation.

TABLE 5-8

Ground Pin	Performance	Correct Indication
A	Remote erase	Upper screen erases
B	Remote erase	Lower screen erases
C	Remote save	Prevents automatic single sweep reset and erase pulse.
E	Remote erase and reset	Both upper and lower screens erase and reset.
F	Remote single sweep reset	Resets single sweep operation.
H	Remote store	Sets upper screen to store when UPPER SCREEN STORAGE is set to OFF.
J	Remote store	Sets lower screen to store when LOWER SCREEN STORAGE is set to OFF.

d. Change the UPPER and LOWER SCREEN STORAGE to OFF and the NORM-SINGLE SWEEP to NORM position.

CHECK Z AXIS MODULATION

48. Check Z Axis Input Grid Modulation

a. Requirement—5 volt signal causes noticeable modulation.

b. Set the front panel controls as follows:

HORIZONTAL DISPLAY	A
A TIME/CM	.5 mSEC
A TRIGGERING MODE	AUTO
A TRIGGERING SOURCE	NORM

c. Apply the signal from the CAL OUT connector through a BNC T connector and two 50 Ω coaxial cables to the Test Load/Pulser Ext Input connector and the EXT CRT GRID connector on the rear panel of the Type 549.

d. Set the AMPLITUDE CALIBRATOR to 5 VOLT position, adjust the A LEVEL control for a stable display and the Test Load/Pulser Variable control for a 2 cm amplitude signal.

e. Set the CRT GRID SELECTOR switch to EXT position.

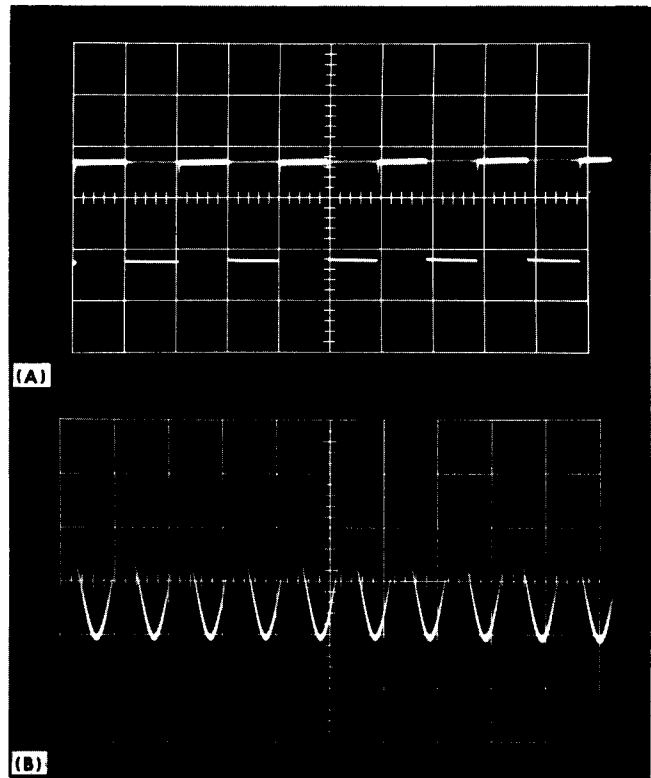


Fig. 5-13. Z axis modulation (A) Grid modulation. (B) Cathode modulation.

f. Check—Z axis modulation. The negative portion of the calibrator signal must show noticeable decrease in intensity level (see Fig. 5-13).

g. Return the CRT GRID SELECTOR switch to NORMAL position and disconnect all coaxial cables.

49. Check Z Axis Input Cathode Modulation

a. Requirement—A 10 volt high frequency signal will cause noticeable modulation.

b. Turn the POWER switch OFF then replace the Test Load/Pulser plug-in unit with a Type 1A1 or equivalent amplifier unit, set the A TIME/CM switch to 20 μ SEC and turn the POWER switch ON.

c. Apply an approximate 50 kHz signal from the Constant Amplitude Signal Generator through a BNC T connector and two coaxial cables to the EXT CRT CATHODE connector and the Input connector of the Vertical plug-in unit (Type 1A1).

d. Monitor the signal amplitude of the signal generator and adjust its output amplitude for a signal amplitude of 10 volts peak to peak.

e. Check—Intensity modulation must be visible on the display with the upper portion of the sine wave dimmed and the lower portion intensified. The INTENSITY control setting may require adjustment to observe the modulation. Fig. 5-13.

f. Remove the Constant Amplitude Signal Generator signal and cables from the Type 549 and replace the BNC cap on the EXT CRT CATHODE connector.

SECTION 6

CALIBRATION

Introduction

This calibration procedure can be used either for complete calibration of the Type 549 to return it to original performance, or as an operational check of instrument performance. Completion of every step in this procedure returns the Type 549 to original factory performance standards. If it is desired to merely touch up the calibration, perform only those steps entitled Adjust.

NOTE

The Adjust steps provide a check of instrument performance before the adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met.

General Information

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section of the Instruction Manual.

This procedure is arranged in a sequence which allows this instrument to be calibrated with the least interaction of adjustments and reconnection of equipment. If desired, the steps may be performed out of sequence or a step may be done individually. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts of the instrument. When a step interacts with others, the steps which need to be checked will be noted.

The location of test points and adjustments is shown in each step. Waveforms which are helpful in determining the correct adjustments or operation are also shown.

EQUIPMENT REQUIRED

(see Figs. 6-1 and 6-2)

General

The following equipment or its equivalent is required for complete calibration of the Type 549. Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Special Calibration Fixtures

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed under Equipment Required can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Test oscilloscope. Bandwidth, DC to 30 MHz; minimum deflection factor, 0.005 volts/division. Tektronix 540-series Oscilloscope with Type B Plug-In Unit and Tektronix P6006 Probe recommended.

2. Test Load/Pulser Plug-In Unit, containing a pulse generator capable of producing pulses with a risetime of 3 ns or faster. Tektronix Calibration Fixture 067-0521-00.

3. Plug-in unit, bandwidth DC to 30 MHz. Tektronix 1-series plug-in units (1A1, 1A2) recommended.

4. $1\times$ probe. Tektronix P6028 Probe recommended. Part No. 010-0074-00.

5. Variable autotransformer. Must be capable of supplying at least 650 watts over a voltage range of 94 to 138 volts (187 to 279 volts for 230-volt nominal line). If autotransformer does not have an AC (RMS) voltmeter to indicate output voltage, monitor output with an AC (RMS) voltmeter. For example, General Radio W10MT3W Metered Variac Autotransformer.

6. Time-mark generator. Marker outputs, 5 seconds to .1 microsecond; sine-wave output, 50 MHz (20 ns); accuracy 0.001%. Tektronix Type 184 Time-Mark Generator recommended.

7. Standard amplitude calibrator. Amplitude accuracy within 0.25%; signal amplitude, range 100 millivolts to 100 volts in calibrated steps with a frequency of approximately 1 kHz. Must have mixed display feature. Tektronix Calibration Fixture 067-0502-00 recommended.

8. Constant amplitude signal generator. Frequency range 50 kHz and 350 kHz to above 30 MHz. Output amplitude, variable to 6 volts, with an amplitude accuracy within $\pm 3\%$ from 50 kHz to above 30 MHz. Tektronix 191 Constant Amplitude Signal Generator recommended.

9. DC voltmeter. Minimum sensitivity rating 20,000 ohms/volts; range at least 4000 volts full scale with an accuracy checked to within 1% at 12.4, 100, 150, 225, 300, 350, 500 volts and at least 3% at 3700 volts.

10. Microammeter (two). Minimum range 0 to 60 μ A.

11. Termination. Impedance, 50 ohm; accuracy $\pm 3\%$; BNC type connectors. Tektronix Part No. 011-0049-00.

12. Coaxial cables (three). Impedance, 50 ohm; length 42 inches; connectors, BNC. Tektronix Part No. 012-0057-00.

13. T connector, BNC. Tektronix Part No. 103-0030-00.

14. Adapter, GR to BNC Female. Tektronix Part No. 017-0063-00.

15. Viewing Hood. Tektronix Part No. 016-0039-00.

16. Patch cord, about 4 inches long. Equipped with alligator clips on each end.

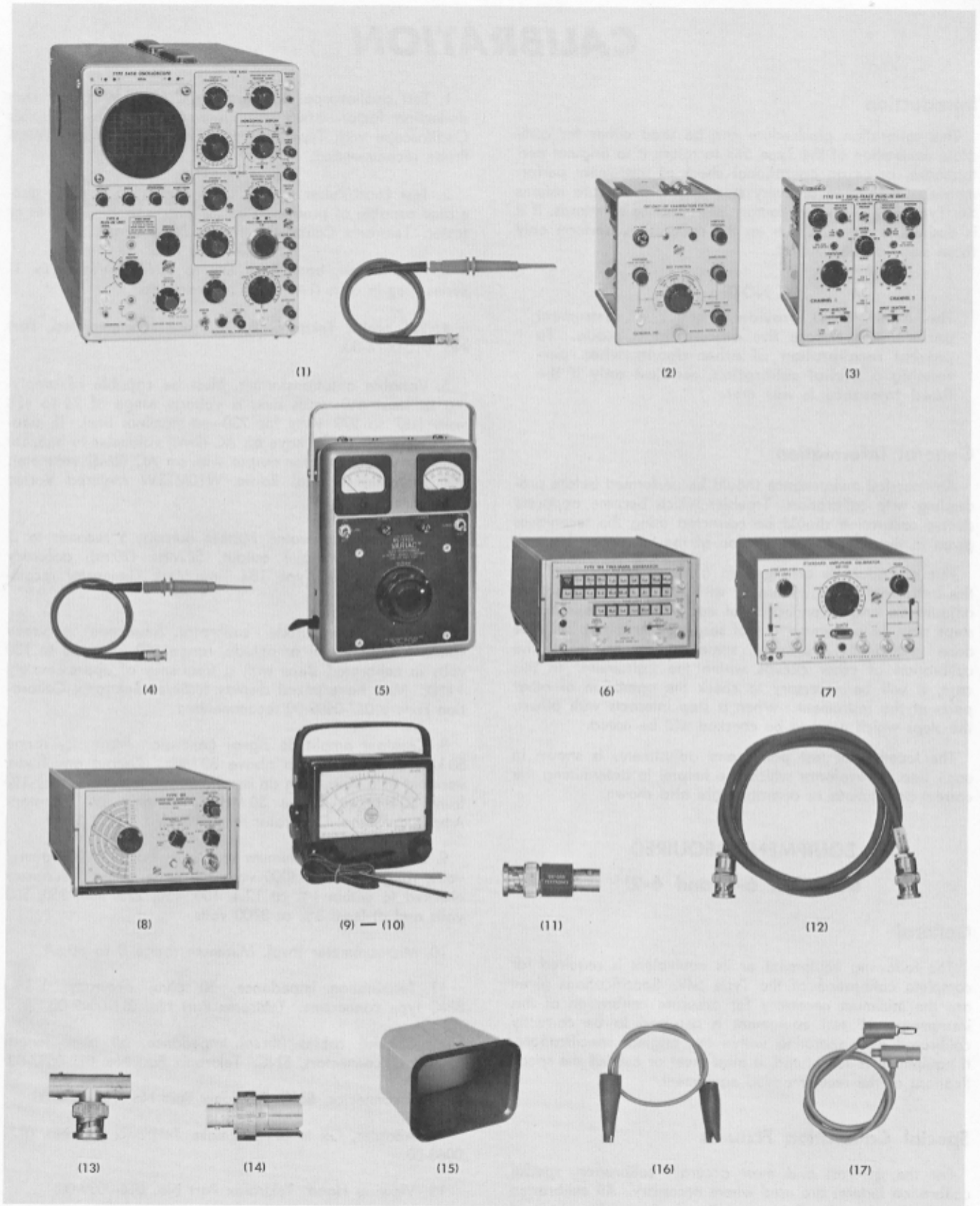


Fig. 6-1. Equipment required for calibrating the Type 549.

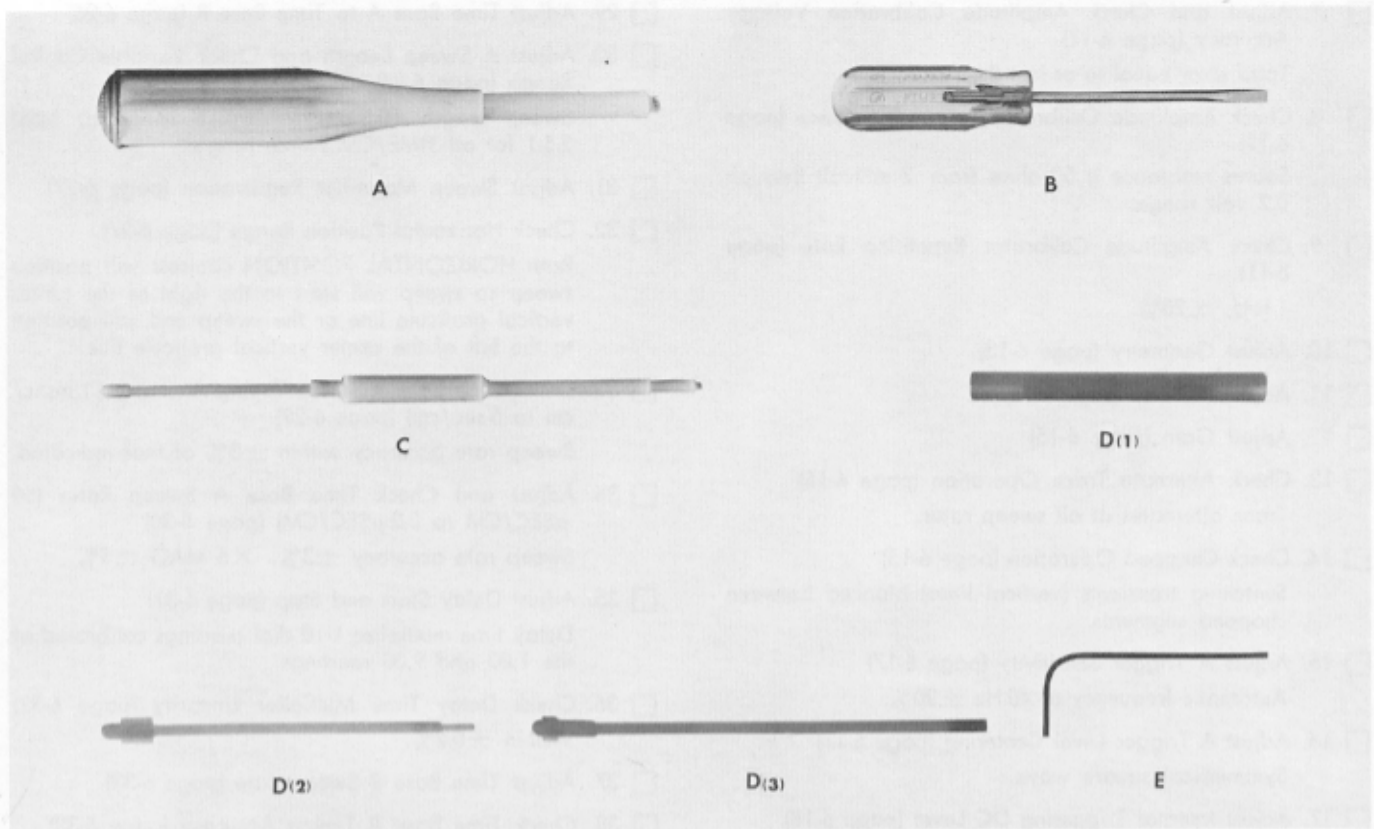


Fig. 6-2. Adjusting tools required for calibrating the Type 549.

17. Patch cord, about 18 inches long, BNC to banana plug.

18. Adjustment tools

Description	Tektronix Part No.
a. Insulated screwdriver, 1½ inch shaft, non-metallic	003-0000-00
b. Screwdriver, 3/32 inch bit	003-0192-00
c. Tuning rod, 5 inches	003-0301-00
d. Alignment, tool kit	003-0007-00
Includes:	
Handle	003-0307-00
Insert, for 5/64 inch (ID) hex cores	003-0310-00
Insert, with screwdriver tip	003-0334-00
e. Hexagonal Key wrench, 1/16 inch	003-0106-00
f. Hexagonal key wrench, 5/64 inch	003-0090-00

CALIBRATION RECORD AND INDEX

This Abridged Calibration Procedure is provided to aid in checking the operation of the Type 549. It may be used as a calibration guide by the experienced calibrator, or it may be used as a calibration record. Since the step numbers and titles used here correspond to those in the

complete Calibration Procedure, the following procedure serves as an index to locate a step in the complete Calibration Procedure. Characteristics are those listed in the Characteristics section of the Instruction Manual.

Type 549 Serial No. _____

Calibration Date _____

- 1. Adjust -150 Volt Power Supply (page 6-7)
- 2. Check Low Voltage Power Supply Regulation and Ripple (page 6-7)
- 3. Adjust High Voltage Power Supply (page 6-8)
-3700 Volts, ±100 volts.
- 4. Adjust Intensity Range (page 6-8)
Spot just visible on screen with Intensity control fully clockwise.
- 5. Check High Voltage Regulation (page 6-8)
No trace blooming when input line voltage is changed through 103.5 to 126.5 VAC.
- 6. Adjust Graticule Position and Check Scan Area (page 6-8)
Position center graticule line to the slit between upper and lower storage target. Scan area at least 6 × 10 cm.

Calibration—Type 549

- 7. Adjust and Check Amplitude Calibration Voltage Accuracy (page 6-11)
Total error equal to or less than $\pm 2\%$.
- 8. Check Amplitude Calibrator Source Resistance (page 6-11)
Source resistance is 50 ohms from .2 millivolt through 0.2 volt range.
- 9. Check Amplitude Calibrator Repetition Rate (page 6-11)
1 kHz, $\pm 25\%$.
- 10. Adjust Geometry (page 6-13)
- 11. Adjust DC Bal (page 6-14)
- 12. Adjust Gain (page 6-15)
- 13. Check Alternate Trace Operation (page 6-15)
Trace alternates at all sweep rates.
- 14. Check Chopped Operation (page 6-15)
Switching transients (vertical lines) blanked between chopped segments.
- 15. Adjust A Trigger Sensitivity (page 6-17)
Automatic frequency of 40 Hz $\pm 20\%$.
- 16. Adjust A Trigger Level Centering (page 6-17)
Symmetrical square wave.
- 17. Adjust Internal Triggering DC Level (page 6-18)
Stable triggering in the + and - positions of the SLOPE switch.
- 18. Check A Trigger Level Control Position (page 6-18)
White dot on the Triggering LEVEL control centers in the gap between the + and - arrows.
- 19. Adjust A Preset Adjustment (page 6-18)
- 20. Adjust B Trigger Level Centering Adjustment (page 6-20)
Symmetrical square wave.
- 21. Check B Trigger Level Control Position (page 6-21)
White dot on the Triggering LEVEL control centers in the gap between the + and - arrows.
- 22. Adjust B Preset Adjustment (page 6-22)
- 23. Adjust the A Lockout Level (page 6-22)
Sawtooth to gate amplitude ratio between 1:1 and 2:3. Gate amplitude equal to or greater than 9 volts.
- 24. Adjust the B Lockout Level (page 6-22)
Sawtooth to gate amplitude ratio between 1:1 and 2:3. Gate amplitude equal to or greater than 9 volts.
- 25. Check Single Sweep Operation (page 6-23)
- 26. Adjust Magnifier Gain (page 6-25)
- 27. Adjust Sweep Calibration (page 6-25)
Correct sweep timing for indicated B TIME/CM AND DELAY TIME switch settings.
- 28. Adjust B Sweep Length (page 6-25)
Variable from 4 cm or less to 10 cm or more.
- 29. Adjust Time Base A to Time Base B (page 6-26)
- 30. Adjust A Sweep Length and Check Variable Control Range (page 6-27)
Sweep length 10.5 cm; VARIABLE range at least 2.5:1 for all TIME/CM switch ranges.
- 31. Adjust Sweep Magnifier Registration (page 6-27)
- 32. Check Horizontal Position Range (page 6-27)
Both HORIZONTAL POSITION controls will position sweep so sweep will start to the right of the center vertical graticule line or the sweep end will position to the left of the center vertical graticule line.
- 33. Check Time Base A Sweep Timing Accuracy (.1 msec/cm to 5 sec/cm) (page 6-29)
Sweep rate accuracy within $\pm 3\%$ of that indicated.
- 34. Adjust and Check Time Base A Sweep Rates (50 μ SEC/CM to 0.2 μ SEC/CM) (page 6-30)
Sweep rate accuracy $\pm 3\%$. $\times 5$ MAG $\pm 5\%$.
- 35. Adjust Delay Start and Stop (page 6-31)
Delay time multiplier 1-10 dial readings calibrated at the 1.00 and 9.00 readings.
- 36. Check Delay Time Multiplier Linearity (page 6-32)
Within $\pm 0.2\%$.
- 37. Adjust Time Base B Sweep Rate (page 6-33)
- 38. Check Time Base B Timing Accuracy (page 6-33)
Within $\pm 3\%$ of indicated sweep rate.
- 39. Check A Sweep Holdoff Time (page 6-35)
- 40. Check B Sweep Holdoff Time (page 6-35)
- 41. Adjust DC Shift (page 6-37)
- 42. Adjust High Frequency Response (page 6-37)
Optimum fast-rise square-wave response.
- 43. Check the Effect of Display Position on Transient Response (page 6-37)
Peak-to-peak aberrations due to display position must not exceed 3%.
- 44. Check Risetime (page 6-37)
Less than or equal to 12 ns.
- 45. Check Vertical Signal Out (page 6-38)
Amplitude 1.5 V per cm of display deflection $\pm 20\%$; risetime less than or equal to 0.5 μ s.
- 46. Check Vertical Amplitude Bandwidth (page 6-40)
Equal to or higher than 30 MHz.
- 47. Check Vertical Signal Out Bandwidth (page 6-40)
Equal to or higher than 700 kHz.
- 48. Adjust External Horizontal DC Balance (page 6-42)
Baseline should not shift more than 2 mm (1 minor graticule division).
- 49. Adjust External Horizontal $10\times$ Compensation (page 6-42)
Optimum square-wave response, not more than 3% aberrations.

- 50. Check External Horizontal Input Deflection Factor (page 6-42)
 - 1× equal to or less than 0.2 V/cm.
 - 10× equal to or less than 2.0 V/cm.
- 51. Check External Horizontal Amplifier Bandwidth (page 6-43)
 - Bandwidth equal to or higher than 350 kHz.
- 52. Adjust FG Cath Level and Backplate Balance (page 6-44)
 - Flood cathode to 175 V with respect to +300 V and balance both targets
- 53. Adjust Collimation (page 6-45)
 - Maximum uniform brightness over the storage target area.
- 54. Adjust Backplate Level (page 6-45)
- 55. Adjust Erase Pulse (page 6-48)
- 56. Check Viewing Time and After Sweep Auto Erase Operation (page 6-49)
 - Viewing time variable from approximately 0.5 s to 5.0 s. Automatic erasure and resets single sweep at the end of sweep.
- 57. Adjust Non-Store Level (page 6-49)
 - Screen erases promptly when a fully written screen is changed from STORE to OFF mode.
- 58. Adjust Enhance Width and Enhance Level (page 6-49)
 - Maximum writing speed without background deterioration.
- 59. Check Storage Writing Speed (page 6-51)
 - Must equal 0.5 cm/μs or higher.
- 60. Check Enhance Writing Speed (page 6-52)
 - Writing speed equal to or greater than 5 cm/μs.
- 61. Check Integrate Traces Operation (page 6-54)
 - Stored Trace disappears when INTEGRATE TRACES button is depressed, and reappears when button is released.
- 62. Adjust Sawtooth Current (page 6-54)
 - 0.2 mA/cm of sweep, at pin 6 of J-11 connector.

CALIBRATION PROCEDURE

General

In the following calibration procedure, a test equipment setup is shown for each major setup change. Complete control settings are listed beneath the picture. As an aid in locating individual controls which have been changed during complete calibration, the control names are printed in bold type. If only a partial calibration is preformed, start with the setup preceding the desired portion of the procedure.

NOTE

When performing a complete recalibration, best performance will be provided if each adjustment is made to the exact setting, even if the Check is within the allowable tolerance. The following procedure uses the equipment listed under Equipment Required. If substitute equipment is used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary

1. Remove the side and bottom covers from the Type 549 and install the Test Load/Pulser Plug-In Unit.

CAUTION

Check **LINE RANGE**, **LOW-MED-HIGH** Selector switches for correct setting.

2. Connect the autotransformer to a suitable power source.
3. Connect the Type 549 power cord to the autotransformer output.
4. Set the Autotransformer to 115 (or 230) volts and **LINE RANGE** switch to **MED** (115 or 230 V) position.
5. Turn **POWER** switch **ON**.
6. Check—Delay time of the delay relay. The relay armature should pull in with an audible click within 15 to 60 seconds.
7. Allow at least 20 minutes warm up at ambient temperature of 25° C, ±5° C, for stabilizing before checking the instrument to given accuracy.

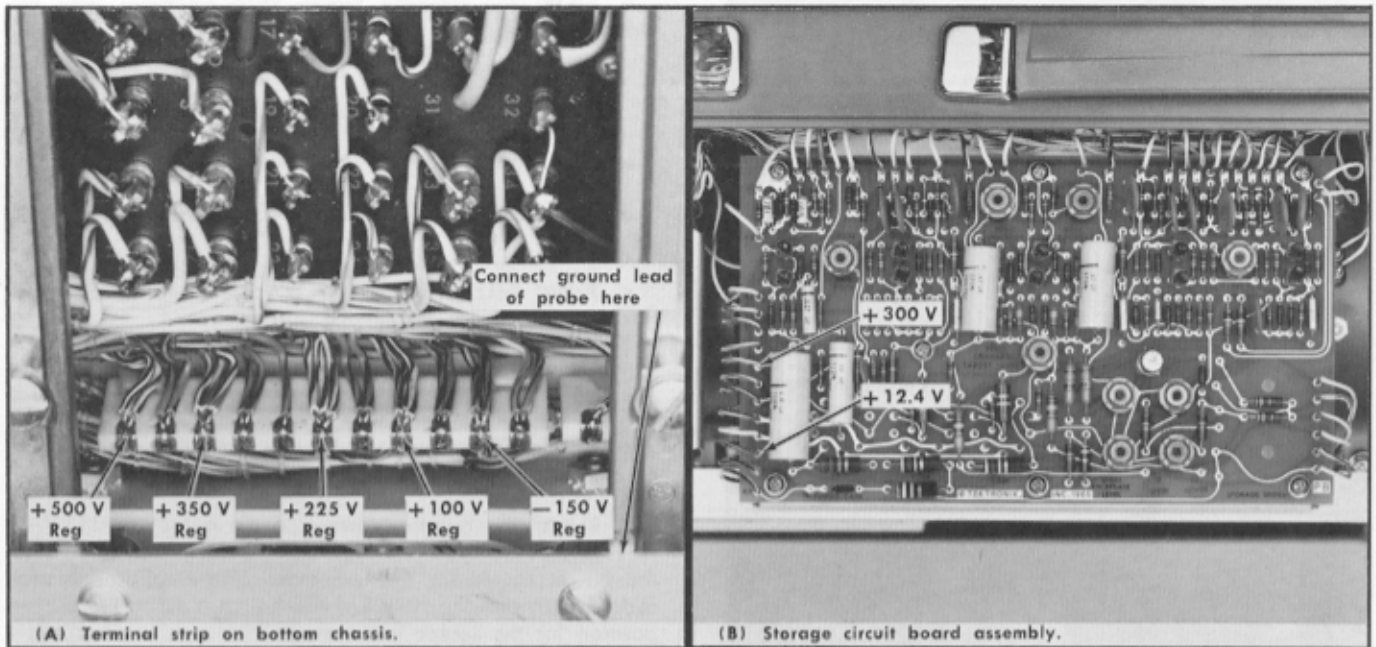


Fig. 6-4. Low Voltage power supply test point locations.

Test Oscilloscope

Time/Cm	5 msec
Input Selector	AC
Volts/cm	.005

1. Adjust —150-Volt Power Supply

- a. Equipment setup is shown in Fig. 6-3.
- b. Connect the DC voltmeter between the —150-volt check-point and ground (see Fig. 6-4A).
- c. Adjust —150 Adj R616 for —150 volt reading. Fig. 6-5B.
- d. Interaction—Operation of all circuits within the Type 549 are affected by —150 volt supply.

2. Check Low Voltage Power Supply Regulation and Ripple

- a. Equipment setup is shown in Fig. 6-3.
- b. Connect the DC voltmeter between each low voltage check-point and chassis ground to check regulation and connect the 1X probe from the test oscilloscope to each point to check ripple. See Fig. 6-4.
- c. Check each voltage and ripple amplitude against tolerances listed in Table 6-1.

NOTE

Ripple must be checked at the check points illustrated.

Set the Load/Pulser Unit Test Function Selector first to Low Load, autotransformer at 127 VAC (254 VAC), then set the Test Function switch at High Load, autotransformer at 103 VAC (206 VAC) and repeat the check.

d. Set the Type 549 LINE RANGE switch to LOW 104 V (208 V) position and again check each voltage and ripple amplitude against tolerances listed in Table 6-1. Check with the test plug-in, Test Function selector first at High Load, autotransformer at 94 VAC (187 VAC), then with the Test Function switch at Low Load, autotransformer at 114 VAC (228 VAC).

e. Set the LINE RANGE switch to HIGH 127 V (254 V) position and again check each voltage and ripple amplitude against tolerances listed in Table 6-1. Check with the Load/Pulser Unit, Test Function selector at Low Load, autotransformer at 139 VAC (278 VAC) then with the Test Function selector at High Load, autotransformer at 115 VAC (230 VAC).

TABLE 6-1

Supply	Tolerance ¹	Maximum Ripple
—150 V	±3.0 V	5 mV
—12.4 V	±.5 V	10 mV
+100 V	±3 V	10 mV
+225 V	±6.75 V	5 mV
+300 V ²	±15 V	100 mV
+350 V	±10.5 V	20 mV
+500 V	±15 V	20 mV

¹Applicable when line contains 2% or less harmonic distortion.

²Push INTEGRATE TRACES button and check the 300 V supply for not more than 3 volt change.

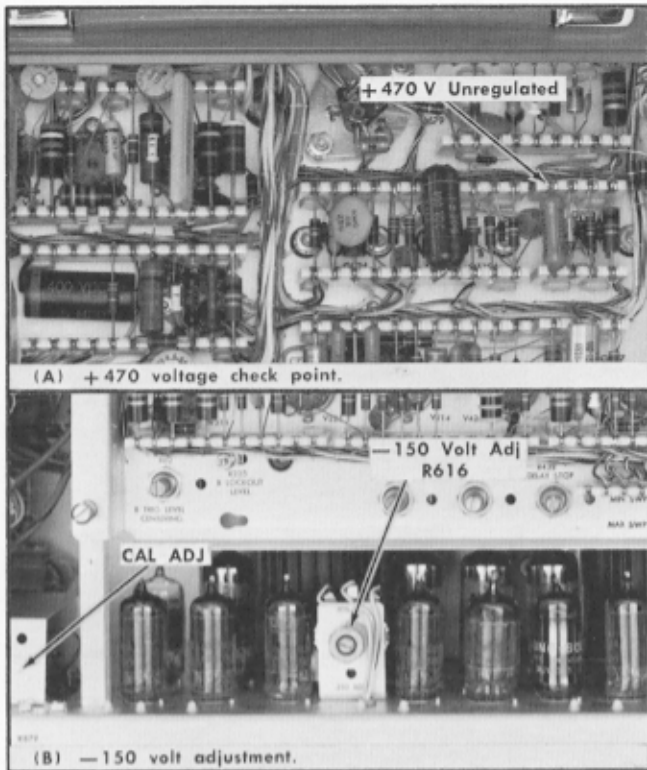


Fig. 6-5. Location of +470 volt check and -150 volt adjustment.

f. Set the test plug-in unit Test Function selector to Low Load, LINE RANGE switch to MED and the autotransformer for 115 VAC (230 VAC) output.

g. Disconnect the test oscilloscope probe and the DC voltmeter.

3. Adjust High Voltage Power Supply ①

- Equipment setup is shown in Fig. 6-3.
- Connect the DC voltmeter between the -3700 volt supply and ground (see Fig. 6-5).
- Adjust the High Voltage adjustment R855 (see Fig. 6-6) for -3700 volts.
- Interaction—Operation of storage and the CRT circuits within the Type 549 depend on this adjustment.

4. Adjust Intensity Range ①

- Equipment setup is given in Step 3.
- Push the LOCATE button and center the display with the HORIZONTAL and Vertical position controls.
- Set the NORM-SINGLE SWEEP switch to SINGLE SWEEP position.
- Turn the Intensity Range adjustment R815 (Fig. 6-6) fully counterclockwise and then turn the INTENSITY control fully clockwise.

e. Adjust the Intensity Range R815 clockwise until the writing beam (spot) is just visible on the screen.

5. Check High Voltage Regulation

- Equipment setup is given in step 4.
- Set the NORM-SINGLE SWEEP switch to NORM position.
- Adjust INTENSITY and FOCUS controls for a defocused trace with nominal brightness.
- Change output voltage of the autotransformer from 103.5 to 126.5 VAC.
- Check—There must not be any indication of blooming or more than ± 40 volt change in the high voltage.
- Return the autotransformer to an output of 115 VAC (230 VAC). The Type 549 may now be connected directly to the power source for the remainder of the calibration procedure, provided the LINE RANGE switch is set to the proper position for the source line voltage.
- Turn the INTENSITY control fully counterclockwise and remove the DC voltmeter.

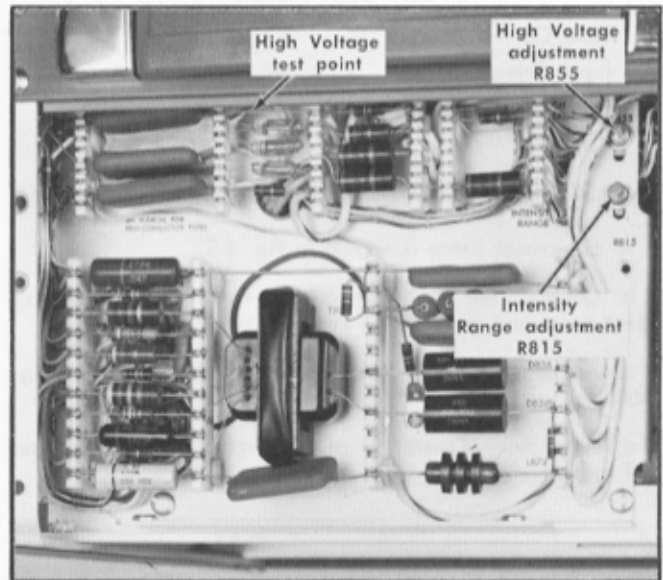


Fig. 6-6. Location of High Voltage test point, High Voltage adjustment R855 and Intensity Range adjustment R815.

6. Adjust Graticule Position and Check Scan Area ①

- Equipment setup is given in Step 5.
- Adjust INTENSITY, FOCUS and ASTIG controls for a well focused trace with nominal brightness.
- Remove the bezel nuts and bezel to expose the graticule alignment cam. See Fig. 4-7, Section 4.

d. Adjust the variable nylon cam to align the center horizontal graticule line to the slit between the two storage screens, then tighten the set-screw in the cam.

e. Push the STORE buttons for the UPPER and LOWER SCREEN STORAGE.

f. Write the entire storage area by slowly positioning the

trace vertically over the display area.

g. Check—The scan area is at least 6×10 cm.

h. Push both ERASE buttons to erase the screen area, then push both OFF buttons for the UPPER and LOWER SCREEN STORAGE.

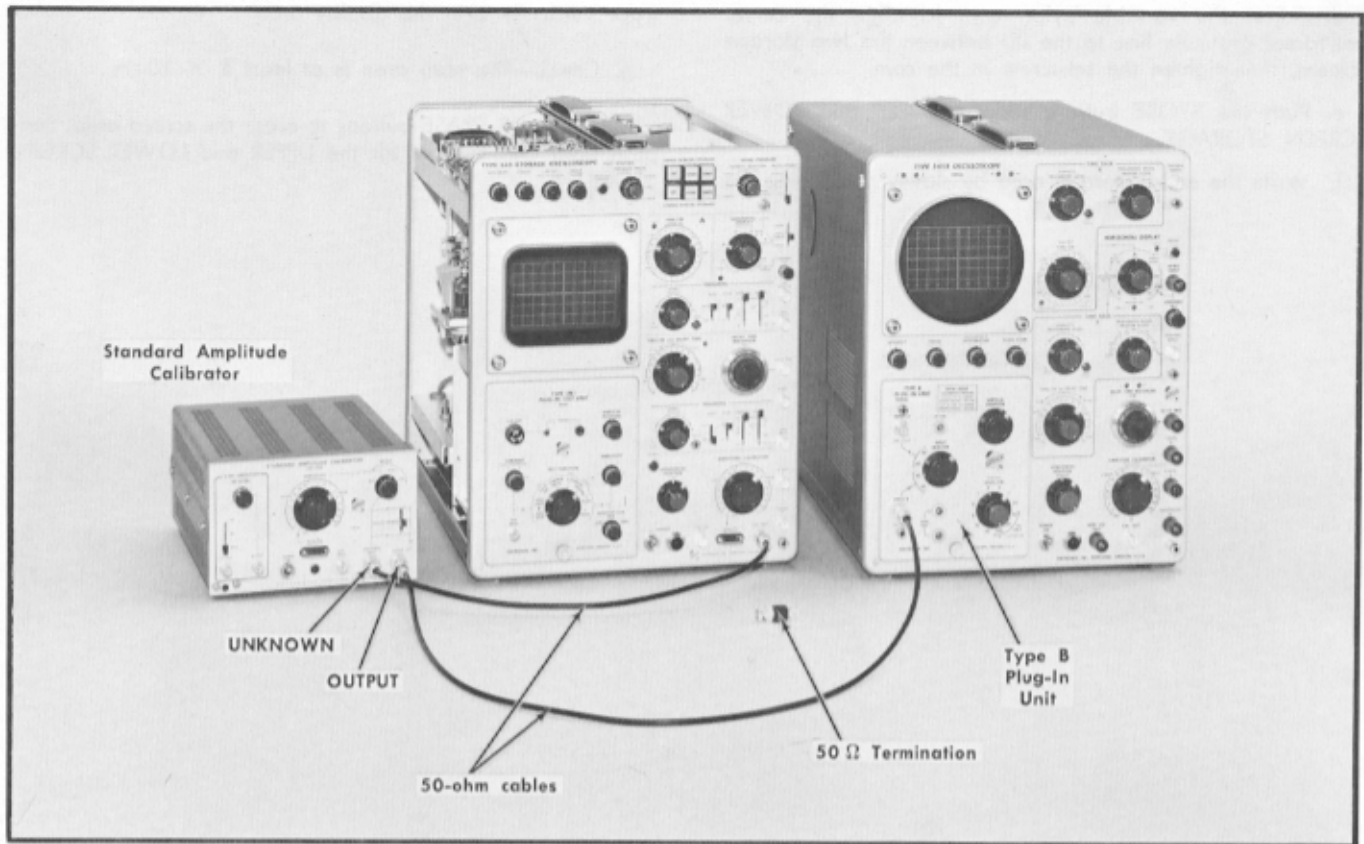


Fig. 6-7. Equipment setup for steps 7, 8 and 9.

Type 549

CRT controls

INTENSITY	Counterclockwise
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC
LENGTH	Clockwise

DELAY TIME MULTIPLIER

1-10	1.00
------	------

TRIGGERING controls (both A and B)

LEVEL	Clockwise
STABILITY	Clockwise
Lever controls	All in up position
HORIZONTAL POSITION	Midrange
FINE	Midrange

AMPLITUDE CALIBRATOR 100 Volts

Test Plug-In Unit

Test Function	Low Load
Variable	Counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

Test Oscilloscope

Time/cm	5 msec
Triggering	Auto
Coupling	AC
Slope	+
Source	Line
Volts/cm	.5

7. Adjust and Check Amplitude Calibrator Voltage Accuracy

- a. Equipment setup is shown in Fig. 6-7.
- b. Set the Standard Amplitude Calibrator to +100 VOLTS and the Mode selector to \pm DC mixed.
- c. Remove V875 from the Amplitude Calibrator circuit.
- d. Adjust the Cal Ampl R879 (Fig. 6-8) for a null on the test oscilloscope display (display appears as a straight line).
- e. Check the error at each AMPLITUDE CALIBRATOR output voltage setting as listed in Table 6-2. Error is listed as trace separation amplitude.

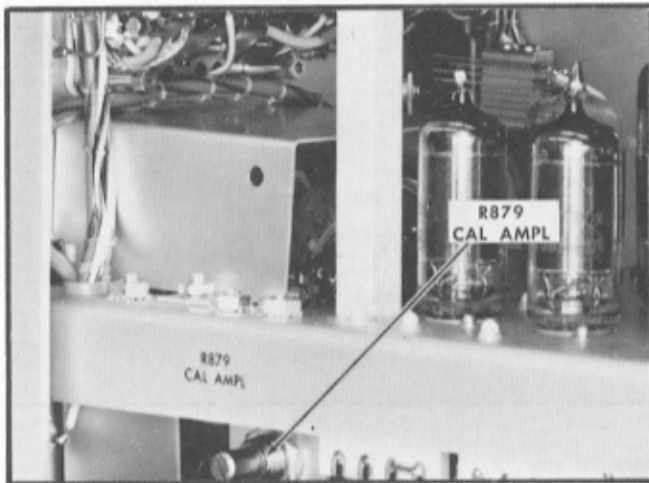


Fig. 6-8. Location of Cal Amp adjustment R879.

TABLE 6-2

Standard Amplitude Calibrator & Type 549 AMPLITUDE CALIBRATOR	Test Oscilloscope Volts/cm	Max Error ^a Allowed $\pm 2\%$
100	.5	0 Adjusted
50	.5	2 cm
20	.2	2 cm
10	.1	2 cm
5	.05	2 cm
2	.02	2 cm
1	.01	2 cm
.5	.005	2 cm
.2	.005	8 mm
.1	.005	4 mm

^aThe Standard Amplitude Calibrator chops between the two voltage levels. The test oscilloscope display will show a square-wave voltage difference between the two calibrator levels (a straight line trace represents zero (0) voltage difference).

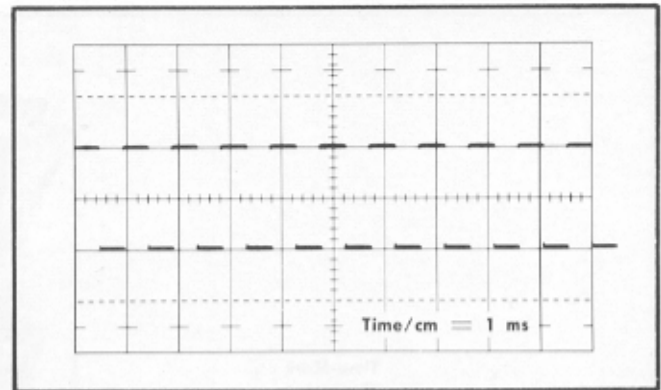


Fig. 6-9. Typical display showing Amplitude Calibrator repetition rate.

- f. Add the error (in %) found in the 0.1 volt position to the worst error in the same direction (+ or -) found in the previous positions.
- g. Check—Total error must be less than $\pm 2\%$.

8. Check Amplitude Calibrator Output Resistance

- a. Equipment setup is shown in Fig. 6-7.
- b. Terminate the AMPLITUDE CALIBRATOR output into a 50 ohm termination between the Standard Amplitude Calibrator unknown input connector and the 50 ohm coaxial cable.
- c. Set the AMPLITUDE CALIBRATOR to 0.2 volts, the Standard Amplitude Calibrator to 0.1 volts and the test oscilloscope Volts/cm to .005 position.
- d. Check—Straight line display on the test oscilloscope within ± 0.4 cm deflection ($\pm 2\%$).
- e. Replace V875 and remove the 50 ohm termination. Reconnect the 50 ohm coaxial cable to the unknown input connector of the Standard Amplitude Calibrator.

9. Check Amplitude Calibrator Repetition Rate

- a. Equipment setup is shown in Fig. 6-7.
- b. Set the AMPLITUDE CALIBRATOR selector to .2 VOLTS, the Standard Amplitude Calibrator output selector to Unknown position.
- c. Set the test oscilloscope Trigger Slope to +Int, Time/cm to 1 mSEC, and Volts/cm to .1 volts position.
- d. Check—Test oscilloscope display contains 7.5 to 12.5 cycles in 10 divisions (repetition rate is 1 kHz $\pm 25\%$). See Fig. 6-9.
- e. Disconnect all test equipment from the Type 549.

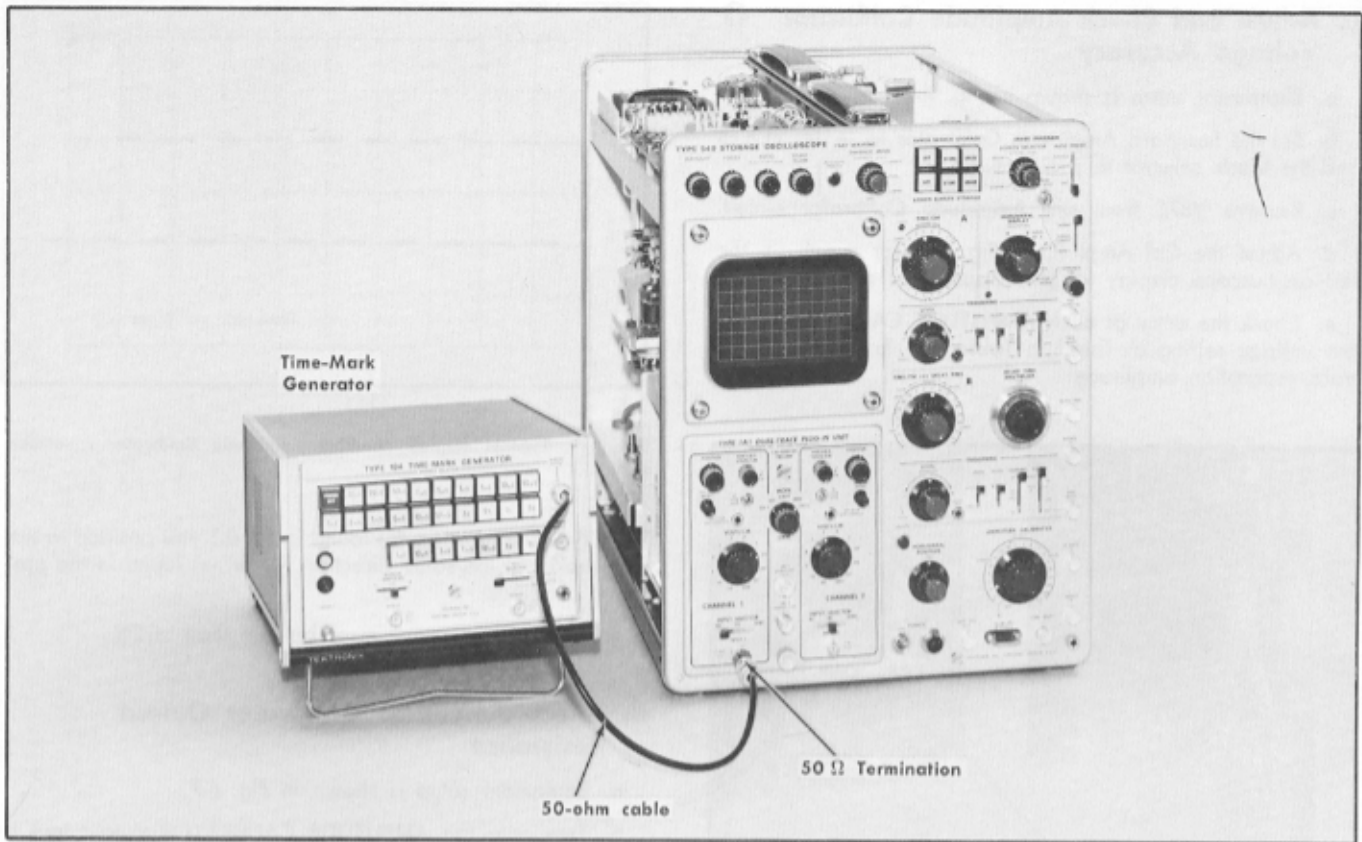


Fig. 6-10. Equipment setup for step 10.

Type 549

CRT controls

INTENSITY	Nominal brightness
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF

LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC
LENGTH	Clockwise

TRIGGERING controls (both A and B)

LEVEL	Clockwise
STABILITY	Clockwise
Lever controls	All in up position
DELAY TIME MULTIPLIER	
1-10	1.00
HORIZONTAL POSITION	Midrange
FINE	Midrange
AMPLITUDE CALIBRATOR	OFF

10. Adjust Geometry

IMPORTANT

Flood gun beam collimation must be within performance specifications before performing this step. See step 53.

- a. Equipment setup is shown in Fig. 6-10.
- b. Turn the POWER switch to OFF then replace the test plug-in unit with a 1-series (Type 1A1, 1A2 or equivalent) plug-in unit. Turn the Type 549 POWER switch ON.
- c. Apply 1.0 ms markers from the Time-Mark Generator to the Type 1A1 input connector through a 50 ohm coaxial cable and 50 ohm termination.
- d. Adjust the Vertical position control to place the display baseline below the graticule area and set the Volts/cm switch so the time-markers over-scan the graticule area.
- e. Adjust the Geometry R846 (Fig. 6-11C) for optimum straight vertical markers parallel to the extreme left and right graticule vertical lines (Fig. 6-11B).
- f. Remove the time marker signals from the vertical input connector.
- g. Turn the POWER switch OFF and remove the Type 1A1. Re-install the test plug-in unit Load/Pulsar. Turn the POWER switch ON.

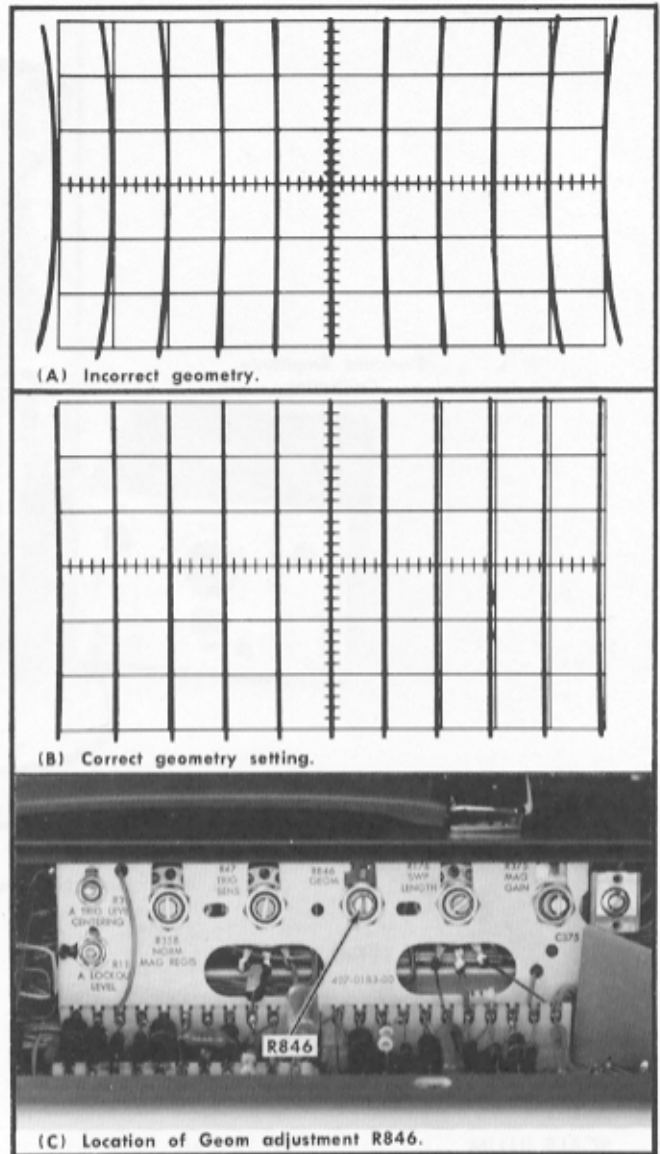


Fig. 6-11. Geometry adjustment.

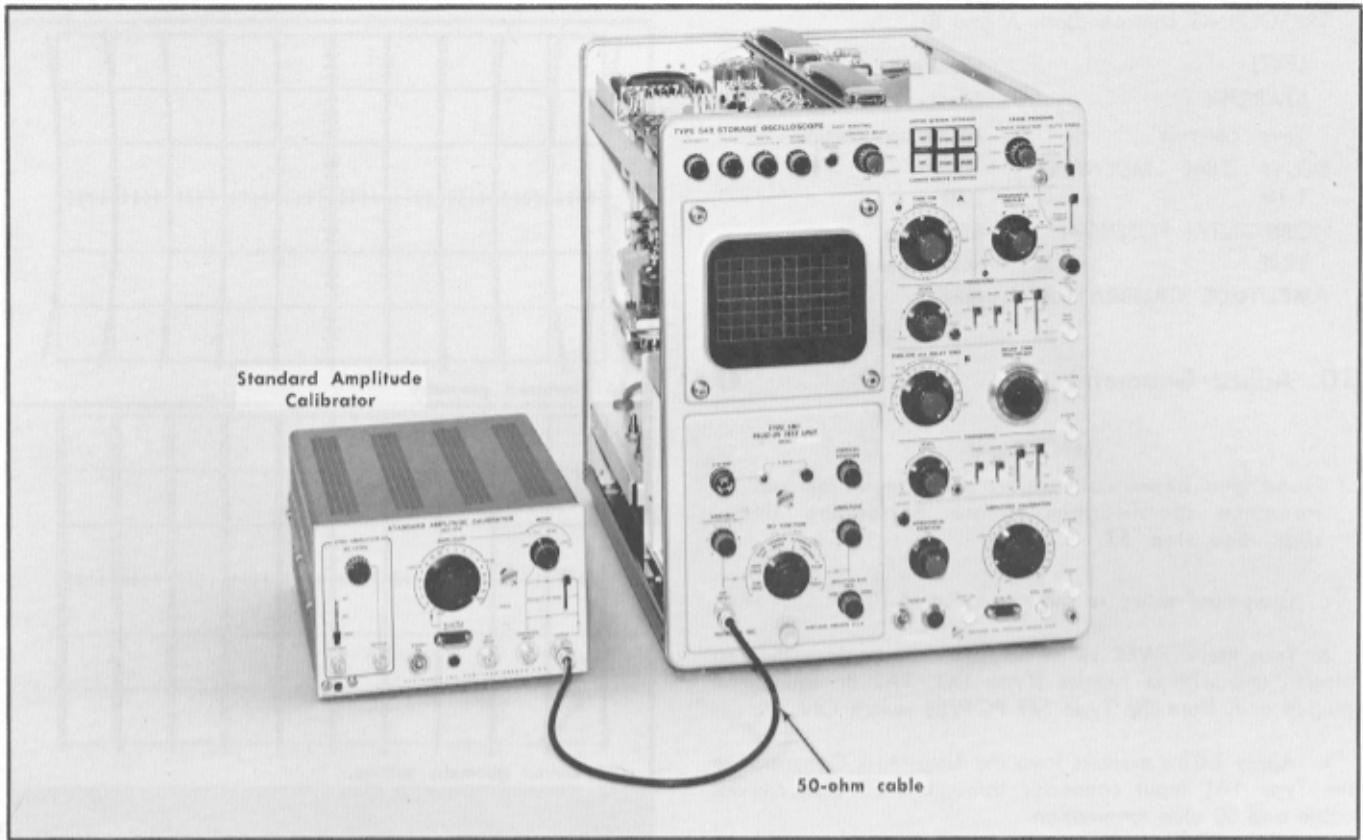


Fig. 6-12. Equipment setup for steps 11 through 14.

TYPE 549

CRT controls

INTENSITY	Nominal brightness
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC

LENGTH	Clockwise
TRIGGERING controls (both A and B)	
LEVEL	Clockwise
STABILITY	Clockwise
Lever controls	All in up position
DELAY TIME MULTIPLIER	
1-10	1.00
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	OFF

Test Plug-In Load/Pulsar Unit

Test Function	Common Mode
Variable	Counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

11. Adjust DC Balance

- a. Equipment setup is shown in Fig. 6-12.
- b. Adjust the DC Bal R495 (see Fig. 6-13) to position the trace to the horizontal graticule center line.

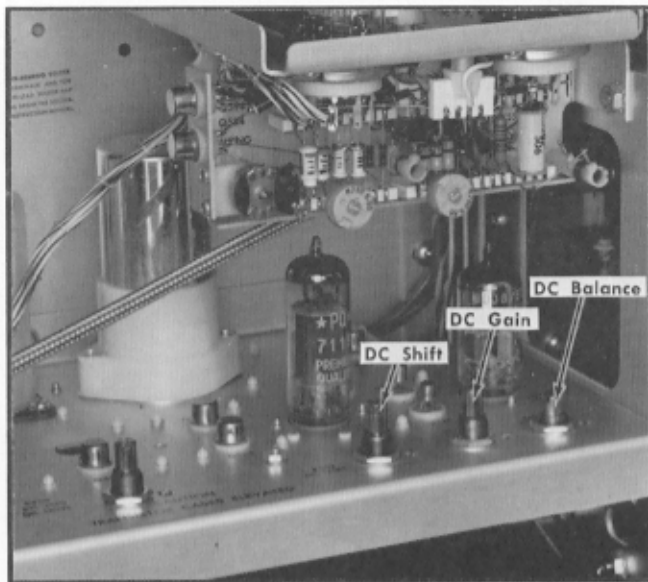


Fig. 6-13. Vertical amplifier DC adjustments.

12. Adjust Gain

IMPORTANT

Collimation must be within performance specification before performing this step. See step 53.

- Equipment setup is shown in Fig. 6-12.
- Set the test unit Test Function switch to Gain Set position.
- Apply a 100 volt square wave from the Standard Amplitude Calibrator to the test plug-in unit Ext Input connector.
- Adjust the Gain adjustment R520, (see Fig. 6-13) for a display amplitude of 4 cm.
- Adjust DC shift R502 for minimum waveform tilt.

13. Check Alternate Trace Operation

- Equipment setup is shown in Fig. 6-12.
- Change the test plug-in unit Test Function switch to the Alternate position.
- Set the Standard Amplitude Calibrator output to 20 volts, then center the display with the position controls.
- Check—Alternate trace operation at all settings of the A TIME/CM switch. At the slow sweep rates, alternate traces will consist of a single spot, then two spots vertically separated in amplitude according to the amplitude of the input signal from the amplitude calibrator.

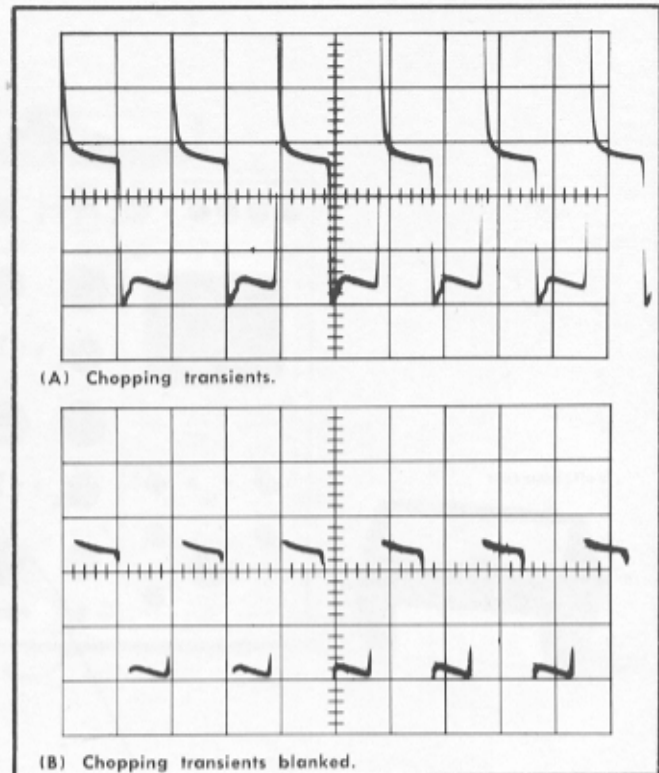


Fig. 6-14. Typical display when checking chopped operation.

- Set the HORIZONTAL DISPLAY switch to B position.
- Check—Alternate trace operation at all settings of the B TIME/CM AND DELAY TIME switch.
- Remove the Standard Amplitude Calibrator signal from the Ext Input connector.

14. Check Chopped Operation

- Equipment setup is given in step 13.
- Set the test plug-in unit Test Function switch to the Chopped position.
- Set the B TIME/CM AND DELAY TIME switch to 5 μ SEC.
- Check—Display area for a chopped waveform approximately 1 cycle per 2 cm. Fig. 6-14A.
- Set the CRT CATHODE SELECTOR switch (rear panel) to CHOPPED BLANKING position.
- Check—CRT display for complete blanking of switching transients (vertical lines) between chopped segments. Fig. 6-14B.
- Return the CRT CATHODE SELECTOR switch to NORMAL position.

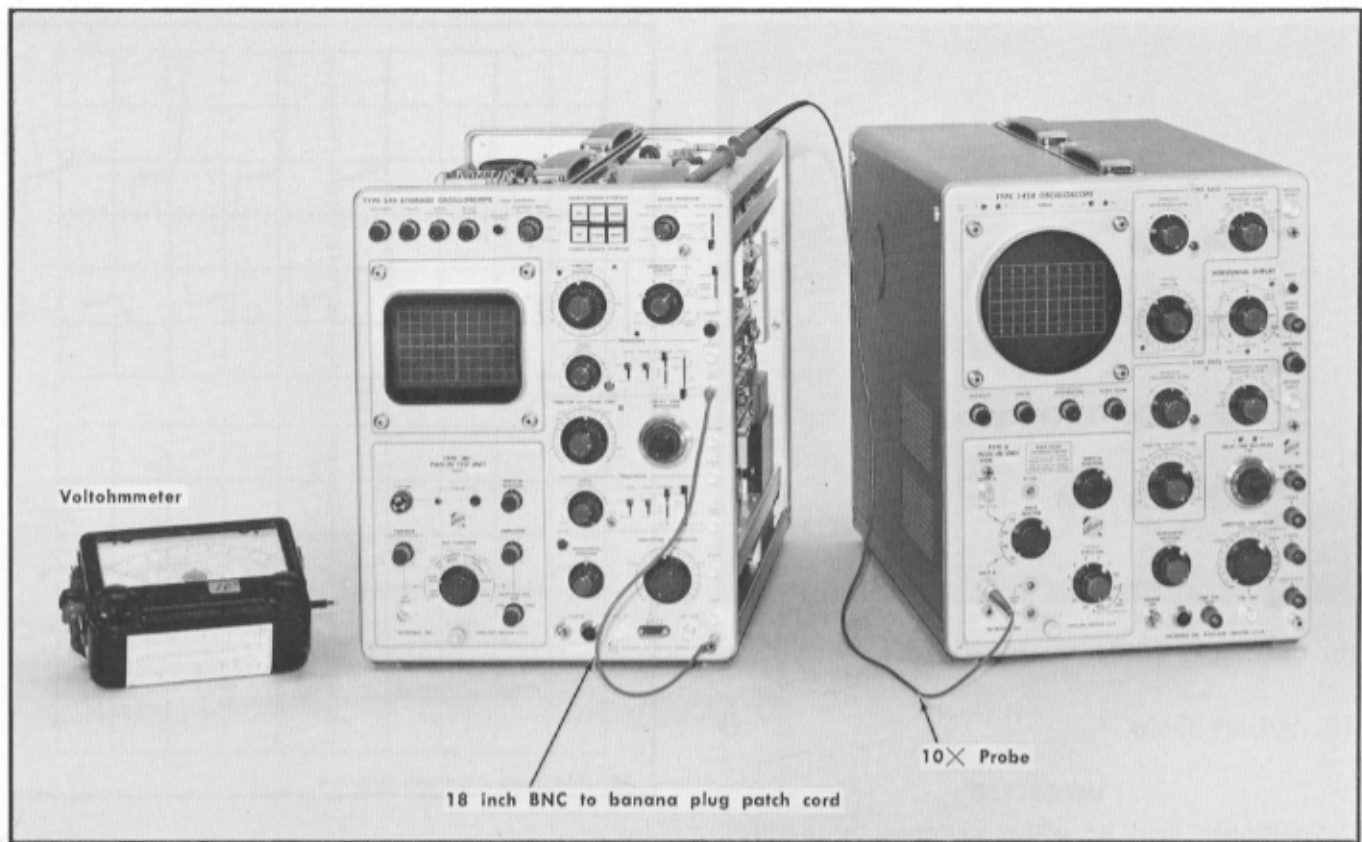


Fig. 6-15. Equipment setup for steps 15 through 19.

TIME BASE A TRIGGERING ADJUSTMENTS

IMPORTANT

Collimation must be within performance specifications before performing timing adjustments. See step 53.

Type 549

CRT controls

INTENSITY	Nominal brightness
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	MIN
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF

HORIZONTAL DISPLAY	A
MAGNIFIER	OFF

NORM-SINGLE SWEEP	NORM
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC
LENGTH	Clockwise
DELAY TIME MULTIPLIER 1-10	1.00

TRIGGERING controls (both A and B)

LEVEL	Clockwise
STABILITY	Clockwise
Lever controls	All in up position
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	1.0 VOLT

Test Plug-In Load/Pulsar Unit

Test Function	High Load
Variable	Counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

Test Oscilloscope

Time/cm	5 msec
Volts/cm	0.5

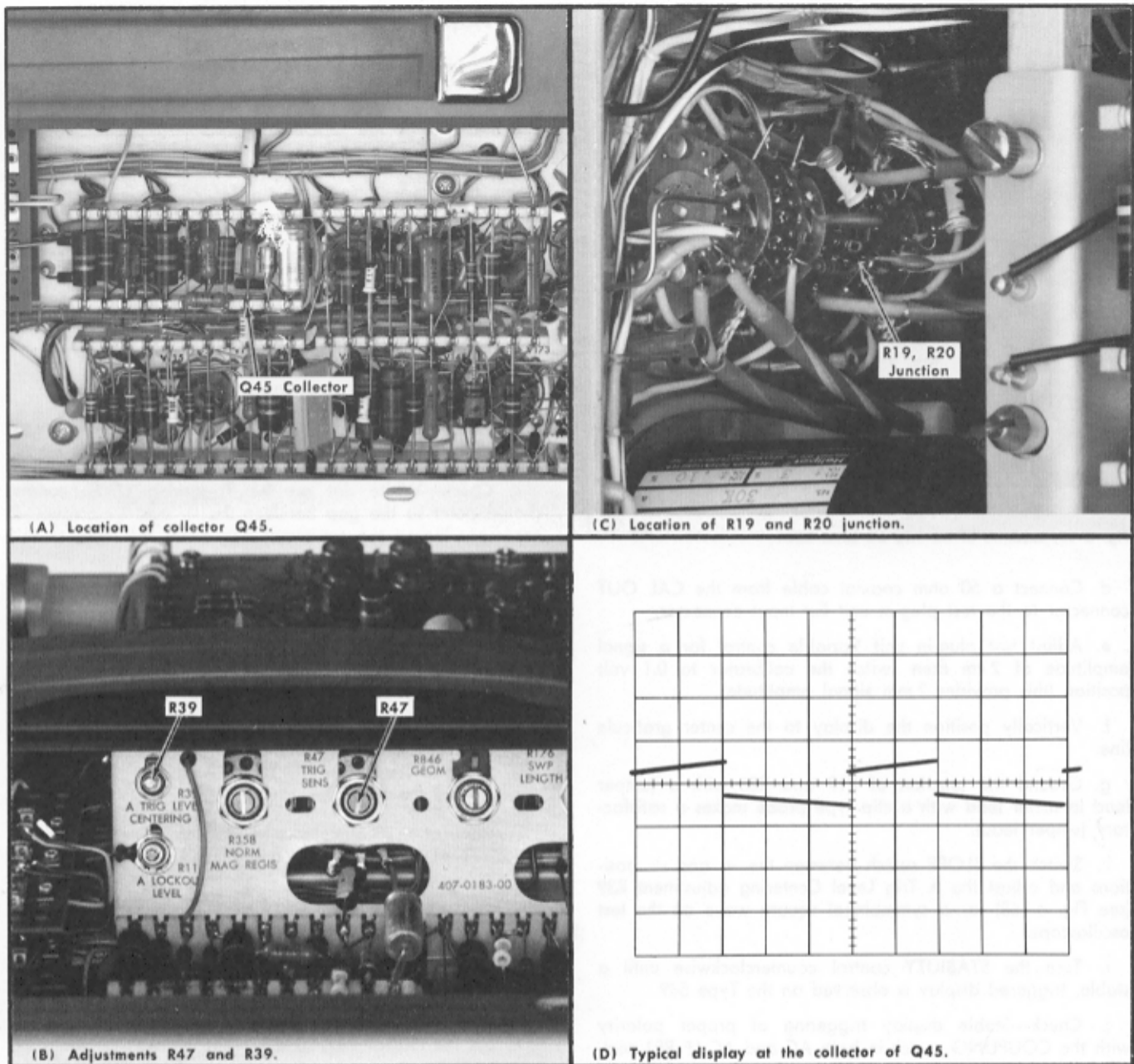


Fig. 6-16. Setting A Trigger Sensitivity R47.

15. Adjust A Trigger Sensitivity



- a. Equipment setup is shown in Fig. 6-15.
- b. Connect a 10 \times probe from the test oscilloscope to the collector of Q45 (see Fig. 6-16A).
- c. Connect a BNC to banana plug patch cord from the TRIG INPUT connector to the ground terminal and set the A TRIGGERING SOURCE switch to EXT.
- d. Adjust the Trig Sens R47 (Fig. 6-16B) for a frequency of 40 Hz (test oscilloscope display of 1 cycle/5 cm).

- e. Remove the patch cord from the TRIG INPUT connector.

16. Adjust A Trigger Level Centering



- a. Equipment setup is given in step 15.
- b. Set the test oscilloscope Time/cm switch to the 0.5 msec position.
- c. Change the Type 549 A TRIGGERING MODE switch to TRIG and the SOURCE switch to NORM position.

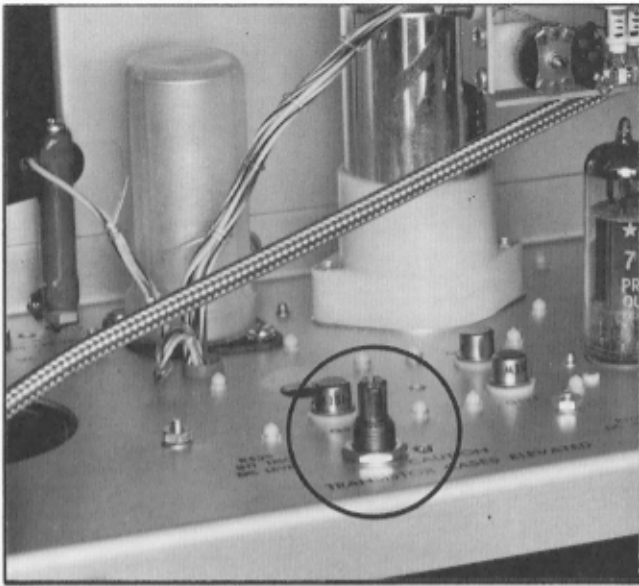


Fig. 6-17. Location of Int Trig DC Level R539.

- d. Connect a 50 ohm coaxial cable from the CAL OUT connector to the test plug-in unit Ext Input connector.
- e. Adjust test plug-in unit Variable control for a signal amplitude of 2 cm then switch the calibrator to 0.1 volt position (this provides 2 mm signal amplitude).
- f. Vertically position the display to the center graticule line.
- g. Ground the junction of R19 and R20 with a jumper lead (a meter lead with a clip type probe makes a satisfactory jumper lead).
- h. Switch the SLOPE switch between the + and - positions and adjust the A Trig Level Centering adjustment R39 (see Fig. 6-16B) for a symmetrical square wave on the test oscilloscope.
- i. Turn the STABILITY control counterclockwise until a stable, triggered display is observed on the Type 549.
- j. Check—Stable display triggering of proper polarity with the COUPLING switch in both AC and AC LF REJ positions and the SLOPE switch in either + or - position.
- k. Disconnect the 10X probe from the collector of Q45.

17. Adjust Internal Triggering DC LEVEL ①

- a. Equipment setup is given in step 16.
- b. Vertically center the display on the graticule centerline and change the COUPLING switch to DC position.
- c. Adjust the Int Trig DC Level R539 (see Fig. 6-17), for a stable triggered display with the SLOPE switch in either + or - positions.
- d. Remove the grounding lead from the junction of R19 and R20.

18. Check A Trigger Level Control Position

- a. Equipment setup is given in step 17.
- b. With the STABILITY control adjusted as in step 16, turn the LEVEL control until the sweep is again triggered.
- c. Check—White dot on the Triggering LEVEL control should point to the gap between the + and - arrows. If necessary loosen the set screw and move the knob to this position, then tighten the set screw.
- d. Remove the AMPLITUDE CALIBRATOR signal from the vertical Input connector.

19. Adjust A Preset Adjustment ①

- a. Equipment setup is given in step 18.
- b. Set the Time Base A TIME/CM switch to 0.1 mSEC position and the MODE switch to AUTO.
- c. Connect the voltmeter between the center tap of the A PRESET ADJ potentiometer and ground.
- d. Slowly turn the PRESET ADJ from fully counterclockwise position clockwise until the trace appears and note the meter reading.
- e. Continue turning the A PRESET ADJ clockwise until the trace brightens and note the meter reading.
- f. Set the PRESET ADJ at a voltage halfway between the two readings noted.
- g. Disconnect the voltmeter.

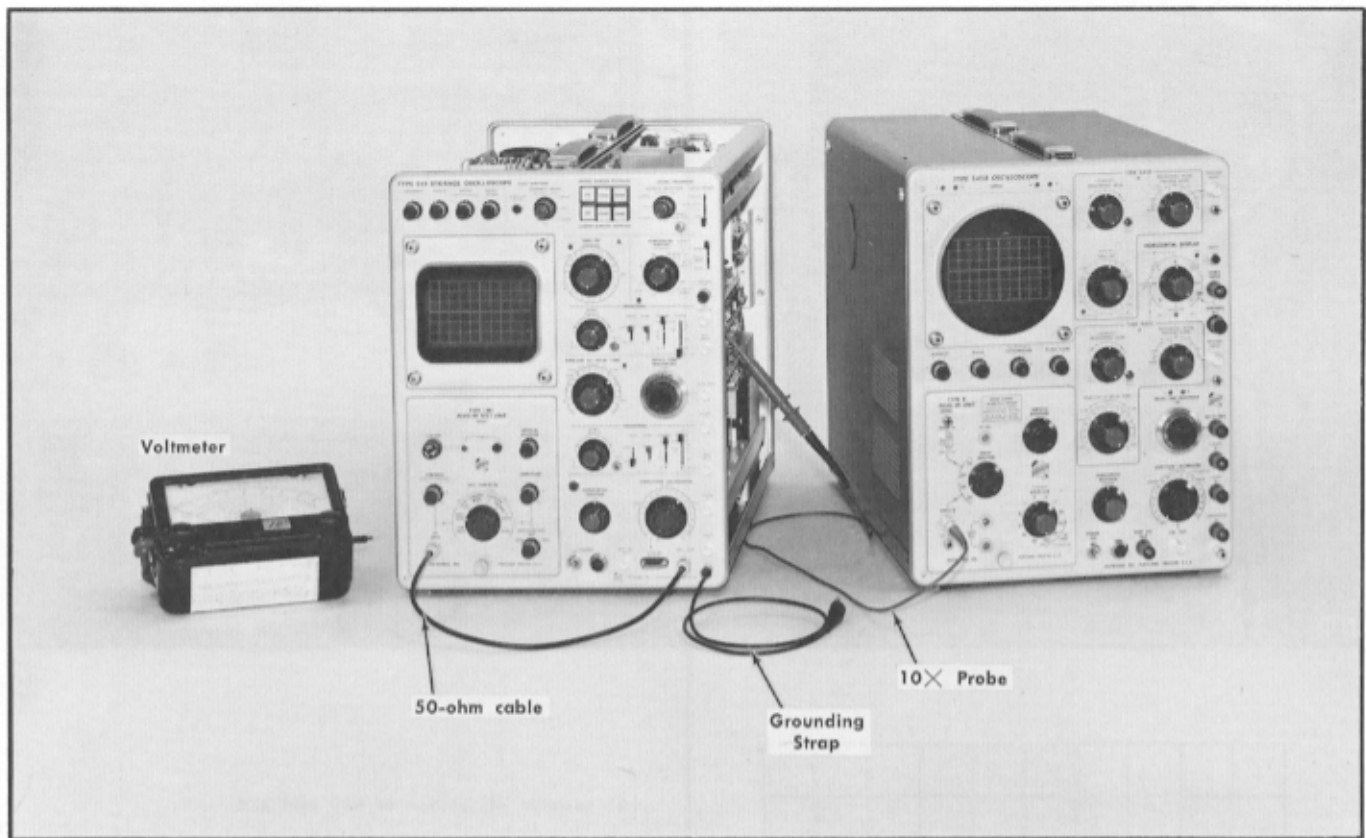


Fig. 6-18. Equipment setup for steps 20 through 24.

TIME BASE B TRIGGERING ADJUSTMENTS

IMPORTANT

Collimation must be within performance specifications before performing sweep timing adjustments. See step 53.

Type 549

CRT controls

INTENSITY	Nominal brightness
FOCUS	Midrange
ASTIG	Midrange
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	MIN
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF

HORIZONTAL DISPLAY

B

MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
A TIME/CM	0.1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	0.1 mSEC
LENGTH	Clockwise
DELAY TIME MULTIPLIER 1-10	1.00

TRIGGERING controls (both A and B)

LEVEL	Clockwise
STABILITY	Clockwise
Lever controls	All in up position
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	1 VOLT

Test Plug-In Load/Pulsar Unit

Test Function	High Load
Variable	Counterclockwise
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Counterclockwise

Test Oscilloscope

Time/cm	0.5 msec
Volts/cm	0.5

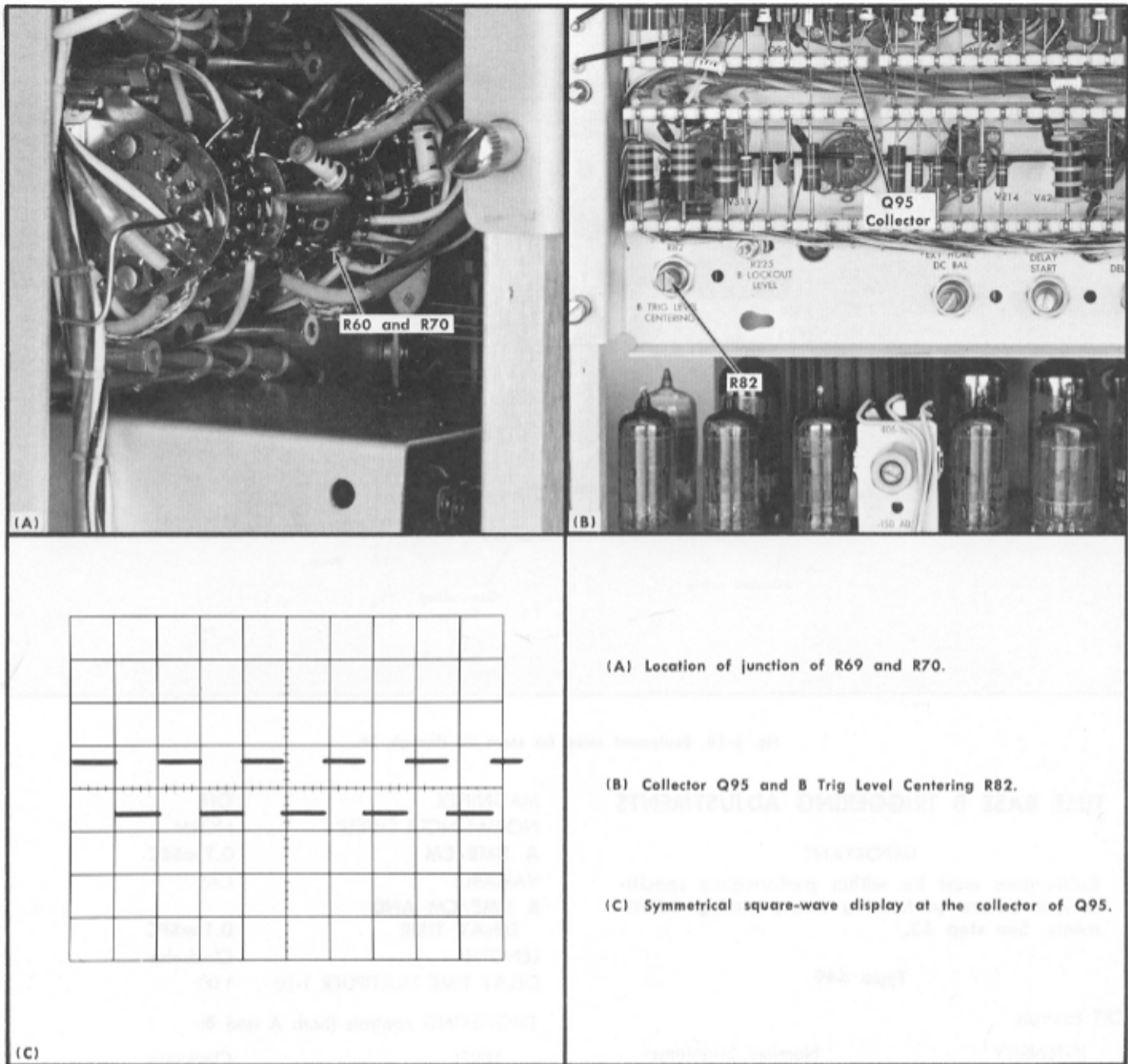


Fig. 6-19. Adjusting B Trigger Level Centering.

20. Adjust B Trigger Level Centering ❶

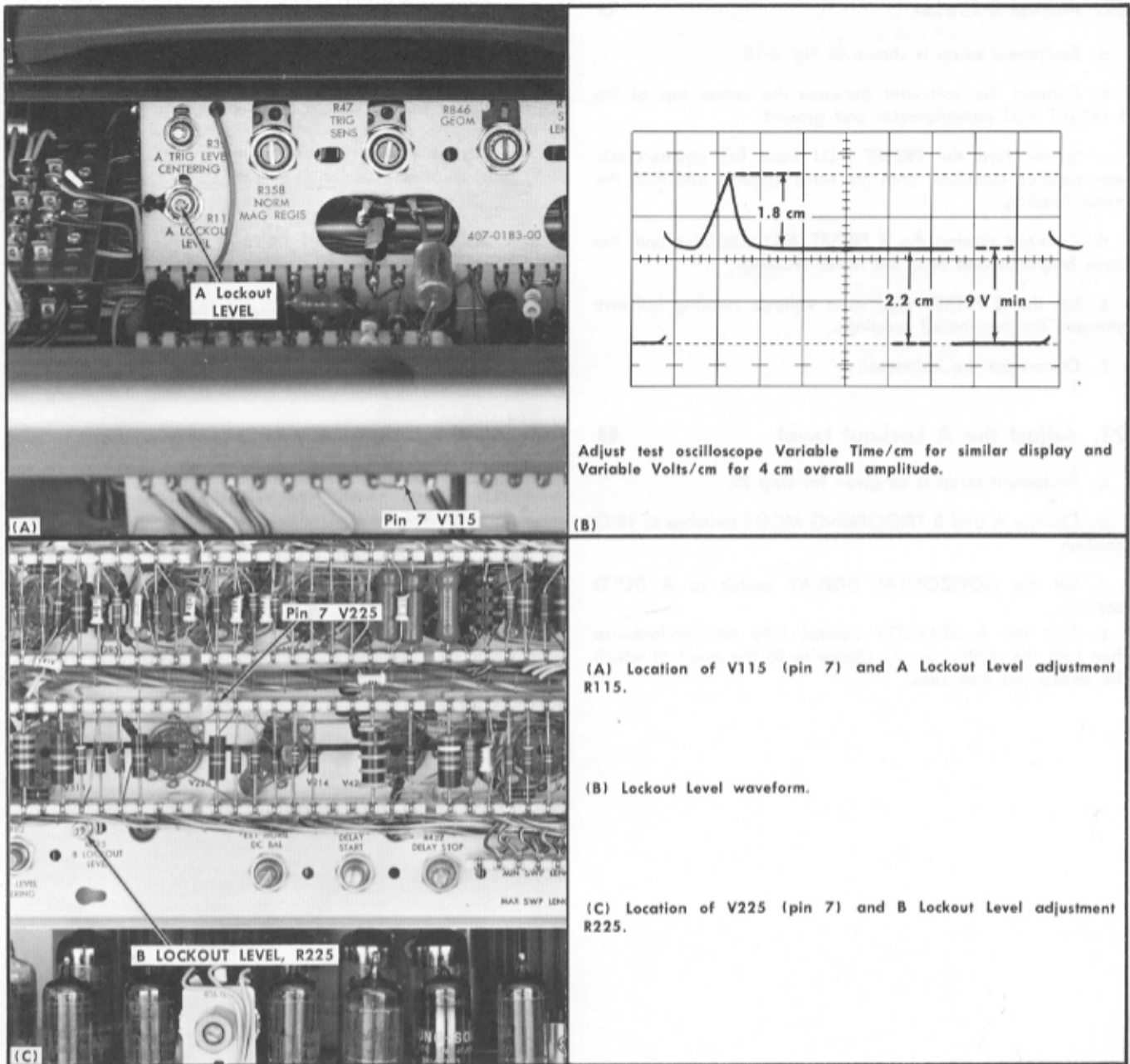
- a. Equipment setup is shown in Fig. 6-18.
- b. Set the B Triggering MODE switch to TRIG position.
- c. Connect a 50 ohm coaxial cable from the CAL OUT connector to the test plug-in unit Ext Input connector and set up as in step 16e for a 2 mm display amplitude.
- d. Vertically center the display at the graticule center.
- e. Connect a 10× probe from the test oscilloscope to the collector of Q94. Fig. 6-19B.

f. Ground the junction of R69 and R70 with a jumper lead (see Fig. 6-19A).

g. Switch the B Triggering SLOPE switch between + and - positions and adjust the B Trig Level Centering adjustment R82, (see Fig. 6-19B) for a symmetrical square wave display on the test oscilloscope. Fig. 6-19C.

h. Turn the STABILITY control counterclockwise until a stable, triggered display is observed.

i. Check—Stable triggering of proper polarity with the COUPLING switch in both the AC and AC LF REJ positions and the SLOPE switch in + and - positions.



Adjust test oscilloscope Variable Time/cm for similar display and Variable Volts/cm for 4 cm overall amplitude.

(A) Location of V115 (pin 7) and A Lockout Level adjustment R115.

(B) Lockout Level waveform.

(C) Location of V225 (pin 7) and B Lockout Level adjustment R225.

Fig. 6-20. Adjusting A and B Lockout Level.

- j. Remove the 10X probe from the collector of Q95.
- k. Adjust for a 4 mm signal using Calibrator and test plug-in unit Variable control as in step 16e.
- l. Change the COUPLING switch to DC position.
- m. Check—Stable triggering and proper polarity with the SLOPE switch in both + and - positions. If readjustment of the Triggering LEVEL control is required, recheck A Internal Level adjustment, step 17.
- n. Remove the grounding clip lead from the junction of R69 and R70.

21. Check B Trigger Level Control Position

- a. Equipment setup is shown in step 20.
- b. Turn the B Triggering LEVEL control until the sweep is again triggered as observed when the shorting patch lead was connected.
- c. Check—White dot on the Triggering LEVEL control should point to the gap between the + and - arrows. If necessary, loosen the set screw and move the knob to this position then tighten the set screw.
- d. Remove the coaxial signal cable from the AMPLITUDE CALIBRATOR.

22. Adjust B Preset



- a. Equipment setup is shown in Fig. 6-18.
- b. Connect the voltmeter between the center tap of the B PRESET ADJ potentiometer and ground.
- c. Slowly turn the PRESET ADJ from full counterclockwise position clockwise until the trace appears and note the meter reading.
- d. Continue turning the B PRESET ADJ clockwise until the trace brightens and note the meter reading.
- e. Set the B PRESET ADJ to a voltage reading halfway between the two noted readings.
- f. Disconnect the voltmeter.

23. Adjust the A Lockout Level



- a. Equipment setup is as given for step 22.
- b. Change A and B TRIGGERING MODE switches to TRIG position.
- c. Set the HORIZONTAL DISPLAY switch to A DLY'D position.
- d. Turn the A STABILITY control fully counterclockwise then turn the control slowly clockwise to the point at which the sweep just free runs.

e. Connect the test oscilloscope through the 10× probe to pin 7 of V115, Fig. 6-20A. Adjust the test oscilloscope triggering and gain controls for a stable display with an amplitude of 4 major divisions.

f. Adjust the A Lockout Level R115, (Fig. 6-20) for a sawtooth-to-gate amplitude ratio between 1:1 and 2:3. The gate portion of the waveform must have an amplitude of 9 volts or more.

24. Adjust B Lockout Level



- a. Equipment setup is given for step 23.
- b. Turn the A STABILITY control fully clockwise to free run the A sweep.
- c. Turn the B STABILITY control fully counterclockwise, then turn the control slowly clockwise until the sweep just free runs.
- d. Set the NORM-SINGLE SWEEP switch to SINGLE SWEEP position and set the AUTO ERASE switch to AFTER SWEEP position. Adjust the VIEWING TIME control for a periodic sweep approximately every 0.5 second.
- e. Connect the 10× probe from the test oscilloscope to pin 7 of V225 (Fig. 6-20C). Adjust the B Lockout Level R225 for a sawtooth-to-gate amplitude ratio between 1:1 and 2:3. The gate amplitude must be equal to or greater than 9 volts.
- f. Remove the 10× probe from pin 7 of V225.

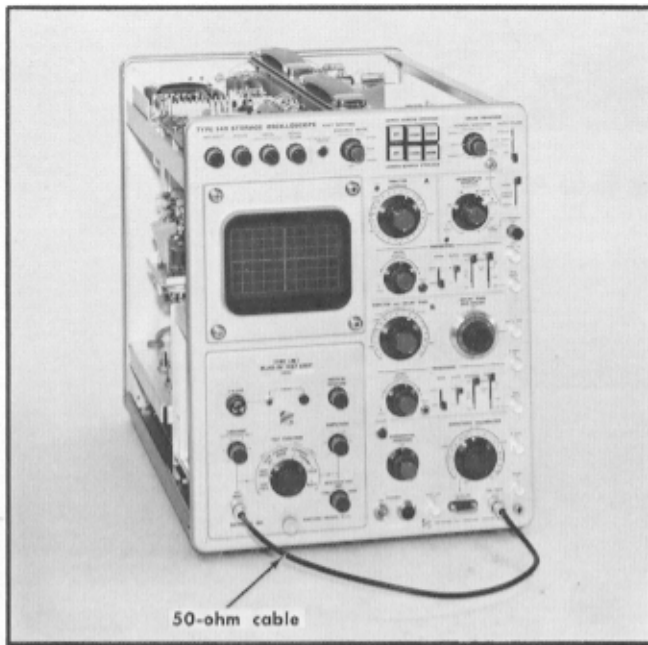


Fig. 6-21. Equipment setup for step 25.

Type 549

CRT controls

INTENSITY	Normal intensity
FOCUS	Adjust for well defined trace
ASTIG	Adjust for well defined trace
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Counterclockwise
AUTO ERASE	OFF

HORIZONTAL DISPLAY

MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM

Time Base A

TIME/CM	.2 mSEC
VARIABLE	CAL

Triggering controls

LEVEL	CW
STABILITY	PRESET
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM

Time Base B

TIME/CM AND DELAY TIME	.5 mSEC
Length	Clockwise

Triggering controls

LEVEL	CW
STABILITY	PRESET
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM

DELAY TIME MULTIPLIER 1-10	1.00
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	1.0 volt

Test Plug-In Load/Pulsar Unit

Test Function	High Load
Variable	CCW
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	CCW

25. Check Single Sweep Operation

- a. Equipment setup is shown in Fig. 6-21.
- b. Apply the AMPLITUDE CALIBRATOR signal to the Ext Input connector of the test plug-in unit and adjust the Variable control for a display amplitude of 1 cm.
- c. Change the AMPLITUDE CALIBRATOR switch to 0.1 VOLT position.
- d. Adjust B and A LEVEL controls for a triggered intensified sweep.
- e. Remove the calibrator signal, change the NORM-SINGLE SWEEP switch to SINGLE SWEEP position.
- f. Push the SINGLE SWEEP switch to the RESET position and check that the READY neon is lit.
- g. Re-apply the calibrator signal to the Ext Input connector. A single intensified sweep must occur and the READY neon must extinguish.
- h. Repeat by resetting the single sweep with the ERASE AND RESET button and check the single sweep operation.

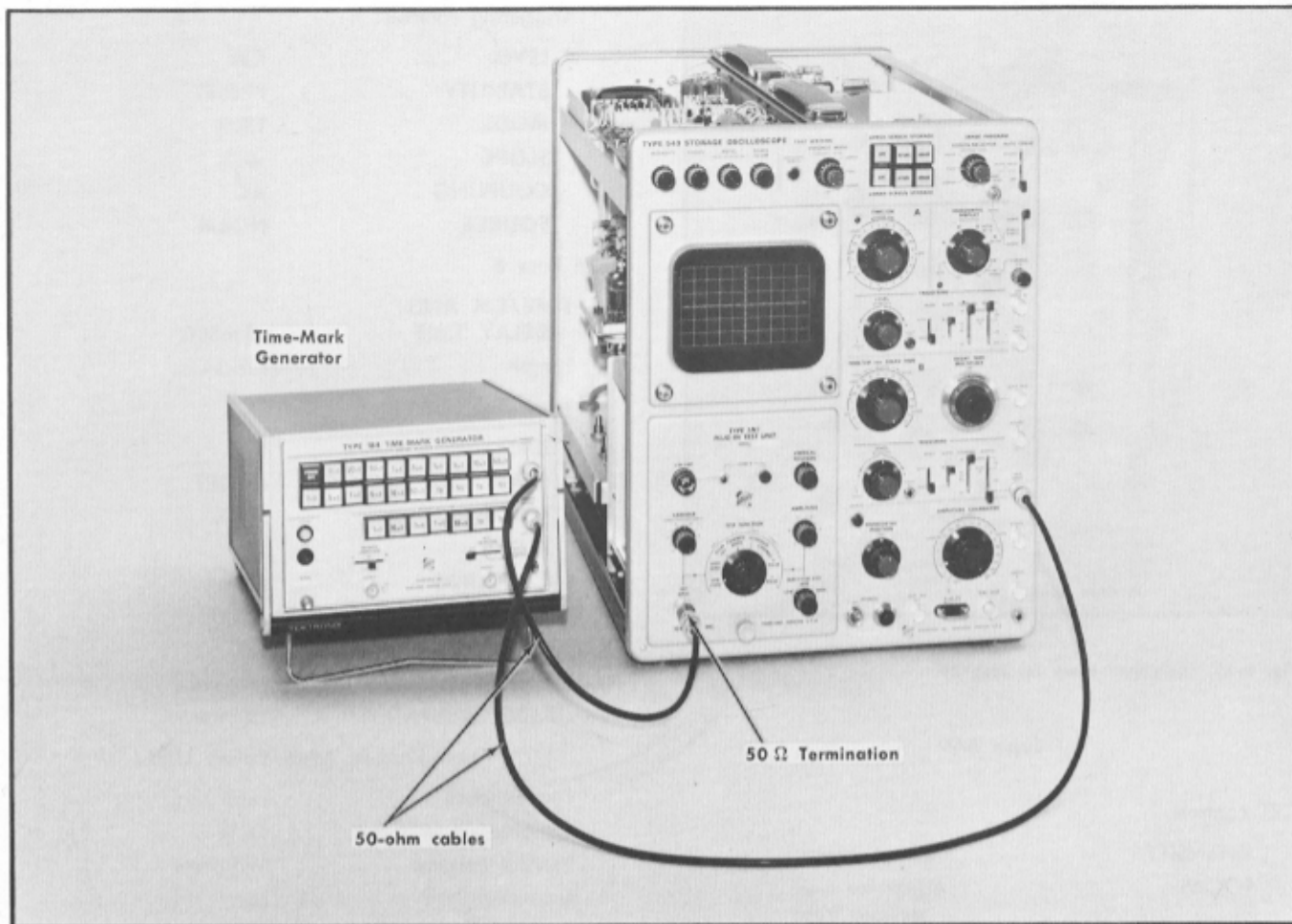


Fig. 6-22. Equipment setup for steps 26 through 32.

Type 549

CRT controls

INTENSITY	Normal intensity
FOCUS	Adjust for well defined trace
ASTIG	Adjust for well defined trace
SCALE ILLUM	As desired

Storage controls

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Counterclockwise
AUTO ERASE	OFF
HORIZONTAL DISPLAY MAGNIFIER	B
NORM-SINGLE SWEEP	×5 NORM

Time Base A

TIME/CM VARIABLE	.2 mSEC CAL
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Triggering controls

LEVEL	Midrange
STABILITY	PRESET
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM

Time Base B

TIME/CM AND DELAY TIME LENGTH	1.0 mSEC Clockwise
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Triggering controls

LEVEL	Midrange
STABILITY	PRESET
MODE	TRIG
SLOPE	+

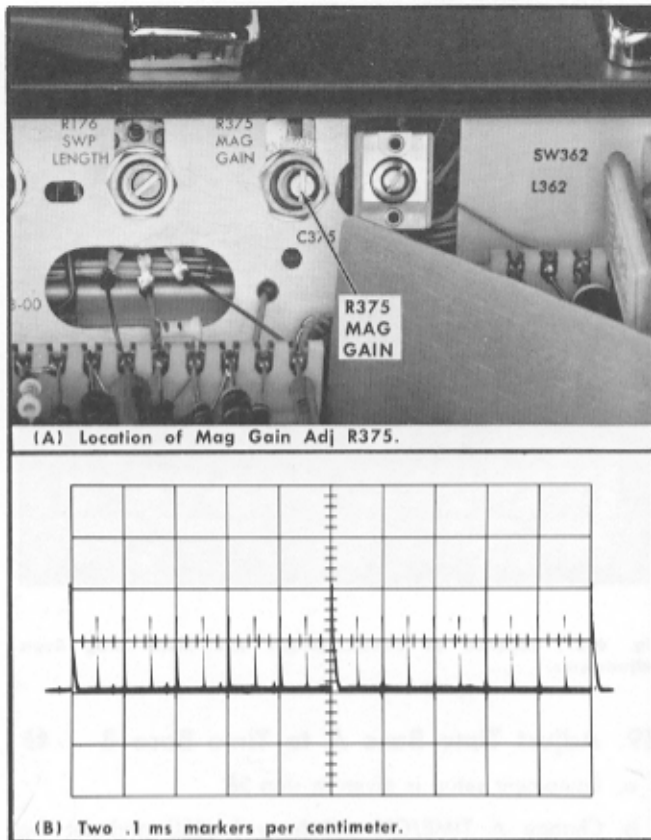


Fig. 6-23. Adjusting Magnifier gain.

COUPLING	AC
SOURCE	EXT
DELAY TIME MULTIPLIER 1-10	1.00
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	OFF

Test Plug-In Load/Pulsar Unit

Test Function	High Load
Variable	CCW
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	CCW

26. Adjust Magnifier Gain

- a. Equipment setup is shown in Fig. 6-22.
- b. Apply 1 ms trigger signal from the Time-Mark Generator to B TRIG INPUT connector.
- c. Apply .1 ms and 1 ms markers from the Time-Mark Generator to the Ext Input of the test plug-in unit.
- d. Adjust the Mag Gain R375 (Fig. 6-23A) for two .1 ms markers/cm. See Fig. 6-23B. Check that MAG neon is lit.

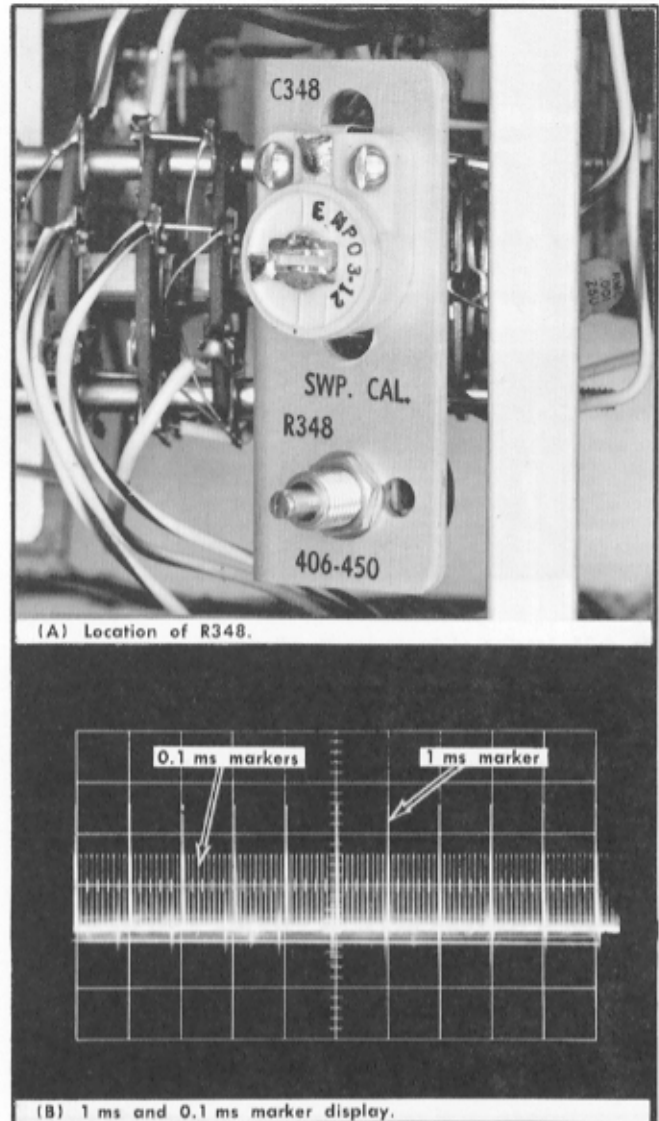


Fig. 6-24. Sweep Calibration adjustments.

NOTE

Unless otherwise noted, use the center 8 cm when adjusting or checking timing.

27. Adjust Sweep Calibration

- a. Equipment setup is given in step 26.
- b. Turn the MAGNIFIER switch to OFF.
- c. ADJUST the Swp Cal R348 (Fig. 6-24) for 1 ms marker per centimeter.

28. Adjust B Sweep Length

- a. Equipment setup is given in step 28.

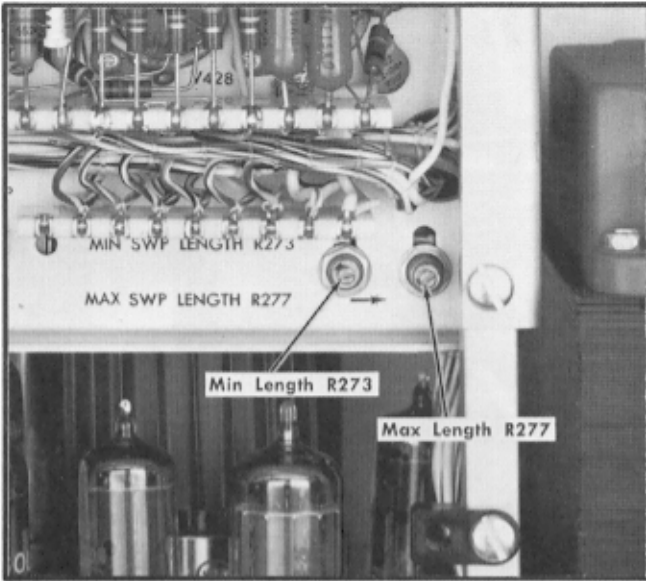


Fig. 6-25. Location of Sweep Length adjustments.

- b. Set B LENGTH control fully clockwise.
- c. Adjust Max Swp Length R277 (Fig. 6-25) for a sweep length of 10.5 cm.
- d. Rotate the Length control fully counterclockwise (4 CM position).
- e. Adjust the Min Swp Length R273 (Fig. 6-25) for a sweep length of 3.5 cm.
- f. Repeat these adjustments because of the interaction, then set the LENGTH control to the 10 CM position.

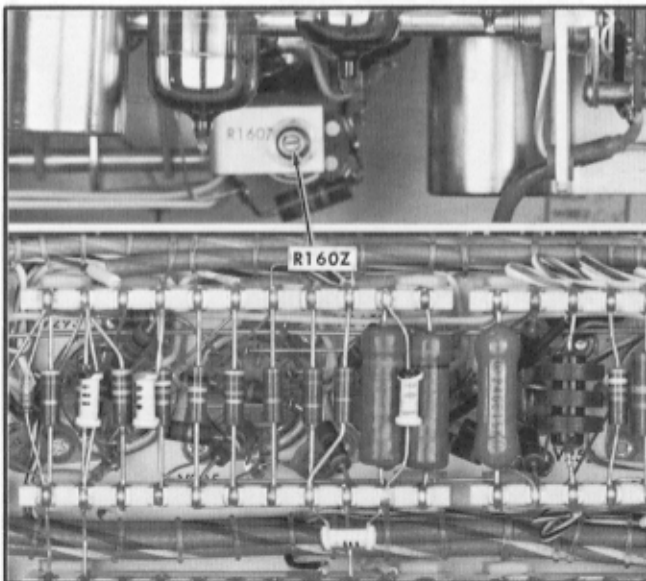


Fig. 6-26. Location of R160Z timing potentiometer.

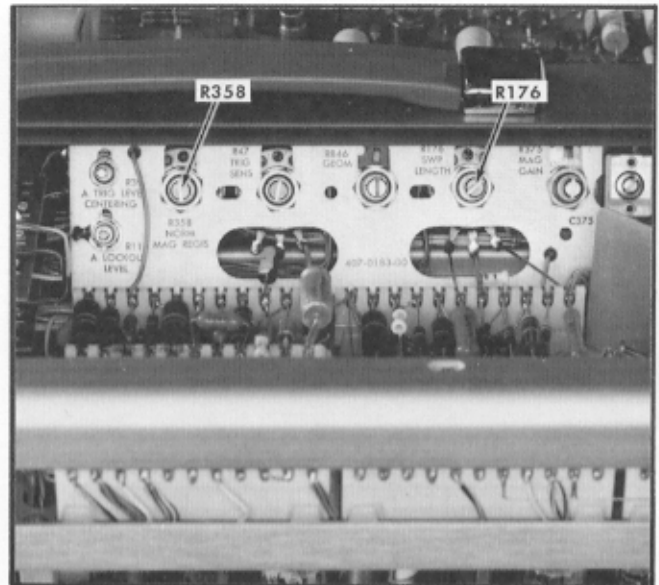


Fig. 6-27. Location of Sweep Length and Norm Mag Regis adjustments.

29. Adjust Time Base A to Time Base B

- a. Equipment setup is given in step 28.
- b. Change A TIME/CM switch to 1 mSEC and set the HORIZONTAL DISPLAY to A position.

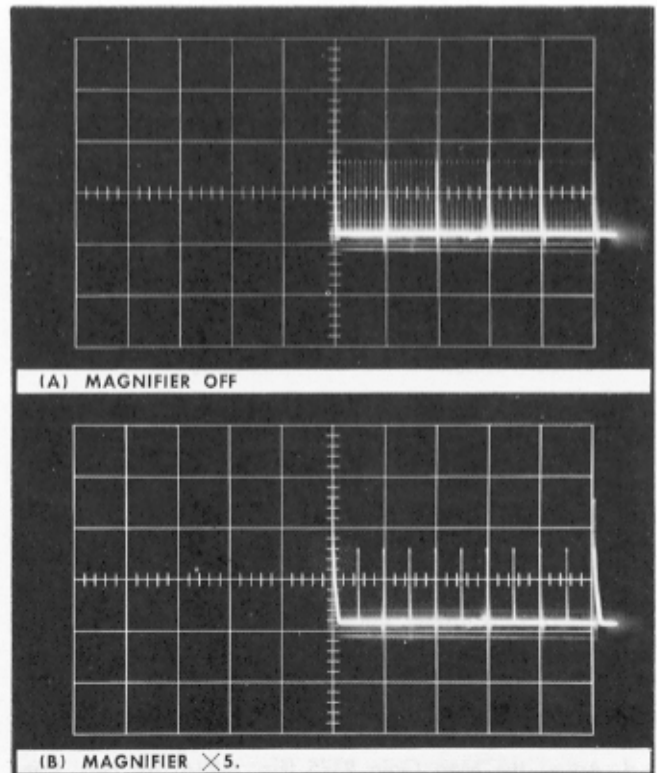


Fig. 6-28. Correct adjustment of Norm Mag Regis R358.

c. Remove the trigger signal from the B TRIG INPUT connector and apply the signal to the A TRIG INPUT. Set the A Triggering SOURCE switch to EXT position and the B Triggering SOURCE switch to NORM.

d. Adjust timing potentiometer R160Z for 1 ms marker/cm. See Fig. 6-26.

30. Adjust A Sweep Length and Check Variable Control Range ①

a. Equipment setup is given in step 29.

b. Adjust the A Swp Length R176 (Fig. 6-27) for a sweep length of 10.5 cm.

c. Turn the VARIABLE control fully counterclockwise.

d. Check—CRT display for TIME μ CM equal to or greater than 2.5 times the TIME/CM switch setting (5 or more 1 ms markers/2 cm). The UNCAL neon must light when the VARIABLE control is out of the CAL switch position.

e. Return the VARIABLE control to the CAL position.

31. Adjust Sweep Magnifier Registration ①

a. Equipment setup is as given for step 30.

b. Turn the MAGNIFIER switch to the $\times 5$ position, then position the trace so that the zero time marker is directly behind the center graticule line.

c. Turn the MAGNIFIER switch to OFF and adjust the Norm Mag Regis R358 (Fig. 6-27) to position the zero time marker directly behind the center graticule line (see Fig. 6-28).

d. Repeat this procedure because of the interaction between the sweep length adjustments.

32. Check Horizontal Position Range

a. Equipment setup is as given for step 31.

b. Rotate the HORIZONTAL POSITION and FINE controls fully clockwise.

c. Check—The sweep start must position to the right of the graticule centerline.

d. Rotate the HORIZONTAL POSITION and FINE controls fully counterclockwise.

e. Check—The end of the sweep must position to the left of the graticule centerline.

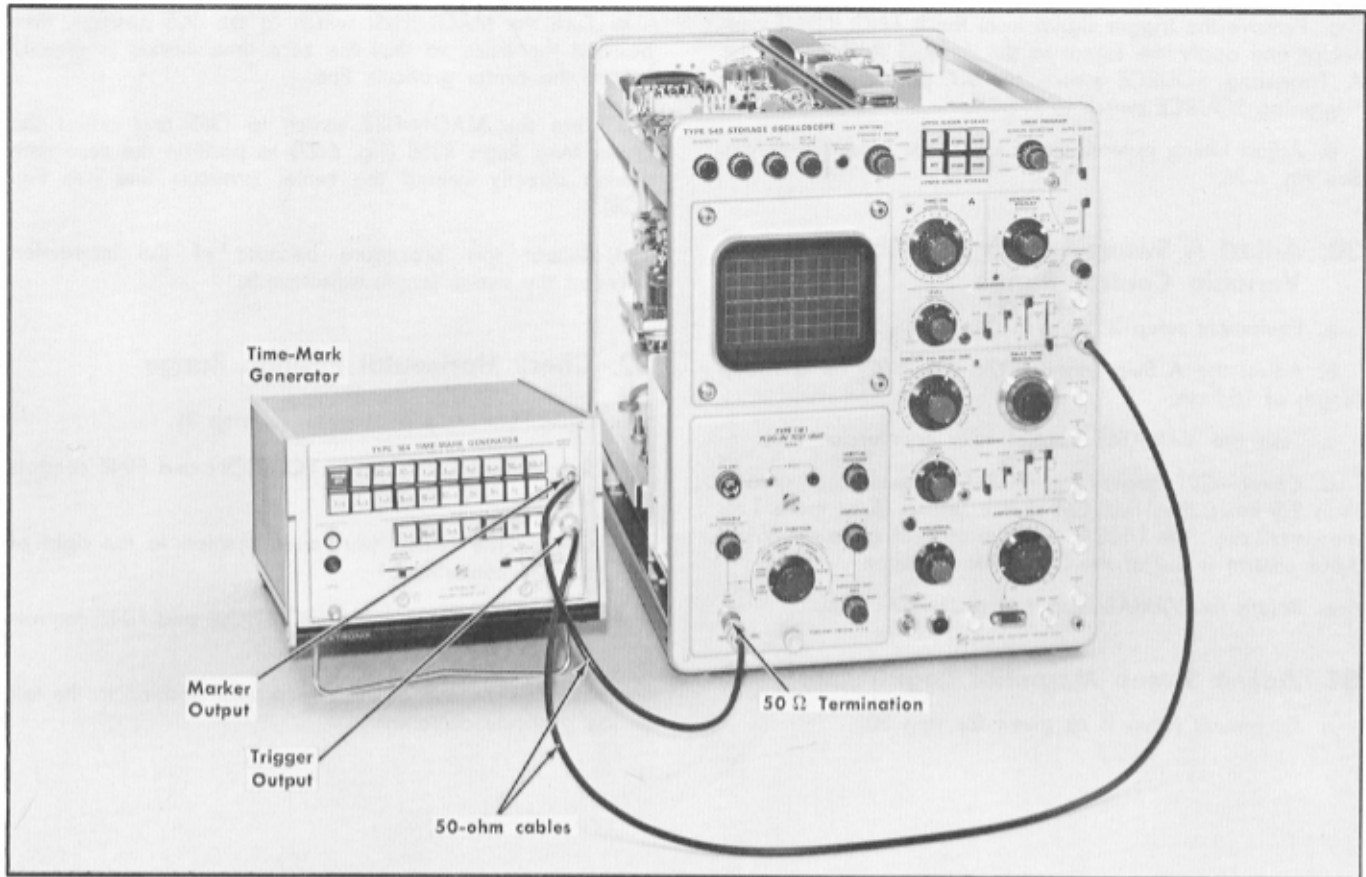


Fig. 6-29. Equipment setup for steps 33 through 38.

Type 549

CRT controls	
INTENSITY	Normal intensity
FOCUS	Adjust for well defined trace
ASTIG	Adjust for well defined trace
SCALE ILLUM	As desired
Storage controls	
ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	Counterclockwise
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM

Time Base A and B

TIME/CM	.2 mSEC
VARIABLE	CAL
Triggering controls	
LEVEL	Midrange
STABILITY	PRESET
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	EXT
DELAY TIME MULTIPLIER 1-10	1.00
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	OFF

Test Plug-In Load/Pulser Unit

Test Function	High Load
Variable	5.0
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	CCW

TABLE 6-3

A TIME/CM	Time Marker Selector	Trigger Selector	Markers/cm	Maximum Error
.1 mSEC	.1 ms	1 ms	1	±2.4 mm
.2 mSEC			2	±2.4 mm
.5 mSEC	.5 ms	10 ms	1	±2.4 mm
1 mSEC	1 ms		1	±2.4 mm
2 mSEC			2	±2.4 mm
5 mSEC	5 ms	.1 s	1	±2.4 mm

Change the controls as follows:

A SOURCE	NORM (INT)
AUTO ERASE	AFTER SWEEP
VIEWING TIME	MIN
UPPER AND LOWER SCREEN STORAGE	STORE
NORMAL-SINGLE SWEEP	SINGLE SWEEP

A periodic stored display may now be used to check the slower sweep rates.

10 mSEC	10 ms		1	±2.4 mm
20 mSEC			2	±2.4 mm
50 mSEC	50 ms		1	±2.4 mm
.1 SEC	.1 s		1	±2.4 mm
.2 SEC			2	±2.4 mm
.5 SEC	.5 s		1	±2.4 mm
1 SEC	1 s		1	±2.4 mm
2 SEC			2	±2.4 mm
5 SEC	5 s		1	±2.4 mm

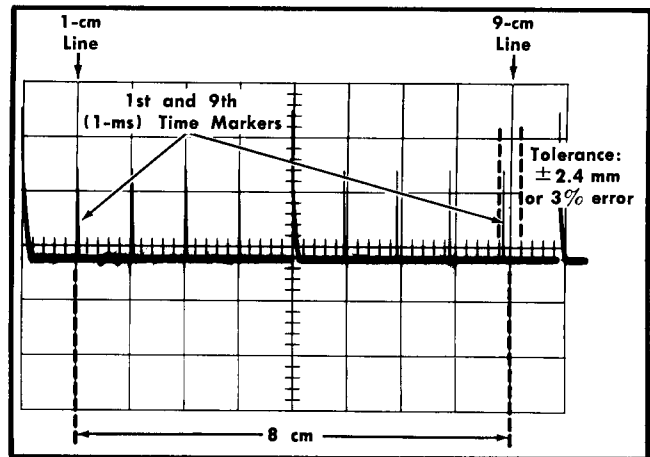


Fig. 6-30. Determining sweep rate accuracy.

33. Check Time Base A Sweep Timing Accuracy (.1 mSEC/CM to 5 SEC/CM)

- Equipment setup is as shown in Fig. 6-29.
- Adjust CRT controls for a well focused display with nominal brightness.
- Set the Time Base A TIME/CM switch and marker selector for the Time-Mark Generator as per Table 6-3, check the timing accuracy over the center 8 cm (see Fig. 6-30).

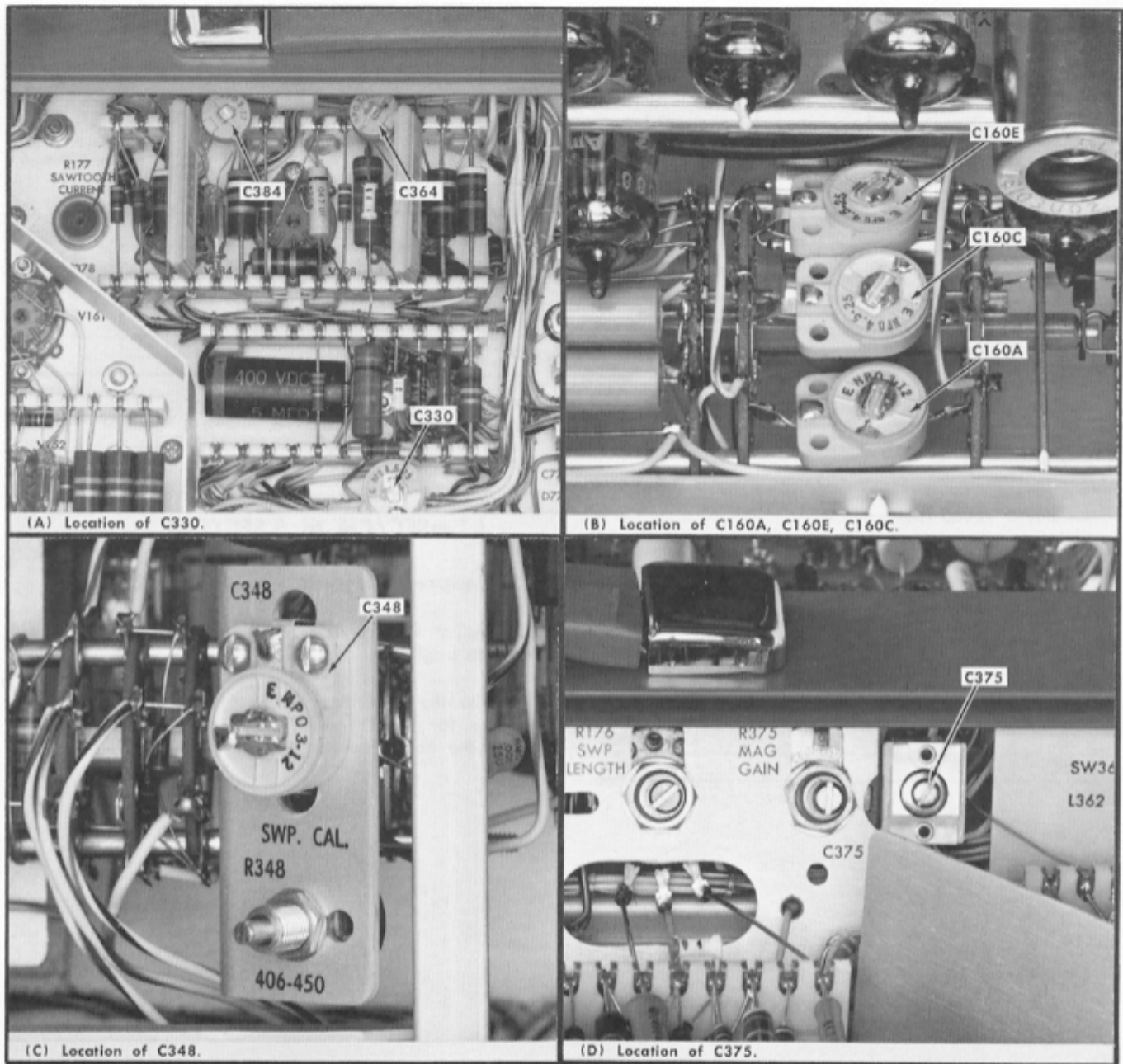


Fig. 6-31. Time Base A Timing adjustments.

34. Adjust and Check Time Base A Sweep Rates (50 μ SEC/CM to 0.2 μ SEC/CM)

- a. Equipment setup is as given for step 33.
- b. Set the A TIME/CM switch to 50 μ SEC position and turn the MAGNIFIER to $\times 5$ position.
- c. Return the Type 549 to conventional mode. Depress both OFF buttons for UPPER and LOWER SCREEN STORAGE, switch the AUTO ERASE to OFF, set the NORM-SINGLE

SWEEP switch to NORM position and set the A SOURCE switch to EXT.

- d. Set the Time-Mark Generator trigger selector and the marker selector to 10 μ s.

- e. Position the trace so the zero time marker is aligned with the center graticule line.

- f. Switch the TIME/CM between the 50 μ SEC and the .1 mSEC position.

TABLE 6-4

TIME/CM	Time Marker Selector	Adjust ⁴	Markers/cm	Maximum Error in mm
MAGNIFIER to $\times 5$				
.5 μ SEC	.1 μ S	C160A	1 marker/cm	± 4.0
MAGNIFIER to OFF				
10 μ SEC	10 μ S	C160E	1 marker/cm	± 2.4
1 μ SEC	1 μ S	C160C	1 marker/cm	± 2.4
.1 μ SEC	.1 μ S	C348	1 marker/cm	± 2.4
MAGNIFIER to $\times 5$				
.1 μ SEC	20 nS	C364	1 cycle/cm	± 4.0
		C384	(center of sweep)	± 4.0
Exclude the first 7 cycles of the display. Adjust C375 for 1 cycle/cm in the first 3 to 4 centimeters of the sweep.				
.1 μ SEC	20 nS	Check	1 cycle/cm	± 4.0
.2 μ SEC	50 nS	Check	2 cycle/cm	± 4.0
Check at beginning, (exclude the first 7 cycles) middle and end of sweep. Due to interaction of the high frequency timing adjustments it may be necessary to repeat the adjustments and checks to this point.				
MAGNIFIER to OFF				
.2 μ SEC	.1 μ S	Check	2 cycles/cm	± 2.4
2 μ SEC	1 μ S	Check	2 marker/cm	± 2.4
5 μ SEC	5 μ S	Check	1 marker/cm	± 2.4
20 μ SEC	10 μ S	Check	2 marker/cm	± 2.4
50 μ SEC	50 μ S	Check	1 marker/cm	± 2.4

⁴The linearity error of the sweep on any TIME/CM setting with the MAGNIFIER on or off must not exceed 2 mm. See Fig. 6-32.

g. Adjust C330 (Fig. 6-31) so the zero marker for both the .1 mSEC and 50 μ SEC/CM position occurs at the same position.

h. Turn the MAGNIFIER switch to OFF, A TIME/CM to 10 μ SEC and proceed with adjustments listed in Table 6-4.

35. Adjust Delay Start and Stop



a. Equipment setup is as given in step 34.

b. Set A Triggering SOURCE switch to NORM. Remove the Time-Mark Generator trigger signal from the A TRIG INPUT connector and apply the trigger signal to the B TRIG INPUT connector. Set B Triggering SOURCE switch to EXT position.

c. Set the A TIME/CM switch to 5 μ SEC and the B TIME/CM switch to 1 mSEC position.

d. Set the Time-Mark Generator marker selector for 1 ms markers and the trigger selector for 1 ms trigger signals.

e. Free run the A sweep by setting the A MODE switch to TRIG and turning the STABILITY and LEVEL controls fully clockwise.

f. Set the HORIZONTAL DISPLAY switch to B INTEN BY A, then adjust B Triggering LEVEL control for a stable display.

g. With the DELAY TIME MULTIPLIER 1-10 dial set at 1.00, adjust the Delay Start R436, (Fig. 6-33) to position the

intensified portion to the 1st time mark (1 cm from the start of the trace).

h. Change the DELAY TIME MULTIPLIER 1-10, (Fig. 6-33) until the brightened portion starts at the 9th time mark (9 cm from the start of the trace).

i. Repeat the Delay Start and Stop adjustments until a satisfactory setting is obtained for both.

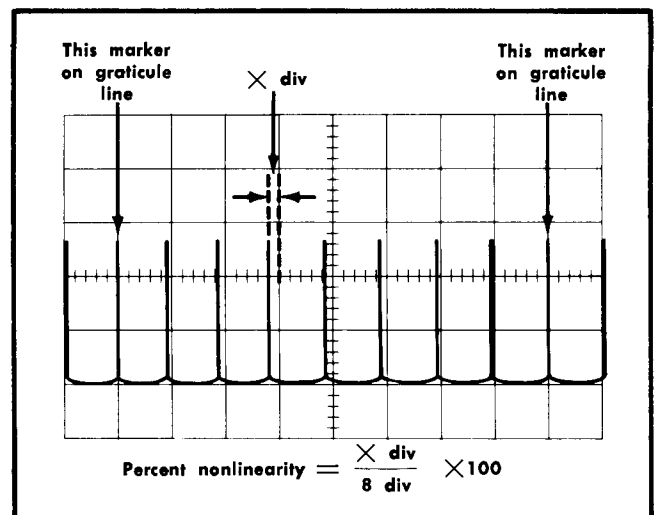


Fig. 6-32. Linearity measurement.

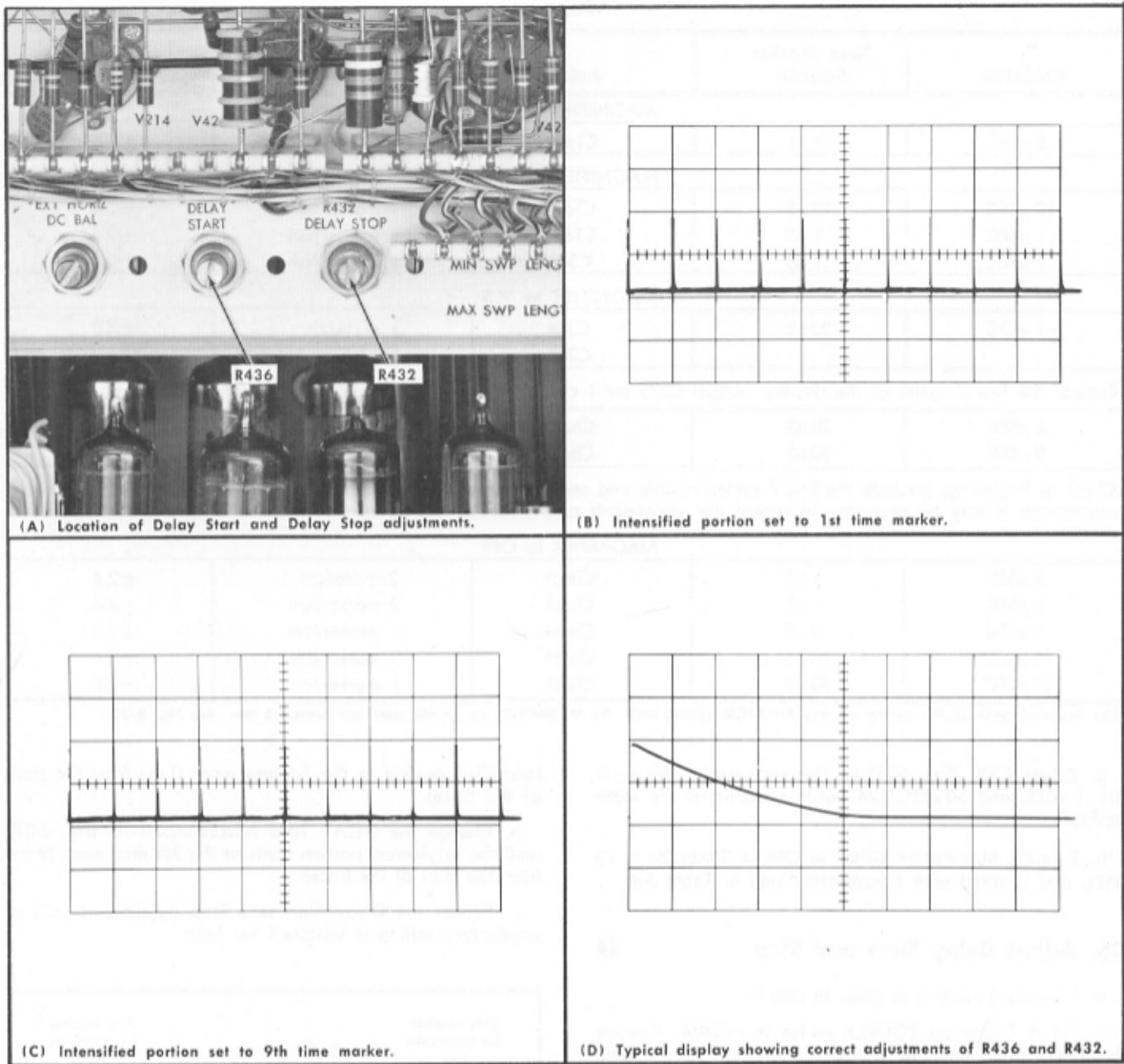


Fig. 6-33. Delay Start and Stop adjustment.

j. Set the DELAY TIME MULTIPLIER 1-10 control for a dial reading of 1.00 and switch the HORIZONTAL DISPLAY switch to A DLY'D.

k. Adjust the Delay Start R436 so that the leading edge of the time mark is at the start of the trace (see Fig. 6-33C).

l. Set the DELAY TIME MULTIPLIER 1-10 control for a dial reading of 9.00 and adjust the Delay Stop R432, until the leading edge of the time mark is at the start of the trace.

36. Check Delay Time Multiplier Incremental Linearity

a. Equipment setup is given in step 35.

b. With the HORIZONTAL DISPLAY switch first in the B INTEN BY A position for rough setting and then in the A DLY'D position, adjust the DELAY TIME MULTIPLIER dial so the sweep starts on the leading edge of the 2nd (2 cm from the graticule edge) 1 ms time mark.

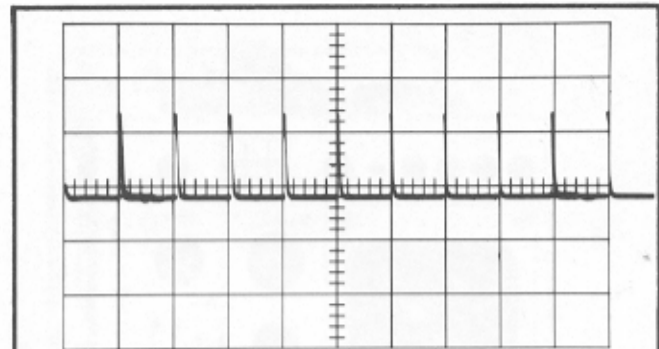
- c. Check—The DELAY TIME MULTIPLIER dial must read 2.00 ± 2 minor dial divisions ($\pm 0.2\%$).
- d. Repeat this accuracy check between each major dial division to 9.00. Incremental accuracy is $\pm 0.2\%$.

37. Adjust Time Base B Sweep Rate ①

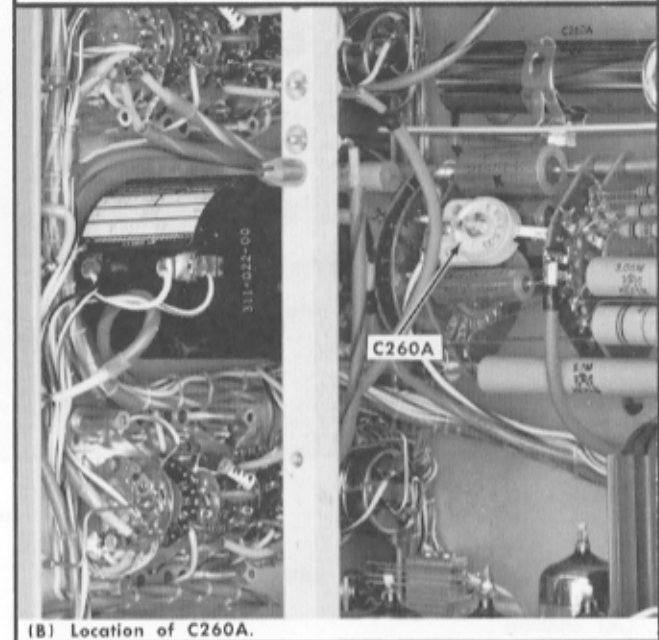
- a. Equipment setup is given in step 36.
- b. Set Time Base B TIME/CM switch to $5 \mu\text{SEC}$ and Time Base A TIME/CM switch to $.5 \mu\text{SEC}$.
- c. Set the Time-Mark Generator marker selector for $5 \mu\text{S}$ time markers.
- d. With the HORIZONTAL DISPLAY switch first in the B INTEN BY A position for a rough setting and then in the A DLY'D position adjust the DELAY TIME MULTIPLIER 1-10 dial so the sweep starts at the leading edge of the 1st time marker and note the dial reading (approximately 1.00).
- e. Rotate the DELAY TIME MULTIPLIER exactly 8.00 divisions above the setting for step d (approximate setting 9.00). See Fig. 6-34A.
- f. Adjust C260A (see Fig. 6-43B) so the sweep starts at the leading edge of the 9th time marker.
- g. Repeat the procedure to compensate for circuit interaction.

TABLE 6-5

Time Base B TIME/CM	Time-Mark Generator Marker Output	Trigger Output	CRT Display Markers/Centimeter
$2 \mu\text{SEC}$	$1 \mu\text{S}$	$10 \mu\text{S}$	2
$5 \mu\text{SEC}$	$5 \mu\text{S}$		1
$10 \mu\text{SEC}$	$10 \mu\text{S}$		1
$20 \mu\text{SEC}$	$10 \mu\text{S}$		2
$50 \mu\text{SEC}$	$50 \mu\text{S}$		1
.1 mSEC	.1 mS	.1 mS	1
.2 mSEC	.1 mS		2
.5 mSEC	.5 mS		1
1 mSEC	1 mS	1 mS	1
2 mSEC	1 mS		2
5 mSEC	5 mS		1
10 mSEC	10 mS	.1 S	1
20 mSEC	10 mS		2
50 mSEC	50 mS		1
.1 SEC	.1 S		1
.2 SEC	.1 S		2
.5 SEC	.5 S	1 S	1
1 SEC	1 S		1



(A) Intensified 1st and 9th time markers.



(B) Location of C260A.

Fig. 6-34. Adjusting Time Base B sweep rate.

38. Check Time Base B Sweep Timing Accuracy

- a. Equipment setup is given in step 37.
- b. Set the HORIZONTAL DISPLAY to B and adjust B LEVEL control if necessary for a triggered display.
- c. Check—Set the B TIME/CM switch and Time-Mark Generator as in Table 6-5 and check the timing accuracy over the center 8 cm. Accuracy must be within $\pm 3\%$ (2.4 mm).
- d. Remove the Time-Mark Generator, marker and trigger signals.

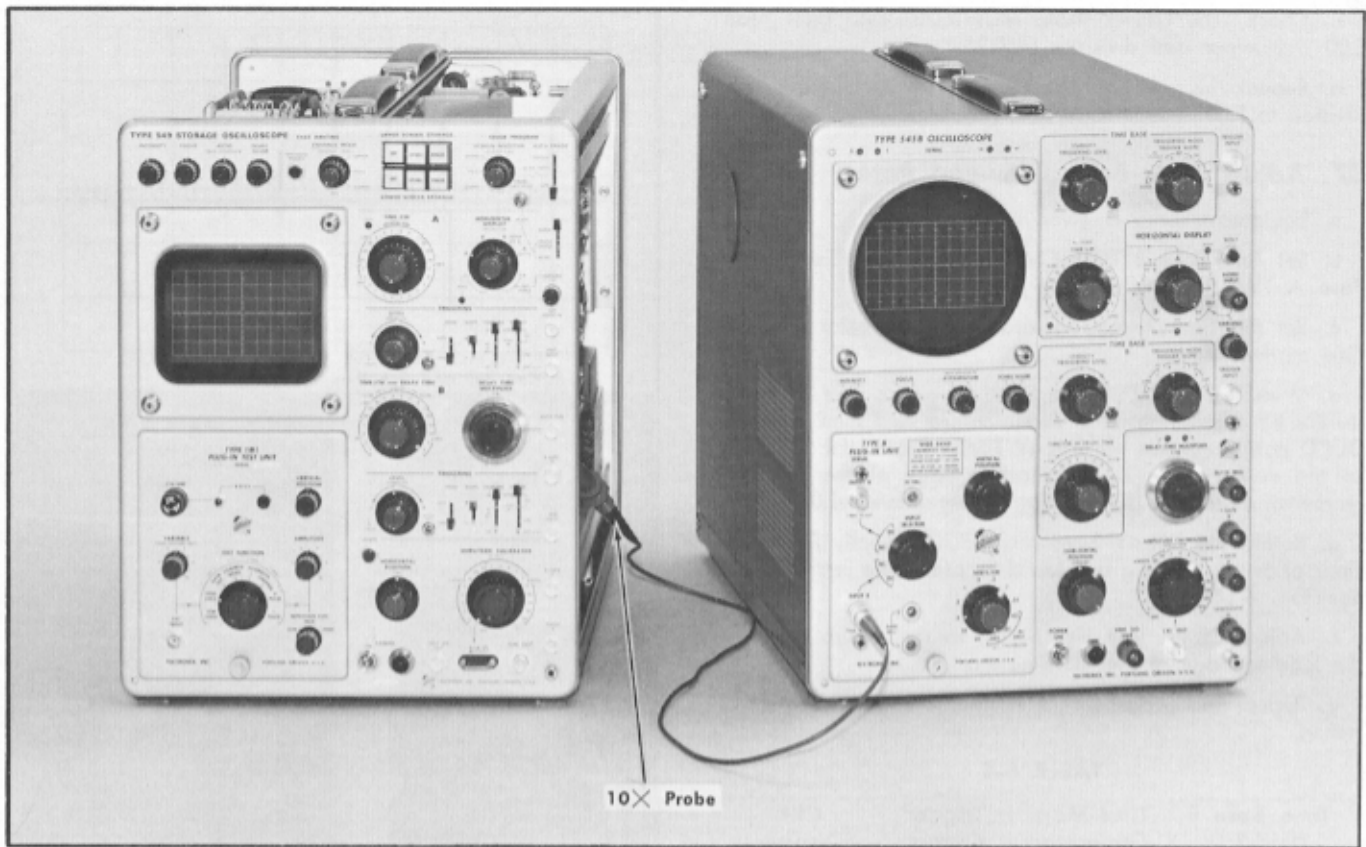


Fig. 6-35. Equipment setup for steps 39 and 40.

Type 549

CRT controls

- INTENSITY Normal intensity
- FOCUS Adjust for well defined trace
- ASTIG Adjust for well defined trace
- SCALE ILLUM As desired

Storage controls

- ENHANCE MODE OFF
- ENHANCE LEVEL Counterclockwise
- UPPER SCREEN STORAGE OFF
- LOWER SCREEN STORAGE OFF
- SCREEN SELECTOR FULL
- VIEWING TIME Counterclockwise
- AUTO ERASE OFF
- HORIZONTAL DISPLAY A
- MAGNIFIER OFF
- NORM-SINGLE SWEEP NORM

Time Base A

- TIME/CM VARIABLE .1 μ SEC
- CAL CAL

Triggering controls

- LEVEL CW
- STABILITY PRESET

- MODE
- SLOPE
- COUPLING
- SOURCE

- TRIG
- +
- AC
- NORM

Time Base B

- TIME/CM AND DELAY 2 μ SEC
- TIME TIME
- LENGTH Clockwise

Triggering controls

- LEVEL CW
- STABILITY PRESET
- MODE TRIG
- SLOPE +
- COUPLING AC
- SOURCE NORM
- DELAY TIME MULTIPLIER 1.00
- 1-10
- HORIZONTAL POSITION Midrange
- AMPLITUDE CALIBRATOR OFF

Test Plug-In Load/Pulsar Unit

- Test Function High Load
- Variable CCW
- Vertical Position Midrange
- Repetition Rate Low
- Amplitude CCW

Test Oscilloscope

Time/cm	2 μ SEC
Volts/cm	5.0
Coupling	DC
Slope	+

39. Check A Sweep Holdoff Time

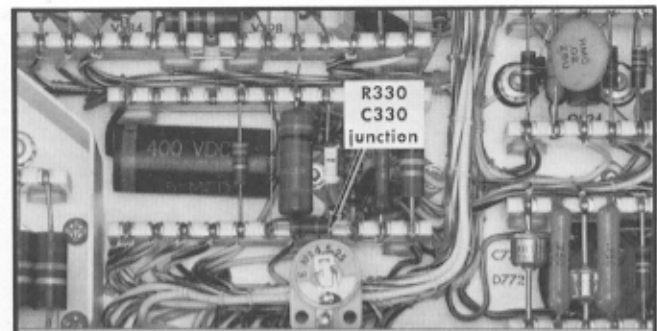
- Test equipment setup is shown in Fig. 6-35.
- Connect a 10 \times probe from the test oscilloscope to the junction of R330-C330 (see Fig. 6-36) and adjust test oscilloscope controls for a stable display.
- Check—A sweep for the following holdoff times. See Fig. 6-36.

A TIME/CM	HOLDOFF TIME
.1 μ SEC to .5 μ SEC	4 μ s to 9 μ s
1 μ SEC to 50 μ SEC	15 μ s to 40 μ s
.1 μ SEC to .5 mSEC	150 μ s to 400 μ s
1 mSEC to 5 mSEC	1.5 ms to 4 ms
10 mSEC to 50 mSEC	15 ms to 40 ms
.1 SEC to 5 SEC	150 ms to 400 ms

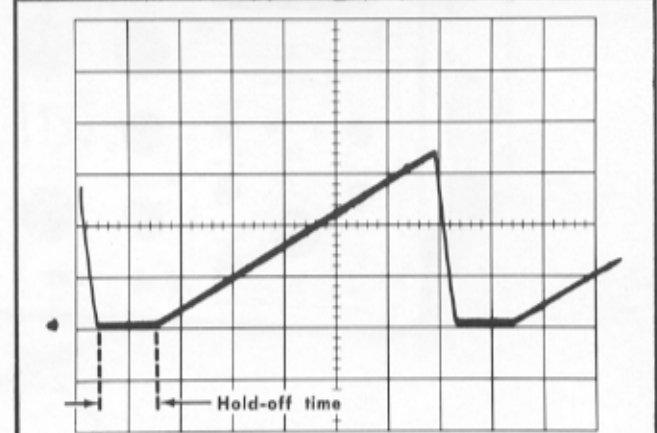
40. Check B Sweep Holdoff Time

- Equipment setup is given in step 39.
- Set HORIZONTAL DISPLAY switch to B position.
- Check—B sweep for the following holdoff times:

B TIME/CM	HOLDOFF TIME
2 μ SEC to 10 μ SEC	15 to 40 μ s
20 μ SEC to .1 μ SEC	0.15 to 0.4 ms
.2 mSEC to 1 mSEC	1.5 ms to 4 ms



(A) Location of R330-C330 junction.



(B) Holdoff time measurement.

Fig. 6-36. Checking holdoff time.

2 mSEC to 10 mSEC	15 ms to 40 ms
20 mSEC to 1 SEC	150 ms to 400 ms

- Disconnect the 10 \times probe from the junction of R330 and C330.

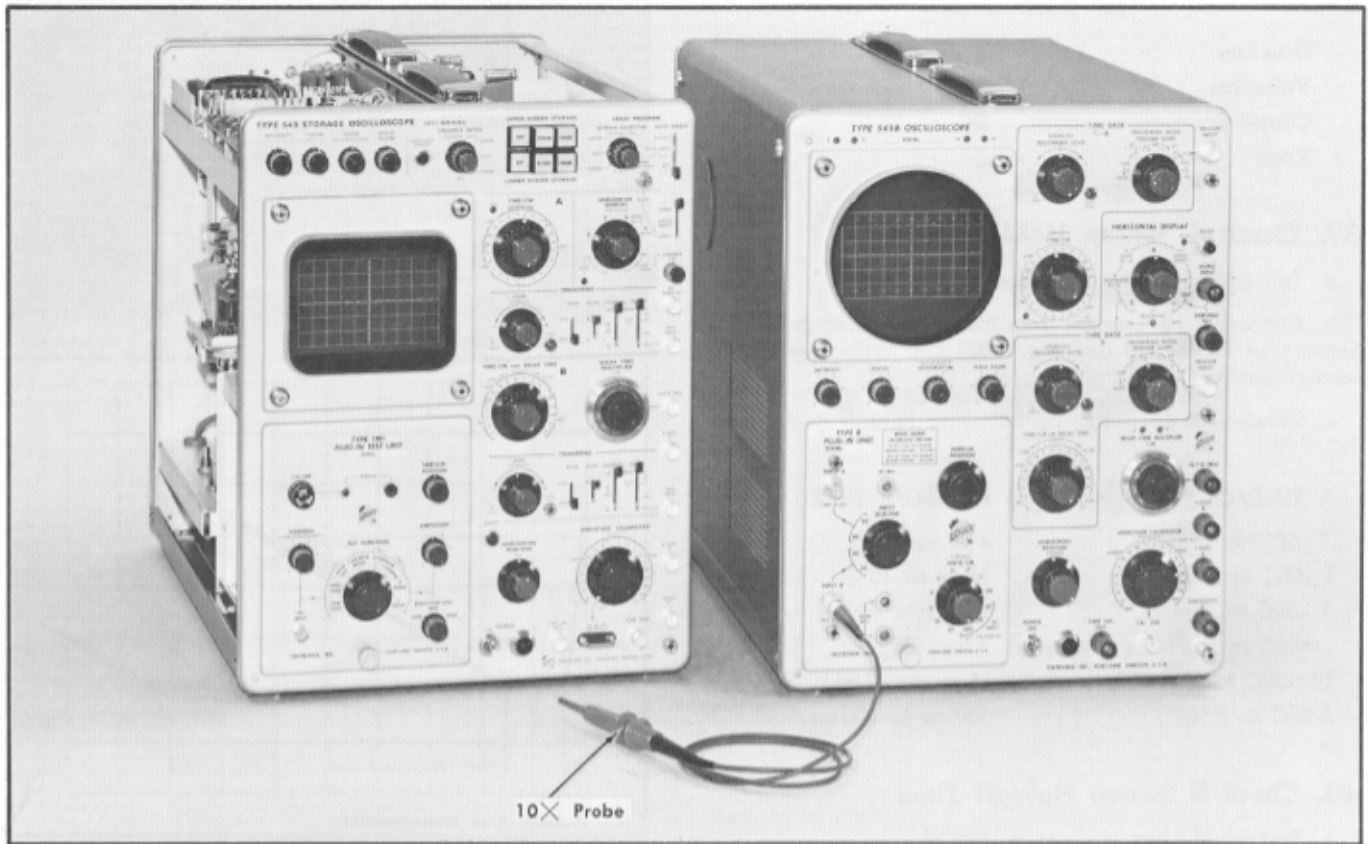


Fig. 6-37. Equipment setup for steps 41 through 45.

Type 549

CRT controls

- INTENSITY Normal intensity
- FOCUS Adjust for well defined trace
- ASTIG Adjust for well defined trace
- SCALE ILLUM As desired

Storage controls

- ENHANCE MODE OFF
- ENHANCE LEVEL Counterclockwise
- UPPER SCREEN STORAGE OFF
- LOWER SCREEN STORAGE OFF
- SCREEN SELECTOR FULL
- VIEWING TIME Counterclockwise
- AUTO ERASE OFF

- HORIZONTAL DISPLAY A
- MAGNIFIER OFF
- NORM-SINGLE SWEEP NORM

Time Base A

- TIME/CM** .5 mSEC
- VARIABLE CAL

Triggering controls

- LEVEL CW
- STABILITY PRESET
- MODE TRIG
- SLOPE +
- COUPLING AC
- SOURCE NORM

Time Base B

- TIME/CM AND DELAY**
- TIME** .5 mSEC
- LENGTH Clockwise

Triggering controls

LEVEL	CW
STABILITY	PRESET
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM
DELAY TIME MULTIPLIER	
1-10	1.00
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	OFF

Test Plug-In Load/Pulsar Unit

Test Function	+PULSE
Variable	CCW
Vertical Position	Midrange
Repetition Rate	Low
Amplitude	Adjusted for 4 cm display amplitude

41. Adjust DC Shift

- a. Equipment setup is shown in Fig. 6-37.
- b. Adjust the A Triggering controls for a stable display.
- c. Adjust the DC Shift R502 (Fig. 6-38) for minimum waveform tilt.

42. Adjust High Frequency Response

- a. Equipment setup is as given in step 41.
- b. Change the test plug-in unit Repetition Rate switch to High position.
- c. Adjust for optimum high frequency response as follows: (Fig. 6-39).

With A TIME/CM switch at .1 μ SEC or .2 μ SEC, adjust L588, L589, L598, L599, C520 and R580 for minimum rolloff and overshoot on front corner of the waveform. When making this adjustment keep the front corner level with the top of the waveform.

Adjust L554, C551 and C581 for minimum rolloff or overshoot with the A TIME/CM switch at .2 μ SEC or .5 μ SEC. Again be sure that the front corner does not begin to tilt.

With A TIME/CM at 1 μ SEC or 2 μ SEC position, adjust C568 for minimum ringing and L560 for minimum tilt on the front corner of the waveform.

- d. Change the test plug-in unit Test Function switch to -Pulse and the A Triggering SLOPE switch to - position.
- e. Vertically center the display about the graticule center line.
- f. Check—Peak-to-peak aberration with either (+) or (-) pulse; must not exceed 1 mm.

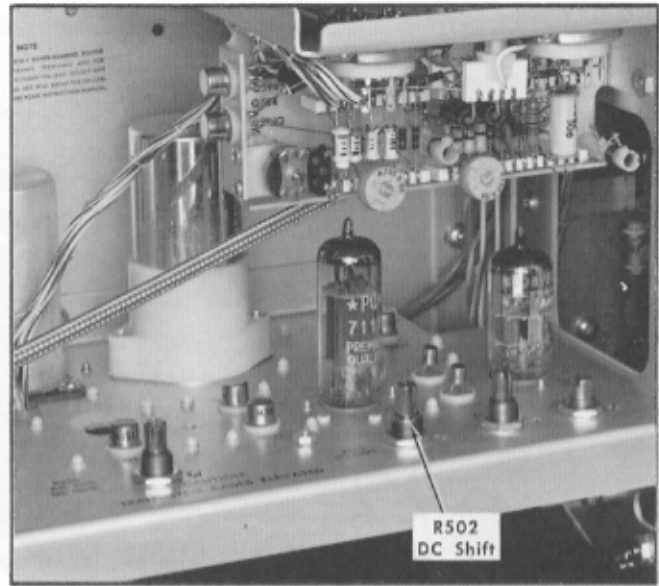


Fig. 6-38. Location of DC Shift adjustment R502.

43. Check Effect of Display Position on Transient Response

- a. Equipment setup is given in step 42.
- b. Position the bottom of the - pulse 0.5 cm from the top graticule line.
- c. Check—Peak-to-peak aberrations; must not exceed 2 mm.
- d. Change the test plug-in unit Test Function switch to +Pulse and the A Triggering SLOPE to +.
- e. Position the top of the + pulse 0.5 cm from the bottom graticule line.
- f. Check—Peak-to-peak aberrations; must not exceed 2 mm. See Fig. 6-39C.

44. Check Risetime

- a. Equipment setup is given in step 43.
- b. Increase the signal amplitude to 5 cm.
- c. Set the A TIME/CM switch to .1 μ SEC and the MAGNIFIER to $\times 5$.
- d. Measure the risetime of the + pulse. (10% to 90% of its amplitude) Fig. 6-39C.
- e. Check—Risetime must be less than or equal to 12 ns.
- f. Change the test plug-in unit Test Function selector to -Pulse and the A Triggering SLOPE to - position.
- g. Measure the risetime for the - pulse.
- h. Check—Time must be less than or equal to 12 ns.

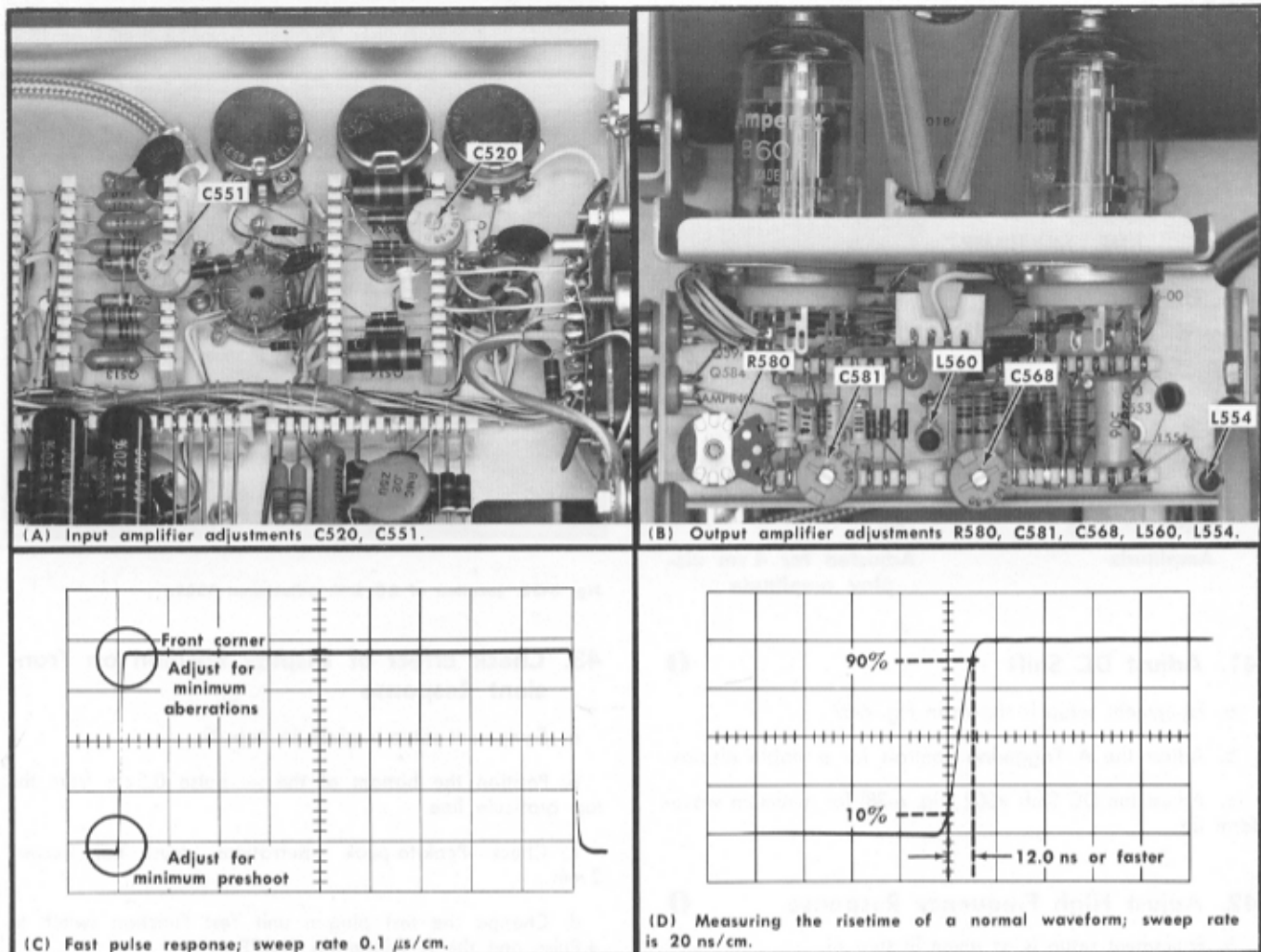


Fig. 6-39. Vertical amplifier compensation checks and adjustments.

45. Check Vertical Signal Out

- a. Equipment setup is as given for step 44.
- b. Connect a 10 \times probe from the test oscilloscope to the VERT SIG OUT connector and adjust for a triggered display.
- c. Check—The peak-to-peak amplitude of the vertical

signal out should range between 6 and 9 volts.

- d. Measure the risetime of the + pulse.
- e. Check—Risetime should be less than or equal to 0.5 μs .
- f. Turn the POWER off, remove the test plug-in unit, install a 1-series vertical plug-in unit (Type 1A1 or 1A2) and turn POWER switch ON.

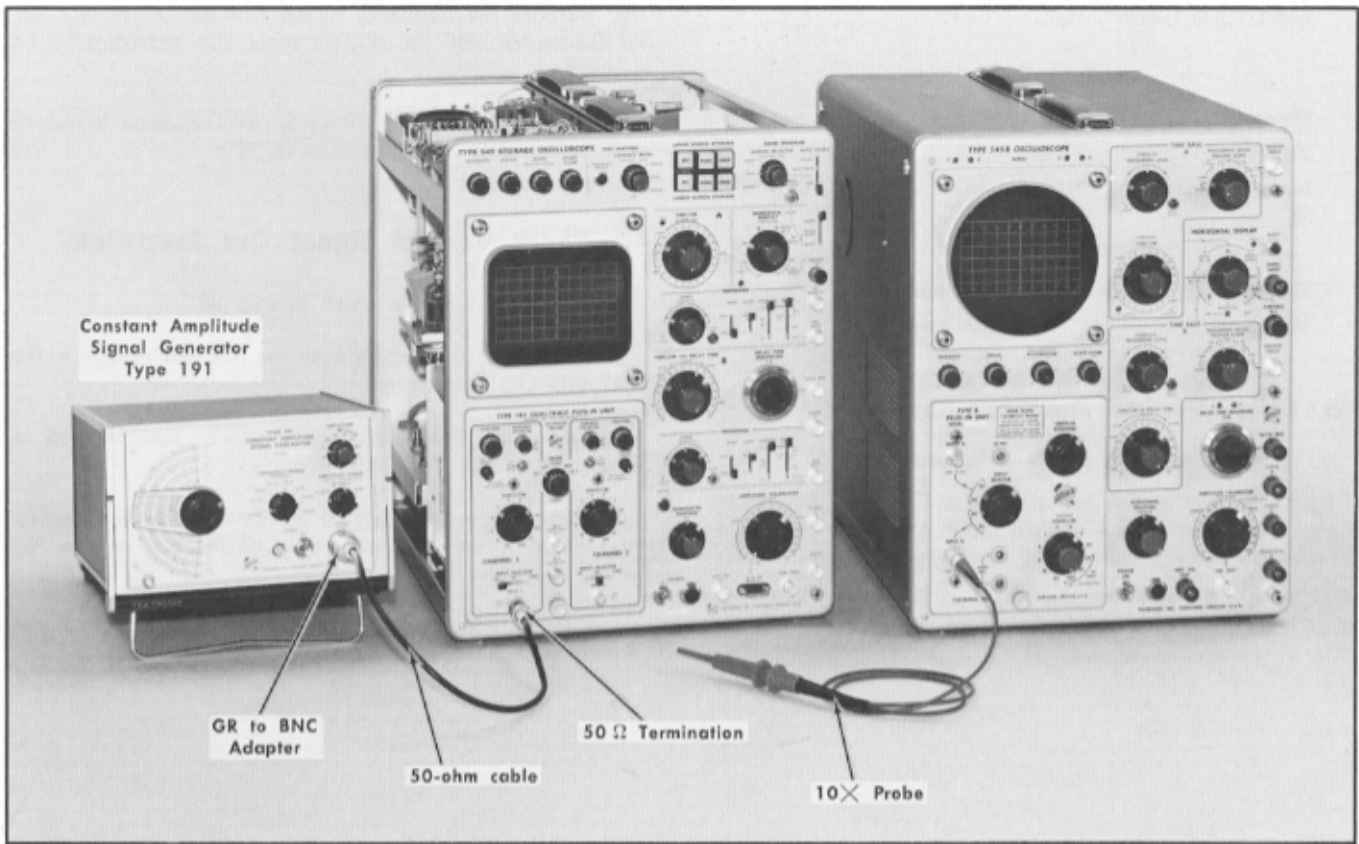


Fig. 6-40. Equipment setup for steps 46 and 47.

Type 549		VARIABLE	CAL
CRT controls		Triggering controls	
INTENSITY	Normal intensity	LEVEL	CW
FOCUS	Adjust for well defined trace	STABILITY	PRESET
ASTIG	Adjust for well defined trace	MODE	TRIG
SCALE ILLUM	As desired	SLOPE	+
		COUPLING	AC
		SOURCE	NORM
Storage controls		Time Base B	
ENHANCE MODE	OFF	TIME/CM AND DELAY	
ENHANCE LEVEL	Counterclockwise	TIME	.5 mSEC
UPPER SCREEN STORAGE	OFF	LENGTH	Clockwise
LOWER SCREEN STORAGE	OFF	Triggering controls	
SCREEN SELECTOR	FULL	LEVEL	CW
VIEWING TIME	Counterclockwise	STABILITY	PRESET
AUTO ERASE	OFF	MODE	TRIG
HORIZONTAL DISPLAY	A	SLOPE	+
MAGNIFIER	OFF	COUPLING	AC
NORM-SINGLE SWEEP	NORM	SOURCE	NORM
Time Base A		DELAY TIME MULTIPLIER	
TIME/CM	.2 mSEC	1-10	1.00
		HORIZONTAL POSITION	Midrange

Calibration—Type 549

AMPLITUDE CALIBRATOR OFF

Type 1A1

Mode CH 1
Volts/cm .05
Input Selector AC

Test Oscilloscope

Time/cm 0.2 msec
Volts/cm As required

46. Check Vertical Amplifier Bandwidth

- a. Equipment setup is shown in Fig. 6-40.
- b. Apply the output signal of the Constant Amplitude Signal Generator to the vertical input connector through a 50 ohm coaxial cable and a 50 ohm termination.
- c. With a Constant Amplitude Signal Generator frequency of 50 kHz, adjust the amplitude control for a display amplitude of 4 major divisions.

d. Increase the frequency of the Constant Amplitude Signal Generator until the display amplitude decreases to 2.8 divisions.

e. Check—Constant Amplitude Signal Generator frequency must be equal to or higher than 30 MHz.

47. Check Vertical Signal Out Bandwidth

a. Equipment setup is given in step 46.

b. Connect a 10× probe from the test oscilloscope to the VERT SIG OUT connector.

c. Adjust the test oscilloscope vertical sensitivity for a display amplitude of 4 divisions.

d. Increase the frequency of the Constant Amplitude Signal Generator until the amplitude of the test oscilloscope display decreases to 2.8 cm.

e. Check—Frequency of the Constant Amplitude Signal Generator should be equal to or higher than 700 kHz .

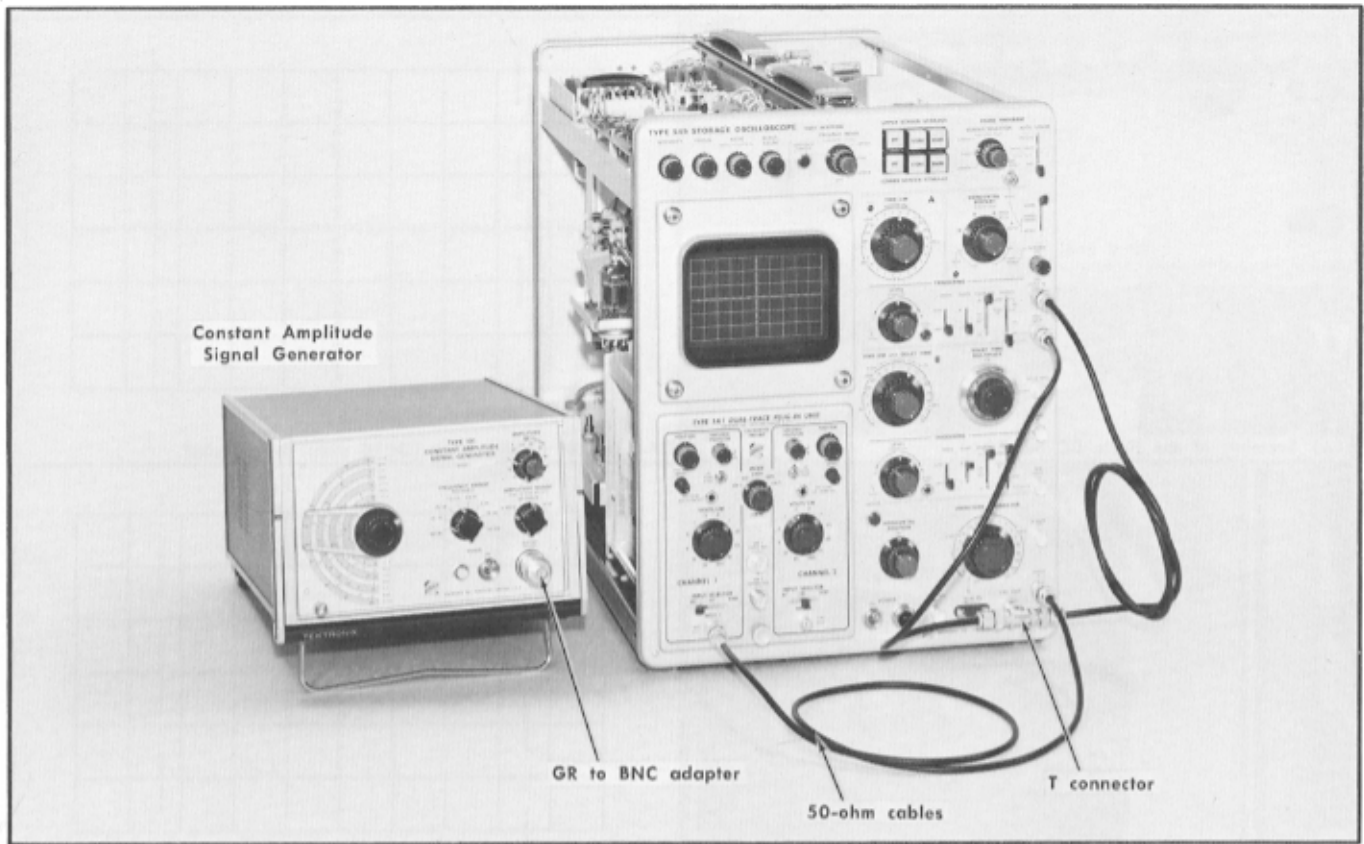


Fig. 6-41. Equipment setup for steps 48 through 51.

Type 549

CRT controls

INTENSITY Normal intensity
 FOCUS Adjust for well defined trace
 ASTIG Adjust for well defined trace
 SCALE ILLUM As desired

Storage controls

ENHANCE MODE OFF
 ENHANCE LEVEL Counterclockwise
 UPPER SCREEN STORAGE OFF
 LOWER SCREEN STORAGE OFF
 SCREEN SELECTOR FULL
 VIEWING TIME Counterclockwise
 AUTO ERASE OFF
HORIZONTAL DISPLAY 1X
 MAGNIFIER OFF
 NORM-SINGLE SWEEP NORM

Time Base A

TIME/CM .5 mSEC
 VARIABLE CAL

Triggering controls

LEVEL 0
STABILITY PRESET
MODE TRIG
SLOPE —
COUPLING AC
SOURCE EXT

Time Base B

TIME/CM AND DELAY
TIME .5 mSEC
LENGTH Clockwise

Triggering controls

LEVEL CW
STABILITY PRESET
MODE TRIG
SLOPE +
COUPLING AC
SOURCE NORM
HORIZONTAL POSITION Midrange
AMPLITUDE CALIBRATOR 1.0 Volt

Type 1A1

Volts/cm 20
Input Selector AC
Mode CH 1

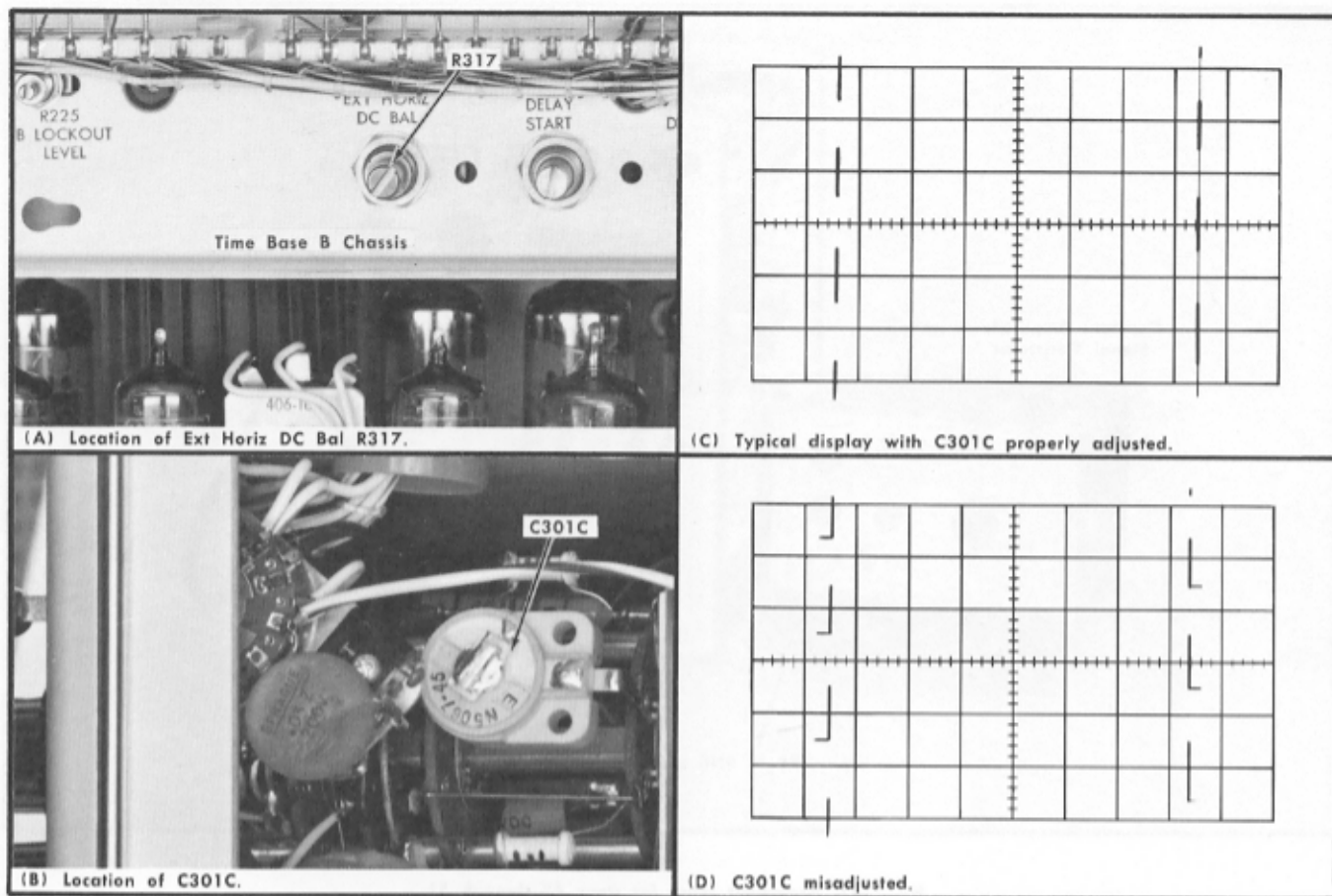


Fig. 6-42. External horizontal adjustments.

48. Adjust External Horizontal DC Balance ①

- a. Equipment setup is shown in Fig. 6-41.
- b. Apply the output cable from the SWEEP A connector to the Vertical Input connector.
- c. Connect the CAL OUT connector through a BNC T connector and two 50 ohm coaxial cables to the EXT HORIZ IN connector and the A TRIG INPUT connector.
- d. Adjust A Triggering LEVEL control for a stable triggered display.
- e. Adjust the HORIZONTAL POSITION controls to center the display on the graticule.
- f. Adjust the Ext Horiz DC Bal R317 (see Fig. 6-42) for no horizontal shift of the waveform baseline (to the left) while rotating the VARIABLE 1:10 control from a clockwise to fully counterclockwise position.
- g. Change the HORIZONTAL DISPLAY switch to 10X position.
- h. Check—The baseline should not shift more than 2 mm as the VARIABLE 1:10 control is rotated through its range.

49. Adjust External Horizontal 10X Compensation ①

- a. Equipment setup is given in step 48.
- b. Turn the VARIABLE 1:10 control fully clockwise and change the HORIZONTAL DISPLAY switch to the 10X position.
- c. Change the AMPLITUDE CALIBRATOR to 10 volts and center the display with the HORIZONTAL POSITION controls.
- d. Adjust C301C for optimum square-wave response. Aberrations should not exceed $\pm 3\%$. Fig. 6-42C and 6-42D.

50. Check External Horizontal Input Deflection Factor

- a. Equipment setup is as given for step 49.
- b. Set the VARIABLE 1:10 control fully clockwise, the AMPLITUDE CALIBRATOR at 1.0 volt and the HORIZONTAL DISPLAY switch to 1X position.
- c. Check—Horizontal deflection of 5 cm or more must be observed.

d. Change the HORIZONTAL DISPLAY switch to 10× position and the AMPLITUDE CALIBRATOR to 10 VOLT position.

e. Check—Horizontal deflection should be 5 cm or more.

f. Change the VARIABLE 1-10 control to fully counter-clockwise position and the HORIZONTAL DISPLAY switch to 1×. Note the amplitude of the horizontal deflection.

g. Change the HORIZONTAL DISPLAY switch to the 10× position and the VARIABLE 1-10 control fully clockwise.

h. Check the horizontal deflection amplitude. Must be equal to or greater than the amplitude noted in step f.

i. Set the AMPLITUDE CALIBRATOR switch to the 1 volt position, the VARIABLE 1-10 control fully clockwise and the HORIZONTAL DISPLAY switch to 1× position.

j. Set the A STABILITY control to PRESET and adjust the LEVEL control for a stable display.

k. Note the display signal amplitude and aberrations.

l. Change the HORIZONTAL DISPLAY switch to 10× position and the AMPLITUDE CALIBRATOR to 10 volt position.

m. Check and compare the display amplitude and wave shape with the display in step k. Amplitude must be within $\pm 2\%$ and aberrations in both the 1× and 10× positions must be less than $\pm 5\%$.

51. Check External Horizontal Amplifier Bandwidth

a. Equipment setup is given in step 50.

b. Remove the AMPLITUDE CALIBRATOR signal and apply a 50 kHz signal from the Constant Amplitude Signal Generator (Type 191) to the EXT HORIZ IN connector.

c. Set the HORIZONTAL DISPLAY switch to 1× position and the VARIABLE 1-10 control fully clockwise.

d. Adjust the output of the Constant Amplitude Signal Generator for 6 cm of horizontal deflection.

e. Increase the Constant Amplitude Signal Generator frequency until the display amplitude decreases to 4.2 cm.

f. Check—Constant Amplitude Signal Generator frequency must be equal to or greater than 350 kHz.

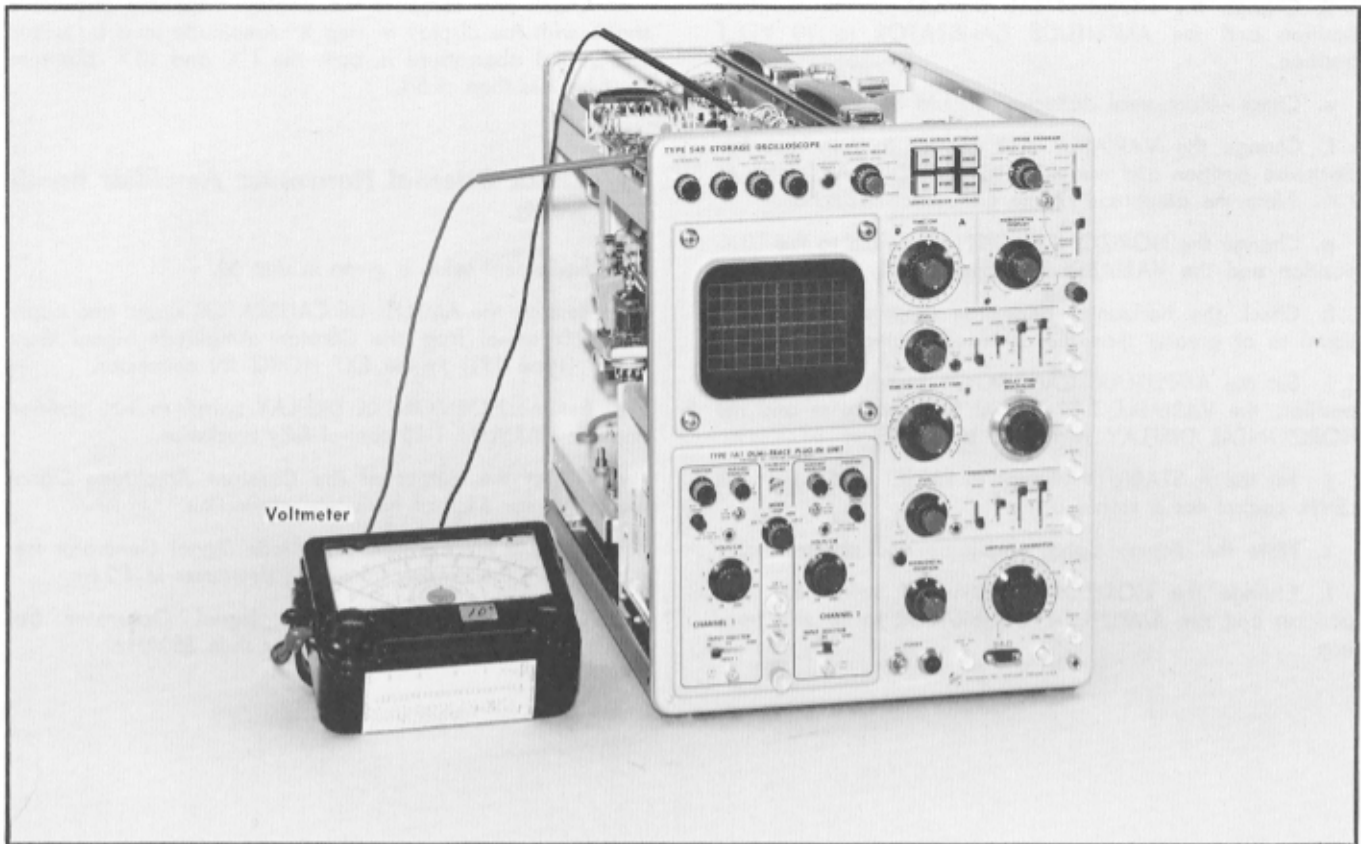


Fig. 6-43. Equipment setup for steps 52 through 54.

STORAGE SYSTEM

Checks and adjustments of the storage system should be performed in sequence because there is interaction between adjustments. Check the high voltage adjustment and the Intensity Range setting step 4 and 5 before proceeding with the storage circuit adjustments.

Type 549

CRT controls

INTENSITY	Fully counterclockwise
FOCUS	Midrange
ASTIG	Midrange

Storage System

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER and LOWER SCREEN STORAGE	STORE

Erase Program

SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
NORM-SINGLE SWEEP	NORM

Time Base A

TIME/CM	0.1 mSEC
VARIABLE	CAL
LEVEL	Clockwise
STABILITY	Clockwise
MODE	TRIG
SLOPE	+
COUPLING	AC
SOURCE	NORM

Vertical Plug-In Unit (Type 1A1 or equivalent)

Volts/cm	1.0
Input Selector	AC

52. Adjust Flood Gun Cathode Potential and Backplate Balance. ①

a. Equipment setup as shown in Fig. 6-43.

b. Connect a voltmeter, set to 250 volt range, between +300 V (pin +300 on storage circuit assembly board) and the Flood Cathode TP.

c. Adjust FG Cath Level R1185 for a meter reading of 175 volts.

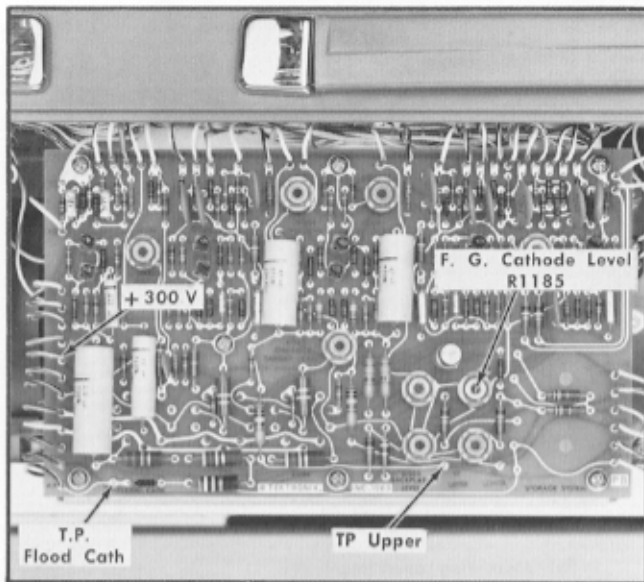


Fig. 6-44. Adjust FG Cath Level R1185 for voltmeter reading of 175 volts between +300 volt supply and TP Cathode.

d. Connect the voltmeter between TP Upper and TP Lower and adjust Backplate Bal R1050 for a voltmeter reading of zero. Fig. 6-45.

53. Adjust Collimation

- a. Equipment setup is given in step 52.
- b. Connect a voltmeter between TP Upper (upper target) and TP Flood Cathode (flood gun cathode). The voltmeter reading is the operating voltage.
- c. Adjust the Backplate Level R1055 for a voltmeter reading of 160 volts. Adjust INTENSITY control for a sweep of nominal intensity.
- d. Write the entire storage screen area by slowly positioning the trace vertically. If the screen fails to write, increase the operating voltage in steps of 10 volts and repeat the process until the screen will completely write within the graticule area.
- e. Turn the Collimation adjustment R1070 fully counter-clockwise or until two bright spots appear, then turn it clockwise for maximum uniform brightness over the storage area.
- f. Erase the screen by pushing both ERASE buttons, then switch to conventional mode by depressing both OFF buttons for the UPPER and LOWER SCREEN STORAGE.
- g. Interaction—Collimation affects sweep timing, vertical gain, linearity and storage capabilities.

54. Adjust Backplate Level

- a. Equipment setup is as given for step 53.

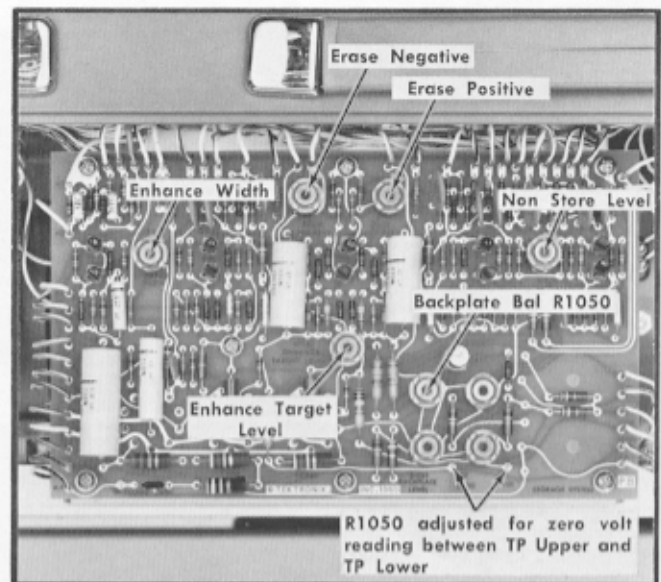


Fig. 6-45. Adjust Backplate Bal R1050 for voltmeter reading of 0 volts.

b. Set the INTENSITY control for 20 μ A writing beam current as follows:

1. Apply an approximate 50 kHz sine wave from the Constant Amplitude Signal Generator to the vertical Input connector and set the amplitude control for a 3.2 cm display. Center display within graticule area with HORIZONTAL and Vertical position controls.
2. Switch the A Triggering MODE switch to AUTO and the A TIME/CM switch to 20 μ SEC position.
3. Set the INTENSITY control for an approximate 20 μ A beam current (this is slightly above normal operating brightness), then adjust the FOCUS and ASTIG controls for optimum display definition.
4. Turn the POWER switch to OFF and remove the signal from the Constant Amplitude Signal Generator.
5. Carefully remove the left and right horizontal deflection leads from the CRT neck pins. Position the deflection lead connectors so they will not short to ground or to other voltage points.

NOTE

Do not bend the neck pins. Grip the metal pin connectors and pull directly away from the CRT neck.

6. Connect the right horizontal deflection plate (CRT pin) through a microammeter to the 500 volt supply. The 500 V terminal on the circuit board assembly is convenient. See Fig. 6-47.

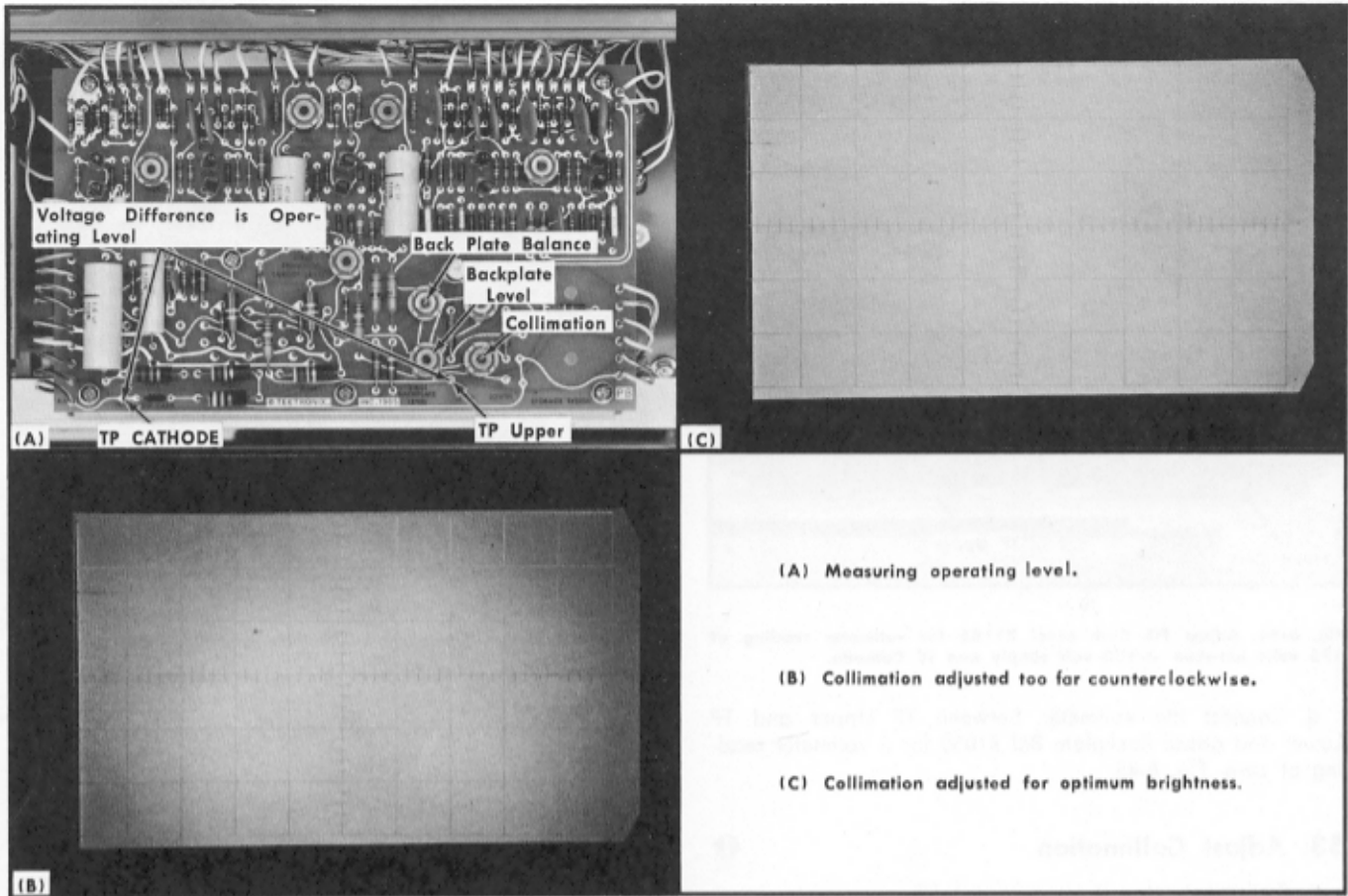


Fig. 6-46. Adjusting collimation.

- (A) Measuring operating level.
- (B) Collimation adjusted too far counterclockwise.
- (C) Collimation adjusted for optimum brightness.

7. Connect the left horizontal deflection plate through a second microammeter to the 100 V supply.
8. Set both meters to a range greater than 100 μ A. (Flood gun current plus writing beam current may exceed 100 μ A.)
9. Turn the POWER switch to ON, the A MODE switch to TRIG, STABILITY and LEVEL controls fully clockwise and A TIME/CM switch to 5 SEC position.
10. After the time delay interval for the power supply voltages to turn on, depress the INTEGRATE TRACES button. This will interrupt the flood gun current and while holding the button depressed, measure the algebraic sum of the two microammeter readings during the unblanking period.
11. Adjust the INTENSITY control for a writing beam current of 20 μ A. Note the position of the INTENSITY control.

NOTE

It may be convenient to mark the 20 μ A INTENSITY control position on the front panel for ease of setup. The beam current must be rechecked if the

FOCUS or ASTIG controls are readjusted from their initial setting.

12. Turn the POWER switch to OFF. Remove both microammeters and reconnect the horizontal deflection leads to the left and right CRT deflection plate pins.
13. Reconnect the voltmeter between TP Upper and TP Flood Cath.

- c. Turn the POWER switch to ON and the TIME/CM switch to the 0.1 mSEC position.
- d. Set the INTENSITY control for 20 μ A beam current and adjust FOCUS and ASTIG controls for optimum focus.
- e. Set the NORM-SINGLE SWEEP switch to the SINGLE SWEEP position.
- f. Adjust Backplate Level R1055 for an operating point that is midway between the writing threshold and the upper writing limit.

Writing threshold is found as follows:

1. Set the UPPER and LOWER SCREEN STORAGE to STORE.

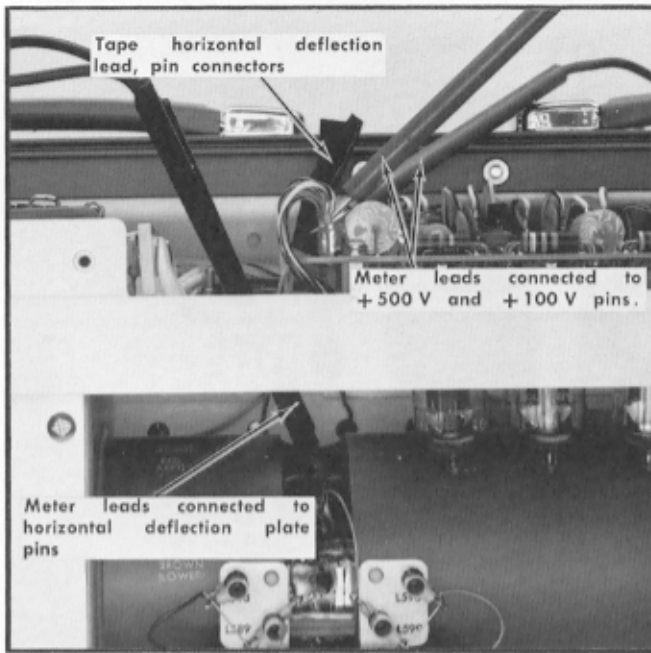


Fig. 6-47. Measuring CRT beam current.

2. Depress both ERASE buttons to prepare the target area for storage.

3. Write 3 or more lines per cm on the target area by depressing the NORM-SINGLE SWEEP switch to RESET. After each line is written, change the vertical position of the spot before writing the next trace.

4. Carefully check the written lines visually for breaks or gaps. If no breaks or gaps are evident after 10 seconds, adjust the Backplate Level to reduce the operating voltage by 5 volts.

5. Erase twice, wait 10 seconds then write again and check for breaks or gaps.

6. Repeat this procedure of decreasing the operating voltage level in 5 volt steps until breaks of approximately 0.025 inches occur. This is the writing threshold.

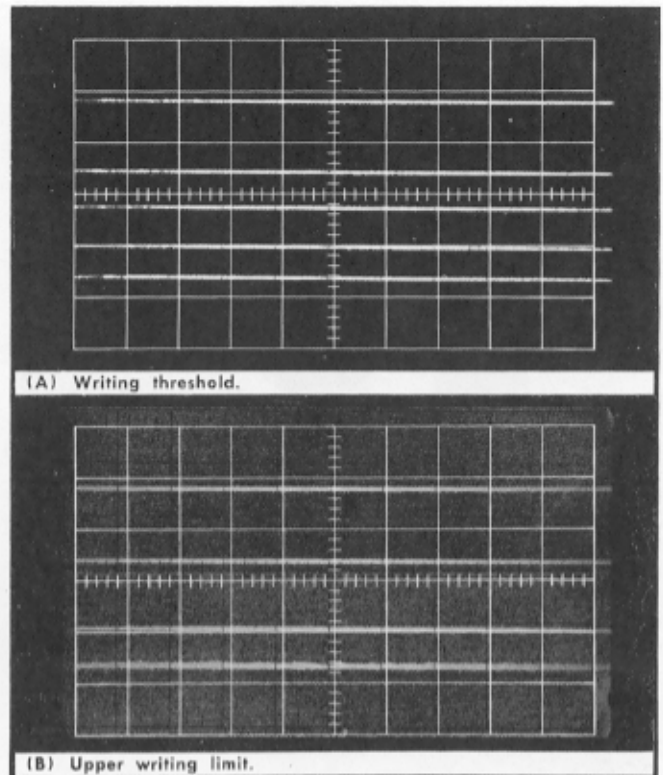


Fig. 6-48. Writing limits.

Record this operating voltage point and return the voltage to its original level.

NOTE

Do not change the INTENSITY, FOCUS or ASTIG control settings.

g. Upper Writing Limit is found as follows: Raise the operating voltage in 5 volt steps. Carefully observe the stored lines between each step for indications of fade-up. The operating voltage which produces a trace spread of 0.025 inches greater than its normal width, or a background spot greater than 0.025 inches which becomes as bright as the written area, is the upper writing limit. Record this voltage.

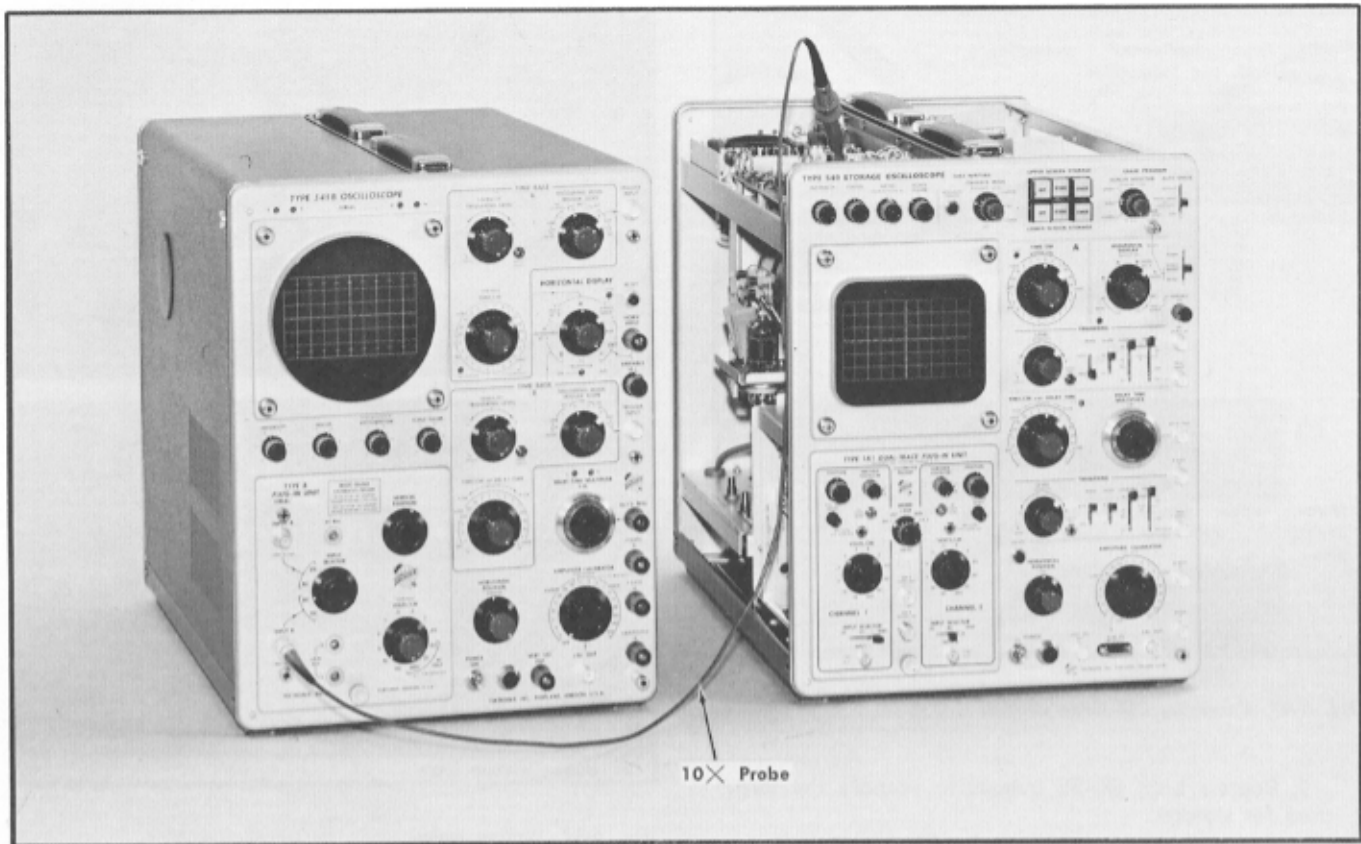


Fig. 6-49. Equipment setup for steps 55 through 58.

Type 549

CRT controls

INTENSITY Fully counterclockwise
 FOCUS Midrange
 ASTIG Midrange

Storage System

ENHANCE MODE OFF
 ENHANCE LEVEL Counterclockwise
 UPPER and LOWER SCREEN STORAGE STORE

Erase Program

SCREEN SELECTOR FULL
 VIEWING TIME MIN
AUTO ERASE AFTER SWEEP
 HORIZONTAL DISPLAY A
NORM-SINGLE SWEEP SINGLE SWEEP

Time Base A

TIME/CM .5 mSEC
 VARIABLE CAL
 LEVEL Clockwise
 STABILITY Clockwise

MODE TRIG
 SLOPE +
 COUPLING AC
 SOURCE NORM

Vertical Plug-In Unit (Type 1A1 or equivalent)

Volts/cm 1.0
 Input Selector Gnd

Test Oscilloscope

Time/cm 20 msec
 Volts/cm 10
 Coupling AC
 Triggering For a triggered display

55. Adjust Erase Pulse

a. Equipment setup is shown in Fig. 6-49.

b. Adjust INTENSITY, FOCUS and ASTIG controls for a well focused trace of nominal brightness. Connect a 10x probe to TP Upper terminal.

c. Preset Erase Negative R1043, for maximum negative amplitude of the erase pulse. (Do not permit bottom of negative pulse to limit or square off.)

d. Adjust Erase Positive R1033, for minimum amplitude. If mottled areas appear on the target, increase the amplitude until these disappear. If this adjustment appears to have no effect, set the adjustment for minimum amplitude. Many targets will erase properly at minimum amplitude.

e. Check erase pulse for a time duration of 70 to 130 ms. Fig. 6-50.

f. Slowly reduce the Erase Negative amplitude by adjusting Erase Negative R1033, until the target fails to erase properly. This is the critical value for good erasure. Increase the amplitude 20 volts from this critical erase value. Do not permit the bottom of the negative pulse to square or limit. In some instruments this critical value may not show. If this occurs, adjust R1033 for minimum negative amplitude.

56. Check Viewing Time and After Sweep Auto Erase

- Equipment setup is as given for step 55.
- Change the AUTO ERASE switch to PERIODIC position.
- Set the test oscilloscope Time/Cm switch to 1 sec.
- Measure the viewing time with the VIEWING TIME control fully counterclockwise. The time between erase pulses should equal or be less than 0.5 seconds.
- Measure the viewing time with the VIEWING TIME control fully clockwise. The time between erase pulses should equal 5 seconds or more.
- Change the A TIME/CM switch to 0.1 SEC position and set the AUTO ERASE switch to AFTER SWEEP.
- Check for an automatic erase and reset after each sweep with a variable time between consecutive erase and single sweep cycles determined by the VIEWING TIME control position.) Time between erasures should be the same as the previous check on viewing time.
- Change the AUTO ERASE switch to the OFF position and press the ERASE AND RESET button.
- Check—The screen should erase, followed by a single sweep which stores.

57. Adjust Non Store Level ①

- Equipment setup is as given for step 56.
- Push both UPPER and LOWER SCREEN STORAGE OFF buttons for conventional operation.
- Set the NORM-SINGLE SWEEP switch to NORM.
- Turn the Non Store Level R1169 fully counterclockwise.
- Adjust the INTENSITY control for a sweep of nominal intensity.

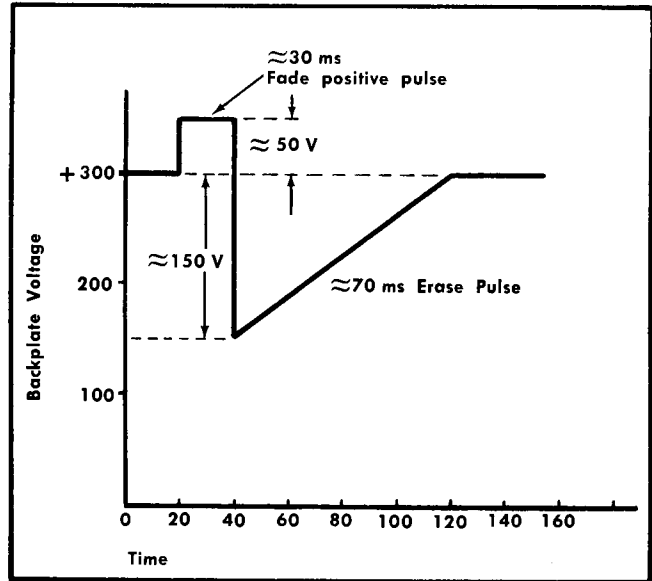


Fig. 6-50. Erase waveform.

- Write the complete storage area by vertically positioning the free running sweep over the screen storage area.
- Rotate the Non Store Level clockwise until the screen is no longer stored.
- Switch the screen storage to STORE and again write the screen storage area.
- Switch the screen storage to OFF position. If the screen remains stored or is slow to erase, rotate the Non Store Level adjustment further clockwise.
- Repeat this procedure until the screen erases promptly when the screen storage is switched from STORE to OFF.

58. Adjust Enhance Width and Enhance Level ①

- Equipment setup is as given for step 57.
- Change the ENHANCE MODE switch to the FULL position and set the ENHANCE LEVEL control midrange. Set the AUTO ERASE switch to AFTER SWEEP and the VIEWING TIME control to MIN position.
- Connect the test oscilloscope 10X probe to TP Upper, on the circuit board assembly.
- Connect a coaxial cable from the Type 549 +GATE A connector to the test oscilloscope Trig Input connector. Trigger the test oscilloscope with the +GATE A signal.
- Adjust Enhance Width R1132 for an enhance pulse width of 1 ms, Fig. 6-51B (enhance pulse appears after the erase cycle).

Calibration—Type 549

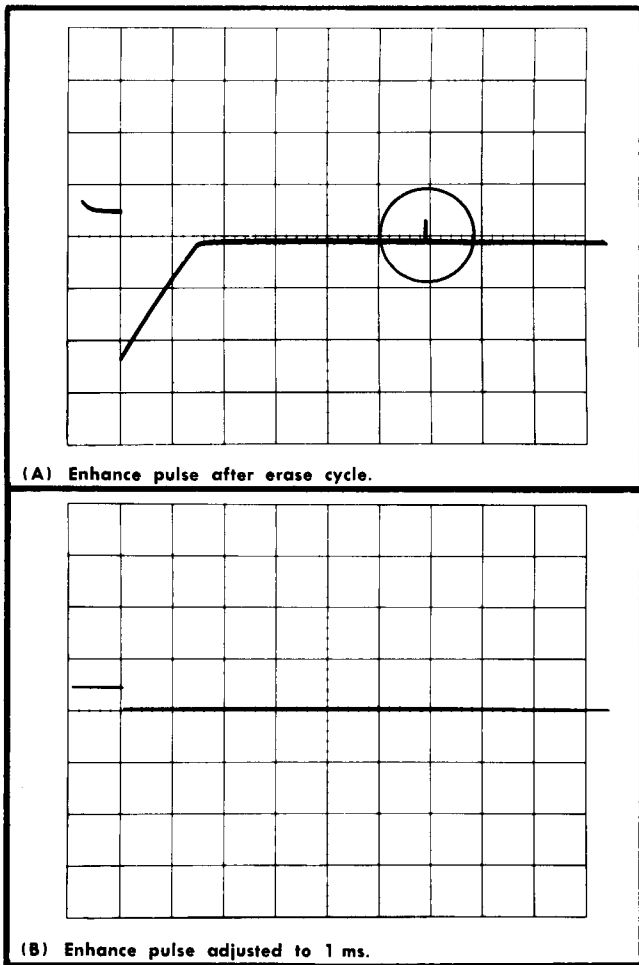


Fig. 6-51. Enhance pulse adjustment.

f. Change the NORM-SINGLE SWEEP switch to NORM position then depress both OFF buttons for the UPPER and LOWER SCREEN STORAGE.

g. Set the A TIME/CM switch to $.2 \mu\text{SEC}$ position and free run the sweep by turning the STABILITY and LEVEL control fully clockwise.

h. Set the NORM-SINGLE SWEEP switch to the SINGLE SWEEP position and depress both STORE buttons for the UPPER and LOWER SCREEN STORAGE.

i. Adjust the INTENSITY, FOCUS and ASTIG controls until a stored trace is visible, then adjust FOCUS and ASTIG for optimum focus.

j. Slowly adjust the ENHANCE LEVEL control clockwise for optimum storage without background deterioration. If the sweep stores without breaks, increase the TIME/CM switch setting for a faster sweep rate.

k. Adjust the Enhance Width R1132 and then ENHANCE LEVEL control for optimum storage of the sweep, without fade positive indication on the screen. (If optimum setting cannot be found, set the Enhance Width for a pulse width of 1 ms.)

l. With the ENHANCE LEVEL control set for optimum storage carefully adjust the Enhance Target Level R1140, for maximum writing speed without background deterioration.

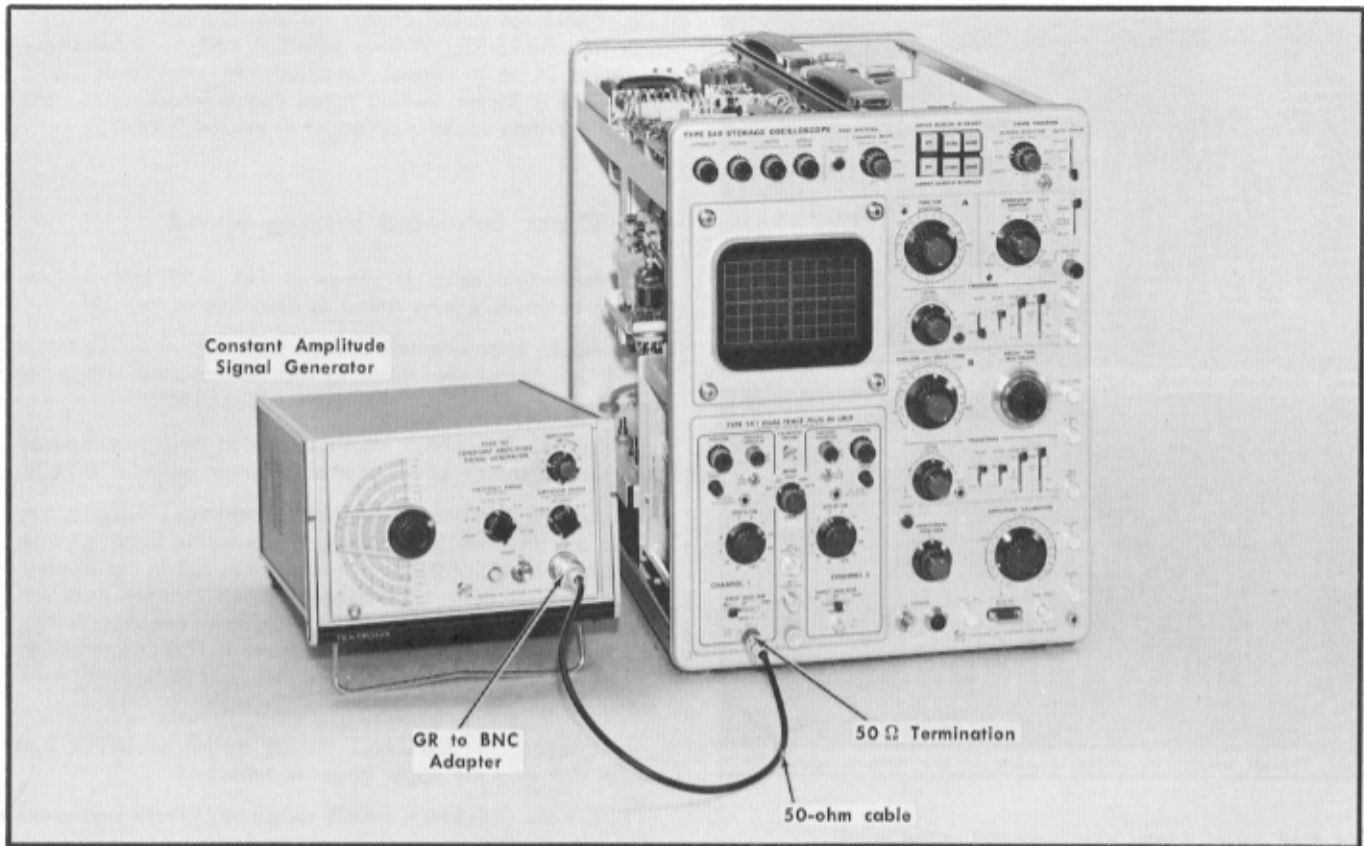


Fig. 6-52. Equipment setup for steps 59 and 60.

Type 549

CRT controls

INTENSITY	As required for trace of nominal brightness
FOCUS	Midrange
ASTIG	Midrange

Storage System

ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER SCREEN STORAGE	OFF
LOWER SCREEN STORAGE	OFF

Erase Program

SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
NORM-SINGLE SWEEP	NORM

Time Base A

TIME/CM	20 μ SEC
----------------	--------------

VARIABLE LEVEL STABILITY

CAL Midrange PRESET

All TRIGGERING switches up

Vertical Plug-In Unit (1A1 or equivalent)

Volts/Cm	0.5
Input Selector	AC

59. Check Storage Writing Speed

- a. Equipment setup is shown in Fig. 6-52.
- b. Apply a 50 kHz sine wave from the Constant Amplitude Signal Generator to the input of the vertical plug-in unit (Type 1A1 or 1A2) and adjust the output signal amplitude control for a displayed amplitude of 3.2 cm.
- c. Adjust the A TIME/CM switch and VARIABLE control to display 15 cycles in 10 cm.
- d. Set the NORM-SINGLE SWEEP switch to SINGLE SWEEP position and the AUTO ERASE switch to AFTER SWEEP.
- e. Push both STORE buttons for the UPPER and LOWER SCREEN STORAGE and adjust the VIEWING TIME control to an approximate 3 second viewing time position.

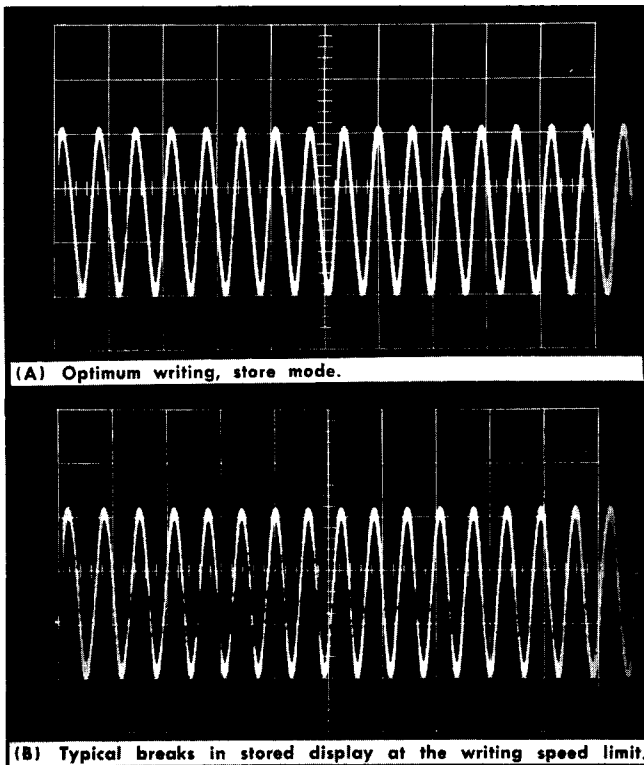


Fig. 6-53. Typical display when measuring writing speed.

f. Adjust the INTENSITY, FOCUS and ASTIG controls for optimum writing speed. Fig. 6-53.

g. Check the stored display for breaks greater than 0.025 inch (see Fig. 6-53). Writing speed in $\text{cm}/\mu\text{s} = \text{Frequency in MHz} \times \pi \times \text{signal amplitude in cm}$. Since signal amplitude is 3.2 cm, writing speed equals frequency in $\text{MHz} \times 10$. Writing speed must equal or exceed $0.5 \text{ cm}/\mu\text{s}$.

60. Check Enhanced Writing Speed

a. Equipment setup is shown in Fig. 6-52 with controls set for optimum writing speed as described in step 59f.

b. Apply approximately 500 kHz signal from the Constant Amplitude Signal Generator to the vertical Input connector of the Type 549 plug-in unit (Type 1A1 or 1A2).

c. Set the ENHANCE MODE switch to FULL position and turn the ENHANCE LEVEL control to obtain optimum storage.

d. Set the A TIME/CM switch to maintain 15 cycles per 10 cm and increase the input frequency of the signal generator until a break of 0.025 inch is noted in the stored display. Fade positive spots or background deterioration must not exceed 0.025 inch. This is the maximum enhance writing speed and must equal or exceed $5 \text{ cm}/\mu\text{s}$. Enhanced writing speed in $\text{cm}/\mu\text{s} = \text{Sine wave frequency in MHz} \times 10$ (with signal amplitude of 3.2 cm).

e. Change the ENHANCE MODE switch to UPPER and check that only the upper target is enhanced.

f. Set the ENHANCE MODE switch to LOWER and check that only the lower target is enhanced.

g. Set the ENHANCE MODE switch to OFF.

h. Remove the sine wave signal from the signal generator.

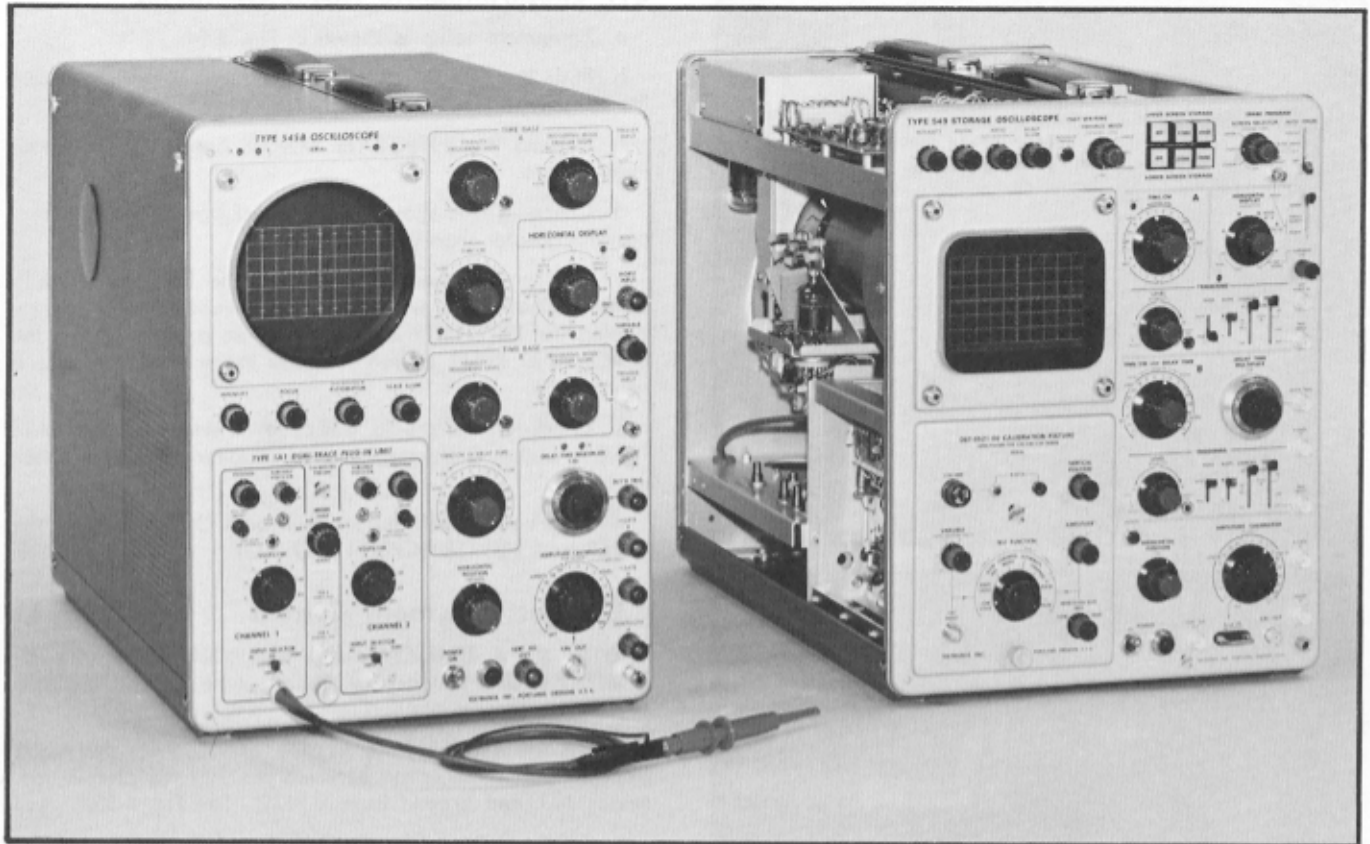


Fig. 6-54. Equipment setup for steps 61 and 62.

Type 549

CRT controls

INTENSITY
FOCUS
ASTIG
SCALE ILLUM

Counterclockwise
 Midrange
 Midrange
 As desired

Storage controls

ENHANCE MODE
ENHANCE LEVEL
UPPER SCREEN STORAGE
LOWER SCREEN STORAGE
SCREEN SELECTOR
VIEWING TIME
AUTO ERASE
HORIZONTAL DISPLAY
MAGNIFIER
NORM-SINGLE SWEEP

OFF
 Counterclockwise
STORE
STORE
 FULL
 MIN
 OFF
 A
 OFF
SINGLE SWEEP

Time Base A

TIME/CM
VARIABLE

.5 mSEC
CAL

Triggering controls

LEVEL
STABILITY
MODE
SLOPE
COUPLING
SOURCE

CW
CW
TRIG
+
AC
NORM

Time Base B

TIME/CM AND DELAY TIME LENGTH

1.0 mSEC
Clockwise

Triggering controls

LEVEL
STABILITY
MODE
SLOPE
COUPLING
SOURCE

CW
CW
TRIG
+
AC
NORM

DELAY TIME MULTIPLIER 1-10
HORIZONTAL POSITION
FINE
AMPLITUDE CALIBRATOR

1.00
Midrange
Midrange
OFF

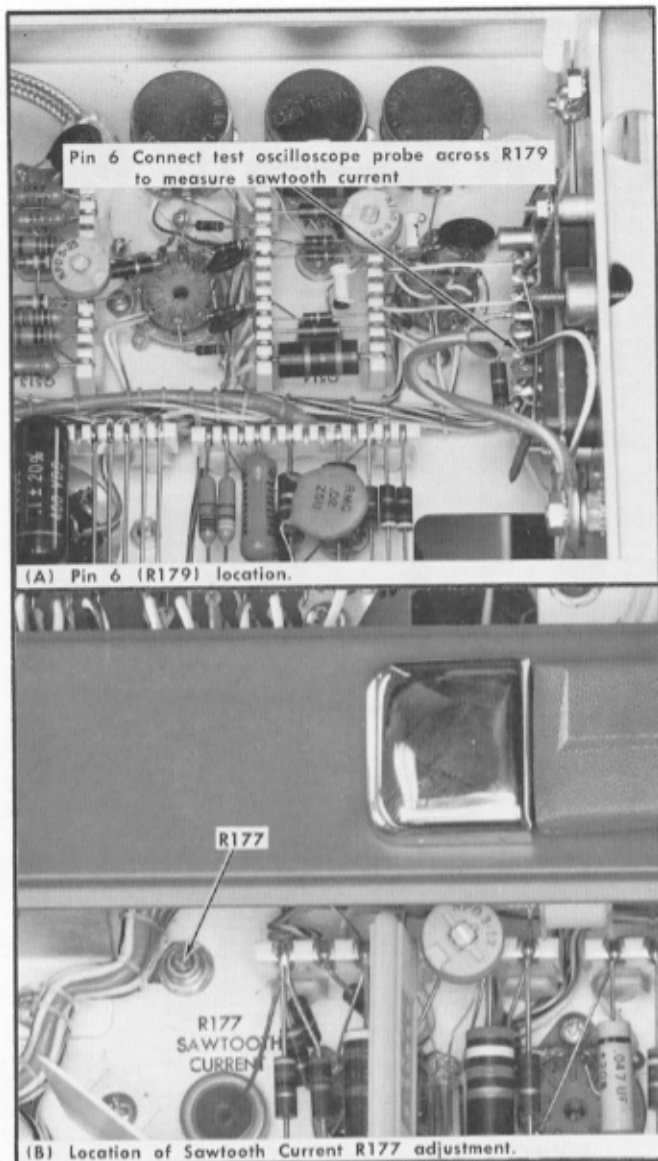


Fig. 6-55. Adjusting sawtooth current to 2.1 mA.

61. Check Integrate Traces Operation

- a. Equipment setup is shown in Fig. 6-54.
- b. Push the ERASE AND RESET button twice to prepare the target.
- c. Depress the INTEGRATE TRACES button for 2 seconds then release.
- d. Check—There should be no background spots (deterioration) greater than 0.025 inch.
- e. Increase the beam intensity to the level at which a trace will just store with single sweep operation by slowly turning the INTENSITY control clockwise and depressing the ERASE AND RESET button to erase the screen and write a new sweep.
- f. Check—Trace should disappear when the INTEGRATE TRACES button is depressed and reappear when the button is released.
- g. Push both ERASE buttons then both OFF buttons for the UPPER and LOWER SCREEN STORAGE.

62. Adjust Sawtooth Current

- a. Set the A TIME/CM switch to 1 mSEC position, HORIZONTAL DISPLAY switch to A and place all TRIGGERING switches in the up position.
- b. Set the Type 549 on its side and connect the probe from the test oscilloscope between pin 6 of the plug-in connector J-11 and ground (across R179). See Fig. 6-55A.
- c. Set the test oscilloscope Volts/cm deflection to 1 Volt/cm, the Time/cm switch to 20 ms and adjust the triggering for a stable display.
- d. Adjust the Sawtooth Current adjustment R177 (see Fig. 6-55B) for 2.1 volt display amplitude (with a 10.5 cm trace length on the Type 549).
- e. Disconnect the test oscilloscope probe and set the Type 549 in its upright position.

This completes the calibration of the Type 549. Replace the top and bottom covers. If the instrument has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Characteristics section of the Instruction Manual.

ABBREVIATIONS AND SYMBOLS

A or amp	amperes	L	inductance
AC or ac	alternating current	λ	lambda—wavelength
AF	audio frequency	\gg	large compared with
α	alpha—common-base current amplification factor	$<$	less than
AM	amplitude modulation	LF	low frequency
\approx	approximately equal to	lg	length or long
β	beta—common-emitter current amplification factor	LV	low voltage
BHB	binding head brass	M	mega or 10^6
BHS	binding head steel	m	milli or 10^{-3}
BNC	baby series "N" connector	M Ω or meg	megohm
X	by or times	μ	micro or 10^{-6}
C	carbon	mc	megacycle
C	capacitance	met.	metal
cap.	capacitor	MHz	megahertz
cer	ceramic	mm	millimeter
cm	centimeter	ms	millisecond
comp	composition	—	minus
conn	connector	mtg hdw	mounting hardware
\sim	cycle	n	nano or 10^{-9}
c/s or cps	cycles per second	no. or #	number
CRT	cathode-ray tube	ns	nanosecond
csk	countersunk	OD	outside diameter
Δ	increment	OHB	oval head brass
dB	decibel	OHS	oval head steel
dBm	decibel referred to one milliwatt	Ω	ohm
DC or dc	direct current	ω	omega—angular frequency
DE	double end	p	pico or 10^{-12}
$^{\circ}$	degrees	/	per
$^{\circ}$ C	degrees Celsius (degrees centigrade)	%	percent
$^{\circ}$ F	degrees Fahrenheit	PHB	pan head brass
$^{\circ}$ K	degrees Kelvin	ϕ	phi—phase angle
dia	diameter	π	pi—3.1416
\div	divide by	PHS	pan head steel
div	division	+	plus
EHF	extremely high frequency	\pm	plus or minus
elect.	electrolytic	PIV	peak inverse voltage
EMC	electrolytic, metal cased	plstc	plastic
EMI	electromagnetic interference (see RFI)	PMC	paper, metal cased
EMT	electrolytic, metal tubular	poly	polystyrene
ϵ	epsilon—2.71828 or % of error	prec	precision
\geq	equal to or greater than	PT	paper, tubular
\leq	equal to or less than	PTM	paper or plastic, tubular, molded
ext	external	pwr	power
F or f	farad	Q	figure of merit
F & I	focus and intensity	RC	resistance capacitance
FHB	flat head brass	RF	radio frequency
FHS	flat head steel	RFI	radio frequency interference (see EMI)
Fil HB	fillister head brass	RHB	round head brass
Fil HS	fillister head steel	ρ	rho—resistivity
FM	frequency modulation	RHS	round head steel
ft	feet or foot	r/min or rpm	revolutions per minute
G	giga or 10^9	RMS	root mean square
g	acceleration due to gravity	s or sec.	second
Ge	germanium	SE	single end
GHz	gigahertz	Si	silicon
GMV	guaranteed minimum value	SN or S/N	serial number
GR	General Radio	\ll	small compared with
$>$	greater than	T	tera or 10^{12}
H or h	henry	TC	temperature compensated
h	height or high	TD	tunnel diode
hex.	hexagonal	THB	truss head brass
HF	high frequency	θ	theta—angular phase displacement
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	UHF	ultra high frequency
HV	high voltage	V	volt
Hz	hertz (cycles per second)	VAC	volts, alternating current
ID	inside diameter	var	variable
IF	intermediate frequency	VDC	volts, direct current
in.	inch or inches	VHF	very high frequency
incd	incandescent	VSWR	voltage standing wave ratio
∞	infinity	W	watt
int	internal	w	wide or width
\int	integral	w/	with
k	kilohms or kilo (10^3)	w/o	without
k Ω	kilohm	WW	wire-wound
kc	kilocycle	xmfr	transformer
kHz	kilohertz		

PARTS ORDERING INFORMATION

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

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

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

SPECIAL NOTES AND SYMBOLS

- ×000 Part first added at this serial number
- 00× Part removed after this serial number
- *000-0000-00 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
- Use 000-0000-00 Part number indicated is direct replacement.
- ① Screwdriver adjustment.
- Control, adjustment or connector.

SECTION 7

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulbs			
B125 ¹	260-0779-00		READY
B160W	150-0035-00	Neon, A1D T2	UNCAL
B167	150-0027-00	Neon, NE-23	
B171	150-0027-00	Neon, NE-23	
B267	150-0002-00	Neon, NE-2	100-199
B267	150-0027-00	Neon, NE-2 V	200-up
B271	150-0002-00	Neon, NE-2	100-199
B271	150-0027-00	Neon, NE-2 V	200-up
B347	150-0035-00	Neon, A1D T2	MAG
B386	150-0027-00	Neon, NE-23	
B601	150-0031-00	Incandescent, #44	
B602	150-0031-00	Incandescent, #44	
B603	150-0001-00	Incandescent, #47	
B865	150-0030-00	Neon, NE-2V	
B866	150-0030-00	Neon, NE-2V	
B867	150-0030-00	Neon, NE-2V	

Capacitors

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

C11	283-0001-00	0.005 μ F	Cer	500 V	
C12	281-0523-00	100 pF	Cer	350 V	
C14	281-0526-00	1.5 pF	Cer	500 V	± 0.5 pF
C16	283-0000-00	0.001 μ F	Cer	500 V	
C20	283-0000-00	0.001 μ F	Cer	500 V	
C24	283-0092-00	0.03 μ F	Cer	200 V	+80%-20%
C32	283-0004-00	0.02 μ F	Cer	150 V	
C36	283-0057-00	0.1 μ F	Cer	200 V	+80%-20%
C48	283-0006-00	0.02 μ F	Cer	500 V	
C49	290-0287-00	47 μ F	EMT	25 V	
C61	283-0001-00	0.005 μ F	Cer	500 V	
C62	281-0523-00	100 pF	Cer	350 V	
C64	281-0526-00	1.5 pF	Cer	500 V	± 0.5 pF
C66	283-0000-00	0.001 μ F	Cer	500 V	
C70	283-0000-00	0.001 μ F	Cer	500 V	
C74	283-0092-00	0.03 μ F	Cer	200 V	+80%-20%
C76	283-0057-00	0.1 μ F	Cer	200 V	+80%-20%
C81	281-0523-00	100 pF	Cer	350 V	
C87	281-0513-00	27 pF	Cer	500 V	
C90	290-0114-00	47 μ F	EMC	6 V	

¹Part of SW925. Furnished as a unit.

Capacitors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
C95	283-0023-00	0.1 μ F Cer	10 V
C101	283-0000-00	0.001 μ F Cer	500 V
C104	283-0001-00	0.005 μ F Cer	500 V
C109	283-0000-00	0.001 μ F Cer	500 V
C113	281-0504-00	10 pF Cer	500 V 10%
C118	283-0001-00	0.005 μ F Cer	500 V
C121	281-0513-00	27 pF Cer	500 V
C128	281-0503-00	8 pF Cer	500 V ± 0.5 pF
C132	283-0001-00	0.005 μ F Cer	500 V
C133	281-0503-00	8 pF Cer	500 V ± 0.5 pF
C141	283-0001-00	0.0052 μ F Cer	500 V
C146	281-0516-00	39 pF Cer	500 V 10%
C146	281-0558-00	18 pF Cer	500 V
C148	283-0002-00	0.01 μ F Cer	500 V
C152	283-0002-00	0.01 μ F Cer	500 V
C153	283-0006-00	0.02 μ F Cer	500 V
C156	281-0528-00	82 pF Cer	500 V 10%
C160A	281-0007-00	3-12 pF Cer	Var
C160B	283-0126-00	82 pF Cer	1000 V 5%
C160C	281-0010-00	4.5-25 pF Cer	Var
C160D	283-0126-00	82 pF Cer	1000 V 5%
C160E	281-0010-00	4.5-25 pF Cer	Var
C160F } C160G } C160H } C160J } C160K }	*295-0098-00	0.001 μ F 0.01 μ F 0.1 μ F 1 μ F 270 pF	Timing Capacitor Cer 500 V 10%
C165	281-0525-00	470 pF Cer	500 V
C167	283-0000-00	0.001 μ F Cer	500 V
C180A	283-0536-00	220 pF Mica	500 V 10%
C180B	285-0543-00	0.0022 μ F PTM	400 V
C180C	285-0566-00	0.022 μ F PTM	200 V 10%
C180D	285-0572-00	0.1 μ F PTM	200 V
C180E	285-0572-00	0.1 μ F PTM	200 V
C181	281-0515-00	27 pF Cer	500 V ± 1.35 pF
C187	283-0001-00	0.005 μ F Cer	500 V
C190	281-0511-00	22 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
C200	283-0001-00	0.005 μ F Cer	500 V
C201	283-0001-00	0.005 μ F Cer	500 V
C203	283-0000-00	0.001 μ F Cer	500 V
C209	283-0001-00	0.005 μ F Cer	500 V
C212	283-0000-00	0.001 μ F Cer	500 V
C221	281-0504-00	10 pF Cer	500 V 10%
C226	283-0001-00	0.005 μ F Cer	500 V
C231	281-0513-00	27 pF Cer	500 V

Capacitors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
C234	281-0518-00	47 pF Cer	500 V
C241	281-0534-00	3.3 pF Cer	500 V
C250	281-0516-00	39 pF Cer	500 V
C260A	281-0010-00	4.5-25 pF Cer	Var
C260B	283-0126-00	82 pF Cer	1000 V
C260C	*295-0098-00	0.001 μ F	Timing Capacitor
C260D		0.01 μ F	
C260E		0.1 μ F	
C260F		1 μ F	
C260G		270 pF Cer	
C267	283-0000-00	0.001 μ F Cer	500 V
C280A	281-0574-00	82 pF Cer	500 V
C280B	285-0501-00	0.001 μ F PTM	600 V
C280C	285-0695-00	0.01 μ F PTM	200 V
C280D	285-0572-00	0.1 μ F PTM	200 V
C280E	285-0572-00	0.1 μ F PTM	200 V
C295	281-0506-00	12 pF Cer	500 V
C301C	281-0012-00	7-45 pF Cer	Var
C301E	281-0546-00	330 pF Cer	500 V
C301H	281-0506-00	12 pF Cer	500 V
C320	283-0001-00	0.005 μ F Cer	500 V
C330	281-0010-00	4.5-25 pF Cer	Var
C331	281-0592-00	4.7 pF Cer	500 V
C335	285-0537-00	0.5 μ F MPT	400 V
C340	281-0501-00	4.7 pF Cer	500 V
C347	283-0000-00	0.001 μ F Cer	500 V
C348	281-0007-00	3-12 pF Cer	Var
C355	281-0526-00	1.5 pF Cer	500 V
C356	283-0001-00	0.005 μ F Cer	500 V
C364	281-0061-00	5.5-18 pF Cer	Var
C375	281-0023-00	9-180 pF Mica	Var
C378	290-0000-00	6.25 μ F EMT	300 V
C384	281-0061-00	5.5-18 pF Cer	Var
C390	281-0501-00	4.7 pF Cer	500 V
C393	285-0629-00	0.047 μ F PTM	100 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
C454	281-0518-00	47 pF Cer	500 V
C457	283-0001-00	0.005 μ F Cer	500 V
C471	290-0185-00	2 x 40 μ F EMC	250 V
C472	283-0079-00	0.01 μ F Cer	250 V
C475	285-0526-00	0.1 μ F PTM	400 V
C476A,B,C	290-0062-00	40x20x10 μ F EMC	475 V
C477	285-0526-00	0.1 μ F PTM	400 V
C489	281-0593-00	3.9 pF Cer	10%

Capacitors (Cont)

Ckt. No.	Tektronix Part No.		Description			S/N Range
C493	283-0002-00	0.01 μ F	Cer	500 V		
C506	285-0526-00	0.1 μ F	PTM	400 V		
C513	283-0002-00	0.01 μ F	Cer	500 V		
C514	283-0088-00	1100 pF	Cer	500 V	5%	
C515	283-0003-00	0.01 μ F	Cer	150 V		X620-up
C520	281-0022-00	8-50 pF	Cer			
C521	281-0510-00	22 pF	Cer	500 V		
C524	283-0088-00	1100 pF	Cer	500 V	5%	
C532	283-0002-00	0.01 μ F	Cer	500 V		
C534	283-0006-00	0.02 μ F	Cer	500 V		100-619
C534	281-0580-00	470 pF	Cer	500 V	10%	620-up
C542	283-0002-00	0.01 μ F	Cer	500 V		
C544	283-0003-00	0.01 μ F	Cer	150 V		X620-up
C551	281-0075-00	5-25 pF	Cer			
C553	283-0003-00	0.01 μ F	Cer	150 V		X620-up
C556	283-0103-00	180 pF	Cer	500 V	5%	
C557	283-0077-00	330 pF	Cer	500 V	5%	100-619
C557	283-0084-00	270 pF	Cer	1000 V	5%	620-up
C566	283-0103-00	180 pF	Cer	500 V	5%	
C567	283-0084-00	270 pF	Cer	1000 V	5%	100-619
C567	283-0077-00	330 pF	Cer	500 V	5%	620-up
C568	281-0022-00	8-50 pF	Cer			
C570	283-0000-00	0.001 μ F	Cer	500 V		
C572	283-0006-00	0.02 μ F	Cer	500 V		
C574	281-0571-00	82 pF	Cer	500 V		
C578	281-0536-00	1000 pF	Cer	500 V	10%	
C579	281-0543-00	270 pF	Cer	500 V	10%	
C580	281-0513-00	27 pF	Cer	500 V		
C581	281-0022-00	8-50 pF	Cer			
C582	283-0088-00	1100 pF	Cer	500 V	5%	
C590	283-0006-00	0.02 μ F	Cer	500 V		
C592	283-0088-00	1100 pF	Cer	500 V	5%	
C597	283-0000-00	0.001 μ F	Cer	500 V		
C601	283-0057-00	0.1 μ F	Cer	200 V	+80%—20%	
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	290-0016-00	125 μ F	EMC	350 V		
C648	285-0002-00	0.01 μ F	Cer	500 V		
C649	290-0012-00	2 x 40 μ F	EMC	250 V		
C650	285-0510-00	0.01 μ F	PTM	400 V		
C670	290-0019-00	150 μ F	EMC	250 V		
C671	290-0019-00	150 μ F	EMC	250 V		
C679A,B,C	290-0195-00	20x10x10 μ F	EMC	250/350/450 V		
C680	285-0510-00	0.01 μ F	PTM	400 V		
C688	285-0510-00	0.01 μ F	PTM	400 V		
C700	290-0017-00	125 μ F	EMC	450 V		
C710	285-0511-00	0.01 μ F	PTM	600 V		
C730	290-0017-00	125 μ F	EMC	450 V		
C740	285-0510-00	0.01 μ F	PTM	400 V		
C760A,B	290-0013-00	2 x 40 μ F	EMC	450 V		

Capacitors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C770	290-0212-00	2000 μ F	EMC	25 V	
C774	290-0106-00	10 μ F	EMT	15 V	
C789	290-0201-00	100 μ F	EMT	15 V	
C791	283-0002-00	0.01 μ F	Cer	500 V	
C793	283-0002-00	0.01 μ F	Cer	500 V	
C795	283-0001-00	0.005 μ F	Cer	500 V	
C802	283-0006-00	0.02 μ F	Cer	500 V	
C803	283-0032-00	470 pF	Cer	500 V	5%
C806	285-0502-00	0.001 μ F	PTM	1000 V	
C823	283-0006-00	0.02 μ F	Cer	500 V	
C826	283-0071-00	0.0068 μ F	Cer	5000 V	
C827	285-0572-00	0.1 μ F	PTM	200 V	
C837	283-0071-00	0.0068 μ F	Cer	5000 V	
C838	283-0071-00	0.0068 μ F	Cer	5000 V	
C842	283-0071-00	0.0068 μ F	Cer	5000 V	
C844	283-0000-00	0.001 μ F	Cer	500 V	
C854	285-0519-00	0.047 μ F	PTM	400 V	
C858	283-0071-00	0.0068 μ F	Cer	5000 V	
C865	283-0071-00	0.0068 μ F	Cer	5000 V	
C867	285-0622-00	0.1 μ F	PTM	100 V	
C871	283-0077-00	330 pF	Cer	500 V	5%
C873	283-0057-00	0.1 μ F	Cer	200 V	+80%—20%
C874	283-0077-00	330 pF	Cer	500 V	5%
C885	281-0513-00	27 pF	Cer	500 V	
C893	281-0525-00	470 pF	Cer	500 V	
C897	281-0523-00	100 pF	Cer	350 V	
C901	281-0509-00	15 pF	Cer	500 V	10%
C912	281-0523-00	100 pF	Cer	350 V	
C916	285-0633-00	0.22 μ F	PTM	100 V	10%
C918	283-0092-00	0.02 μ F	Cer	200 V	+80%—20%
C919	285-0576-00	1 μ F	PTM	100 V	10%
C921	283-0078-00	0.001 μ F	Cer	500 V	
C923	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C926	283-0001-00	0.005 μ F	Cer	500 V	
C928	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C931	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C947	290-0187-00	4.7 μ F	EMT	35 V	
C951	283-0111-00	0.1 μ F	Cer	50 V	
C955	283-0092-00	0.3 μ F	Cer	200 V	+80%—20%
C957	283-0000-00	0.001 μ F	Cer	500 V	
C1002	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1005	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1008	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1022	290-0136-00	2.2 μ F	EMT	20 V	
C1028	290-0135-00	15 μ F	EMT	20 V	

Capacitors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
C1049	285-0623-00	0.47 μ F	PTM	100 V	
C1102	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1105	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1108	283-0092-00	0.03 μ F	Cer	200 V	+80%—20%
C1122	290-0136-00	2.2 μ F	EMT	20 V	
C1128	290-0135-00	15 μ F	EMT	20 V	
C1131	281-0509-00	15 pF	Cer	500 V	10%
C1146	285-0650-00	0.027 μ F	PTM	100V	5%
C1149	285-0623-00	0.47 μ F	PTM	100V	
C1195	285-0526-00	0.1 μ F	PTM	400 V	
C1196	283-0079-00	0.01 μ F	Cer	250 V	

Diodes

D29	152-0141-00	Silicon	1N3605		
D30	152-0141-00	Silicon	1N3605		
D32	152-0141-00	Silicon	1N3605		
D43	152-0064-00	Zener	1N961A	0.4 W, 10 V, 10%	
D46	152-0141-00	Silicon	1N3605		
D47	152-0141-00	Silicon	1N3605		
D48	*152-0185-00	Silicon	Replaceable by 1N3605		
D49	152-0126-00	Zener	1N3024A	1 W, 15 V, 10%	
D78	152-0141-00	Silicon	1N3605		
D79	152-0141-00	Silicon	1N3605		
D81	152-0141-00	Silicon	1N3605		
D82	152-0141-00	Silicon	1N3605		
D93	*151-0185-00	Silicon	Replaceable by 1N3605		
D112	152-0008-00	Germanium			
D121	152-0008-00	Germanium			
D129	*152-0061-00	Silicon	Tek Spec		
D147	*152-0061-00	Silicon	Tek Spec		
D152	152-0246-00	Silicon	Low leakage 0.25 W, 40 V		X520-up
D153	*152-0061-00	Silicon	Tek Spec		100-902
D153	*152-0233-00	Silicon	Selected from 1N3606		903-up
D155	*152-0233-00	Silicon	Selected from 1N3606		X903-up
D156	152-0243-00	Zener	1N965B 0.4 W, 15 V, 5%		X903-up
D219	152-0008-00	Germanium			
D231	152-0008-00	Germanium			
D233	*152-0061-00	Silicon	Tek Spec		
D252	152-0246-00	Silicon	Low leakage 0.25 W, 40 V		X520-up
D334	152-0242-00	Silicon	1N486A		
D515	152-0059-00	Zener	1M12.6Z5 1 W, 12.6 V		X620-up
D553	152-0071-00	Germanium	ED 2007		
D552	*152-0185-00	Silicon	Replaceable by 1N3605		X620-up
D554	152-0071-00	Germanium	ED 2007		
D555	*152-0185-00	Silicon	Replaceable by 1N3605		X620-up
D642A,B,C,D (4)	152-0066-00	Silicon	1N3194		
D672A,B,C,D (4)	152-0066-00	Silicon	1N3194		
D679	152-0066-00	Silicon	1N3194		
D702A,B (2)	152-0066-00	Silicon	1N3194		
D703	*152-0107-00	Silicon	Replaceable by 1N647		
D704	152-0101-00	Zener	1N3041B 1 W, 75 V, 5%		

Diodes (Cont)

Ckt. No.	Tektronix Part No.		Description	S/N Range
D707	*152-0107-00	Silicon	Replaceable by 1N647	
D732A,B (2)	152-0066-00	Silicon	1N3194	
D762A,B,C,D (4)	152-0066-00	Silicon	1N3194	
D772	152-0198-00	Silicon	MR1032A (Motorola)	
D773	*152-0107-00	Silicon	Replaceable by 1N647	
D782	152-0198-00	Silicon	MR1032A (Motorola)	
D819	*152-0185-00	Silicon	Replaceable by 1N3605	
D825	*152-0107-00	Silicon	Replaceable by 1N647	
D826	152-0218-00	Silicon	10,000 V	
D836	152-0218-00	Silicon	10,000 V	
D841	*152-0107-00	Silicon	Replaceable by 1N647	
D844	152-0135-00	Zener	1N3042A 1 W, 82 V, 10%	
D865	*152-0107-00	Silicon	Replaceable by 1N647	100-109X
D900	*152-0107-00	Silicon	Replaceable by 1N647	
D901	*152-0107-00	Silicon	Replaceable by 1N647	
D902	*152-0061-00	Silicon	Tek Spec	
D906	*152-0061-00	Silicon	Tek Spec	
D921	*152-0061-00	Silicon	Tek Spec	
D924	*152-0185-00	Silicon	Replaceable by 1N3605	
D927	*152-0185-00	Silicon	Replaceable by 1N3605	
D928	*152-0185-00	Silicon	Replaceable by 1N3605	
D930	*152-0185-00	Silicon	Replaceable by 1N3605	
D932	*152-0185-00	Silicon	Replaceable by 1N3605	
D945	*152-0185-00	Silicon	Replaceable by 1N3605	
D947	*152-0185-00	Silicon	Replaceable by 1N3605	
D951	*152-0185-00	Silicon	Replaceable by 1N3605	
D1001	*151-0185-00	Silicon	Replaceable by 1N3605	
D1005	*152-0185-00	Silicon	Replaceable by 1N3605	
D1009	*152-0061-00	Silicon	Tek Spec	
D1013	*152-0185-00	Silicon	Replaceable by 1N3605	
D1021	*152-0185-00	Silicon	Replaceable by 1N3605	
D1022	*152-0185-00	Silicon	Replaceable by 1N3605	
D1025	*152-0185-00	Silicon	Replaceable by 1N3605	
D1026	*152-0185-00	Silicon	Replaceable by 1N3605	
D1027	*152-0185-00	Silicon	Replaceable by 1N3605	
D1029	*152-0185-00	Silicon	Replaceable by 1N3605	
D1073	*152-0185-00	Silicon	Replaceable by 1N3605	
D1101	*152-0185-00	Silicon	Replaceable by 1N3605	
D1105	*152-0185-00	Silicon	Replaceable by 1N3605	
D1109	*152-0061-00	Silicon	Tek Spec	
D1113	*152-0185-00	Silicon	Replaceable by 1N3605	
D1121	*152-0185-00	Silicon	Replaceable by 1N3605	
D1122	*152-0185-00	Silicon	Replaceable by 1N3605	
D1125	*152-0185-00	Silicon	Replaceable by 1N3605	
D1126	*152-0185-00	Silicon	Replaceable by 1N3605	

Diodes (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
D1127	*152-0185-00	Silicon	Replaceable by 1N3605
D1129	*152-0185-00	Silicon	Replaceable by 1N3605
D1134	*152-0185-00	Silicon	Replaceable by 1N3605
D1146	*152-0185-00	Silicon	Replaceable by 1N3605
D1182	152-0190-00	Zener	1N977A 0.4 W, 47 V, 10%
D1193	*152-0185-00	Silicon	Replaceable by 1N3605

Fuses

F601	159-0026-00	3.2 A, 3AG, Slo-Blo	100-109
F601	159-0011-00	6.25 A, 3AG, Slo-Blo	110-up
F602	159-0026-00	3.2 A, 3AG, Slo-Blo	

Connectors

J5	131-0106-00	BNC, coaxial, 1 contact, female	
J11	131-0018-00	16 contact, female	
J55	131-0106-00	BNC, coaxial, 1 contact, female	
J193	131-0106-00	BNC, coaxial, 1 contact, female	
J199	131-0106-00	BNC, coaxial, 1 contact, female	
J299	131-0106-00	BNC, coaxial, 1 contact, female	
J300	131-0106-00	BNC, coaxial, 1 contact, female	
J429	131-0106-00	BNC, coaxial, 1 contact, female	
J549	131-0106-00	BNC, coaxial, 1 contact, female	
J840	131-0106-00	BNC, coaxial, 1 contact, female	
J869	131-0106-00	BNC, coaxial, 1 contact, female	
J899	131-0274-00	BNC, insulated	
J925	136-0089-00	Socket, 9 pin, female	

Relays

K600	148-0021-00	Delay	
K601	148-0016-00	45 VDC	

Inductors

L75	108-0245-00	3.9 μ H	
L249	*108-0165-00	4.7 mH	
L362	*108-0358-00	Coil, Reed Drive	
L424	*108-0015-00	255 μ H	
L513	276-0507-00	Core, Ferramic Suppressor	
L528	*308-0318-00	1.5 k Ω /8 μ H 2 W, WW, 1%	
L551	*108-0260-00	0.1 μ H	
L552	*119-0034-00	Delay Line Assembly	100-819
L552	*119-0034-02	Delay Line Assembly	820-up
L553	*108-0287-00	Coil, Reed Drive	
L554	*114-0055-00	3.6-8.3 μ H	Var Core 276-0506-00

Inductors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
L560	*114-0130-00	1.45-2.9 μ H	Var
L561	*108-0181-00	0.2 μ H	Core 276-0506-00
L588	*114-0198-00	2.2-4.4 μ H	Var
L589	*114-0199-00	6.2-12.7 μ H	Var
L598	*114-0198-00	2.2-4.4 μ H	Var
L599	*114-0199-00	6.2-12.7 μ H	Var
L859	*108-0323-00	Beam Rotator	Core 276-0506-00
L862	108-0362-00	50 mH	
LR45	*108-0293-00	27 μ H	(wound on a 680 Ω resistor)
LR84	*108-0294-00	300 μ H	(wound on a 2.7 k Ω resistor)
LR139	*108-0164-00	1.2 mH	(wound on a 3.6 k Ω resistor)
LR529	*108-0292-00	12 μ H	(wound on a 100 Ω resistor)

Transistors

Q34	*151-0127-00	Silicon	Selected from 2N2369	
Q35	*151-0127-00	Silicon	Selected from 2N2369	
Q45	*151-0127-00	Silicon	Selected from 2N2369	
Q85	*151-0126-00	Silicon	Replaceable by 2N2484	
Q95	*151-0126-00	Silicon	Replaceable by 2N2484	
Q513	*151-0121-00	Silicon	Selected from 2N3118	
Q514	*151-0127-00	Silicon	Selected from 2N2369	
Q523	*151-0121-00	Silicon	Selected from 2N3118	
Q524	*151-0127-00	Silicon	Selected from 2N2369	
Q533	*151-0121-00	Silicon	Selected from 2N3118	
Q534	*151-0126-00	Silicon	Replaceable by 2N2484	
Q543	*151-0121-00	Silicon	Selected from 2N3118	100-619
Q543	151-0190-00	Silicon	2N3904	620-up
Q553	*151-0188-01	Silicon	Replaceable by 2N3251	X620-up
Q584	*151-0160-00	Silicon	Selected from 2N3137	
Q594	*151-0160-00	Silicon	Selected from 2N3137	
Q703	151-0168-00	Silicon	40264	
Q774	*151-0151-00	Silicon	Replaceable by 2N930	
Q784	*151-0151-00	Silicon	Replaceable by 2N930	
Q787	151-0165-00	Germanium	2N3614	
Q823	*151-0151-00	Silicon	Replaceable by 2N930	
Q824	151-0168-00	Silicon	40264	
Q935	*151-0159-00	Silicon	Replaceable by 2N918	
Q945	*151-0159-00	Silicon	Replaceable by 2N918	
Q1015	*151-0159-00	Silicon	Replaceable by 2N918	
Q1025	*151-0159-00	Silicon	Replaceable by 2N918	
Q1033	*151-0159-00	Silicon	Replaceable by 2N918	
Q1043	*151-0159-00	Silicon	Replaceable by 2N918	
Q1073	151-0150-00	Silicon	2N3440	
Q1115	*151-0159-00	Silicon	Replaceable by 2N918	
Q1125	*151-0159-00	Silicon	Replaceable by 2N918	
Q1135	*151-0159-00	Silicon	Replaceable by 2N918	

Transistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q1145	*151-0159-00	Silicon	Replaceable by 2N918
Q1193	*151-0151-00	Silicon	Replaceable by 2N930
Q1194	151-0168-00	Silicon	40264

Resistors

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

R12	316-0104-00	100 k Ω	1/4 W			
R14	316-0225-00	2.2 M Ω	1/4 W			
R15	316-0105-00	1 M Ω	1/4 W			
R16	316-0474-00	470 k Ω	1/4 W			
R17 ^a	311-0096-00	100 k Ω		Var		
R18	302-0223-00	22 k Ω	1/2 W			100-619X
R19	316-0474-00	470 k Ω	1/4 W			100-619
R19	315-0622-00	6.2 k Ω	1/4 W		5%	620-up
R20	316-0563-00	56 k Ω	1/4 W			100-619
R20	315-0123-00	12 k Ω	1/4 W		5%	620-up
R22	302-0101-00	100 Ω	1/2 W			
R23	302-0101-00	100 Ω	1/2 W			
R24	302-0222-00	2.2 k Ω	1/2 W			
R26	303-0123-00	12 k Ω	1 W		5%	
R27	306-0223-00	22 k Ω	2 W			
R29	301-0623-00	62 k Ω	1/2 W		5%	
R31	301-0182-00	1.8 k Ω	1/2 W		5%	
R32	302-0152-00	1.5 k Ω	1/2 W			
R33	301-0124-00	120 k Ω	1/2 W		5%	
R34	305-0123-00	12 k Ω	2 W		5%	
R35	303-0223-00	22 k Ω	1 W		5%	
R36	302-0100-00	10 Ω	1/2 W			
R37	308-0301-00	10 k Ω	3 W		WW	1%
R38	303-0183-00	18 k Ω	1 W			5%
R39	311-0176-00	100 k Ω		Var		
R43	308-0364-00	9.65 k Ω	3 W		WW	1%
R44	302-0680-00	68 Ω	1/2 W			
R46	308-0301-00	10 k Ω	3 W		WW	1%
R47	311-0308-00	50 Ω		Var		
R48	305-0103-00	10 k Ω	2 W			5%
R49	308-0252-00	390 Ω	3 W		WW	5%
R56	315-0272-00	2.7 k Ω	1/4 W			5%
R57	315-0272-00	2.7 k Ω	1/4 W			5%
						X620-up
						X620-up
R62	316-0104-00	100 k Ω	1/4 W			
R64	316-0225-00	2.2 M Ω	1/4 W			
R65	316-0105-00	1 M Ω	1/4 W			
R66	316-0474-00	470 Ω	1/4 W			
R67 ^a	311-0096-00	100 k Ω		Var		
R68	302-0223-00	22 k Ω	1/2 W			100-619X

^aFurnished as a unit with R106 and SW106.

^aFurnished as a unit with R211 and SW211.

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R69	316-0474-00	470 kΩ	1/4 W		100-619
R69	315-0622-00	6.2 kΩ	1/4 W		620-up
R70	316-0563-00	56 kΩ	1/4 W		100-619
R70	315-0123-00	12 kΩ	1/4 W		620-up
R72	302-0101-00	100 Ω	1/2 W		
R73	302-0101-00	100 Ω	1/2 W		
R74	302-0332-00	3.3 kΩ	1/2 W		
R75	301-0242-00	2.4 kΩ	1/2 W		5%
R76	302-0100-00	10 Ω	1/2 W		
R77	303-0393-00	39 kΩ	1 W		5%
R78	301-0753-00	75 kΩ	1/2 W		5%
R79	303-0393-00	39 kΩ	1 W		5%
R81	301-0153-00	15 kΩ	1/2 W		5%
R82	311-0026-00	100 kΩ		Var	
R85	301-0331-00	330 Ω	1/2 W		5%
R87	301-0432-00	4.3 kΩ	1/2 W		5%
R88	303-0123-00	12 kΩ	1 W		5%
R90	301-0432-00	4.3 kΩ	1/2 W		5%
R92	303-0203-00	20 kΩ	1 W		5%
R93	302-0561-00	560 Ω	1/2 W		
R95	302-0152-00	1.5 kΩ	1/2 W		
R97	303-0223-00	22 kΩ	1 W		5%
R100	302-0103-00	10 kΩ	1/2 W		
R101	302-0394-00	390 kΩ	1/2 W		
R102	302-0105-00	1 MΩ	1/2 W		
R103	302-0470-00	47 Ω	1/2 W		
R104	302-0224-00	220 kΩ	1/2 W		
R105	311-0219-00	200 kΩ		Var	
R106 ⁴	311-0096-00	100 kΩ		Var	
R107	301-0914-00	910 kΩ	1/2 W		5%
R108	301-0104-00	100 kΩ	1/2 W		5%
R109	301-0184-00	180 kΩ	1/2 W		5%
R110	302-0470-00	47 Ω	1/2 W		
R112	304-0683-00	68 kΩ	1 W		
R113	302-0274-00	270 kΩ	1/2 W		
R114	302-0474-00	470 kΩ	1/2 W		
R115	311-0125-00	50 kΩ		Var	
R116	302-0104-00	100 kΩ	1/2 W		
R117	302-0470-00	47 Ω	1/2 W		
R118	302-0123-00	12 kΩ	1/2 W		
R119	306-0223-00	22 kΩ	2 W		
R121	308-0077-00	1 kΩ	3 W		WW
R124	302-0123-00	12 kΩ	1/2 W		
R125	302-0104-00	100 kΩ	1/2 W		
R127	302-0470-00	47 Ω	1/2 W		
R128	*310-0555-00	6/3 kΩ	3 W		Prec
R129	302-0104-00	100 kΩ	1/2 W		

⁴Furnished as a unit with R17 and SW106.

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range	
R131	302-0470-00	47 Ω	1/2 W	
R132	302-0470-00	47 Ω	1/2 W	
R133	324-0339-00	33.2 kΩ	1 W	Prec 1%
R134	324-0335-00	30.1 kΩ	1 W	Prec 1%
R135	302-0470-00	47 Ω	1/2 W	
R136	308-0294-00	8 kΩ	5 W	WW 5%
R137	302-0102-00	1 kΩ	1/2 W	
R138	302-0473-00	47 kΩ	1/2 W	
R141	301-0683-00	68 kΩ	1/2 W	5%
R142	301-0105-00	1 MΩ	1/2 W	5%
R143	302-0103-00	10 kΩ	1/2 W	
R144	302-0185-00	1.8 MΩ	1/2 W	
R145	302-0105-00	1 MΩ	1/2 W	
R146	302-0474-00	470 kΩ	1/2 W	
R147	301-0823-00	82 kΩ	1/2 W	5%
R148	301-0203-00	20 kΩ	1/2 W	5%
R151	302-0102-00	1 kΩ	1/2 W	
R152	304-0122-00	1.2 kΩ	1 W	
R153	302-0101-00	100 Ω	1/2 W	
R154	308-0286-00	8.2 kΩ	3 W	WW 5%
R155	302-0685-00	6.8 MΩ	1/2 W	X820-up
R156	302-0271-00	270 Ω	1/2 W	
R157	316-0104-00	100 kΩ	1/4 W	X903-up
R160A	323-0385-01	100 kΩ	1/2 W	Prec 1/2%
R160B	323-0385-01	100 kΩ	1/2 W	Prec 1/2%
R160C	323-0725-01	300 kΩ	1/2 W	Prec 1/2%
R160D	323-0481-01	1 MΩ	1/2 W	Prec 1/2%
R160E	323-0481-01	1 MΩ	1/2 W	Prec 1/2%
R160F	325-0010-01	3 MΩ	1 W	Prec 1/2%
R160G	325-0007-01	10 MΩ	2 W	Prec 1/2%
R160H	325-0007-01	10 MΩ	2 W	Prec 1/2%
R160J	323-1409-01	180 kΩ	1/2 W	Prec 1/2%
R160K	323-0395-01	127 kΩ	1/2 W	Prec 1/2%
R160T	304-0563-00	56 kΩ	1 W	
R160V	302-0105-00	1 MΩ	1/2 W	
R160W	302-0104-00	100 kΩ	1/2 W	
R160X	302-0103-00	10 kΩ	1/2 W	
R160Y	311-0108-00	20 kΩ		Var
R160Z	311-0066-00	500 Ω		Var
R164	306-0223-00	22 kΩ	2 W	
R165	306-0223-00	22 kΩ	2 W	
R166	306-0223-00	22 kΩ	2 W	
R167	302-0155-00	1.5 MΩ	1/2 W	
R168	302-0473-00	47 kΩ	1/2 W	
R171	302-0470-00	47 kΩ	1/2 W	
R172	302-0470-00	47 kΩ	1/2 W	
R173	302-0471-00	470 Ω	1/2 W	

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R174	308-0294-00	8 k Ω	5 W		WW	5%
R175	323-0365-00	61.9 k Ω	1/2 W		Prec	1%
R176	311-0008-00	2 k Ω		Var		
R177	311-0154-00	50 k Ω		Var		
R178	308-0051-00	4 k Ω	5 W		WW	5%
R179	302-0102-00	1 k Ω	1/2 W			
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	1/2 W			
R189	302-0473-00	47 k Ω	1/2 W			
R190	302-0473-00	47 k Ω	1/2 W			
R191	301-0114-00	110 k Ω	1/2 W			5%
R192	302-0470-00	47 Ω	1/2 W			
R193	302-0470-00	47 Ω	1/2 W			
R194	304-0472-00	4.7 k Ω	1 W			
R196	302-0104-00	100 k Ω	1/2 W			
R199	304-0104-00	100 k Ω	1 W			
R200	302-0470-00	47 Ω	1/2 W			
R201	302-0470-00	47 Ω	1/2 W			
R202	302-0103-00	10 k Ω	1/2 W			
R203	302-0394-00	390 k Ω	1/2 W			
R204	302-0105-00	1 M Ω	1/2 W			
R206	302-0470-00	47 Ω	1/2 W			
R209	302-0224-00	220 k Ω	1/2 W			
R210	311-0219-00	200 k Ω		Var		
R211 ^a	311-0096-00	100 k Ω		Var		
R212	301-0914-00	910 k Ω	1/2 W			5%
R214	301-0104-00	100 k Ω	1/2 W			5%
R215	301-0154-00	150 k Ω	1/2 W			5%
R216	302-0470-00	47 Ω	1/2 W			
R219	302-0683-00	68 k Ω	1/2 W			
R221	302-0274-00	270 k Ω	1/2 W			
R222	301-0434-00	430 k Ω	1/2 W			5%
R223	302-0470-00	47 Ω	1/2 W			
R224	302-0104-00	100 k Ω	1/2 W			
R225	311-0125-00	50 k Ω		Var		
R230	304-0223-00	22 k Ω	1 W			
R231	302-0472-00	4.7 k Ω	1/2 W			
R232	302-0101-00	100 Ω	1/2 W			

^aFurnished as a unit with R67 and SW211.

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description			S/N Range
R233	302-0104-00	100 kΩ	1/2 W		100-109
R233	301-0104-00	100 kΩ	1/2 W		110-up
R234	301-0682-00	6.8 kΩ	1/2 W		100-109
R234	323-0269-00	6.19 kΩ	1/2 W	Prec	110-up
R235	301-0682-00	6.8 kΩ	1/2 W		100-109
R235	323-0269-00	6.19 kΩ	1/2 W	Prec	110-up
R236	301-0622-00	6.2 kΩ	1/2 W		5%
R237	301-0274-00	270 kΩ	1/2 W		5%
R241	324-0339-00	33.2 kΩ	1 W	Prec	1%
R243	324-0335-00	30.1 kΩ	1 W	Prec	1%
R244	308-0108-00	15 kΩ	5 W	WW	5%
R244	308-0320-00	15.6 kΩ	3 W	WW	1%
R246	302-0101-00	100 Ω	1/2 W		
R247	302-0222-00	2.2 kΩ	1/2 W		
R248	302-0473-00	47 kΩ	1/2 W		
R249	302-0822-00	8.2 kΩ	1/2 W		
R250	302-0272-00	2.7 kΩ	1/2 W		
R255	316-0106-00	10 MΩ	1/4 W		X820-up
R260A	*312-0644-00	204 kΩ	1/2 W	Matched Set	
R260B		306 kΩ	1/2 W		
R260C		510 kΩ	1/2 W		
R260D		2.04 MΩ	1 W		
R260E		3.06 MΩ	1 W		
R260F		5.1 MΩ	2 W		
R264	306-0224-00	220 kΩ	2 W		
R267	302-0155-00	1.5 MΩ	1/2 W		
R268	302-0104-00	100 kΩ	1/2 W		
R271	302-0101-00	100 Ω	1/2 W		
R272	301-0822-00	8.2 kΩ	1/2 W		5%
R273	311-0326-00	10 kΩ		Var	
R274	305-0153-00	15 kΩ	2 W		5%
R276	311-0016-00	10 kΩ		Var	
R277	311-0113-00	100 kΩ		Var	100-109
R277	311-0086-00	2.5 kΩ		Var	110-1109
R277	311-0387-00	5 kΩ		Var	1110-up
R278	301-0393-00	39 kΩ	1/2 W		5%
R278	303-0912-00	9.1 kΩ	1 W		5%
R278	305-0912-00	9.1 kΩ	2 W		5%
R279	303-0123-00	12 kΩ	1 W		5%
R280	302-0125-00	1.2 MΩ	1/2 W		100-109X
R281	302-0475-00	4.7 MΩ	1/2 W		
R282	302-0102-00	1 kΩ	1/2 W		
R283	302-0102-00	1 kΩ	1/2 W		
R291	302-0101-00	100 Ω	1/2 W		
R293	302-0473-00	47 kΩ	1/2 W		
R295	302-0393-00	39 kΩ	1/2 W		
R296	302-0104-00	100 kΩ	1/2 W		
R297	302-0101-00	100 Ω	1/2 W		
R299	302-0103-00	10 kΩ	1/2 W		
R300	302-0470-00	47 Ω	1/2 W		
R301C	323-0611-00	900 kΩ	1/2 W	Prec	1%
R301E	323-0610-00	111 kΩ	1/2 W	Prec	1%
R303	302-0105-00	1 MΩ	1/2 W		
R311	302-0102-00	1 kΩ	1/2 W		

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range		
R313	306-0333-00	33 k Ω	2 W		
R314	311-0585-00	15 k Ω		Var	
R315	306-0333-00	33 k Ω	2 W		
R317	311-0026-00	100 k Ω		Var	
R319	302-0224-00	220 k Ω	1/2 W		
R320	302-0332-00	3.3 k Ω	1/2 W		
R321	302-0101-00	100 Ω	1/2 W		
R324	306-0273-00	27 k Ω	2 W		
R330	309-0017-00	1.5 M Ω	1/2 W	Prec	1%
R331	301-0474-00	470 k Ω	1/2 W		5%
R332	309-0086-00	3.5 M Ω	1/2 W	Prec	1%
R333 ^a	311-0149-00	100 k Ω		Var	
R334	301-0105-00	1 M Ω	1/2 W		5%
R335	302-0226-00	22 M Ω	1/2 W		
R336	309-0268-00	12.1 M Ω	1/2 W	Prec	1%
R336	310-0069-00	13 M Ω	1 W	Prec	2%
R338 ^a	311-0149-00	200 k Ω		Var	
R340	302-0222-00	2.2 k Ω	1/2 W		
R341	302-0101-00	100 Ω	1/2 W		
R345	304-0104-00	100 k Ω	1 W		
R347	316-0104-00	100 k Ω	1/4 W		
R348	311-0125-00	50 k Ω		Var	
R349	323-0402-00	150 k Ω	1/2 W	Prec	1%
R351	302-0101-00	100 Ω	1/2 W		
R353	304-0104-00	100 k Ω	1 W		
R355	324-0443-00	402 k Ω	1 W	Prec	1%
R356	324-0443-00	402 k Ω	1 W	Prec	1%
R357	304-0223-00	22 k Ω	1 W		
R358	311-0018-00	20 k Ω		Var	
R361	302-0470-00	47 Ω	1/2 W		
R362	308-0301-00	10 k Ω	3 W	WW	1%
R363	302-0331-00	330 Ω	1/2 W		
R364	*310-0506-00	25/6 k Ω	7 W	Prec	1%
R366	302-0470-00	47 Ω	1/2 W		
R373	305-0912-00	9.1 k Ω	2 W		5%
R375	311-0395-00	2.5 k Ω		Var	
R376	305-0912-00	9.1 k Ω	2 W		5%
R377	305-0242-00	2.4 k Ω	2 W		5%
R378	302-0470-00	47 Ω	1/2 W		
R379	301-0104-00	100 k Ω	1/2 W		5%
R380	301-0821-00	820 Ω	1/2 W		5%
R381	302-0470-00	47 Ω	1/2 W		
R382	308-0301-00	10 k Ω	3 W	WW	1%
R384	*310-0507-00	30/6 k Ω	7 W	Prec	1%
R386	302-0101-00	100 Ω	1/2 W		
R387	306-0393-00	39 k Ω	2 W		

^aR333 and R338 furnished as a unit.

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R388	306-0393-00	39 kΩ	2 W
R390	302-0222-00	2.2 kΩ	1/2 W
R391	302-0470-00	47 Ω	1/2 W
R393	302-0391-00	390 Ω	1/2 W
R410	302-0105-00	1 MΩ	1/2 W
R411	302-0101-00	100 Ω	1/2 W
R415	302-0473-00	47 kΩ	1/2 W
R416	302-0123-00	12 kΩ	1/2 W
R421	302-0101-00	100 Ω	1/2 W
R424	302-0103-00	10 kΩ	1/2 W
R425	302-0104-00	100 kΩ	1/2 W
R426	302-0473-00	47 kΩ	1/2 W
R427	302-0101-00	100 Ω	1/2 W
R428	302-0103-00	10 kΩ	1/2 W
R431	308-0054-00	10 kΩ	5 W WW 5%
R432	311-0015-00	10 kΩ	Var
R433	311-0022-00	30 kΩ	Var
R436	311-0141-00	2 kΩ	Var
R437	308-0108-00	15 kΩ	5 W WW 5%
R441	302-0101-00	100 Ω	1/2 W
R443	302-0272-00	2.7 kΩ	1/2 W
R444	323-0385-00	100 kΩ	1/2 W Prec 1%
R446	323-0404-00	158 kΩ	1/2 W Prec 1%
R447	306-0393-00	39 kΩ	2 W
R451	302-0101-00	100 Ω	1/2 W
R453	302-0332-00	3.3 kΩ	1/2 W
R454	302-0103-00	10 kΩ	1/2 W
R455	302-0274-00	270 kΩ	1/2 W
R456	302-0101-00	100 Ω	1/2 W
R457	302-0470-00	47 Ω	1/2 W
R458	302-0470-00	1 kΩ	1/2 W
R471	304-0101-00	100 Ω	1 W
R473	302-0101-00	100 Ω	1/2 W
R475	302-0470-00	47 Ω	1/2 W
R476	302-0470-00	47 Ω	1/2 W
R477	302-0470-00	47 Ω	1/2 W
R479	302-0101-00	100 Ω	1/2 W
R491	316-0470-00	47 Ω	1/4 W
R493	316-0470-00	47 Ω	1/4 W
R494	305-0562-00	5.6 kΩ	2 W 5%
R495	311-0475-00	5 kΩ	Var
R496	305-0562-00	5.6 kΩ	2 W 5%
R498	316-0470-00	47 Ω	1/4 W
R499	301-0622-00	6.2 kΩ	1/2 W 5%
R500	301-0622-00	6.2 kΩ	1/2 W 5%

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R501	315-0154-00	150 k Ω	5%
R502	311-0117-00	5 k Ω	5%
R504	316-0470-00	47 Ω	5%
R506	302-0101-00	100 Ω	5%
R508	308-0304-00	1.5 k Ω	1%
R509	323-0181-00	750 Ω	1%
R510	323-0239-00	3.01 k Ω	1%
R511	322-0093-00	90.9 Ω	1%
R512	308-0329-00	4 k Ω	2%
R513	308-0307-00	5 k Ω	1%
R514	315-0910-00	91 Ω	5%
R515	315-0240-00	24 Ω	5%
R516	315-0240-00	24 Ω	5%
R517	308-0305-00	1.3 k Ω	2%
R517	308-0059-00	2.25 k Ω	5%
R518	323-0400-00	143 k Ω	1%
R518	323-0395-00	127 k Ω	1%
R519	315-0560-00	56 Ω	5%
R520	311-0246-00	500 Ω	5%
R521	308-0127-00	2.5 k Ω	5%
R524	315-0910-00	91 Ω	5%
R525	316-0470-00	47 Ω	5%
R526	322-0093-00	90.9 Ω	1%
R527	323-0239-00	3.01 k Ω	1%
R532	302-0101-00	100 Ω	5%
R533	304-0153-00	15 k Ω	5%
R533	306-0103-00	10 k Ω	5%
R534	304-0823-00	82 k Ω	5%
R535	302-0103-00	10 k Ω	5%
R536	323-0356-00	49.9 k Ω	1%
R537	323-0385-00	100 k Ω	1%
R538	302-0273-00	27 k Ω	5%
R539	311-0191-00	10 k Ω	5%
R542	305-0682-00	6.8 k Ω	5%
R542	315-0100-00	10 Ω	5%
R544	315-0510-00	51 Ω	5%
R545	301-0910-00	91 Ω	5%
R545	315-0620-00	62 Ω	5%
R546	301-0910-00	91 Ω	5%
R546	315-0221-00	220 Ω	5%
R547	302-0102-00	1 k Ω	5%
R547	315-0102-00	1 k Ω	5%
R548	308-0108-00	15 k Ω	5%
R548	315-0100-00	10 Ω	5%
R552	302-0222-00	2.2 k Ω	5%
R553	315-0391-00	390 Ω	5%
R554	323-0166-00	523 Ω	1%
R556	323-0137-00	261 Ω	1%
R557	323-0074-00	57.6 Ω	1%
R558	315-0510-00	51 Ω	5%
R560	321-0025-00	17.8 Ω	1%
R561	323-0126-00	200 Ω	1%

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R563	315-0562-00	5.6 kΩ	1/4 W		5%
R566	323-0137-00	261 Ω	1/2 W	Prec	1%
R567	323-0074-00	57.6 Ω	1/2 W	Prec	1%
R569	321-0437-00	348 kΩ	1/8 W	Prec	1%
R570	321-0307-00	15.4 kΩ	1/8 W	Prec	1%
R571	308-0148-00	600 Ω	10 W	WW	5%
R572	304-0820-00	82 Ω	1 W		
R574	321-0001-00	10 Ω	1/8 W	Prec	1%
R576	321-0001-00	10 Ω	1/8 W	Prec	1%
R578	315-0332-00	3.3 kΩ	1/4 W		5%
R579	315-0102-00	1 kΩ	1/4 W		5%
R580	311-0539-00	150 Ω		Var	
R582	301-0910-00	91 Ω	1/2 W		5%
R584	315-0470-00	47 Ω	1/4 W		5%
R585	315-0104-00	100 kΩ	1/4 W		5%
R587	315-0101-00	100 Ω	1/4 W		5%
R589	*310-0630-00	1.2 kΩ	4 W	Prec	2%
R590	302-0470-00	47 Ω	1/2 W		
R592	301-0910-00	91 Ω	1/2 W		5%
R594	315-0470-00	47 Ω	1/4 W		5%
R595	315-0104-00	100 kΩ	1/4 W		5%
R596	303-0622-00	6.2 kΩ	1 W		5%
R597	315-0101-00	100 Ω	1/4 W		5%
R599	*310-0630-00	1.2 kΩ	4 W	Prec	2%
R602	311-0377-00	25 Ω		Var	
R604	308-0052-00	6 kΩ	5 W	WW	5%
R608	302-0333-00	33 kΩ	1/2 W		
R610	302-0104-00	100 kΩ	1/2 W		
R615	323-0369-00	68.1 kΩ	1/2 W	Prec	1%
R616	311-0015-00	10 kΩ		Var	
R617	323-0356-00	49.9 kΩ	1/2 W	Prec	1%
R618	302-0104-00	100 kΩ	1/2 W		
R621	302-0102-00	1 kΩ	1/2 W		
R622	308-0223-00	35 Ω	3 W	WW	5%
R623	302-0474-00	470 kΩ	1/2 W		
R625	302-0104-00	100 kΩ	1/2 W		
R628	302-0275-00	2.7 MΩ	1/2 W		
R629	302-0275-00	2.7 MΩ	1/2 W		
R632	308-0223-00	35 Ω	3 W	WW	5%
R633	302-0105-00	1 MΩ	1/2 W		
R635	304-0153-00	15 kΩ	1 W		
R636	304-0153-00	15 kΩ	1 W		
R637	302-0154-00	150 kΩ	1/2 W		
R638	302-0273-00	27 kΩ	1/2 W		
R639	302-0683-00	68 kΩ	1/2 W		
R640	304-0100-00	10 Ω	1 W		
R641	304-0100-00	10 Ω	1 W		
R642	308-0223-00	35 Ω	3 W	WW	5%
R643	302-0102-00	1 kΩ	1/2 W		
R644	302-0102-00	1 kΩ	1/2 W		

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range		
R646	308-0053-00	8 k Ω	5 W	WW	5%
R647	308-0037-00	1 k Ω	25 W	WW	5%
R648	302-0100-00	10 Ω	1/2 W		
R650	323-0440-00	374 k Ω	1/2 W	Prec	1%
R651	323-0675-00	543 k Ω	1/2 W	Prec	1%
R663	302-0395-00	3.9 M Ω	1/2 W		
R667	302-0684-00	680 k Ω	1/2 W		
R668	302-0473-00	47 k Ω	1/2 W		
R669	302-0393-00	39 k Ω	1/2 W		
R670	306-0100-00	10 Ω	2 W		
R675	308-0147-00	750 Ω	25 W	WW	5%
R676	308-0102-00	1.25 k Ω	25 W	WW	5%
R677	308-0147-00	750 Ω	25 W	WW	5%
R680	323-0440-00	374 k Ω	1/2 W	Prec	1%
R681	323-0674-00	247 k Ω	1/2 W	Prec	1%
R682	302-0124-00	120 k Ω	1/2 W		
R683	302-0102-00	1 k Ω	1/2 W		
R685	304-0823-00	82 k Ω	1 W		
R686	302-0184-00	180 k Ω	1/2 W		
R688	302-0155-00	1.5 M Ω	1/2 W		
R689	302-0225-00	2.2 M Ω	1/2 W		
R690	302-0102-00	1 k Ω	1/2 W		
R692	308-0223-00	35 Ω	3 W	WW	5%
R693	302-0155-00	1.5 M Ω	1/2 W		
R694	308-0223-00	35 Ω	3 W	WW	5%
R697	302-0105-00	1 M Ω	1/2 W		
R698	302-0274-00	270 k Ω	1/2 W		
R699	302-0563-00	56 k Ω	1/2 W		
R700	306-0100-00	10 Ω	2 W		
R703	302-0183-00	18 k Ω	1/2 W		
R706	308-0127-00	2.5 k Ω	5 W	WW	5%
R707	304-0103-00	10 k Ω	1 W		
R710	324-0458-00	576 k Ω	1 W	Prec	1%
R711	323-0422-00	243 k Ω	1/2 W	Prec	1%
R712	302-0154-00	150 k Ω	1/2 W		
R723	302-0155-00	1.5 M Ω	1/2 W		
R727	302-0105-00	1 M Ω	1/2 W		
R728	302-0564-00	560 Ω	1/2 W		
R729	302-0473-00	47 k Ω	1/2 W		
R730	304-0100-00	10 Ω	1 W		
R731	304-0100-00	10 Ω	1 W		
R732	306-0823-00	82 k Ω	2 W		
R736	308-0102-00	1.25 k Ω	25 W	WW	5%
R740	323-0418-00	221 k Ω	1/2 W	Prec	1%
R741	324-0467-00	715 k Ω	1 W	Prec	1%

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range		
R753	302-0105-00	1 MΩ	1/2 W		
R757	302-0154-00	150 kΩ	1/2 W		
R758	302-0124-00	120 kΩ	1/2 W		
R759	302-0273-00	27 kΩ	1/2 W		
R760	302-0100-00	10 Ω	1/2 W		
R767	308-0066-00	4.5 kΩ	5 W	WW	5%
R770	308-0242-00	0.25 Ω	5 W	WW	5%
R773	302-0393-00	39 kΩ	1/2 W		
R774	323-0386-00	102 kΩ	1/2 W	Prec	1%
R775	323-0283-00	8.66 kΩ	1/2 W	Prec	1%
R777	302-0473-00	47 kΩ	1/2 W		
R778	302-0104-00	100 kΩ	1/2 W		
R780	302-0154-00	150 kΩ	1/2 W		5%
R781	304-0681-00	680 Ω	1 W		
R784	302-0472-00	4.7 kΩ	1/2 W		
R785	302-0104-00	100 kΩ	1/2 W		
R787	308-0242-00	0.25 Ω	5 W	WW	5%
R799	302-0104-00	100 kΩ	1/2 W		
R802	306-0221-00	220 Ω	2 W		
R803	305-0473-00	47 kΩ	2 W		5%
R804	308-0298-00	560 Ω	3 W	WW	5%
R806	302-0104-00	100 kΩ	1/2 W		
R807	302-0393-00	39 kΩ	1/2 W		
R812	302-0102-00	1 kΩ	1/2 W		
R813	302-0101-00	100 Ω	1/2 W		
R814	302-0104-00	100 kΩ	1/2 W		
R815	311-0110-00	100 kΩ		Var	
R816	301-0434-00	430 kΩ	1/2 W		5%
R818	311-0369-00	100 kΩ		Var	
R819	301-0434-00	430 kΩ	1/2 W		5%
R821	301-0105-00	1 MΩ	1/2 W		5%
R822	302-0103-00	10 kΩ	1/2 W		
R823	323-0423-00	249 kΩ	1/2 W	Prec	1%
R824	305-0473-00	47 kΩ	2 W		5%
R825	302-0102-00	1 kΩ	1/2 W		
R826	301-0155-00	1.5 MΩ	1/2 W		5% 100-819
R826	323-0493-00	1.33 MΩ	1/2 W	Prec	1% 820-1109
R826	323-0494-00	1.37 MΩ	1/2 W	Prec	1% 1110-up
R827	315-0393-00	39 kΩ	1/4 W		5% X820-1109X
R831	306-0106-00	10 MΩ	2 W		
R832	306-0106-00	10 MΩ	2 W		
R833	306-0106-00	10 MΩ	2 W		
R834	306-0106-00	10 MΩ	2 W		
R835	302-0393-00	39 kΩ	1/2 W		
R837	302-0565-00	5.6 MΩ	1/2 W		
R840	302-0102-00	1 kΩ	1/2 W		
R841	302-0104-00	100 kΩ	1/2 W		
R845	306-0273-00	27 kΩ	2 W		

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range			
R846	311-0369-00	100 k Ω	Var			
R847 ⁷	311-0472-00	100 k Ω	Var			
R849 ⁸	311-0472-00	2 x 10 Ω	Var			
R851	323-0287-00	9.53 k Ω	1/2 W	Prec	1%	
R852	301-0623-00	62 k Ω	1/2 W		5%	
R854	303-0475-00	4.7 M Ω	1 W		5%	
R855	311-0162-00	1 M Ω		Var		
R856	305-0755-00	7.5 M Ω	2 W		5%	
R857	305-0755-00	7.5 M Ω	2 W		5%	
R858	305-0755-00	7.5 M Ω	2 W		5%	
R860	311-0583-00	2 M Ω		Var		
R861	303-0475-00	4.7 M Ω	1 W		5%	
R862	302-0393-00	39 k Ω	1/2 W			
R864	302-0104-00	100 k Ω	1/2 W			
R865	302-0471-00	470 Ω	1/2 W			
R866	302-0105-00	1 M Ω	1/2 W			
R867	302-0105-00	1 M Ω	1/2 W			
R868	302-0102-00	1 k Ω	1/2 W			
R870	301-0154-00	150 k Ω	1/2 W		5%	
R871	301-0245-00	2.4 M Ω	1/2 W		5%	
R872	302-0102-00	1 k Ω	1/2 W			
R873	302-0221-00	220 Ω	1/2 W			
R874	301-0395-00	3.9 M Ω	1/2 W		5%	
R875	301-0683-00	68 k Ω	1/2 W		5%	
R876	302-0102-00	1 k Ω	1/2 W			
R878	304-0333-00	33 k Ω	1 W			
R879	311-0016-00	10 k Ω		Var		
R880	302-0104-00	100 k Ω	1/2 W			
R883	302-0101-00	100 Ω	1/2 W			
R885	323-0709-01	10.048 k Ω	1/2 W		Prec	1/2%
R886	323-0708-01	6.628 k Ω	1/2 W		Prec	1/2%
R887	323-0707-01	1.782 k Ω	1/2 W		Prec	1/2%
R888	323-0706-01	800 Ω	1/2 W		Prec	1/2%
R889	323-0705-01	452 Ω	1/2 W		Prec	1/2%
R890	323-0704-01	146 Ω	1/2 W		Prec	1/2%
R891	323-0703-01	72.4 Ω	1/2 W		Prec	1/2%
R892	323-0702-01	43.1 Ω	1/2 W		Prec	1/2%
R893	323-0701-01	28.6 Ω	1/2 W		Prec	1/2%
R895	323-0636-00	50 k Ω	1/2 W		Prec	1%
R896	323-0638-00	50 k Ω	1/2 W		Prec	1/4%

⁷R847 and R849 furnished as a unit.

⁸R849 and R847 furnished as a unit.

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R897	323-0637-00	50 Ω	1/2 W	Prec	1/4 %
R898	323-0700-01	21.4 Ω	1/2 W	Prec	1/2 %
R899	*308-0090-00	0.25 Ω	1 W	WW	
R901	316-0104-00	100 kΩ	1/4 W		
R902	316-0682-00	6.8 kΩ	1/4 W		
R903	316-0104-00	100 kΩ	1/4 W		
R906	316-0101-00	100 Ω	1/4 W		
R907	316-0104-00	100 kΩ	1/4 W		
R910	311-0584-00	10 MΩ		Var	
R911	315-0474-00	470 kΩ	1/4 W		5%
R912	316-0101-00	100 Ω	1/4 W		
R913	302-0473-00	47 kΩ	1/2 W		
R914	301-0152-00	1.5 kΩ	1/2 W		5%
R915	316-0101-00	100 Ω	1/4 W		
R916	315-0334-00	330 kΩ	1/4 W		5%
R917	319-0077-00	1.62 MΩ	1/4 W	Prec	1%
R918	315-0184-00	180 kΩ	1/4 W		5%
R919	304-0183-00	18 kΩ	1 W		
R921	316-0183-00	18 kΩ	1/4 W		
R922	316-0105-00	1 MΩ	1/4 W		
R923	316-0102-00	1 kΩ	1/4 W		
R924	316-0275-00	2.7 MΩ	1/4 W		
R925	316-0155-00	1.5 MΩ	1/4 W		
R926	316-0184-00	180 kΩ	1/4 W		
R927	302-0470-00	47 Ω	1/2 W		
R928	316-0104-00	100 kΩ	1/4 W		
R929	302-0101-00	100 Ω	1/2 W		
R930	316-0105-00	1 MΩ	1/4 W		
R931	316-0103-00	10 kΩ	1/4 W		
R932	316-0334-00	330 kΩ	1/4 W		
R933	316-0473-00	47 kΩ	1/4 W		
R935	316-0153-00	15 kΩ	1/4 W		
R945	316-0222-00	2.2 kΩ	1/4 W		
R946	316-0103-00	10 kΩ	1/4 W		
R951	316-0103-00	10 kΩ	1/4 W		
R952	316-0222-00	2.2 kΩ	1/4 W		
R954	302-0470-00	47 Ω	1/2 W		
R955	302-0124-00	120 kΩ	1/2 W		
R957	302-0222-00	2.2 kΩ	1/2 W		
R1001	316-0335-00	3.3 MΩ	1/4 W		
R1005	316-0335-00	3.3 MΩ	1/4 W		
R1007	316-0125-00	1.2 MΩ	1/4 W		
R1008	316-0154-00	150 kΩ	1/4 W		
R1009	316-0105-00	1 MΩ	1/4 W		
R1011	316-0103-00	10 kΩ	1/4 W		

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R1012	315-0154-00	150 k Ω	$\frac{1}{4}$ W		5%
R1013	316-0473-00	47 k Ω	$\frac{1}{4}$ W		
R1015	315-0622-00	6.2 k Ω	$\frac{1}{4}$ W		5%
R1021	316-0103-00	10 k Ω	$\frac{1}{4}$ W		
R1023	315-0472-00	4.7 k Ω	$\frac{1}{4}$ W		5%
R1024	315-0221-00	220 Ω	$\frac{1}{4}$ W		5%
R1025	316-0103-00	10 k Ω	$\frac{1}{4}$ W		
R1027	316-0222-00	2.2 k Ω	$\frac{1}{4}$ W		
R1028	301-0124-00	120 k Ω	$\frac{1}{2}$ W		5%
R1029	321-0334-00	29.4 k Ω	$\frac{1}{8}$ W	Prec	1%
R1032	315-0102-00	1 k Ω	$\frac{1}{4}$ W		5%
R1033	311-0462-00	1 k Ω		Var	
R1034	316-0472-00	4.7 k Ω	$\frac{1}{4}$ W		
R1041	315-0335-00	3.3 M Ω	$\frac{1}{4}$ W		5%
R1042	315-0102-00	1 k Ω	$\frac{1}{4}$ W		5%
R1043	311-0462-00	1 k Ω		Var	
R1044	316-0472-00	4.7 k Ω	$\frac{1}{4}$ W		
R1049	321-0395-00	127 k Ω	$\frac{1}{8}$ W		Prec 1%
R1050	311-0464-00	25 k Ω		Var	
R1051	321-0429-00	287 k Ω	$\frac{1}{8}$ W		Prec 1%
R1055	311-0465-00	100 k Ω		Var	
R1060	321-0385-00	100 k Ω	$\frac{1}{8}$ W		Prec 1%
R1061	316-0101-00	100 Ω	$\frac{1}{4}$ W		
R1062	304-0474-00	470 k Ω	1 W		
R1063	316-0101-00	100 Ω	$\frac{1}{4}$ W		
R1064	323-0481-00	1 M Ω	$\frac{1}{2}$ W		Prec 1%
R1065	304-0224-00	220 k Ω	1 W		
R1066	301-0104-00	100 k Ω	$\frac{1}{2}$ W		5%
R1070	311-0464-00	25 k Ω		Var	
R1071	301-0103-00	10 k Ω	$\frac{1}{2}$ W		5%
R1072	301-0203-00	20 k Ω	$\frac{1}{2}$ W		5%
R1073	302-0104-00	100 k Ω	$\frac{1}{2}$ W		
R1074	302-0392-00	3.9 k Ω	$\frac{1}{2}$ W		
R1080	301-0822-00	8.2 k Ω	$\frac{1}{2}$ W		5%
R1081	301-0202-00	2 k Ω	$\frac{1}{2}$ W		5%
R1101	316-0335-00	3.3 M Ω	$\frac{1}{4}$ W		
R1105	316-0335-00	3.3 M Ω	$\frac{1}{4}$ W		
R1107	316-0125-00	1.2 M Ω	$\frac{1}{4}$ W		
R1108	316-0154-00	150 k Ω	$\frac{1}{4}$ W		
R1109	316-0105-00	1 M Ω	$\frac{1}{4}$ W		
R1111	316-0103-00	10 k Ω	$\frac{1}{4}$ W		
R1112	315-0154-00	150 k Ω	$\frac{1}{4}$ W		5%
R1113	316-0473-00	47 k Ω	$\frac{1}{4}$ W		
R1115	315-0622-00	6.2 k Ω	$\frac{1}{4}$ W		5%
R1121	316-0103-00	10 k Ω	$\frac{1}{4}$ W		

Electrical Parts List—Type 549

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
R1123	315-0472-00	4.7 kΩ 1/4 W	5%
R1124	315-0221-00	220 Ω 1/4 W	5%
R1125	316-0103-00	10 kΩ 1/4 W	
R1127	316-0222-00	2.2 kΩ 1/4 W	
R1128	301-0124-00	120 kΩ 1/2 W	5%
R1129	321-0334-00	29.4 kΩ 1/8 W	Prec 1%
R1131	302-0103-00	10 kΩ 1/2 W	
R1132	311-0551-00	500 kΩ	Var
R1133	315-0154-00	150 kΩ 1/4 W	5%
R1134	316-0473-00	47 kΩ 1/4 W	
R1135	316-0473-00	47 kΩ 1/4 W	
R1140	311-0465-00	100 kΩ	Var
R1141	315-0335-00	3.3 MΩ 1/4 W	5%
R1143	315-0472-00	4.7 kΩ 1/4 W	5%
R1144	311-0117-00	5 kΩ	Var
R1145	315-0272-00	2.7 kΩ 1/4 W	5%
R1146	316-0103-00	10 kΩ 1/4 W	
R1149	321-0395-00	127 kΩ 1/8 W	Prec 1%
R1151	321-0429-00	287 kΩ 1/8 W	Prec 1%
R1160	321-0385-00	100 kΩ 1/8 W	Prec 1%
R1161	316-0101-00	100 Ω 1/4 W	
R1162	304-0474-00	470 kΩ 1 W	
R1163	316-0101-00	100 Ω 1/4 W	
R1164	323-0481-00	1 MΩ 1/2 W	Prec 1%
R1165	304-0224-00	220 kΩ 1 W	
R1166	301-0104-00	100 kΩ 1/2 W	5%
R1168	316-0473-00	47 kΩ 1/4 W	
R1169	311-0497-00	50 kΩ	Var
R1182	303-0394-00	390 kΩ 1 W	5%
R1183	301-0334-00	330 kΩ 1/2 W	5%
R1184	301-0224-00	220 kΩ 1/2 W	5%
R1185	311-0551-00	500 kΩ	Var
R1193	301-0104-00	100 kΩ 1/2 W	5%
R1194	308-0393-00	1.6 kΩ 3 W	WW 1%
R1195	306-0104-00	100 kΩ 2 W	
R1196	302-0101-00	100 Ω 1/2 W	

Switches

	Unwired	Wired	
SW5	260-0494-00	*262-0748-00 A TRIGGERING	Lever
SW6	260-0495-00		Lever
SW15	260-0542-00		Lever
SW35	260-0742-00		Lever
			COUPLING SOURCE SLOPE MODE

Switches (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
	Unwired	Wired	
SW55	260-0494-00	*262-0748-00 B TRIGGERING	Lever
SW56	260-0495-00		Lever
SW65	260-0542-00		Lever
SW85	260-0742-00		Lever
SW106 ⁹	311-0096-00	*262-0759-00	Lever
SW125 ¹⁰	260-0496-00		
SW160	260-0746-00		
SW160Y	311-0108-00		
SW211 ¹¹	311-0096-00	*262-0746-00	
SW260	260-0745-00	*262-0747-00	Rotary
SW301	260-0739-00	*262-0750-00	Rotary
SW347A } SW347B }	260-0738-00	*262-0749-00	Rotary
SW362	260-0722-00		Reed
SW368	260-0737-00		Pushbutton
SW369	260-0737-00		Pushbutton
SW380	260-0774-00		Pushbutton
SW553	260-0722-00		Reed
SW601	260-0199-00		Toggle
SW601	260-0276-00		Toggle
SW601	260-0778-00		Toggle
SW602	260-0778-00		Toggle
SW603	260-0773-00		Toggle
SW840	260-0449-00		Slide
SW865	260-0447-00		Slide
SW870	260-0536-00	*262-0731-00	Rotary
SW925 ¹²	260-0779-00		Pushbutton
SW929	260-0741-00	*262-0752-00	Rotary
SW930	260-0744-00		Lever
SW957 ¹³	260-0516-00	*262-0759-00	Micro
SW1001	260-0737-00		Pushbutton
SW1005	260-0737-00		Pushbutton
SW1101	260-0737-00		Pushbutton
SW1105	260-0737-00		Pushbutton
SW1145	260-0740-00	*262-0751-00	Rotary
SW1196	260-0645-00		Pushbutton

Thermal Cutout

TK601	260-0336-00	150°F, ±5°F
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⁹Furnished as a unit with R17 and R106.¹⁰Furnished as a unit with SW957.¹¹Furnished as a unit with R67 and R211.¹²Furnished as a unit with B125.¹³Furnished as a unit with SW125.

Electrical Parts List—Type 549

Transformers

Ckt. No.	Tektronix Part No.	Description	S/N Range
T500	276-0541-00	Core, Ferrite	
T553	*120-0132-00	Toroid	
T601	*120-0422-00	LV Power	
T801	*120-0423-00	HV Power	

Electron Tubes

V24	154-0187-00	6DJ8	
V74	154-0187-00	6DJ8	
V104	154-0022-00	6AU6	
V113	154-0187-00	6DJ8	
V115	154-0022-00	6AU6	
V135	154-0187-00	6DJ8	
V144	154-0187-00	6DJ8	
V145	154-0047-00	12BY7	
V152	154-0016-00	6AL5	
V161	154-0031-00	6CL6	
V173	154-0187-00	6DJ8	
V183	154-0187-00	6DJ8	
V193	154-0187-00	6DJ8	
V214	154-0022-00	6AU6	
V225	154-0022-00	6AU6	
V233	154-0187-00	6DJ8	
V235	154-0187-00	6DJ8	
V245	154-0022-00	6AU6	
V252	*157-0075-00	12AL5, checked	100-519
V252	154-0038-00	12AL5	520-up
V261	154-0040-00	12AU6	100-299
V261	154-0040-05	8426	300-up
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	
V494	154-0187-00	6DJ8	
V514	154-0340-00	7119	
V584	154-0491-00	8608	
V594	154-0491-00	8608	

Electron Tubes (Cont)

Ckt. No.	Tektronix Part No.	Description	S/N Range
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	
V767	154-0044-00	12B4	
V800	154-0494-00	6GF5	
V814	154-0187-00	6DJ8	
V859	*154-0498-00	T5490-202 CRT Standard Phosphor	
V875	154-0022-00	6AU6	
V885	154-0041-00	12AU7	
V915	154-0278-00	6BL8	
V1064	154-0278-00	6BL8	
V1164	154-0278-00	6BL8	

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specified.

PARTS ORDERING INFORMATION

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

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

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

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

- FIG. 1 FRONT AND SWITCHES
- FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE,
STORAGE BOARD AND A SWEEP
- FIG. 3 LOW VOLTAGE POWER
- FIG. 4 RECTIFIER MOUNTING PLATE
- FIG. 5 LOWER VERTICAL AMPLIFIER AND
B SWEEP
- FIG. 6 CATHODE RAY TUBE SHIELD,
MOUNTING BRACKETS AND
UPPER VERTICAL AMPLIFIER
- FIG. 7 RAILS, REAR, AND CABINET
- FIG. 8 CERAMIC STRIPS AND CABLE HARNESS
DETAIL
- FIG. 9 ACCESSORIES

SECTION 8

MECHANICAL PARTS LIST

FIG. 1 FRONT AND SWITCHES

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-1	333-0865-00			1	PANEL, front
-2	331-0037-00			1	GRATICULE, 5 inch, 6 CM Vertical x 10 CM Horizontal
-3	- - - - -			1	FILTER, light, smoke gray (see FIG. 9)
-4	210-0816-00			4	WASHER, rubber
-5	253-0028-00			FT	TAPE, sponge (specify 3 inch length)
-6	200-0654-00			1	COVER, graticule, aluminum
- - - - -	- - - - -			-	mounting hardware: (not included w/cover)
-7	210-0424-00			4	NUT, knurled, $\frac{3}{8}$ -24 x $\frac{9}{16}$ x $\frac{3}{16}$ inch
-8	401-0004-00			1	CAM, nylon, $\frac{3}{8}$ inch OD
- - - - -	- - - - -			-	mounting hardware: (not included w/cam)
-9	211-0023-00			1	SCREW, 4-40 x $\frac{1}{4}$ inch, FHS
-10	213-0088-00			1	SCREW, thread forming, 4-40 x $\frac{3}{16}$ inch, PHS
-11	136-0026-00			1	SOCKET, light, w/out jewel
-12	378-0513-00			1	JEWEL, light, pilot, green
-13	355-0043-00			4	STUD, $\frac{3}{8}$ -32 x 0.897 inch long, 10-32 internal thread
- - - - -	- - - - -			-	each stud includes:
- - - - -	212-0507-00			1	SCREW, 10-32 x $\frac{3}{8}$ inch, PHS
- - - - -	210-0010-00			1	LOCKWASHER, internal, #10
-14	214-0335-00			1	BOLT, current loop, U-shaped
- - - - -	- - - - -			-	mounting hardware (not included w/bolt)
-15	210-0593-00			2	NUT, current loop, $\frac{1}{4}$ hex. x 3-48
-16	361-0059-00			1	SPACER, current loop, $\frac{1}{8}$ x $1\frac{1}{32}$ x $1\frac{3}{32}$ inches
- - - - -	210-0849-00			2	WASHER, fiber, #4
- - - - -	210-0994-00			2	WASHER, flat, 0.125 ID x 0.250 inch OD
- - - - -	210-0201-00			2	LUG, solder, SE #4
- - - - -	210-0442-00			2	NUT, hex., 3-48 x $\frac{3}{16}$ inch
-17	129-0035-00			1	ASSEMBLY, binding post
- - - - -	- - - - -			-	assembly includes:
-18	200-0103-00			1	CAP, binding post
- - - - -	210-0011-00			1	LOCKWASHER, internal, $\frac{1}{4}$ ID x $1\frac{5}{32}$ inch OD
- - - - -	210-0455-00			1	NUT, hex., $\frac{1}{4}$ -28 x $\frac{3}{8}$ x $\frac{3}{32}$ inch
- - - - -	355-0507-00			1	STEM, binding post adapter
- - - - -	- - - - -			-	mounting hardware: (not included w/assembly)
-19	210-0223-00			1	LUG, solder, $\frac{1}{4}$ ID x $\frac{7}{16}$ inch OD, SE
-20	131-0274-00			1	CONNECTOR, insulated, $\frac{1}{2}$ inch diameter hole, BNC
-21	131-0106-00			8	CONNECTOR, coaxial, 1 contact, BNC
-22	366-0115-00			1	KNOB, charcoal—AMPLITUDE CALIBRATOR
- - - - -	- - - - -			-	knob includes:
- - - - -	213-0004-00			1	SCREW, set, 6-32 x $\frac{3}{16}$ inch, HSS
-23	262-0731-00			1	SWITCH, wired—AMPLITUDE CALIBRATOR
- - - - -	- - - - -			-	switch includes:
- - - - -	260-0536-00			1	SWITCH, unwired—AMPLITUDE CALIBRATOR
- - - - -	- - - - -			-	mounting hardware: (not included w/switch)
- - - - -	210-0012-00			2	LOCKWASHER, internal, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
-24	210-0590-00			1	NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y	1 2 3 4 5					Description
					1	2	3	4	5	
1-25	366-0081-00			1						KNOB, red—FINE
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-26	366-0160-00			1						KNOB, charcoal—HORIZONTAL POSITION
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-27	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-28	366-0177-00			1						KNOB, red—B STABILITY
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-29	366-0146-00			1						KNOB, charcoal—B LEVEL
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-30	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-31	366-0215-01			1						KNOB, charcoal—B MODE
-32	366-0215-01			1						KNOB, charcoal—B SLOPE
-33	366-0215-01			1						KNOB, charcoal—B COUPLING
-34	366-0215-01			1						KNOB, charcoal—B SOURCE
-35	262-0748-00			1						SWITCH, wired—B TRIGGERING
	- - - - -			-						switch includes:
-36	260-0742-00			1						SWITCH, unwired—B MODE
-37	260-0542-00			1						SWITCH, unwired—B SLOPE
-38	260-0494-00			1						SWITCH, unwired—B COUPLING
-39	260-0495-00			1						SWITCH, unwired—B SOURCE
-40	213-0044-00			8						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-41	406-0943-00			2						BRACKET, switch mounting
	- - - - -			-						mounting hardware: (not included w/switch)
-42	220-0413-00			4						NUT, switch mounting, hex. rod, 4-40 thread
-43	331-0091-00			1						DIAL, duo dial, w/o brake, charcoal—DELAY TIME MULTIPLIER
-44	366-0038-00			1						KNOB, red—LENGTH
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-45	366-0144-00			1						KNOB, charcoal—TIME/CM AND DELAY TIME
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	Description					
					1	2	3	4	5	
1-46	262-0747-00			1						SWITCH, wired—TIME/CM AND DELAY TIME switch includes:
	260-0745-00			1						SWITCH, unwired—TIME/CM AND DELAY TIME
-47	344-0117-00			1						CLIP, capacitor mounting, $\frac{3}{4}$ inch mounting hardware: (not included w/clip)
-48	211-0504-00			1						SCREW, 6-32 x $\frac{1}{4}$ inch, PHS
	210-0457-00			1						NUT, keps, 6-32 x $\frac{5}{16}$ inch
-49	348-0031-00			2						GROMMET, plastic, $\frac{3}{32}$ inch diameter
-50	407-0185-00			1						BRACKET, switch mounting hardware: (not included w/bracket)
	210-0006-00			2						LOCKWASHER, internal, #6
	210-0449-00			2						NUT, hex., 5-32 x $\frac{1}{4}$ inch
-51	376-0014-00			1						COUPLING, resistor
-52	384-0074-00			1						ROD, extension, $\frac{1}{8}$ x $6\frac{5}{8}$ inches
-53				1						RESISTOR, variable mounting hardware: (not included w/resistor)
-54	210-0012-00			1						LOCKWASHER, internal, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
-55	210-0590-00			2						NUT, hex., $\frac{3}{8}$ -32 x $\frac{7}{16}$ inch mounting hardware: (not included w/switch)
	210-0012-00			1						LOCKWASHER, internal, $\frac{3}{8}$ ID x $\frac{1}{2}$ inch OD
-56	210-0413-00			1						NUT, hex., $\frac{3}{8}$ -32 x $\frac{1}{2}$ inch
-57	366-0215-01			1						KNOB, charcoal—A MODE
-58	366-0215-01			1						KNOB, charcoal—A SLOPE
-59	366-0215-01			1						KNOB, charcoal—A COUPLING
-60	366-0215-01			1						KNOB, charcoal—A SOURCE
-61	262-0748-00			1						SWITCH, wired—A TRIGGERING switch includes:
-62	260-0493-00			1						SWITCH, unwired—A MODE
-63	260-0542-00			1						SWITCH, unwired—A SLOPE
-64	260-0494-00			1						SWITCH, unwired—A COUPLING
-65	260-0495-00			1						SWITCH, unwired—A SOURCE
-66	213-0044-00			8						SCREW, thread forming, 5-32 x $\frac{3}{16}$ inch, PHS
-67	406-0943-00			2						BRACKET, switch mounting mounting hardware: (not included w/switch)
-68	220-0413-00			4						NUT, switch mounting, hex., rod, 4-40 thread
	210-0201-00	X200		1						LUG, solder, SE #4
-69	366-0153-00			1						KNOB, charcoal—VARIABLE 1-10 knob includes:
	213-0020-00			1						SCREW, set, 6-32 x $\frac{1}{8}$ inch, HSS
-70				1						RESISTOR, variable mounting hardware: (not included w/resistor)
	210-0046-00			1						LOCKWASHER, internal, $\frac{1}{4}$ ID x 0.400 inch OD
	210-0940-00			1						WASHER, flat, $\frac{1}{4}$ ID x $\frac{3}{8}$ inch OD
	210-0583-00			1						NUT, hex., $\frac{1}{4}$ -32 x $\frac{5}{16}$ inch

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1 2 3 4 5					
1-71	366-0215-01			1	KNOB, charcoal—NORM SINGLE SWEEP-RESET
-72	262-0759-00			1	SWITCH, wired—NORM SINGLE SWEEP-RESET
	- - - - -			-	switch includes:
	260-0496-00			1	SWITCH, unwired—NORM SINGLE SWEEP-RESET
-73	260-0516-00			1	SWITCH, push
	- - - - -			-	mounting hardware: (not included w/switch)
-74	211-0034-00			2	SCREW, 2-56 x 1/2 inch, RHS
	210-0850-00			2	WASHER, flat, 0.093 ID x 3/32 inch OD
	210-0001-00			1	LOCKWASHER, internal, #2
	210-0259-00			1	LUG, solder
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
	- - - - -			-	mounting hardware: (not included w/switch)
-75	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-76	366-0215-01			1	KNOB, charcoal—AUTO ERASE
-77	260-0744-00			1	SWITCH, unwired—AUTO ERASE
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-78	260-0199-00	100	109	1	SWITCH, toggle—POWER
	260-0276-00	110	619	1	SWITCH, toggle—POWER
	260-0778-00	620		1	SWITCH, toggle—POWER
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0414-00			1	NUT, hex., 15/32-32 x 7/16 inch
-79	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
-80	210-0902-00			1	WASHER, flat, 0.470 ID x 2 1/32 inch OD
	354-0055-00			1	RING, locking, switch
-81	- - - - -			2	RESISTOR, variable
	- - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0011-00			1	LOCKWASHER, internal, 1/4 ID x 15/32 inch OD
-82	210-0471-00			1	NUT, hex., 1/4-32 x 5/16 x 19/32 inch
-83	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-84	358-0054-00			1	BUSHING, banana jack, 1/4-32 x 13/32 inch
-85	352-0084-00			2	HOLDER, neon, black
-86	378-0541-00			2	FILTER, lens, neon, indicator light
-87	200-0609-00			2	COVER, neon holder
-88	366-0177-00			1	KNOB, red—A STABILITY
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-89	366-0146-00			1	KNOB, charcoal—A LEVEL
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-90	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-91	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-92	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-93	211-0538-00			4	SCREW, 6-32 x 5/16 inch, 100° csk, FHS

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
1-94	366-0038-00			1	KNOB, red—VARIABLE CAL
	213-0004-00			-	knob includes:
				1	SCREW, set, 6-32 x 3/16 inch, HSS
-95	366-0144-00			1	KNOB, charcoal—TIME/CM
	213-0004-00			-	knob includes:
				1	SCREW, set, 6-32 x 3/16 inch, HSS
-96	262-0746-00			1	SWITCH, wired—TIME/CM
	260-0746-00			-	switch includes:
				1	SWITCH, unwired—TIME/CM
-97	344-0117-00			1	CLIP, capacitor mounting, 3/4 inch
				-	mounting hardware: (not included w/clip)
-98	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
	210-0457-00			1	NUT, keps, 6-32 x 3/16 inch
-99	348-0031-00			2	GROMMET, plastic, 3/32 inch diameter
-100	407-0184-00			1	BRACKET, switch
	210-0449-00			-	mounting hardware: (not included w/bracket)
				2	NUT, hex., 5-40 x 1/4 inch
-101	210-0203-00			2	LUG, solder, SE #6
-102	376-0014-00			1	COUPLING, resistor
-103	384-0162-00			1	ROD, extension, 1/8 x 87/16 inches
-104				1	RESISTOR, variable
	210-0012-00			-	mounting hardware: (not included w/resistor)
				1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-105	210-0413-00			2	NUT, hex., 3/8-32 x 1/2 inch
-106				1	RESISTOR, variable
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
	210-0012-00			-	mounting hardware: (not included w/switch)
	210-0413-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
				1	NUT, hex., 3/8-32 x 1/2 inch
-107	366-0081-00			1	KNOB, red—MAGNIFIER
	213-0004-00			-	knob includes:
				1	SCREW, set, 6-32 x 3/16 inch, HSS
-108	366-0142-00			1	KNOB, charcoal—HORIZONTAL DISPLAY
	213-0004-00			-	knob includes:
				1	SCREW, set, 6-32 x 3/16 inch, HSS
-109	262-0750-00			1	SWITCH, wired—HORIZONTAL DISPLAY
	260-0739-00			-	switch includes:
				1	SWITCH, unwired—HORIZONTAL DISPLAY
-110	337-0279-00			1	SHIELD, switch
	211-0008-00			-	mounting hardware: (not included w/shield)
	210-0004-00			2	SCREW, 4-40 x 1/4 inch, PHS
	210-0406-00			2	LOCKWASHER, internal, #4
				2	NUT, hex., 4-40 x 3/16 inch
	210-0012-00			-	mounting hardware: (not included w/switch)
				1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-111	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-112	262-0749-00			1						SWITCH, wired—HORIZONTAL DISPLAY (rear)
	- - - - -			-						switch includes:
	260-0738-00			1						SWITCH, unwired—HORIZONTAL DISPLAY (rear)
-113	406-0450-00			1						BRACKET, resistor mounting
	- - - - -			-						mounting hardware: (not included w/bracket)
-114	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
	210-0004-00			2						LOCKWASHER, internal, #4
	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch
-115	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-116	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
	211-0013-00			2						SCREW, 4-40 x 3/8 inch, RHS
	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)
-117	406-0451-00			1						BRACKET, switch mounting
	- - - - -			-						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 x 3/8 inch OD
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-118	210-0840-00			1						WASHER, flat, 0.390 ID x 3/16 inch OD
-119	210-0413-00			1						NUT, hex., 3/8-32 x 1/2 inch
-120	376-0007-00			1						COUPLING, 1 inch long
-121	366-0189-00			1						KNOB, red—VIEWING TIME
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-122	366-0175-00			1						KNOB, charcoal—SCREEN SELECTOR
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-123	262-0752-00			1						SWITCH, wired—SCREEN SELECTOR
	- - - - -			-						switch includes:
	260-0741-00			1						SWITCH, unwired—SCREEN SELECTOR
	384-0381-00			1						ROD, shaft, 1/8 x 2.125 inches long
-124	376-0014-00			1						COUPLING, resistor
-125	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-126	210-0413-00			2						NUT, hex., 3/8-32 x 1/2 inch
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-127	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-128	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	1 2 3 4 5					Description
					1	2	3	4	5	
1-129	366-0189-00			1						KNOB, red—ENHANCE LEVEL
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-130	366-0175-00			1						KNOB, charcoal—ENHANCE MODE
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-131	262-0751-00			1						SWITCH, wired—ENHANCE MODE
	- - - - -			-						switch includes:
	260-0740-00			1						SWITCH, unwired—ENHANCE MODE
	384-0381-00			1						ROD, shaft, 1/8 x 2.125 inches long
-132	376-0014-00			1						COUPLING, resistor
-133	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-134	210-0413-00			2						NUT, hex., 3/8-32 x 1/2 inch
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-135	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-136	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-137	260-0645-00			1						SWITCH, push—INTERGRATE TRACES
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-138	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-139	260-0779-00			1						SWITCH, push—ERASE & RESET
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-140	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-141	366-0220-00			1						KNOB, charcoal—SCALE ILLUM
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-142	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-143	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
	210-0590-00			2						NUT, hex., 3/8-32 x 7/16 inch
-144	366-0254-00			1						KNOB, charcoal—ASTIG
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-145	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-146	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch

FIG. 1 FRONT AND SWITCHES (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	1	2	3	4		5
1-147	366-0220-00			1						KNOB, charcoal—FOCUS
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-148	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-149	210-0013-00			1						LOCKWASHER, internal, 3/8 ID x 1 1/16 inch OD
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-150	366-0220-00			1						KNOB, charcoal—INTENSITY
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-151	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-152	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-153	386-0234-00			1						PLATE, sub-panel, front
	- - - - -			-						plate includes:
	354-0056-00			1						RING, ornamental, 1/8 x 12 5/8 x 15 7/8 inches
-154	366-0343-00			2						KNOB, aluminum—OFF
-155	366-0343-01			2						KNOB, aluminum—STORE
-156	366-0343-02			2						KNOB, aluminum—ERASE
-157	260-0737-00			2						SWITCH, unwired, upper & lower screen storage
	- - - - -			-						mounting hardware for each: (not included w/switch)
-158	361-0100-00			4						SPACER, rod
-159	210-0006-00			4						LOCKWASHER, internal, #6
-160	210-0407-00			4						NUT, hex., 6-32 x 1/4 inch
-161	381-0073-00			2						BAR, retaining, 3/16 x 1/2 x 1 1/2 inches
-162	260-0774-00			1						SWITCH, push—LOCATE
	- - - - -			-						mounting hardware: (not included w/switch)
-163	210-0978-00			1						WASHER, flat, 3/8 ID x 9/16 inch OD
-164	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-165	179-1038-00			1						CABLE HARNESS, storage board

FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE, STORAGE BOARD AND A SWEEP

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	Description				
					1	2	3	4	5
2-1	386-0236-00			1	PLATE, storage board support				
	- - - - -			-	mounting hardware: (not included w/plate)				
	211-0510-00			3	SCREW, 6-32 x 3/8 inch, PHS				
-2	670-0421-00			1	ASSEMBLY, circuit board, storage				
	- - - - -			-	assembly includes:				
	388-0659-00			1	BOARD, circuit storage				
-3	136-0061-00			3	SOCKET, tube, 9 pin				
-4	136-0220-00			10	SOCKET, transistor, 3 pin				
-5	136-0183-00			1	SOCKET, transistor, 3 pin w/contacts				
-6	214-0506-00			46	PIN, connector				
-7	214-0579-00			3	PIN, test point				
	- - - - -			-	mounting hardware: (not included w/assembly)				
-8	385-0146-00			7	ROD, hex., 1/4 x 1 1/16 inch				
-9	211-0601-00			7	SCREW, sems, 6-32 x 5/16 inch, PHB				
	210-1011-00	X910		3	WASHER, plastic, 0.130 ID x 0.375 inch OD				
-10	343-0088-00			2	CLAMP, cable, plastic				
-11	122-0132-00			1	ANGLE, rail, top left				
	- - - - -			-	mounting hardware: (not included w/angle)				
	211-0538-00			4	SCREW, 6-32 x 5/16 inch, 100° csk, FHS				
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch				
-12	337-0777-00			1	SHIELD, high voltage				
	- - - - -			-	mounting hardware: (not included w/shield)				
	210-0803-00			2	WASHER, flat, 0.150 ID x 3/8 inch OD				
-13	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS				
-14	348-0050-00			1	GROMMET, plastic, 3/4 inch diameter				
-15	441-0644-00			1	CHASSIS, Focus & Intensity and High Voltage				
	- - - - -			-	mounting hardware: (not included w/chassis)				
	212-0070-00			2	SCREW, 8-32 x 5/16 inch, 100° csk, FHS				
-16	348-0064-00			1	GROMMET, plastic, 5/8 inch diameter				
-17	348-0056-00			1	GROMMET, plastic, 3/8 inch diameter				
-18	- - - - -			2	RESISTOR, variable				
	- - - - -			-	mounting hardware for each: (not included w/resistor)				
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD				
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch				
-19	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				
-20	136-0015-00			1	SOCKET, tube, 9 pin, w/ground lugs				
	- - - - -			-	mounting hardware: (not included w/socket)				
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS				
-21	136-0158-00			1	SOCKET, tube, 12 pin				
	- - - - -			-	mounting hardware: (not included w/socket)				
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS				

FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE, STORAGE BOARD AND A SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y						Description
					1	2	3	4	5	
2-22	346-0001-00			1						STRAP, transformer mounting
	- - - - -			-						strap includes:
	214-0009-00			2						BOLT, spade, 4-40 x 1/2 inch offset
	- - - - -			-						mounting hardware: (not included w/strap)
	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch
-23	441-0648-00			1						CHASSIS, A Sweep
	- - - - -			-						mounting hardware: (not included w/chassis)
	212-0040-00			4						SCREW, 8-32 x 3/8 inch, 100° csk, FHS
-24	- - - - -			1						TRANSISTOR
	- - - - -			-						mounting hardware: (not included w/transistor)
-25	211-0596-00			2						SCREW, 6-32 x 3/8 inch, PHB
	210-0202-00			1						LUG, solder, SE #6
-26	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-27	- - - - -			3						TRANSISTOR
	- - - - -			-						mounting hardware for each: (not included w/transistor)
-28	211-0596-00			2						SCREW, 6-32 x 3/8 inch, PHB
-29	386-1098-00			1						PLATE, mica, insulator
-30	210-0813-00			2						WASHER, shouldered
-31	210-0803-00			2						WASHER, flat, 0.150 ID x 3/8 inch OD
-32	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-33	136-0181-00			7						SOCKET, transistor, 3 pin
	- - - - -			-						mounting hardware for each: (not included w/socket)
-34	354-0234-00			1						RING, transistor mounting
-35	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-36	432-0047-00			1						BASE, plastic, 1 1/32 h x 1.025 inches ID
-37	386-0253-00			1						PLATE, metal, capacitor mounting
	211-0514-00			2						SCREW, 6-32 x 3/4 inch, PHS
-38	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-39	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-40	386-0254-00			1						PLATE, fiber, capacitor mounting
-41	211-0543-00			2						SCREW, 6-32 x 5/16 inch, RHS
-42	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-43	200-0260-00			1						COVER, capacitor, plastic, 2 1/32 inches
-44	210-0201-00			4						LUG, solder, SE #4
	- - - - -			-						mounting hardware for each: (not included w/lug)
	213-0044-00			1						SCREW, thread forming, 5-32 x 3/16 inch, PHS

FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE, STORAGE BOARD AND A SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
2-45	337-0776-00			1						SHIELD, sweep amplifier
	- - - - -			-						mounting hardware: (not included w/shield)
-46	211-0596-00			3						SCREW, 6-32 x 3/8 inch, PHB
	210-0457-00			3						NUT, keps, 6-32 x 5/16 inch
	210-0863-00			1						WASHER, D shaped, 0.191 ID x 33/64 w x 33/64 inch lg (not shown)
-47	343-0002-00			1						CLAMP, cable, plastic, 3/16 inch
-48	136-0022-00			1						SOCKET, tube, 9 pin
	- - - - -			-						mounting hardware: (not included w/socket)
	213-0044-00			2						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-49	337-0008-00			1						SHIELD, tube, 1 5/16 inches high
-50	136-0015-00			2						SOCKET, tube, 9 pin, w/ground lugs
	- - - - -			-						mounting hardware for each: (not included w/socket)
-51	337-0005-00			1						SHIELD, socket
	211-0033-00			2						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
-52	337-0009-00			1						SHIELD, tube, 2 3/32 inches high
-53	136-0015-00			10						SOCKET, tube, 9 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
-54	136-0008-00			1						SOCKET, tube, 7 pin, w/ground lugs
	- - - - -			-						mounting hardware: (not included w/socket)
	213-0044-00			2						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-55	136-0044-00			2						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
-56	348-0031-00			5						GROMMET, plastic, 3/32 inch diameter
-57	348-0055-00			5						GROMMET, plastic, 1/4 inch diameter
-58	348-0056-00			3						GROMMET, plastic, 0.406 inch OD
-59	348-0050-00			3						GROMMET, plastic, 3/4 inch diameter
-60	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-61	354-0068-00			1						RING, securing
-62	- - - - -			4						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch

Mechanical Parts List—Type 549

FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE, STORAGE BOARD AND A SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	Y	1	2	3		4
2-63	407-0183-00			1						BRACKET, resistor
-64	212-0004-00			-						mounting hardware: (not included w/bracket)
				4						SCREW, 8-32 x 5/16 inch, PHS
-65	- - - - -			5						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
	210-0840-00			1						WASHER, flat, 0.390 ID x 5/16 inch OD
	210-0413-00			1						NUT, hex., 3/8-32 x 1/2 inch
-66	131-0359-00			2						CONNECTOR, terminal feed thru
	- - - - -			-						mounting hardware for each: (not included w/connector)
	358-0136-00			1						BUSHING, plastic

FIG. 3 LOW VOLTAGE POWER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † y	1 2 3 4 5					Description
					1	2	3	4	5	
3-1	441-0647-00			1						CHASSIS, power
	- - - - -			-						mounting hardware: (not included w/chassis)
	212-0040-00			4						SCREW, 8-32 x 3/8 inch, 100° csk, FHS
	212-0004-00			6						SCREW, 8-32 x 5/16 inch, PHS
	210-0804-00			6						WASHER, flat, 0.170 ID x 3/8 inch OD
	210-0458-00			10						NUT, keps, 8-32 x 11/32 inch
-2	337-0290-00			1						SHIELD, calibrator switch
	- - - - -			-						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
-3	406-0023-00			1						BRACKET, resistor
	- - - - -			-						mounting hardware: (not included w/bracket)
	211-0507-00			2						SCREW, 6-32 x 5/16 inch, PHS
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-4	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	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
-5	348-0056-00			4						GROMMET, plastic, 0.406 inch OD
-6	348-0063-00			1						GROMMET, plastic, 1/2 inch diameter
-7	348-0055-00			1						GROMMET, plastic, 1/4 inch diameter
-8	348-0031-00			1						GROMMET, plastic, 1/4 inch diameter
-9	337-0291-00			1						SHIELD, upper calibrator switch
	- - - - -			-						mounting hardware: (not included w/shield)
	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
-10	210-0201-00			3						LUG, solder, SE #4
	- - - - -			-						mounting hardware for each: (not included w/lug)
	213-0044-00			1						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-11	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
-12	211-0543-00			2						SCREW, 6-32 x 5/16 inch, RHS
-13	386-0254-00			1						PLATE, fiber, capacitor mounting
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-14	- - - - -			3						CAPACITOR
	- - - - -			-						mounting hardware for each: (not included w/capacitor)
-15	211-0534-00			2						SCREW, sems, 6-32 x 5/16 inch, PHS
-16	386-0255-00			1						PLATE, metal, capacitor mounting
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch

FIG 3 LOW VOLTAGE POWER (Cont)

Fig. & Index	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q †	Description					
					Y	1	2	3	4	5
3-17	- - - - -	- - - - -	- - - - -	2						CAPACITOR
				-						mounting hardware for each: (not included w/capacitor)
-18	211-0588-00			2						SCREW, 6-32 x 3/4 inch, HHS
-19	432-0048-00			1						BASE, capacitor mounting, plastic, 1 3/8 inches high
-20	386-0254-00			1						PLATE, fiber, capacitor mounting
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-21	- - - - -	- - - - -	- - - - -	1						CAPACITOR
				-						mounting hardware: (not included w/capacitor)
-22	211-0543-00			2						SCREW, 6-32 x 5/16 inch, RHS
-23	386-0252-00			1						PLATE, fiber, capacitor mounting
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-24	200-0293-00			1						COVER, capacitor, plastic, 2 7/16 x 1.365 inches ID
-25	200-0260-00			2						COVER, capacitor, plastic, 2 1/32 x 1.365 inches ID
-26	200-0256-00			1						COVER, capacitor, plastic, 2 1/32 x 1 inch ID
-27	- - - - -	- - - - -	- - - - -	1						RESISTOR, variable
				-						mounting hardware: (not included w/resistor)
-28	210-0840-00			1						WASHER, flat, 0.390 ID x 7/16 inch OD
-29	210-0444-00			1						NUT, hex., aluminum, 1/2 x 7/8 in. long 3/8-32 int. thread
	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-30	406-0108-00			1						BRACKET, alum. resistor
				-						mounting hardware: (not included w/bracket)
-31	211-0507-00			2						SCREW, 6-32 x 5/16 inch, PHS
	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
-32	136-0011-00			2						SOCKET, tube, 8 pin, w/ground lugs
				-						mounting hardware for each: (not included w/socket)
-33	210-0006-00			2						LOCKWASHER, internal, #6
-34	210-0407-00			2						NUT, hex., 6-32 x 1/4 inch
-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	136-0008-00			7						SOCKET, tube, 7 pin, w/ground lug
				-						mounting hardware for each: (not included w/socket)
-38	213-0044-00			2						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-39	- - - - -	- - - - -	- - - - -	1						TRANSFORMER
				-						mounting hardware: (not included w/transformer)
	210-0010-00			4						LOCKWASHER, internal, #10
	210-0458-00			2						NUT, keps, 8-32 x 1 1/32 inch
	210-0564-00			4						NUT, hex., 10-32 x 3/8 x 1/8 inch thick

FIG 3 LOW VOLTAGE POWER (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description
			t	y	1	2	3	
3-40	210-0812-00		4					WASHER, fiber, #10
	212-0033-00		4					SCREW, 8-32 x 3/4 inch, PHS
	212-0509-00		2					SCREW, 10-32 x 5/8 inch, PHS
-41	212-0524-00		4					SCREW, 10-32 x 3 1/4 inches, HHS
-42	212-0534-00		2					SCREW, 10-32 x 1 inch, PHS
-43	381-0221-00		2					BAR, transformer support
-44	384-0612-00		2					ROD, hex., transformer standoff
-45	406-0928-00		1					BRACKET, transformer
-46	210-0202-00		1					LUG, solder, SE #6
	- - - - -		-					mounting hardware: (not included w/lug)
	211-0534-00		2					SCREW, sems, 6-32 x 5/16 inch, PHS
	210-0457-00		2					NUT, keps, 6-32 x 5/16 inch
-47	252-0564-00		FT					PLASTIC, extruded channel (specify 2 inches)
-48	385-0138-00		1					ROD, plastic, 5/16 diameter x 1 9/16 inches long
	- - - - -		-					mounting hardware: (not included w/rod)
-49	213-0104-00		1					SCREW, thread forming, 6-32 x 3/8 inch, THS
-50	337-0648-00		2					SHIELD, heat dissipating

FIG. 4 RECTIFIER MOUNTING PLATE

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t Y	Description
		Eff	Disc		
4-1	386-0235-00 ----- 212-0004-00 212-0040-00 210-0458-00			1 - 6 4 4	PLATE, rectifier mounting - mounting hardware: (not included w/plate) SCREW, 8-32 x 5/16 inch, PHS SCREW, 8-32 x 3/8 inch, 100° csk, FHS NUT, keps, 8-32 x 1 1/32 inch
-2	343-0006-00 -----			2	CLAMP, cable, plastic, 1/2 inch - mounting hardware for each: (not included w/clamp)
-3	210-0863-00			1	WASHER, D shape, 0.191 ID x 33/64 w x 33/64 inch lg
-4	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-5	260-0336-00 -----			1	SWITCH, unwired—THERMAL CUTOUT - mounting hardware: (not included w/switch)
-6	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-7	385-0135-00 ----- 213-0104-00			1 - 1	ROD, plastic, 5/16 diameter x 5/16 inch long - mounting hardware: (not included w/rod) SCREW, thread forming, 6-32 x 3/8 inch, THS
-8	166-0099-00 ----- 211-0507-00			3 - 3	TUBE, spacing, 1/4 x 1 23/32 inches - mounting hardware for each: (not included w/tube) SCREW, 6-32 x 5/16 inch, PHS
-9	337-0656-00 -----			1	SHIELD, plastic, high voltage - mounting hardware: (not included w/shield)
-10	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS
-11	----- ----- 211-0504-00			1 - 2	RELAY - mounting hardware: (not included w/relay) SCREW, 6-32 x 1/4 inch, PHS
-12	202-0102-00 -----			1	COVER, relay - mounting hardware: (not included w/cover)
-13	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
-14	385-0138-00 -----			1	ROD, plastic, 5/16 diameter x 1 9/16 inches long - mounting hardware: (not included w/rod)
-15	213-0104-00			1	SCREW, thread forming, 6-32 x 3/8 inch, THS
-16	136-0015-00 ----- 213-0044-00			1 - 2	SOCKET, tube, 9 pin, w/ground lugs - mounting hardware: (not included w/socket) SCREW, thread forming, 5-32 x 3/16 inch, PHS

FIG. 4 RECTIFIER MOUNTING PLATE (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				†	y	1	2	3		4
4-17	348-0051-00			1						GROMMET, rubber, $\frac{3}{4}$ ID x $1\frac{1}{8}$ inches OD
-18	348-0063-00			1						GROMMET, plastic, 0.485 ID x $\frac{1}{2}$ inch OD
-19	348-0064-00			1						GROMMET, plastic, 0.614 ID x $\frac{5}{8}$ inch OD
-20	348-0055-00			4						GROMMET, plastic, 0.280 ID x $\frac{1}{4}$ inch OD
-21	348-0031-00			2						GROMMET, plastic, 0.202 ID x $\frac{1}{4}$ inch OD
-22	387-0753-00			1						PLATE, plug-in housing, back
	- - - - -			-						mounting hardware: (not included w/plate)
	212-0004-00			3						SCREW, 8-32 x $\frac{5}{16}$ inch, PHS
	210-0804-00			3						WASHER, flat, 0.170 ID x $\frac{3}{8}$ inch OD
-23	131-0018-00			1						CONNECTOR, 16 contact, female
	- - - - -			-						mounting hardware: (not included w/connector)
-24	166-0107-00			2						SPACER, tube, $\frac{1}{4}$ OD x 0.218 inch long
-25	210-0004-00			2						LOCKWASHER, internal, #4
-26	210-0406-00			2						NUT, hex., 4-40 x $\frac{3}{16}$ inch
-27	211-0016-00			2						SCREW, 4-40 x $\frac{5}{8}$ inch, RHS
-28	387-0754-00			1						PLATE, plug-in housing, top
	- - - - -			-						mounting hardware: (not included w/plate)
-29	212-0004-00			5						SCREW, 8-32 x $\frac{5}{16}$ inch, PHS
-30	210-0804-00			3						WASHER, flat, 0.170 ID x $\frac{3}{8}$ inch OD
-31	210-0458-00			4						NUT, keps, 8-32 x $1\frac{1}{32}$ inch
	212-0040-00			2						SCREW, 8-32 x $\frac{3}{8}$ inch, 100° csk, FHS
-32	344-0097-00			2						CLIP, grounding, bronze
-33	387-0755-00			1						PLATE, plug-in housing, bottom
	- - - - -			-						mounting hardware: (not included w/plate)
	212-0004-00			1						SCREW, 8-32 x $\frac{5}{16}$ inch, PHS
	212-0040-00			2						SCREW, 8-32 x $\frac{3}{8}$ inch, 100° csk, FHS
-34	212-0010-00			1						SCREW, 8-32 x $\frac{5}{8}$ inch, PHS
	210-0205-00			1						LUG, solder, SE #8
-35	343-0002-00			1						CLAMP, cable, $\frac{3}{16}$ inch, plastic
-36	210-0863-00			1						WASHER, D shape, 0.191 ID x $\frac{33}{64}$ w x $\frac{33}{64}$ inch lg
	210-0458-00			5						NUT, keps, 8-32 x $1\frac{1}{32}$ inch
-37	351-0058-00			4						GUIDE, shoe, plastic

FIG. 5 LOWER VERTICAL AMPLIFIER AND B SWEEP

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description	Q				
						1	2	3	4	5
5-1	441-0674-00	100	619	1	CHASSIS, lower vertical amplifier					
	441-0674-01	620		1	CHASSIS, lower vertical amplifier					
	- - - - -			-	mounting hardware: (not included w/chassis)					
-2	212-0004-00			3	SCREW, 8-32 x 5/16 inch, PHS					
	210-0804-00			3	WASHER, flat, 0.170 ID x 3/8 inch OD					
-3	- - - - -			1	CAPACITOR					
	- - - - -			-	mounting hardware: (not included w/capacitor)					
	211-0588-00			2	SCREW, 6-32 x 3/4 inch, HHS					
-4	432-0048-00			1	BASE, capacitor mounting, plastic					
-5	386-0255-00			1	PLATE, metal, large capacitor mounting					
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch					
-6	- - - - -			1	CAPACITOR					
	- - - - -			-	mounting hardware: (not included w/capacitor)					
-7	211-0534-00			2	SCREW, sems, 6-32 x 5/16 inch, PHS					
-8	386-0252-00			1	PLATE, fiber, small capacitor mounting					
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch					
-9	200-0257-00			1	COVER, capacitor, plastic					
-10	260-0778-00			1	SWITCH, toggle					
	- - - - -			-	mounting hardware: (not included w/switch)					
-11	210-0414-00			1	NUT, hex., 15/32-32 x 9/16 inch					
-12	210-0473-00	100	959	1	NUT, switch, 15/32-32 x 0.634 inch, 12 sided					
	210-0414-00	960		1	NUT, hex., 15/32-32 x 9/16 inch					
-13	210-0902-00			1	WASHER, flat, 0.470 ID x 2 1/32 OD					
	354-0055-00			1	RING, locking, switch, 15/32 ID x 23/32 inch OD					
-14	136-0181-00			6	SOCKET, transistor, 3 pin					
	- - - - -			-	mounting hardware for each: (not included w/socket)					
-15	354-0234-00			1	RING, socket mounting					
-16	136-0181-00	100	189	1	SOCKET, transistor, 3 pin					
	136-0218-00	190	619	1	SOCKET, transistor, 3 pin, w/solder pins					
	136-0181-00	620		1	SOCKET, transistor, 3 pin					
	- - - - -			-	mounting hardware: (not included w/socket)					
-17	354-0234-00	100	189	1	RING, socket mounting					
	354-0285-00	190	619	1	RING, socket mounting					
	354-0234-00	620		1	RING, socket mounting					
-18	136-0015-00			2	SOCKET, tube, 9 pin, w/ground lugs					
	- - - - -			-	mounting hardware for each: (not included w/socket)					
-19	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS					
-20	- - - - -			2	RESISTOR, variable					
	- - - - -			-	mounting hardware for each: (not included w/resistor)					
-21	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD					
-22	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch					

FIG. 5 LOWER VERTICAL AMPLIFIER AND B SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description					
						1	2	3	4	5
5-23	131-0181-00			2	CONNECTOR, terminal standoff					
	- - - - -			-	mounting hardware for each: (not included w/connector)					
-24	358-0136-00			1	BUSHING, plastic					
-25	119-0034-00	100	819	1	ASSEMBLY, delay line					
	119-0034-02	820		1	ASSEMBLY, delay line					
	- - - - -			-	assembly includes:					
	131-0271-00			2	CONNECTOR, right angle					
	200-0482-00			1	COVER, plastic					
	380-0049-00			1	HOUSING, plastic					
-26	211-0591-00			4	SCREW, 6-32 x 0.875 inch, HHS					
	210-0006-00			4	LOCKWASHER, internal, #6					
	210-0407-00			4	NUT, hex., 6-32 x 1/4 inch					
	- - - - -			-	mounting hardware: (not included w/assembly)					
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch					
-27	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS					
-28	210-0202-00			1	LUG, solder, SE #6					
-29	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					
-30	210-0204-00			1	LUG, solder, DE #6					
	- - - - -			-	mounting hardware: (not included w/lug)					
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS					
-31	348-0050-00			1	GROMMET, plastic, 3/4 inch diameter					
-32	348-0056-00			1	GROMMET, plastic, 3/8 inch diameter					
-33	- - - - -			1	RESISTOR					
	- - - - -			-	mounting hardware: (not included w/resistor)					
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS					
	210-0601-00			1	EYELET, resistor mounting					
	210-0478-00			1	NUT, hex., 5/16 x 2 1/32 inch long					
	210-0203-00			1	LUG, solder, SE #6, long					
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS					
-34	441-0643-00			1	CHASSIS, B Sweep					
	- - - - -			-	chassis includes:					
-35	214-0329-00			2	FASTENER, screw, retractable					
-36	131-0269-00			2	CONNECTOR, pincher, hex., 3/16 inch					
	- - - - -			-	mounting hardware: (not included w/connector)					
	358-0214-00			1	BUSHING, insulated					
	- - - - -			-	mounting hardware: (not included w/chassis)					
-37	212-0004-00			3	SCREW, 8-32 x 5/16 inch, PHS					

FIG. 5 LOWER VERTICAL AMPLIFIER AND B SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	Y	1	2	3		4
5-38	384-0640-00			1						ROD, hinge, chassis
	- - - - -			-						mounting hardware: (not included w/rod)
-39	358-0237-00			1						BUSHING, hinge, rod, plastic
	210-0804-00			1						WASHER, flat, 0.170 ID x 3/8 inch OD
	212-0008-00			1						SCREW, 8-32 x 1/2 inch, PHS
-40	361-0052-00			1						SPACER, hinge pin
-41	381-0215-00			1						BAR, stop, plastic
	- - - - -			-						mounting hardware: (not included w/bar)
-42	212-0004-00			1						SCREW, 8-32 x 5/16 inch, PHS
-43	384-0641-00			1						ROD, anchor
	- - - - -			-						rod includes:
-44	134-0033-00			2						PLUG, banana, male, plastic
-45	214-0370-00			1						PIN, locating, 7/8 inch long
-46	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-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	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-50	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
-51	210-0840-00			1						WASHER, flat, 0.390 ID x 9/16 inch OD
-52	210-0413-00			1						NUT, hex., 3/8-32 x 1/2 inch
-53	- - - - -			3						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-54	210-0940-00			1						WASHER, flat, 1/4 ID x 5/16 inch OD
-55	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-56	136-0181-00			2						SOCKET, transistor, 3 pin
	- - - - -			-						mounting hardware for each: (not included w/socket)
-57	354-0234-00			1						RING, socket mounting
-58	348-0064-00	100	199	2						GROMMET, plastic, 5/8 inch diameter
	348-0012-00	200		2						GROMMET, rubber, 5/8 inch diameter
-59	348-0031-00			1						GROMMET, plastic, 5/32 inch diameter
-60	348-0056-00			2						GROMMET, plastic, 0.406 inch OD
-61	136-0015-00			8						SOCKET
	- - - - -			-						mounting hardware for each: (not included w/socket)
-62	213-0044-00			2						SCREW, thread forming, 5-32 x 3/16 inch, PHS

FIG. 5 LOWER VERTICAL AMPLIFIER AND B SWEEP (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
5-63	136-0008-00			5	SOCKET
	- - - - -			-	mounting hardware for each: (not included w/socket)
-64	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-65	136-0010-00			1	SOCKET, tube, 7 pin, shielded
	- - - - -			-	mounting hardware: (not included w/socket)
	211-0033-00			2	SCREW, sems, 4-40 x 5/16 inch, PHS
	210-0201-00			1	LUG, solder, SE #4
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-66	337-0006-00			1	SHIELD, tube, 7/8 ID x 1 3/8 inches high
-67	136-0044-00			1	SOCKET, tube, 7 pin, w/ground lugs
	- - - - -			-	mounting hardware: (not included w/socket)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-68	136-0181-00	X620		1	SOCKET, transistor, 3 pin
	- - - - -			-	mounting hardware: (not included w/socket)
	354-0234-00			1	RING, socket mounting

FIG. 6 CATHODE RAY TUBE SHIELD, MOUNTING BRACKETS AND UPPER VERTICAL AMPLIFIER

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y	Description				
					1	2	3	4	5
6-1	337-0738-00 ----- 211-0504-00			1	SHIELD, cathode ray tube				
				-	mounting hardware for each: (not included w/shield)				
				4	SCREW, 6-32 x 1/4 inch, PHS (not shown)				
-2	131-0431-00 -----			1	ASSEMBLY, inner band connector				
				-	assembly includes:				
	131-0260-00			1	CONNECTOR, inner band				
-3	131-0371-00			6	CONNECTOR, square pin				
-4	175-0527-00 -----			FT	WIRE, insulated, #22 stranded (specify length)				
				-	mounting hardware for each: (not included w/assembly)				
-5	211-0008-00 210-0801-00 210-0586-00			3	SCREW, 4-40 x 1/4 inch, PHS				
				3	WASHER, flat, 1/8 ID x 3/8 inch OD				
				3	NUT, keps, 4-40 x 1/4 inch				
-6	----- -----			1	COIL				
				-	mounting hardware: (not included w/coil)				
-7	211-0596-00			3	SCREW, 6-32 x 3/8 inch, PHS				
-8	210-0811-00 210-0803-00			2	WASHER, fiber, shouldered				
				1	WASHER, flat, 5/32 ID x 3/8 inch OD				
-9	210-0802-00 210-0457-00			3	WASHER, flat, 3/32 ID x 5/16 inch OD				
				3	NUT, keps, 6-32 x 5/16 inch				
-10	348-0004-00			1	GROMMET, rubber, 3/8 inch				
-11	136-0035-00 ----- 211-0534-00 210-0803-00			2	SOCKET, graticule lamp				
				-	mounting hardware for each: (not included w/socket)				
				1	SCREW, sems, 6-32 x 5/16 inch, PHS				
				1	WASHER, flat, 5/32 ID x 3/8 inch OD				
-12	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch				
-13	407-0181-00 ----- 210-0804-00 212-0004-00 210-0458-00			1	BRACKET, CRT shield support				
				-	mounting hardware: (not included w/bracket)				
				2	WASHER, flat, 3/16 ID x 3/8 inch OD				
				3	SCREW, 8-32 x 5/16 inch, PHS				
				1	NUT, keps, 8-32 x 1 1/32 inch				
-14	407-0182-00 ----- 210-0804-00 210-0004-00 210-0458-00			1	BRACKET, CRT shield support				
				-	mounting hardware: (not included w/bracket)				
				2	WASHER, flat, 3/16 ID x 3/8 inch OD				
				1	SCREW, 8-32 x 5/16 inch, PHS				
				1	NUT, keps, 8-32 x 1 1/32 inch				

FIG. 6 CATHODE RAY TUBE SHIELD, MOUNTING BRACKETS AND UPPER VERTICAL AMPLIFIER (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
6-15	252-0564-00			FT	PLASTIC, extruded channel (specify amount)
-16	407-0187-00			1	BRACKET, upper vertical amplifier support
	- - - - -			-	mounting hardware: (not included w/bracket)
	210-0458-00			2	NUT, keps, 8-32 x 1 ¹ / ₃₂ inch
	210-0804-00			2	WASHER, flat, ³ / ₁₆ ID x ³ / ₈ inch OD
-17	212-0004-00			4	SCREW, 8-32 x ⁵ / ₁₆ inch, PHS
-18	343-0125-00			1	CLAMP, CRT retaining
	- - - - -			-	mounting hardware: (not included w/clamp)
-19	211-0592-00			3	SCREW, 6-32 x 1 inch, SHS
-20	210-0993-00			2	WASHER, flat, ⁵ / ₃₂ ID x ³ / ₄ inch OD
	220-0419-00			1	NUT, square, 6-32 x ⁵ / ₁₆ inch
-21	441-0646-00			1	CHASSIS, upper vertical amplifier
	- - - - -			-	mounting hardware: (not included w/chassis)
	212-0004-00			1	SCREW, 8-32 x ⁵ / ₁₆ inch, PHS
	210-0457-00			1	NUT, keps, 8-32 x 1 ¹ / ₃₂ inch
-22	- - - - -			1	RESISTOR
	- - - - -			-	mounting hardware: (not included w/resistor)
-23	211-0553-00			1	SCREW, 6-32 x 1 ¹ / ₂ inches, RHS
-24	210-0601-00			1	EYELET, tapered barrel
-25	210-0478-00			1	NUT, hex., ⁵ / ₁₆ x ² / ₃₂ inch long
-26	211-0507-00			1	SCREW, 6-32 x ⁵ / ₁₆ inch, PHS
-27	136-0181-00			2	SOCKET, transistor, 3 pin
	- - - - -			-	mounting hardware for each: (not included w/socket)
-28	354-0234-00			1	RING, socket mounting
-29	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0504-00			2	NUT, hex., 0-80 x ⁵ / ₃₂ inch
-30	406-0635-00			1	BRACKET, nylon
	- - - - -			-	mounting hardware: (not included w/bracket)
-31	213-0088-00			2	SCREW, thread forming, 4-40 x ¹ / ₄ inch, PHS
-32	348-0056-00			1	GROMMET, plastic, 0.406 inch diameter
-33	348-0055-00			2	GROMMET, plastic, ¹ / ₄ inch diameter
-34	426-0121-00			1	HOLDER, toroid
	- - - - -			-	mounting hardware: (not included w/holder)
-35	361-0007-00			1	SPACER, plastic, 0.188 inch long
-36	210-0201-00			1	LUG, solder, SE #4
	- - - - -			-	mounting hardware: (not included w/lug)
-37	213-0044-00			1	SCREW, thread forming, 5-32 x ³ / ₁₆ inch, PHS

Mechanical Parts List—Type 549

FIG. 6 CATHODE RAY TUBE SHIELD, MOUNTING BRACKETS AND UPPER VERTICAL AMPLIFIER (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description	
			†	Y	1	2	3		4
6-38	- - - - -		2						COIL
	- - - - -		-						mounting hardware for each: (not included w/coil)
-39	213-0088-00		1						SCREW, thread forming, 4-40 x 1/4 inch, PHS
-40	441-0645-00		1						CHASSIS, tube mounting
	- - - - -		-						mounting hardware: (not included w/chassis)
	212-0004-00		3						SCREW, 8-32 x 5/16 inch, PHS
	210-0804-00		2						WASHER, flat, 3/16 ID x 3/8 inch OD
-41	136-0174-00		2						SOCKET, tube, 9 pin
	- - - - -		-						mounting hardware for each: (not included w/socket)
	213-0044-00		2						SCREW, thread forming, 5-32 x 3/16 inch, PHS
-42	210-0202-00		2						LUG, solder, SE #6
	- - - - -		-						mounting hardware for each: (not included w/lug)
-43	211-0504-00		1						SCREW, 6-32 x 1/4 inch, PHS
-44	210-0407-00		1						NUT, hex., 6-32 x 1/4 inch
-45	407-0186-00		1						BRACKET, coil mounting
	- - - - -		-						mounting hardware: (not included w/bracket)
-46	211-0507-00		2						SCREW, 6-32 x 5/16 inch, PHS
	210-0803-00		2						WASHER, flat, 0.150 ID x 3/8 inch OD
-47	214-0478-00		2						PIN, guide, plastic
	- - - - -		-						mounting hardware for each: (not included w/pin)
-48	361-0007-00		1						SPACER, plastic, 0.188 inch long
-49	348-0085-00		1						GROMMET, plastic

FIG. 7 RAILS, REAR, AND CABINET

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
7-1	122-0108-00			2	ANGLE, rail, bottom, 20.437 inches long
	- - - - -			-	mounting hardware for each: (not included w/angle)
-2	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
	210-0458-00			4	NUT, keps, 8-32 x 1 1/32 inch
-3	122-0019-00			1	ANGLE, frame, 20 7/16 inches
	- - - - -			-	mounting hardware: (not included w/angle)
-4	211-0538-00			4	SCREW, 6-32 x 5/16 inch, FHS
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
-5	381-0247-00			1	ASSEMBLY, top support bar
	- - - - -			-	assembly includes:
-6	367-0043-00			2	ASSEMBLY, handle
	- - - - -			-	each assembly includes:
-7	344-0098-00			4	CLIP, chrome
-8	212-0566-00	100	559	4	SCREW, 10-32 x 5/16 inch, RHS
	212-0507-00	560		4	SCREW, 10-32 x 3/8 inch, PHS
	210-0010-00	X560		4	LOCKWASHER, internal, #10
	- - - - -			-	mounting hardware: (not included w/assembly)
-9	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
-10	381-0073-00			2	BAR, 3/16 x 1/2 x 1 1/2 inches, 8-32 tapped holes
-11	369-0007-00			1	BLADE, fan, 7 inches
-12	147-0026-00			1	MOTOR, fan
	- - - - -			-	mounting hardware: (not included w/motor)
	210-0458-00			4	NUT, keps, 8-32 x 1 1/32 inch
-13	426-0193-00			1	MOUNT, fan motor
	- - - - -			-	mounting hardware: (not included w/mount)
-14	212-0039-00			4	SCREW, 8-32 x 3/8 inch, THS
-15	386-0233-00			1	PLATE, rear sub-panel
	- - - - -			-	plate includes:
	354-0056-00			1	RING, ornamental
-16	260-0773-00			1	SWITCH, toggle—LINE RANGE
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0414-00			1	NUT, hex., 1 5/32 x 7/16 inch
	210-0473-00			1	NUT, switch, 1 5/32-32 x 5/64 inch
	210-0902-00			1	WASHER, 0.470 ID x 2 1/32 inch OD
	354-0055-00			1	RING, switch locking
-17	200-0662-00			1	GUARD, switch
	- - - - -			-	mounting hardware: (not included w/guard)
-18	211-0016-00			2	SCREW, 4-40 x 5/8 inch, RHS

FIG. 7 RAILS, REAR, AND CABINET (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y	Description				
					1	2	3	4	5
7-19	407-0027-00			1	BRACKET, shunt resistor				
	- - - - -			-	mounting hardware: (not included w/bracket)				
	211-0537-00			2	SCREW, 6-32 x 3/8 inch, THS				
-20	- - - - -			1	RESISTOR				
	- - - - -			-	mounting hardware: (not included w/resistor)				
-21	210-0478-00			1	NUT, hex., 5/16 x 2 1/32 inch				
	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS				
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS				
-22	- - - - -			5	RESISTOR				
	- - - - -			-	mounting hardware for each: (not included w/resistor)				
-23	210-0462-00			1	NUT, hex., 8-32 x 1/2 x 23/64 inch				
-24	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches, FIL HS				
	212-0004-00			1	SCREW, 8-32 x 5/16 inch, PHS				
-25	348-0056-00			2	GROMMET, plastic, 0.406 inch diameter				
	210-0809-00			1	WASHER, centering				
-26	386-0232-00			1	PLATE, rear overlay				
	- - - - -			-	mounting hardware: (not included w/plate)				
-27	213-0104-00			4	SCREW, thread forming, 6-32 x 3/8 inch, THS				
-28	352-0002-00			2	ASSEMBLY, fuse holder				
	- - - - -			-	each assembly includes:				
-29	200-0582-00			1	CAP, fuse				
-30	210-0873-00			1	WASHER, rubber, 1/2 ID x 1 1/16 inch OD				
-31	352-0010-00			1	HOLDER, fuse				
	- - - - -			1	NUT, fuse holder				
-32	131-0150-00			1	CONNECTOR, 3 wire motor base				
	- - - - -			-	connector includes:				
	129-0041-00			1	POST, ground				
	200-0185-00			1	COVER				
	205-0014-00			1	SHELL, mounting				
	210-0003-00			2	LOCKWASHER, external, #4				
	210-0551-00			2	NUT, hex., 4-40 x 1/4 inch				
	211-0015-00			1	SCREW, 4-40 x 1/2 inch, RHS				
	214-0078-00			2	PIN, connecting				
	377-0041-00			1	INSERT				
	- - - - -			-	mounting hardware: (not included w/connector)				
-33	213-0104-00			2	SCREW, thread forming, 6-32 x 3/8 inch, THS				
-34	378-0762-00			1	SCREEN, filter				
	- - - - -			-	mounting hardware: (not included w/screen)				
	213-0104-00			4	SCREW, thread forming, 6-32 x 3/8 inch, THS				

FIG. 7 RAILS, REAR, AND CABINET (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				y	1	2	3	4		5
7-35	378-0023-00			1						FILTER, air, foam
-36	380-0018-00			1						HOUSING, aluminum, 10½ x 10½ x 1 inches
	- - - - -			-						mounting hardware: (not included w/housing)
-37	210-0402-00			2						NUT, cap., hex., 8-32 x 5/16 inch
-38	210-0458-00			2						NUT, keps, 8-32 x 1½ inch
-39	212-0031-00			2						SCREW, 8-32 x 1¼ inches, RHS
-40	210-0894-00			2						WASHER, flat, 0.190 ID x 7/16 inch OD
-41	136-0089-00			1						SOCKET, tube, 9 pin
	- - - - -			-						mounting hardware: (not included w/socket)
-42	211-0013-00			4						SCREW, 4-40 x 3/8 inch, RHS
	210-0586-00			4						NUT, keps, 4-40 x ¼ inch
-43	131-0106-00			2						CONNECTOR, coaxial, BNC, 1 contact
-44	260-0447-00			1						SWITCH, unwired—CRT CATHODE
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch
-45	260-0449-00			1						SWITCH, unwired—CRT GRID SELECTOR
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch
-46	386-1093-00			1						PLATE, cabinet bottom
	- - - - -			-						plate includes:
-47	214-0361-00			4						ASSEMBLY, cabinet latch
	- - - - -			-						each assembly includes:
-48	214-0400-00			1						PIN, securing, index
-49	358-0218-00			1						BUSHING, plastic, latch bearing
-50	387-0871-00			1						PLATE, latch index
-51	387-0804-00			1						PLATE, latch locking
-52	214-0359-00			1						SPRING, latch
-53	386-0238-01			1						PLATE, cabinet side, left
	- - - - -			-						plate includes:
-54	134-0028-00			1						PLUG, 2½ inches diameter
	214-0361-00			2						ASSEMBLY, cabinet latch
-55	386-0238-00			1						PLATE, cabinet side, right
	- - - - -			-						plate includes:
	214-0361-00			2						ASSEMBLY, cabinet latch
-56	200-0672-00			2						COVER, BNC connector, w/chain
	- - - - -			-						mounting hardware for each: (not included w/cover)
-57	213-0088-00			1						SCREW, thread forming, 4-40 x ¼ inch, PHS

FIG. 8 CERAMIC STRIPS AND CABLE HARNESS DETAIL

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
8-1	179-1033-00	100	619	1						CABLE HARNESS, B Sweep
	179-1033-01	620		1						
-2	124-0090-00			1						STRIP, ceramic, 3/4 inch h, w/9 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
-3	124-0091-00			12						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
-4	179-1032-00	100	619	1						CABLE HARNESS, A Sweep
	179-1032-01	620		1						
-5	124-0091-00			4						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
-6	124-0088-00			4						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
-7	124-0090-00			2						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
	124-0089-00			6						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
-9	179-1034-00			1						CABLE HARNESS, power, #1
-10	179-1035-00			1						CABLE HARNESS, power, #2
-11	179-1041-00			1						CABLE HARNESS, power, 110 volt

FIG. 8 CERAMIC STRIPS AND CABLE HARNESS DETAIL (Cont)




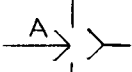



Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				†	Y	1	2	3		4
8-12	124-0088-00			3						STRIP, ceramic, $\frac{3}{4}$ inch h, w/4 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0009-00			2						SPACER, plastic, 0.406 inch long
-13	124-0091-00			10						STRIP, ceramic, $\frac{3}{4}$ 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
-14	124-0090-00			1						STRIP, ceramic, $\frac{3}{4}$ inch h, w/9 notches
	- - - - -			-						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
-15	179-1040-00	100	619	1						CABLE HARNESS, lower vertical amplifier
	179-1040-01	620		1						CABLE HARNESS, lower vertical amplifier
-16	124-0145-00			2						STRIP, ceramic, $\frac{7}{16}$ inch h, w/20 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
-17	124-0147-00			8						STRIP, ceramic, $\frac{7}{16}$ inch h, w/13 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
-18	179-1036-00			1						CABLE HARNESS, rectifier bracket
	179-1042-00			1						CABLE HARNESS, 110 volt (not shown)
-19	124-0090-00			6						STRIP, ceramic, $\frac{3}{4}$ 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
-20	124-0162-00			2						STRIP, ceramic, $\frac{7}{16}$ inch h, w/4 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0007-00			2						SPACER, plastic, 0.188 inch long

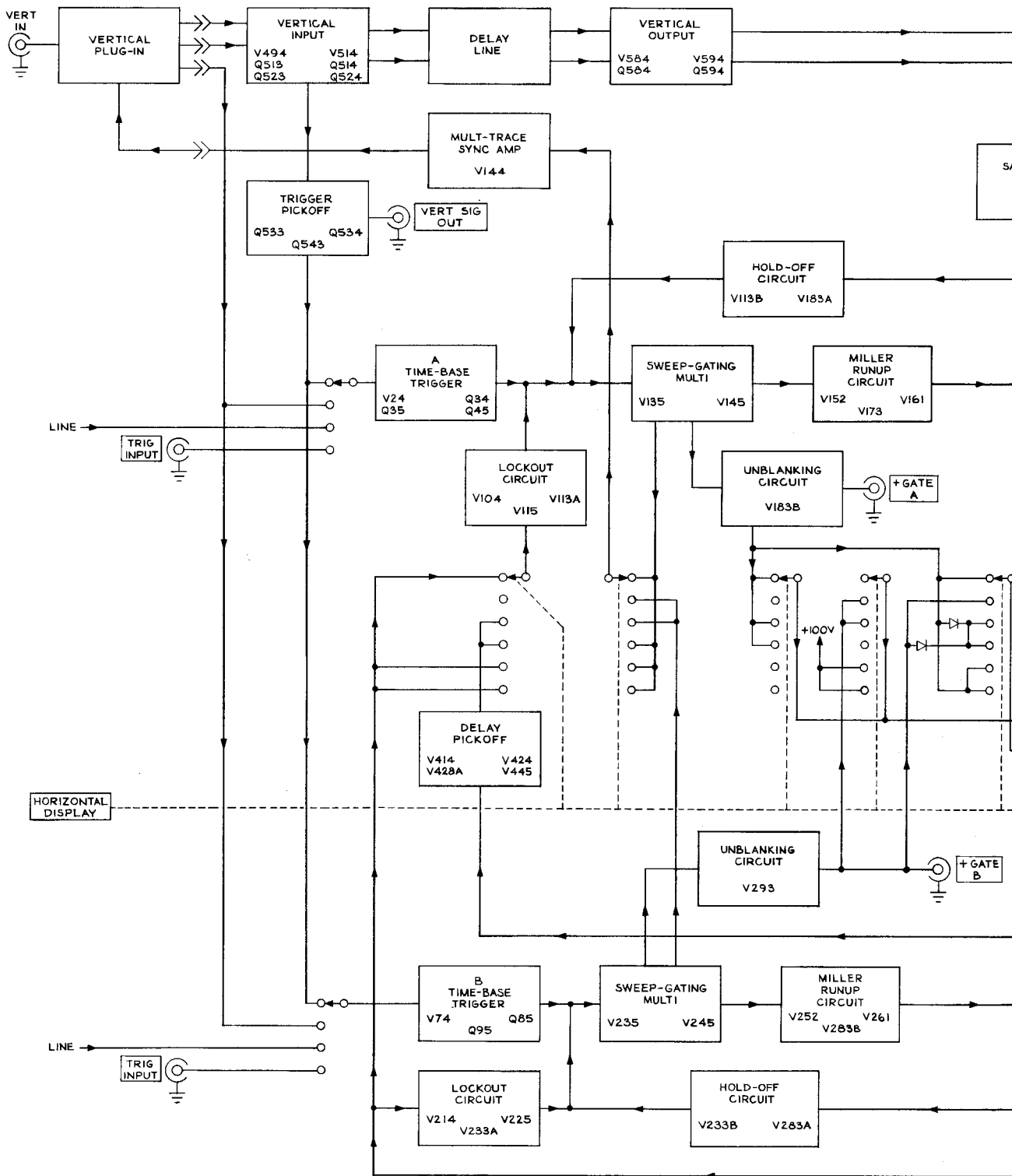
FIG. 8 CERAMIC STRIPS AND CABLE HARNESS DETAIL (Cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † Y	Description
		Eff	Disc		
8-21	179-1043-00			1	ASSEMBLY, cable harness & CRT socket
	- - - - -			-	assembly includes:
-22	136-0202-00			1	SOCKET, CRT
-23	200-0616-00			1	COVER, socket
	214-0464-00			14	PIN, CRT
-24	337-0778-01			1	SHIELD, CRT socket
-25	367-0059-00			1	HANDLE, CRT socket
	- - - - -			-	mounting hardware for each: (not included w/handle)
-26	211-0003-00			2	SCREW, 2-56 x 7/8 inch, RHS
	210-0850-00			2	WASHER, flat, 0.093 ID x 3/32 inch OD
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-27	179-1037-00			1	CABLE HARNESS, high voltage
-28	124-0157-00			6	STRIP, ceramic, 7/16 inch h, w/9 notches
	- - - - -			-	each strip includes:
	355-0082-00			2	STUD, plastic
	- - - - -			-	mounting hardware for each: (not included w/strip)
	361-0039-00			2	SPACER, plastic, 0.531 inch long
-29	124-0091-00			4	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
-30	179-1039-00			1	CABLE HARNESS, upper vertical amplifier
-31	124-0162-00			3	STRIP, ceramic, 7/16 inch h, w/4 notches
	- - - - -			-	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
-32	124-0148-00			2	STRIP, ceramic, 7/16 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
-33	124-0147-00			2	STRIP, ceramic, 7/16 inch h, w/13 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

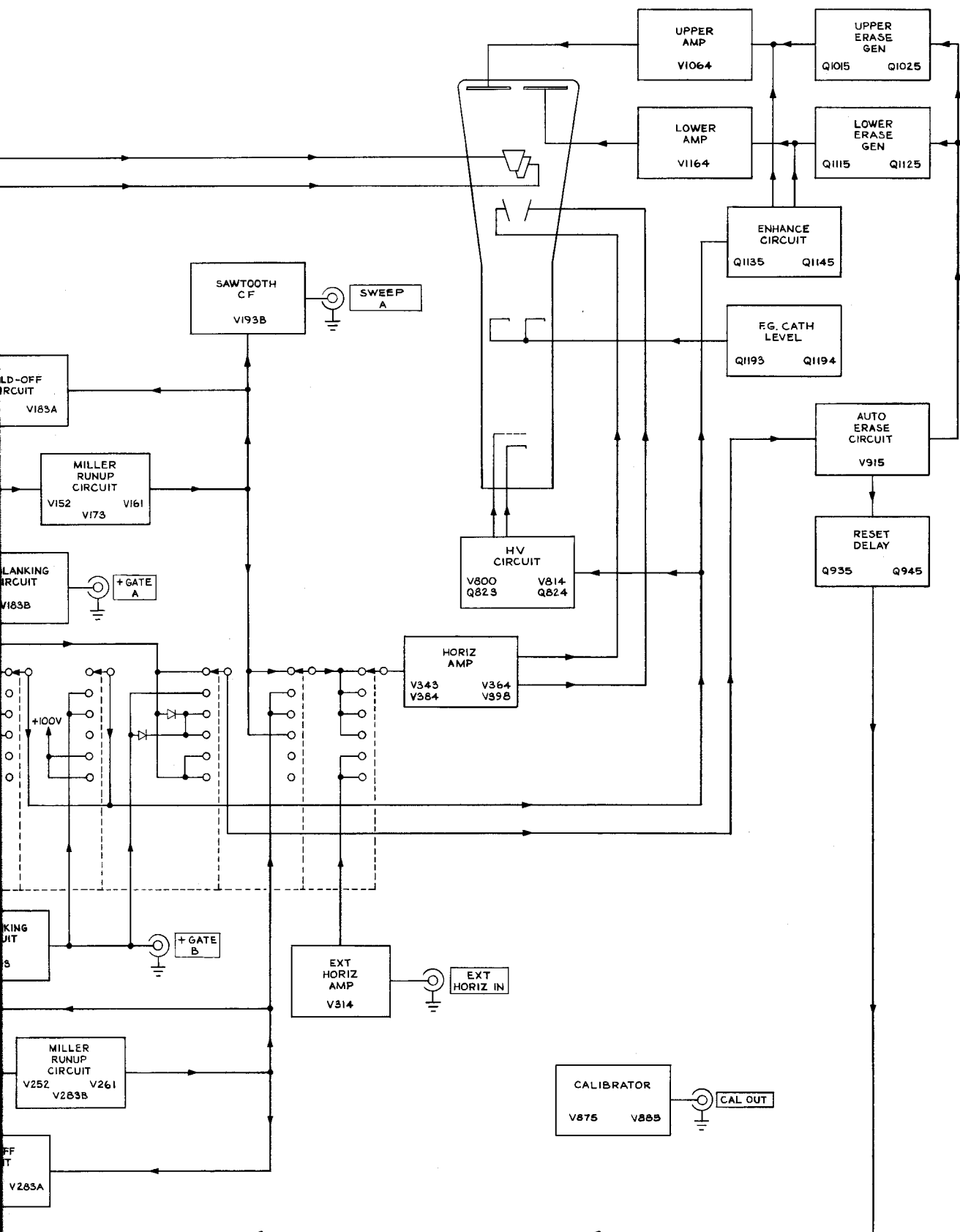
Schematic Symbols

The following symbols are used on the schematic diagrams:

	Screwdriver adjustment
	Front-panel control or connector.
	Clockwise control rotation in direction of arrow.
	Connection made at indicated pin on etched-wiring board.
	Connection soldered to etched-wiring board.
	Blue line encloses components located on etched-wiring board.
	Input from, or output to indicated schematic.



TYPE 549 STORAGE OSCILLOSCOPE



1165

BLOCK DIAGRAM

IMPORTANT

Voltages and waveforms shown in blue on the schematic diagrams were measured and photographed under the following conditions.

Voltages were measured with a 20,000 Ω /Volt VOM. Readings are with respect to chassis ground unless otherwise noted.

Waveforms are photographs taken with a Tektronix Oscilloscope Camera System and a projected graticule mounted on a 540-series Oscilloscope with a Type 1A1 Plug-In Unit and a 10X attenuator probe. An equivalent test oscilloscope having a vertical bandwidth of DC to 20 MHz and a sensitivity of .05 Volts/cm may be used.

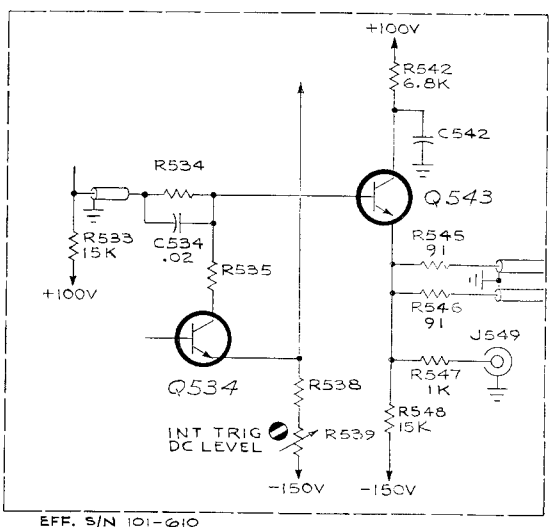
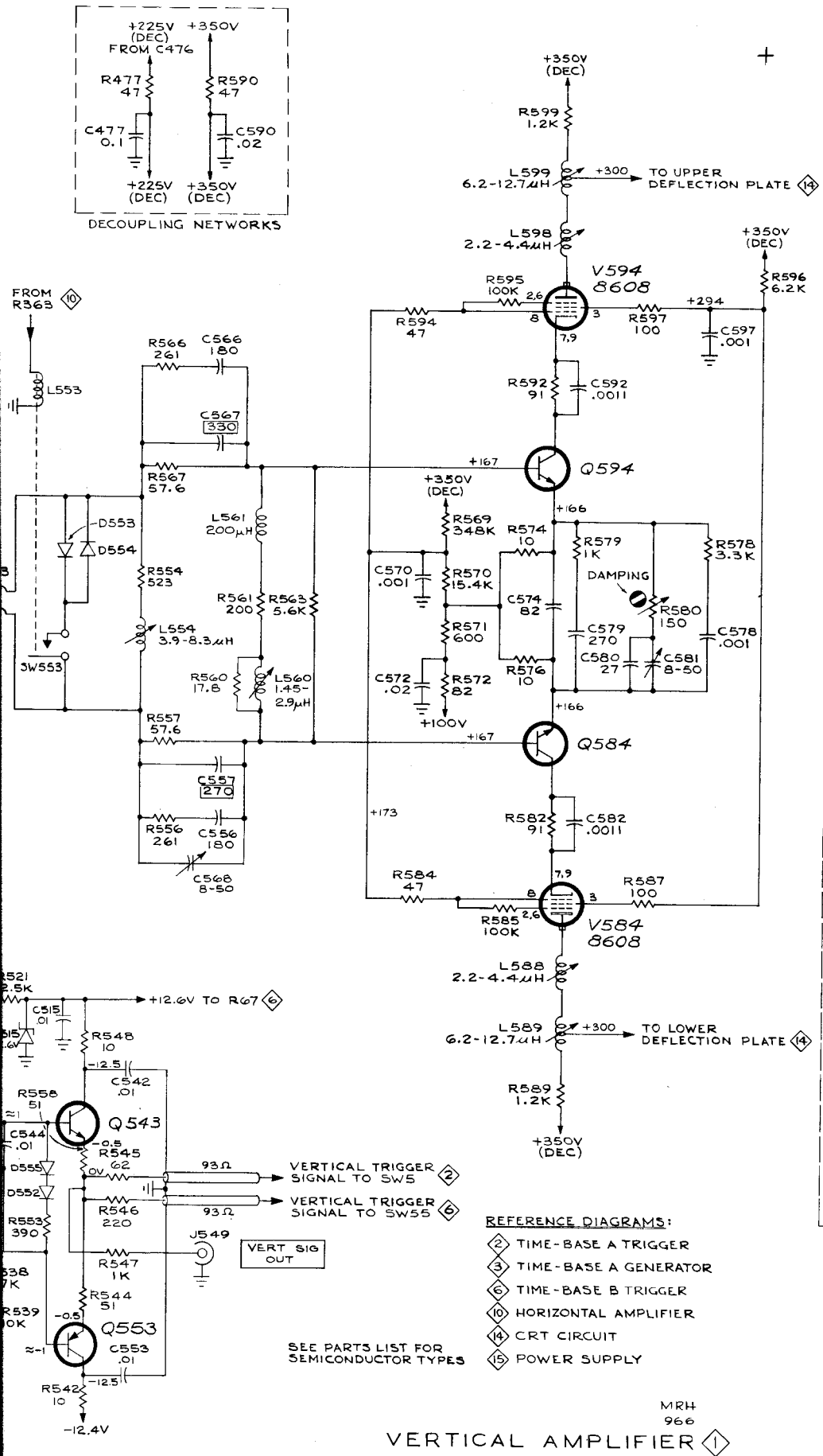
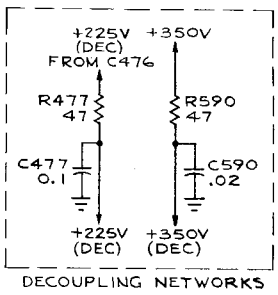
Waveform DC levels are indicated to the right, Volts/cm to the left and Time/cm settings below the waveform.

To indicate true time relationship between signals the test oscilloscope in most cases was externally triggered.

Voltage and waveform values are not absolute but may vary between instruments because of component tolerances. DC level differences between voltmeter readings and the waveform is due to circuit loading.

Before starting to check this instrument, the controls should be set as shown on $\diamond 2$ and not disturbed unless otherwise noted on the diagram. Return the controls to these positions before moving to the next diagram.

The plug-in unit used in the Type 549 Storage Oscilloscope was a Test Load/Pulser Plug-In Unit; however, any letter or 1-series unit may be used. Apply the signal from the CAL OUT connector to the Vertical Input connector of the plug-in unit and adjust the gain for a 1 cm display unless otherwise noted.



- REFERENCE DIAGRAMS:
- ② TIME-BASE A TRIGGER
 - ③ TIME-BASE A GENERATOR
 - ⑥ TIME-BASE B TRIGGER
 - ⑩ HORIZONTAL AMPLIFIER
 - ⑭ CRT CIRCUIT
 - ⑮ POWER SUPPLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

MRH
966

VERTICAL AMPLIFIER ⑭

Type 549 Control Settings:

CRT Controls

INTENSITY	Midrange
FOCUS and ASTIG	Adjust for focused display
SCALE ILLUM	As desired

Storage Controls

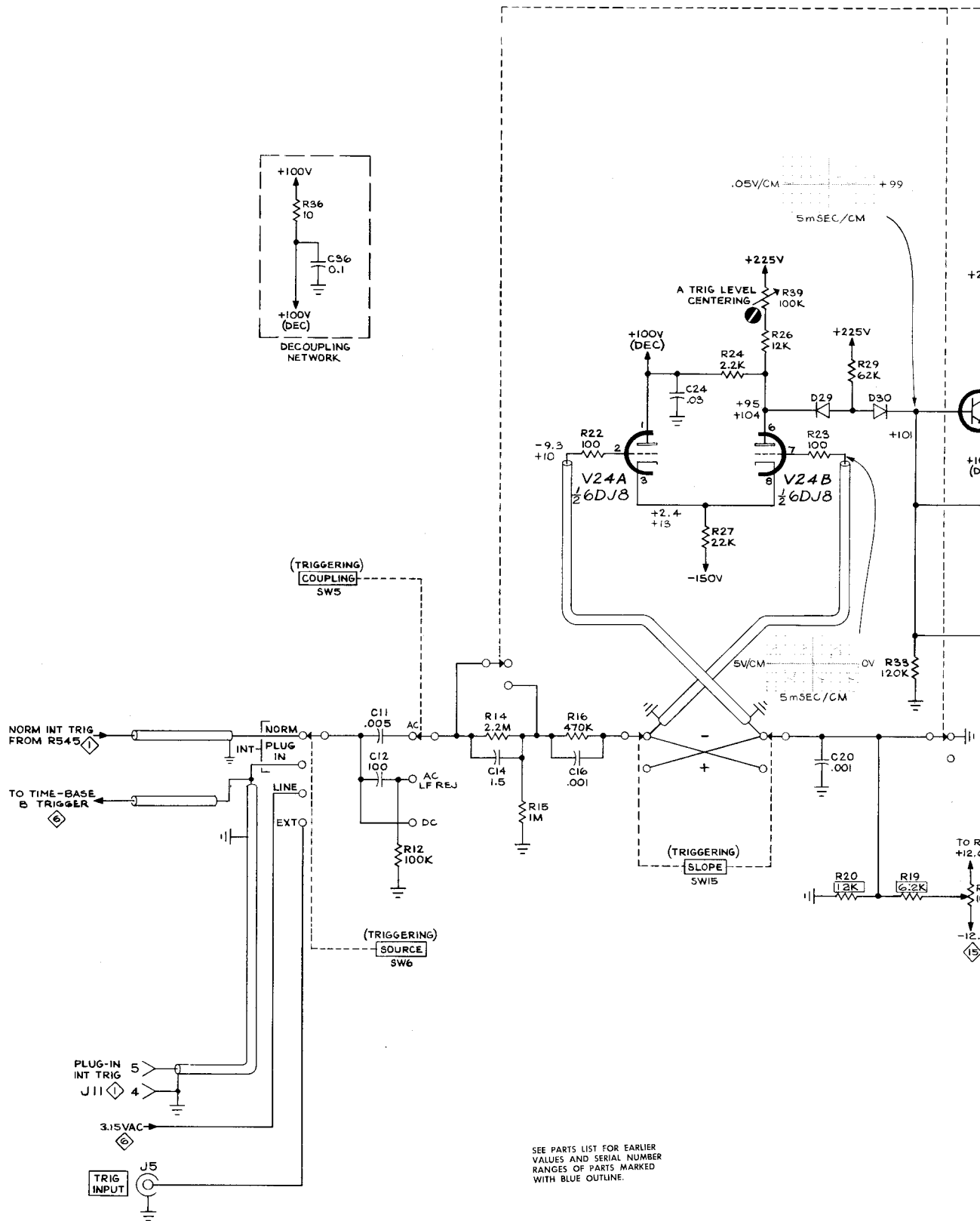
ENHANCE MODE	OFF
ENHANCE LEVEL	Counterclockwise
UPPER and LOWER SCREEN STORAGE	OFF
SCREEN SELECTOR	FULL
VIEWING TIME	MIN
AUTO ERASE	OFF
HORIZONTAL DISPLAY	A
MAGNIFIER	OFF
NORM-SINGLE SWEEP	NORM
A TIME/CM	1 mSEC
VARIABLE	CAL
B TIME/CM AND DELAY TIME	1 mSEC
LENGTH	10 CM
DELAY TIME MULTIPLIER 1-10	2.00

TRIGGERING Controls (Time Base A and B)

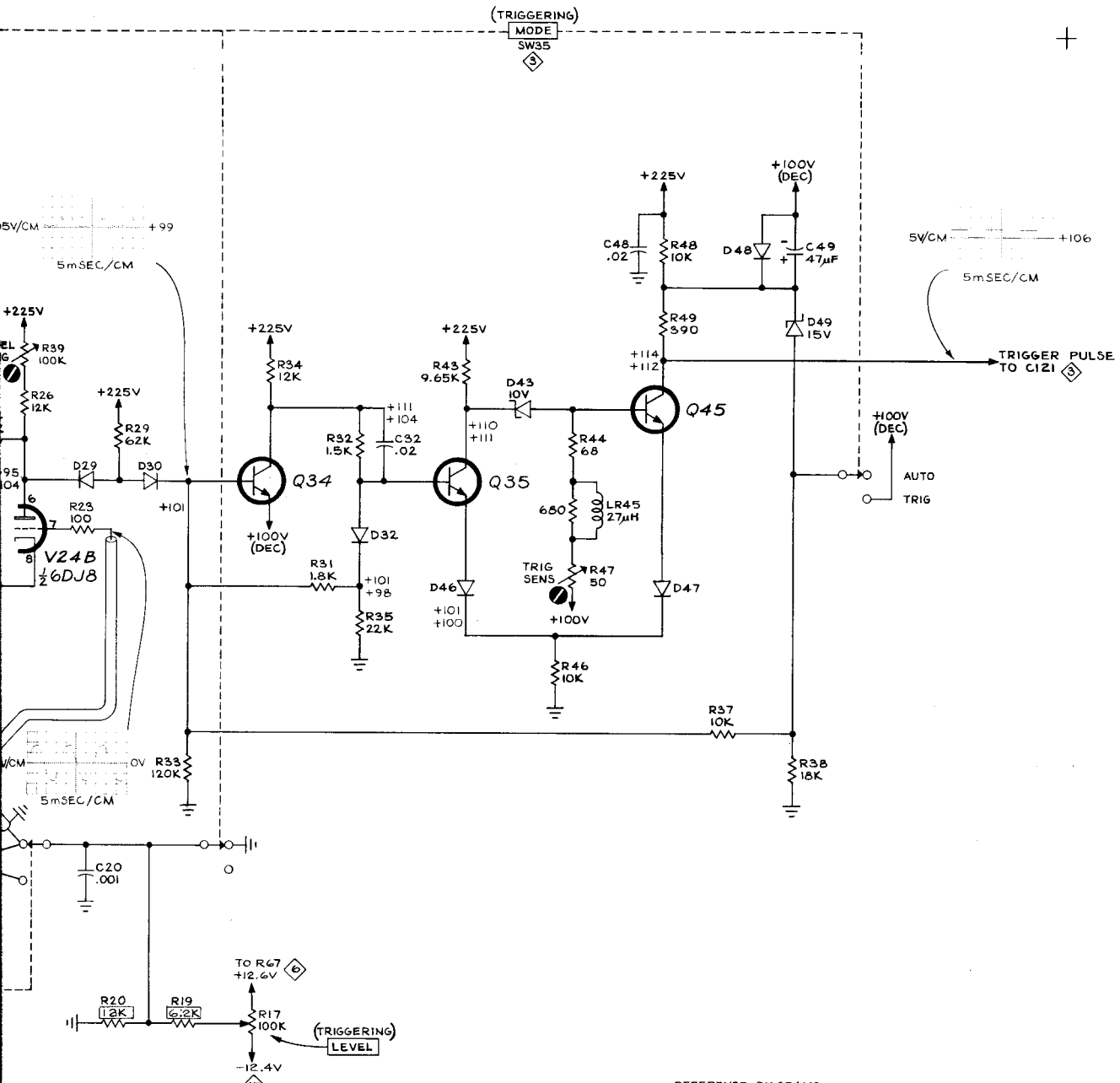
LEVEL	Midrange
STABILITY	PRESET
MODE	TRIG
SLOPE	—
COUPLING	AC
SOURCE	NORM (INT)
HORIZONTAL POSITION	Midrange
AMPLITUDE CALIBRATOR	1 VOLT

Rear Panel Switches

CRT CATHODE SELECTOR	Normal
CRT GRID SELECTOR	Normal
CRT CATHODE Connector	Cap installed
LINE RANGE SELECTOR	MED



TYPE 549 STORAGE OSCILLOSCOPE

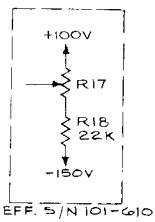


- REFERENCE DIAGRAMS**
- ① VERTICAL AMPLIFIER
 - ③ TIME-BASE A GENERATOR
 - ⑤ POWER SUPPLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

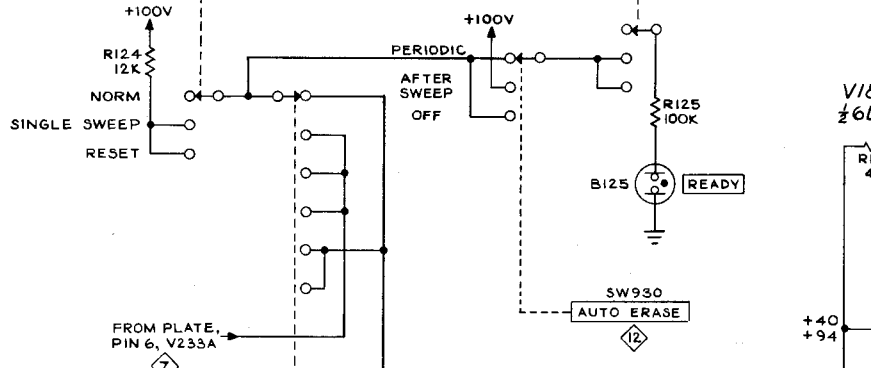
WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on left side of this diagram except as follows:

Waveforms	Center
TRIGGERING LEVEL	LINE
SOURCE	
Voltage Readings (Upper)	Counterclockwise
TRIGGERING LEVEL	LINE
SOURCE	
Voltage Readings (Lower)	Clockwise
TRIGGERING LEVEL	LINE
SOURCE	



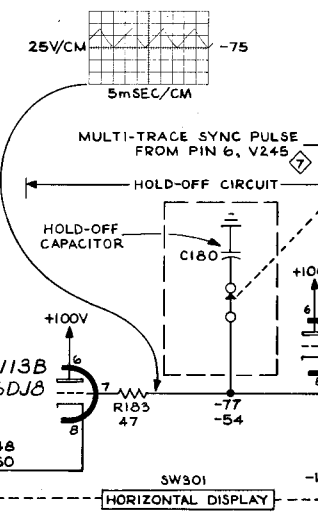
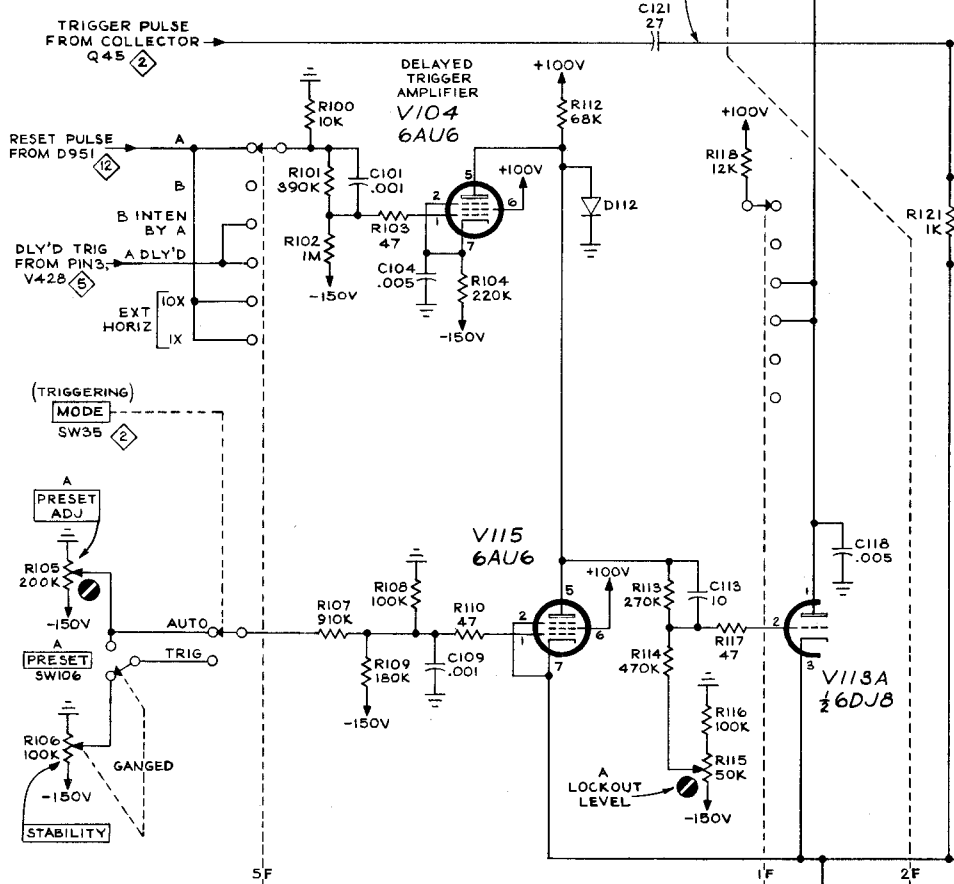
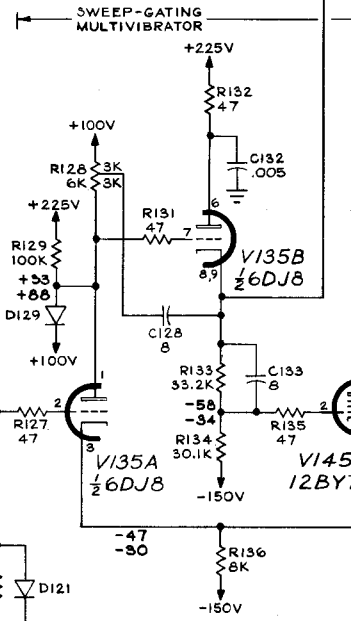
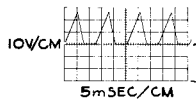
TIME-BASE A TRIGGER ②

SWEEP MODE SW125



WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on diagram (2) except as follows:

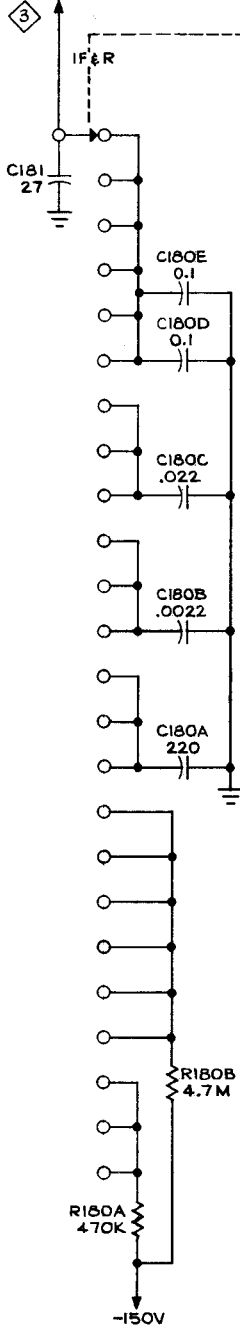
Waveforms	Clockwise
Voltage Readings (Upper)	Counterclockwise, but not in PRESET
Voltage Readings (Lower)	Clockwise



TYPE 549 STORAGE OSCILLOSCOPE

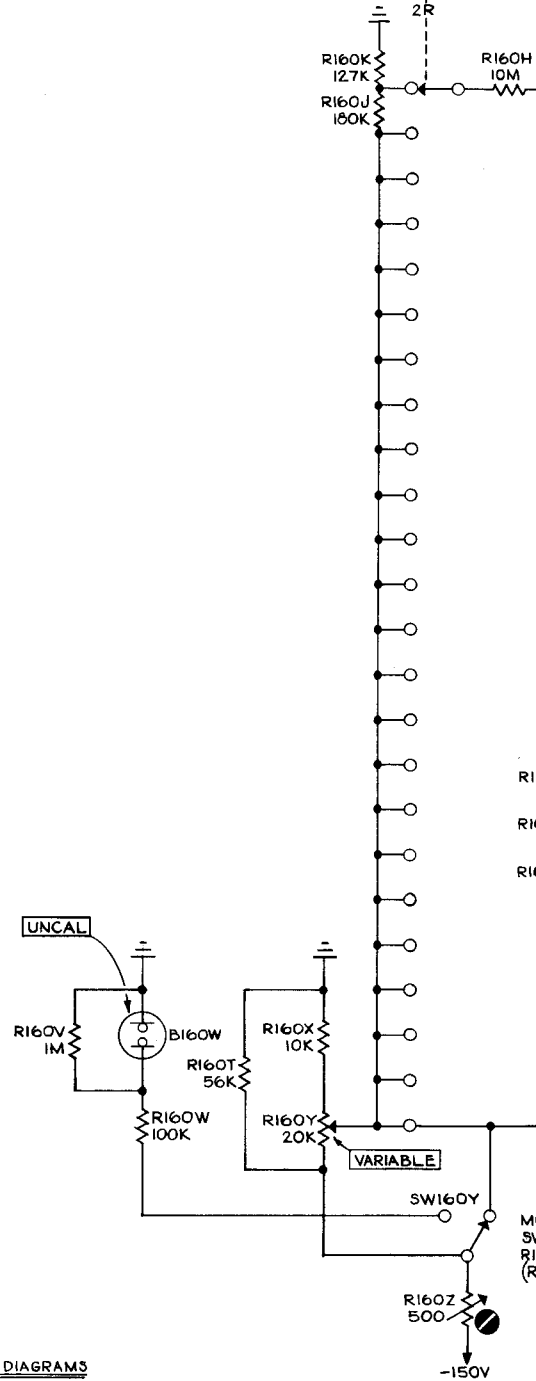
FOR ADDITIONAL SWITCH DETAILS SEE (11)
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

TO CATH, PIN 8, VI83A
HOLD-OFF CF



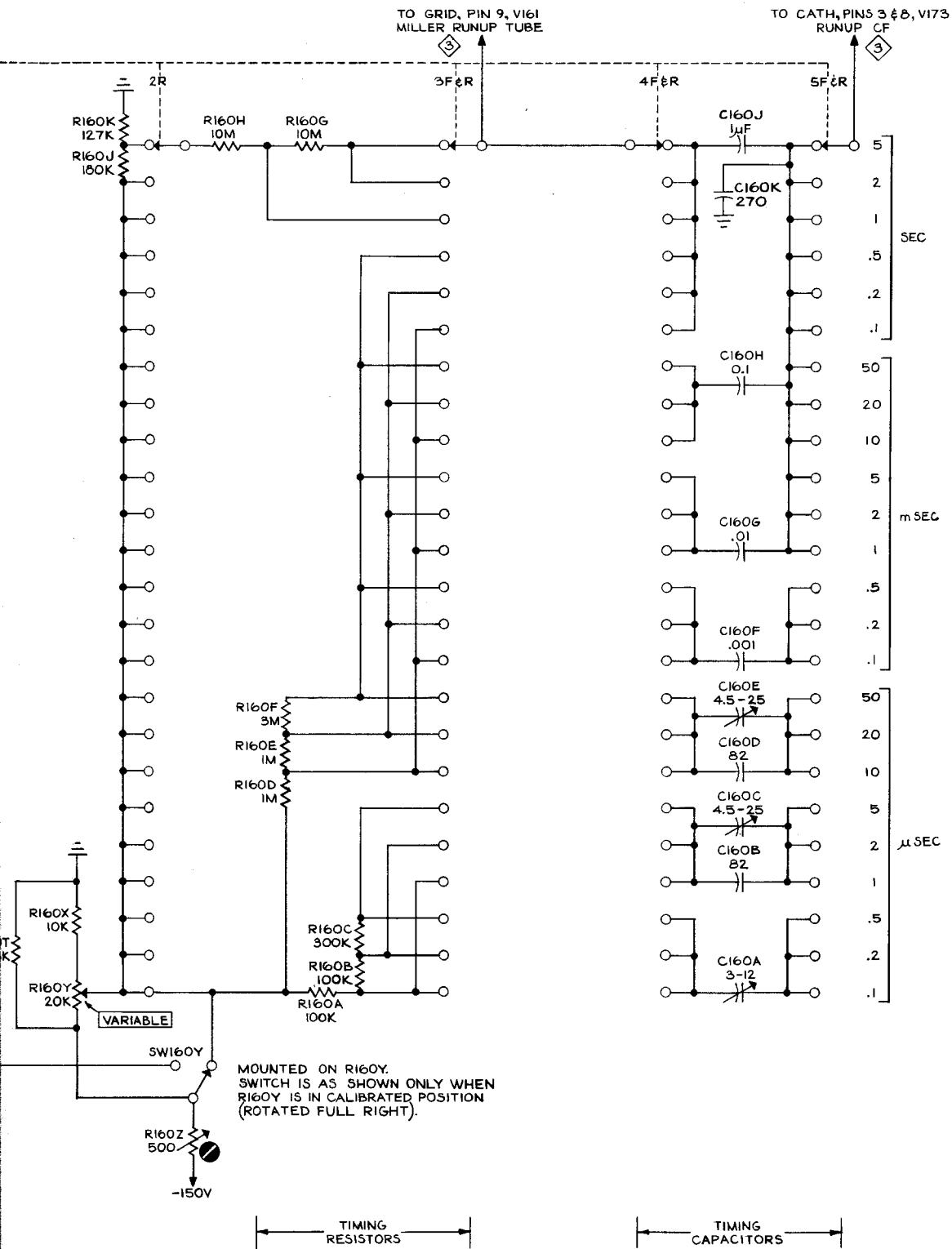
HOLD-OFF
CAPACITORS
& RESISTORS

SW160
TIME/CM



REFERENCE DIAGRAM

3 TIME-BASE A GENERATOR

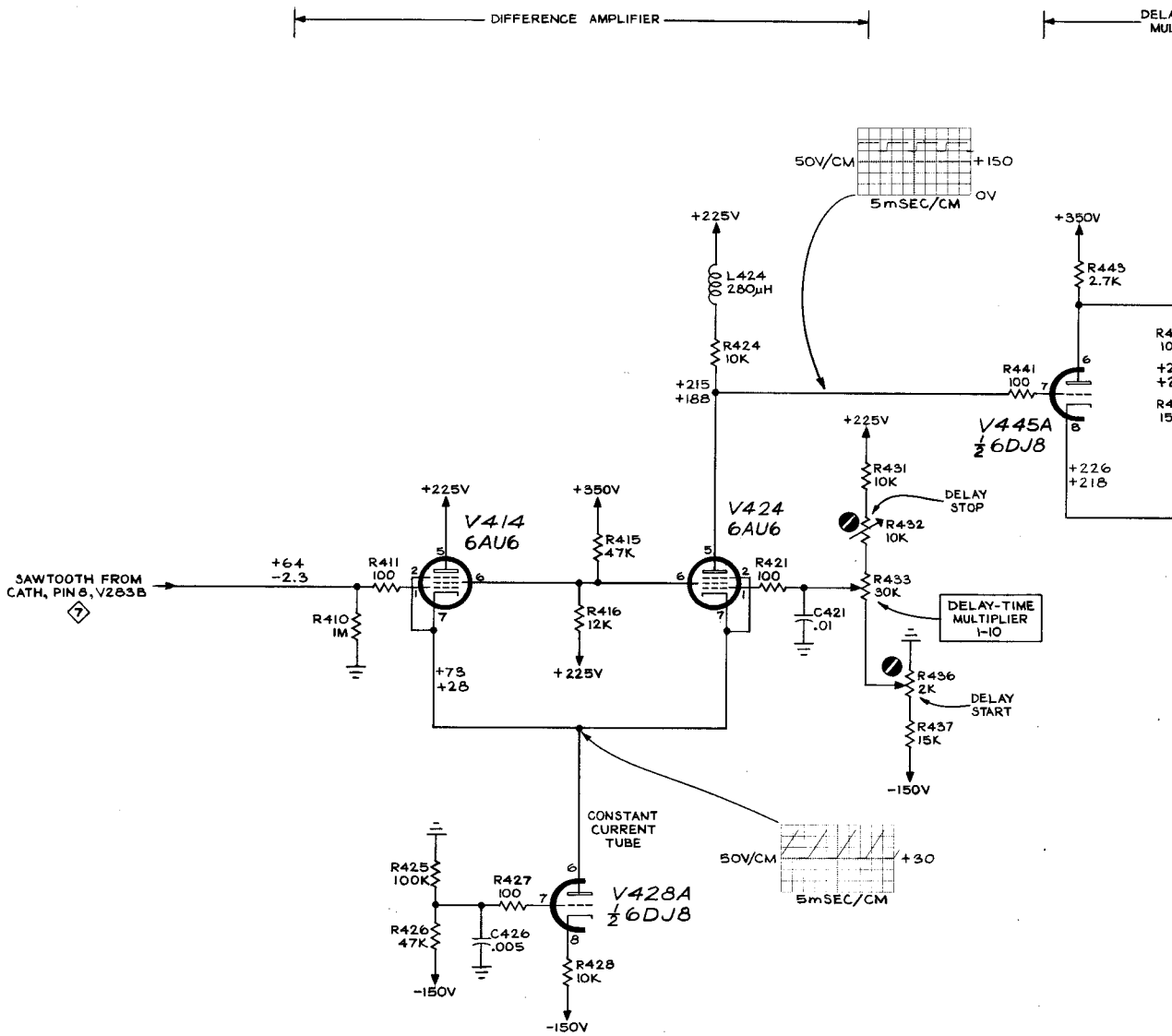


GIN
1065

A

TIME-BASE A TIMING SWITCH





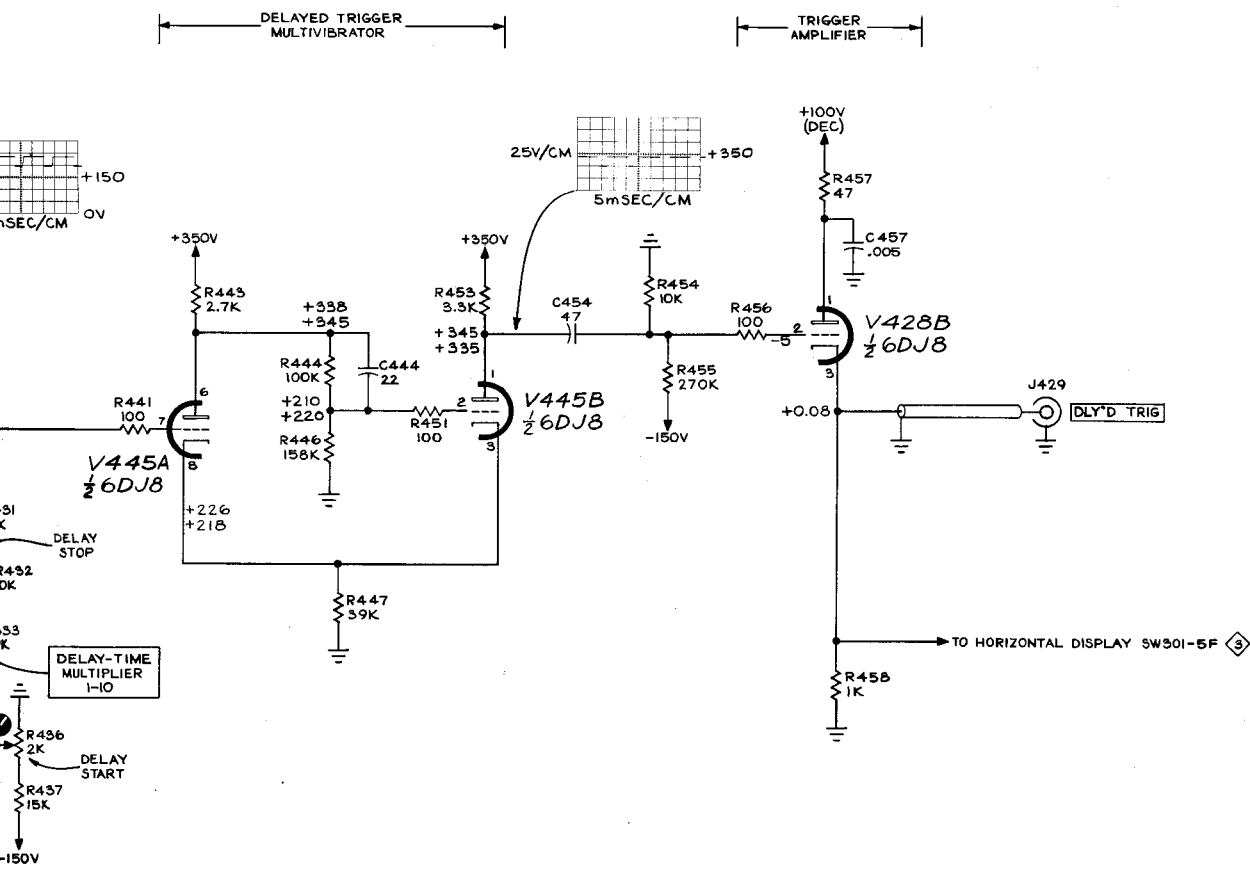
WAVEFORMS and VOLTAGE READINGS were obtained under given on diagram \diamond except as follows:

Voltage Readings (Upper)	
STABILITY (Time-Base B)	Clockwise
Voltage Readings (Lower)	
STABILITY (Time-Base B)	Counterclockwise, but no

TYPE 549 STORAGE OSCILLOSCOPE

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NOTE:
FOR DECOUPLING NETWORKS
SEE TIME-BASE B GENERATOR DIAGRAM 7

REFERENCE DIAGRAMS

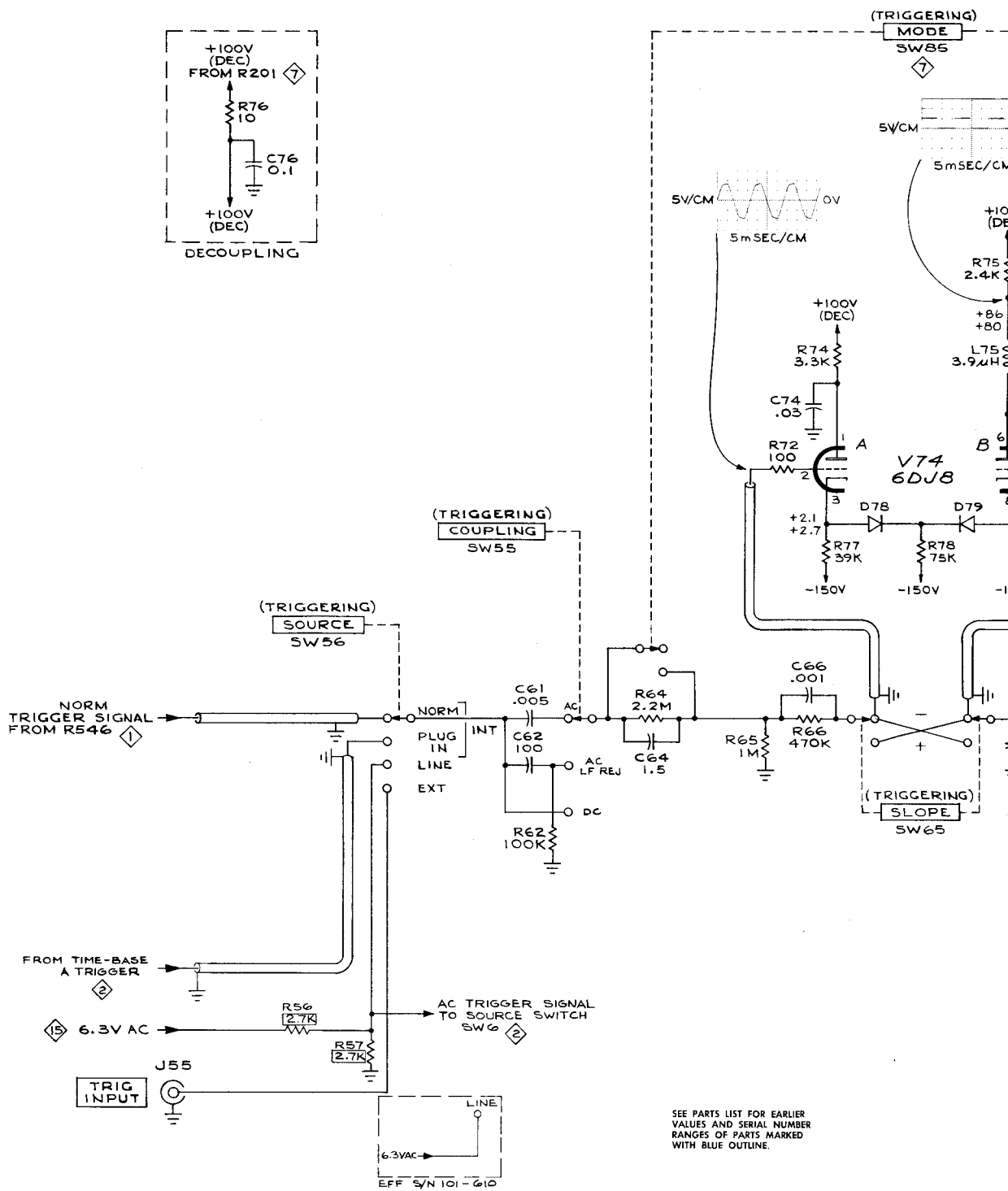
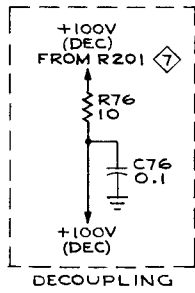
- 3 TIME-BASE A GENERATOR
- 7 TIME-BASE B GENERATOR

RESISTANCE and VOLTAGE READINGS were obtained under conditions of diagram 5 except as follows:

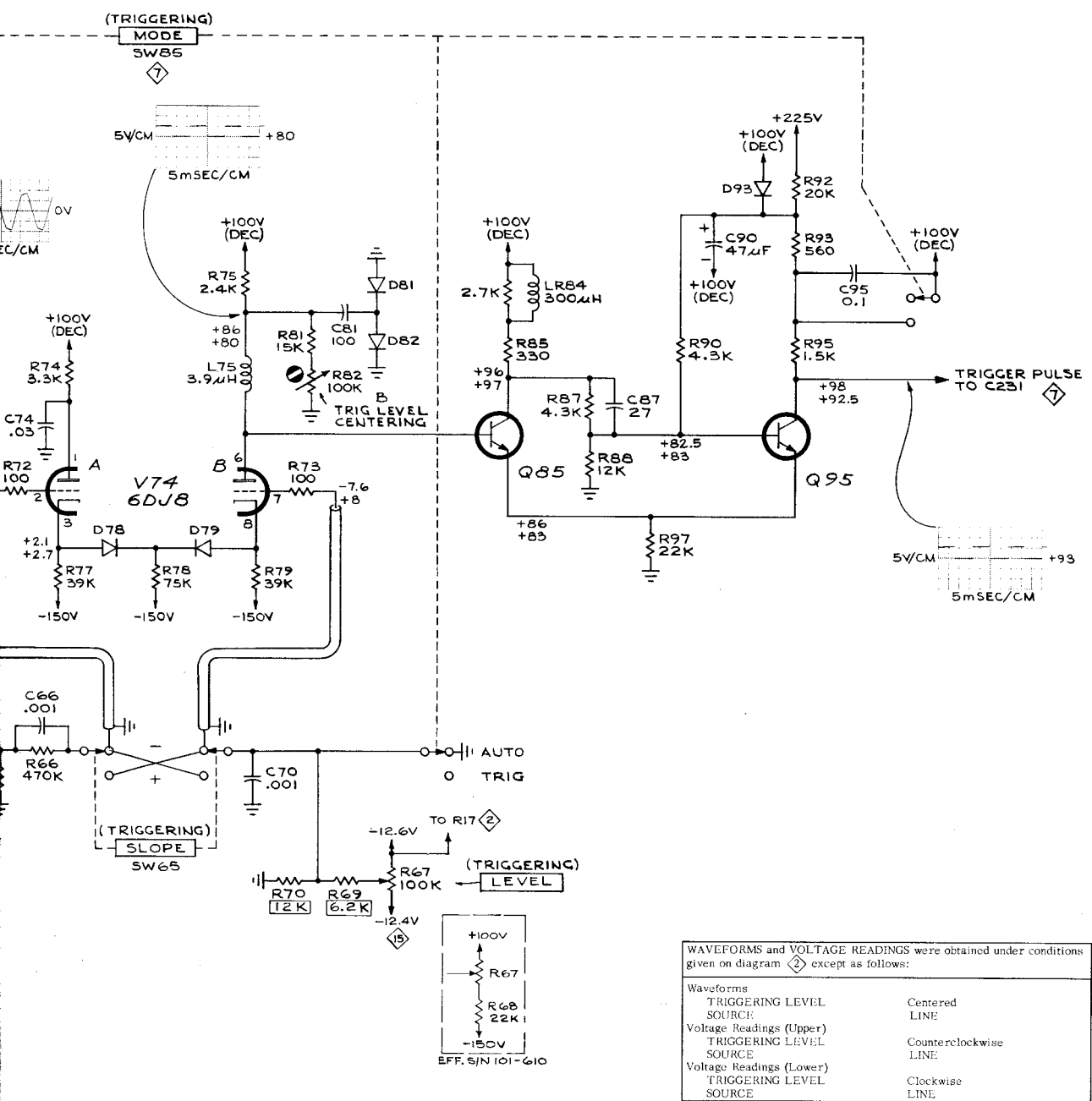
Resistors (Upper)	
Capacitors (Time-Base B)	Clockwise
Resistors (Lower)	
Capacitors (Time-Base B)	Counterclockwise, but not in PRESET

67N
1065

DELAY PICKOFF 5



TYPE 549 STORAGE OSCILLOSCOPE



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

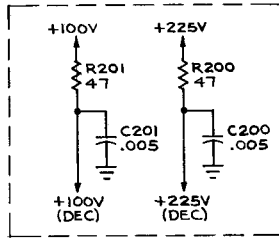
REFERENCE DIAGRAMS:

- ① VERTICAL AMPLIFIER
- ② TIME-BASE B GENERATOR
- ⑤ POWER SUPPLY & HEATER WIRING

EARLIER NUMBER MARKED

B

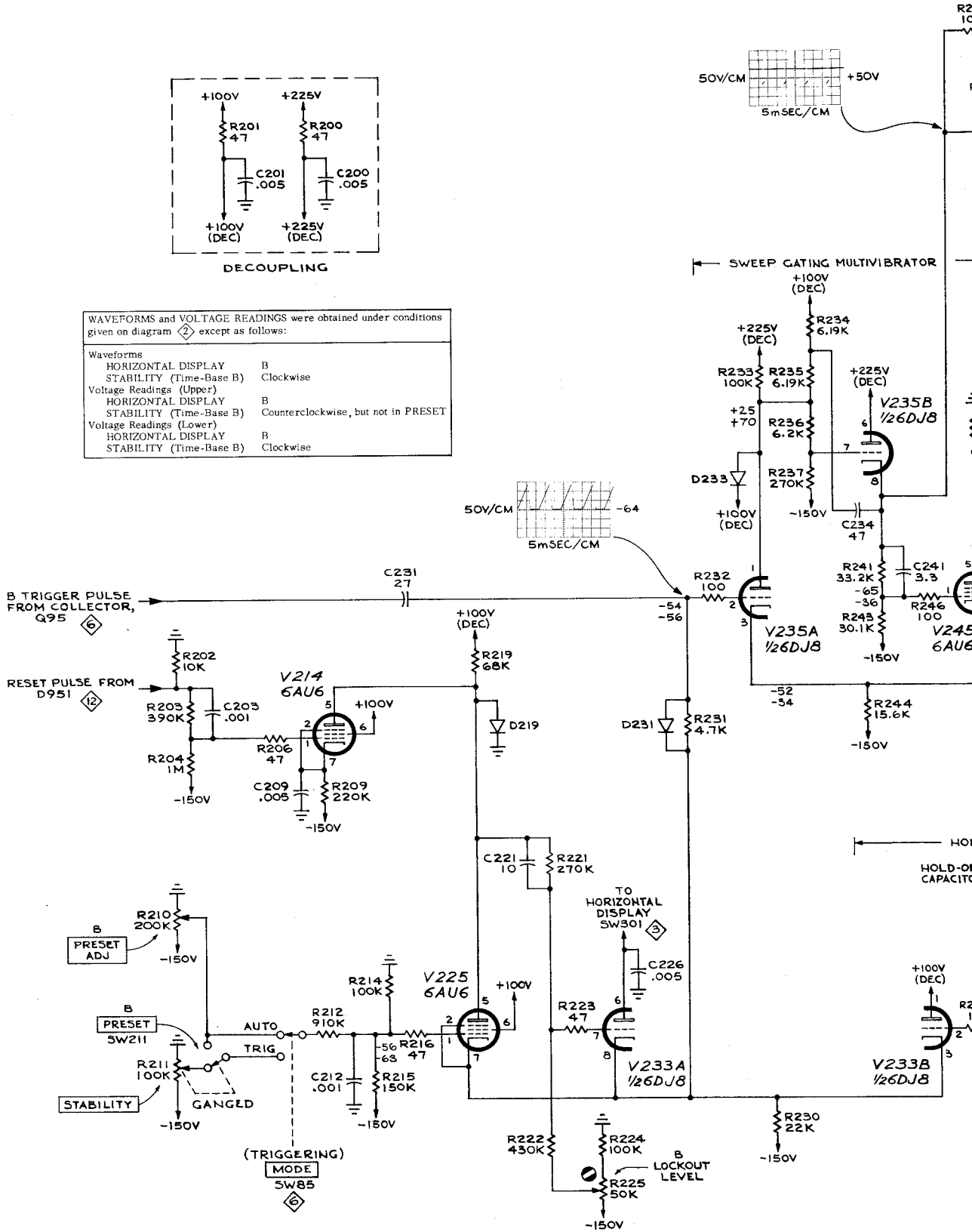
MRH 966
TIME-BASE B TRIGGER ⑥

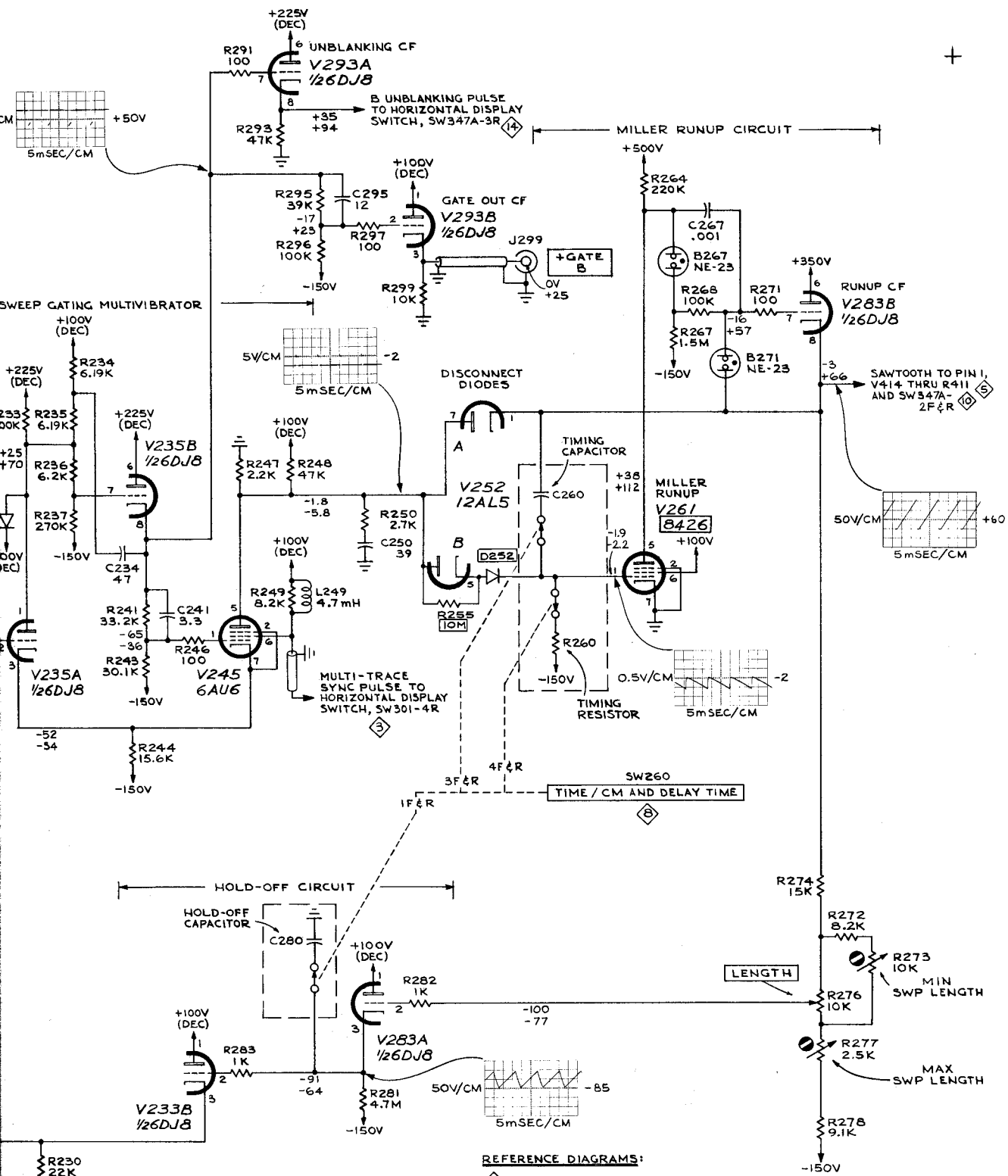


DECOUPLING

WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on diagram (2) except as follows:

Waveforms	
HORIZONTAL DISPLAY	B
STABILITY (Time-Base B)	Clockwise
Voltage Readings (Upper)	B
HORIZONTAL DISPLAY	Counterclockwise, but not in PRESET
Voltage Readings (Lower)	B
HORIZONTAL DISPLAY	B
STABILITY (Time-Base B)	Clockwise



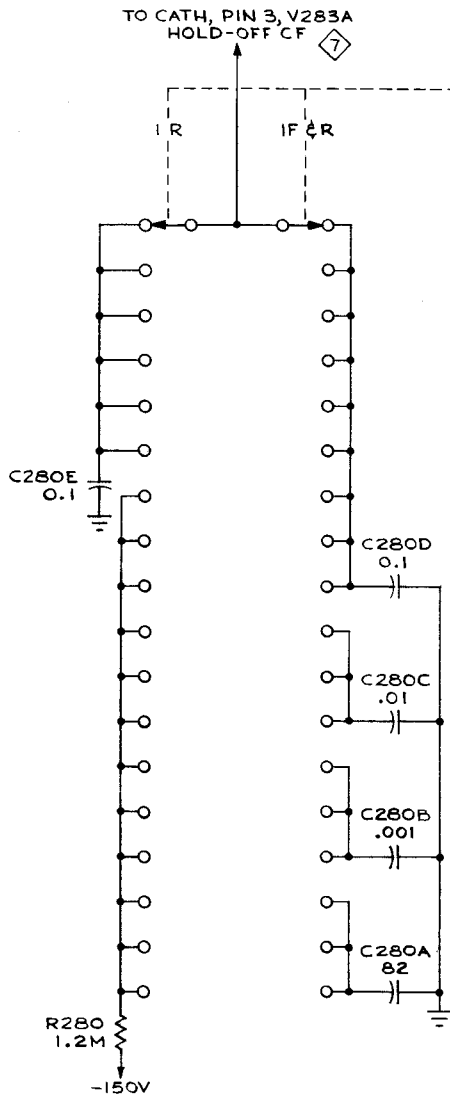


- REFERENCE DIAGRAMS:**
- ③ TIME-BASE A GENERATOR
 - ⑤ DELAY PICKOFF
 - ⑥ TIME-BASE B TRIGGER
 - ⑧ TIME-BASE B TIMING SWITCH
 - ⑩ HORIZONTAL AMPLIFIER
 - ⑫ AUTO ERASE CIRCUIT

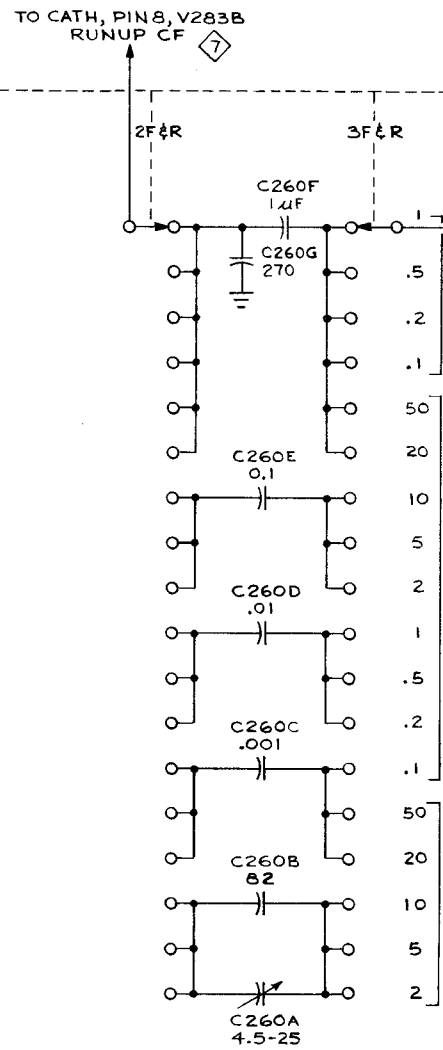
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

MRH
1266

TIME-BASE B GENERATOR ⑦



————— HOLD-OFF CAPACITORS —————



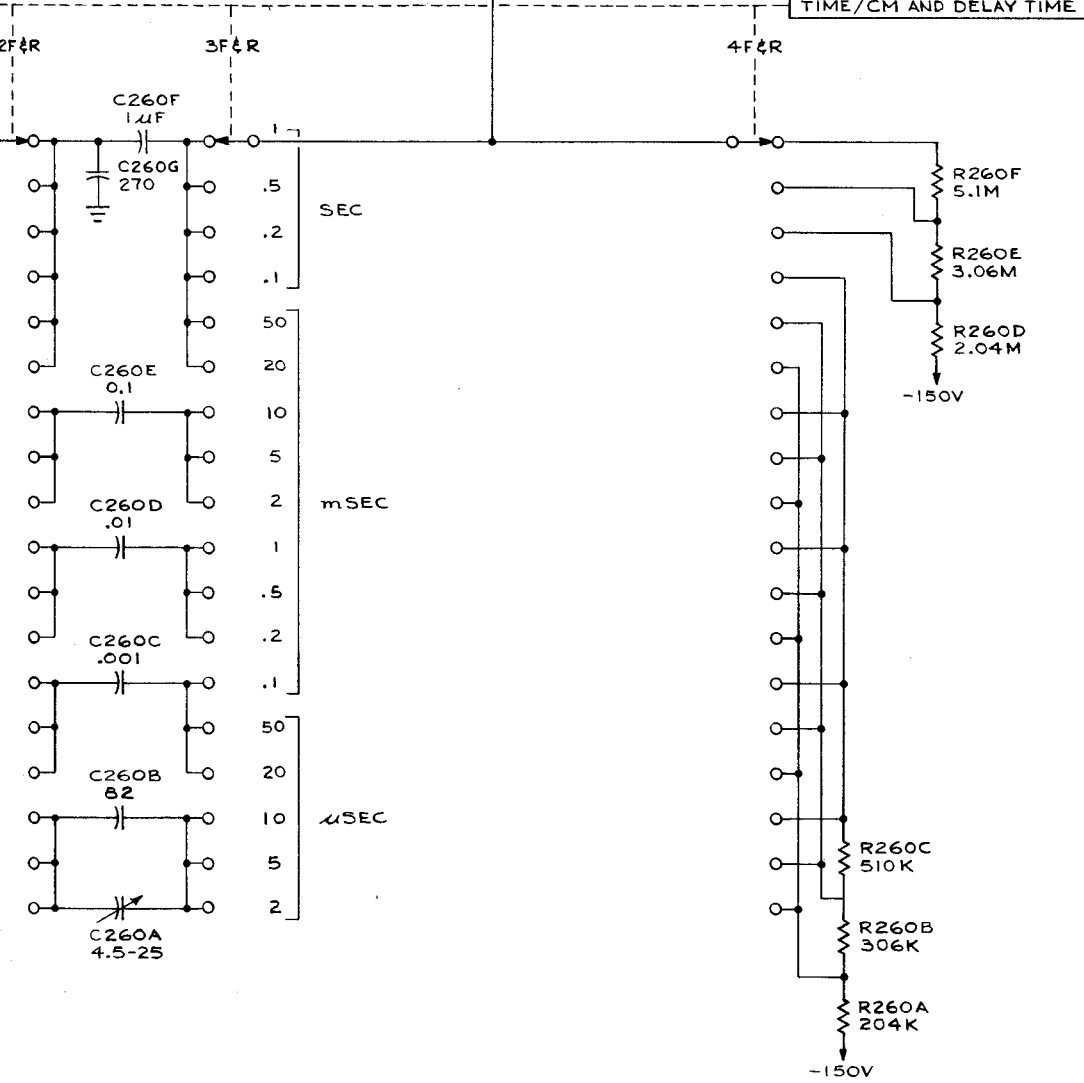
————— TIMING CAPACITORS —————

NB, V283B
P CF

TO GRID, PIN 1, V261
MILLER RUNUP

SW260

TIME/CM AND DELAY TIME



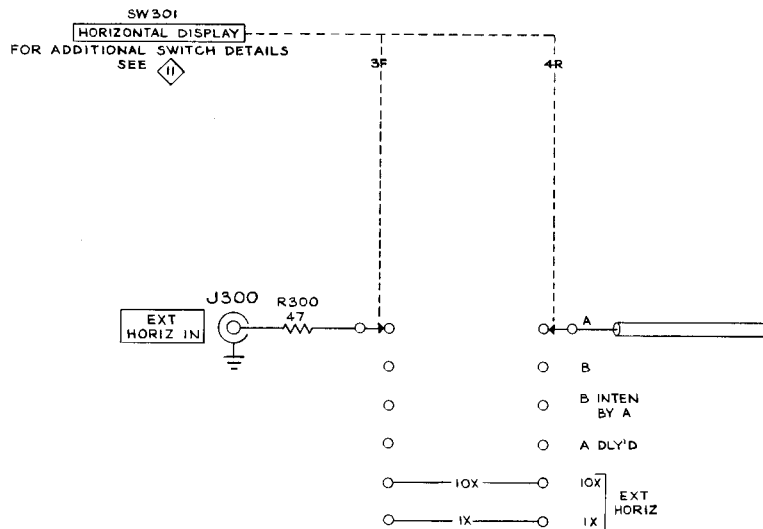
REFERENCE DIAGRAM:

◇ TIME-BASE B GENERATOR

A

TIME-BASE B TIMING SWITCH ◇

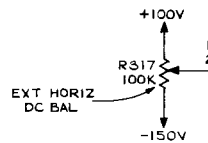
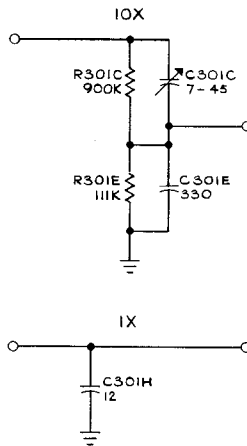
MRH
1165



REFERENCE DIAGRAMS

- 7 TIME-BASE B GENERATOR
- 10 HORIZONTAL AMPLIFIER
- 11 HORIZONTAL DISPLAY SWITCH

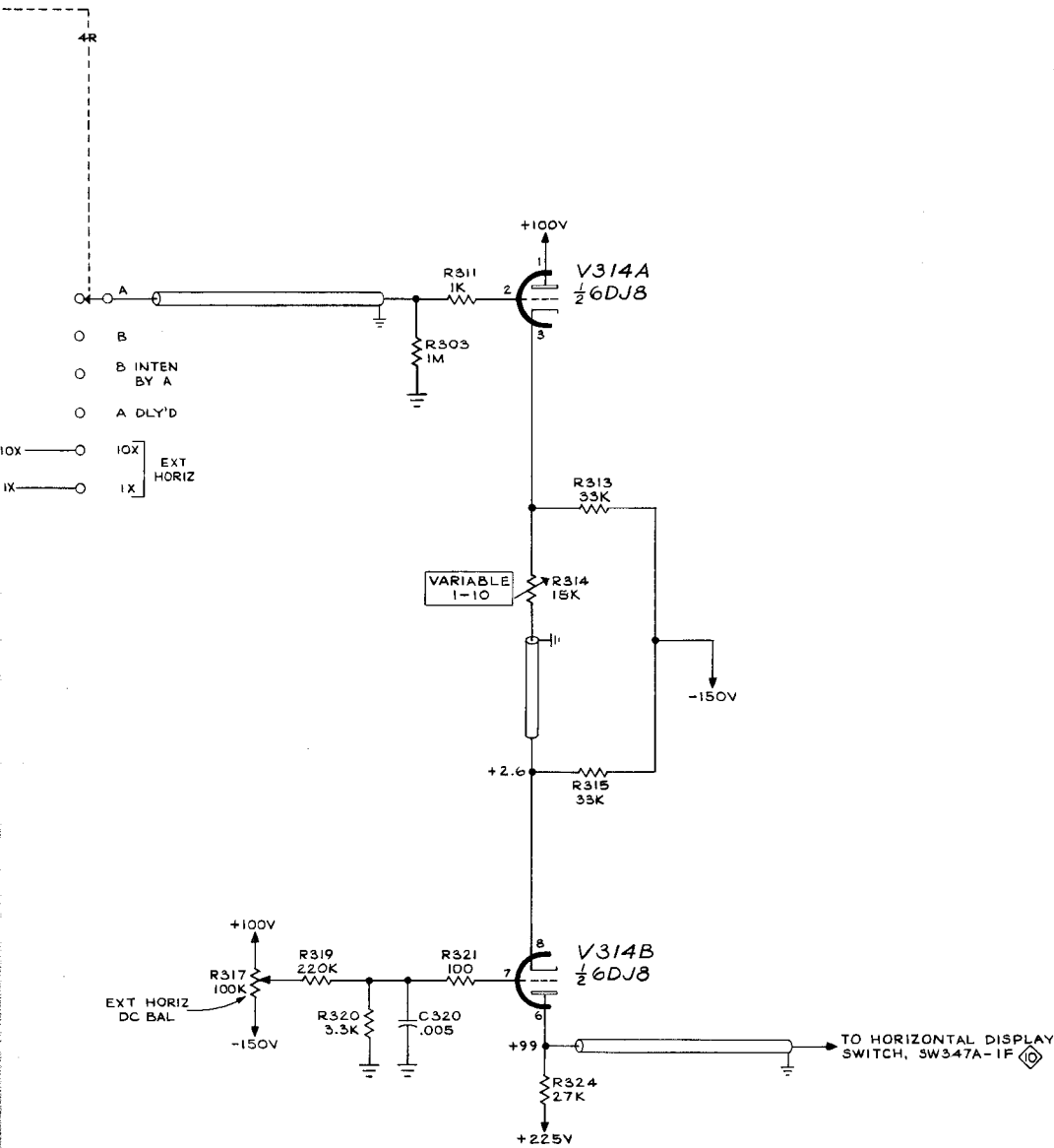
FOR DECOUPLING NETWORKS
SEE 7



VOLTAGE READINGS were obtained under conditions given on diagram 11 except as follows:	
External Horizontal Input Signal	None
HORIZONTAL DISPLAY VARIABLE: 1 - 10	10X Clockwise

TYPE 549 STORAGE OSCILLOSCOPE

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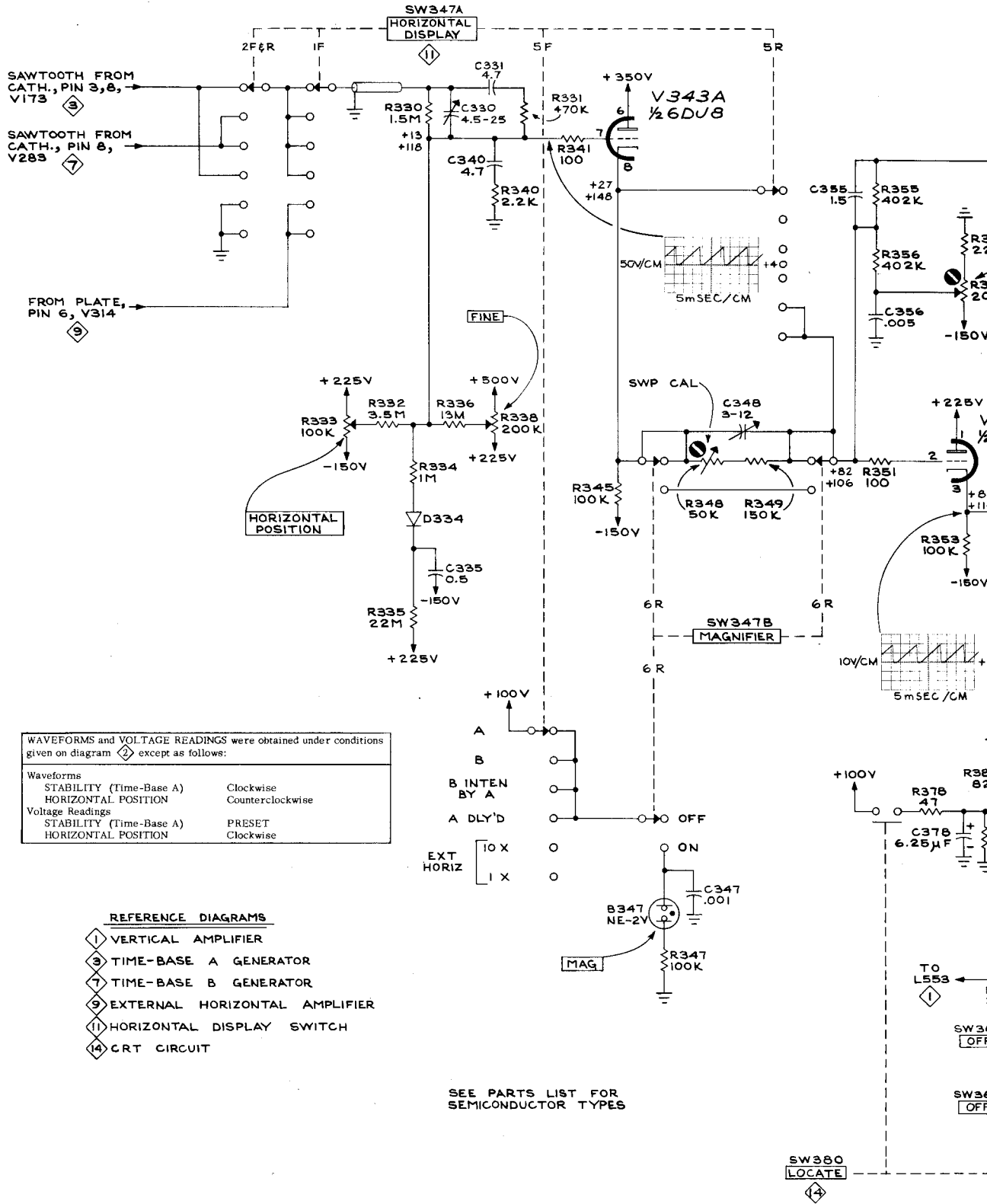
GTS
1065

A₂

EXTERNAL HORIZONTAL AMPLIFIER 9

INPUT CF

DRIVER CF



TYPE 549 STORAGE OSCILLOSCOPE

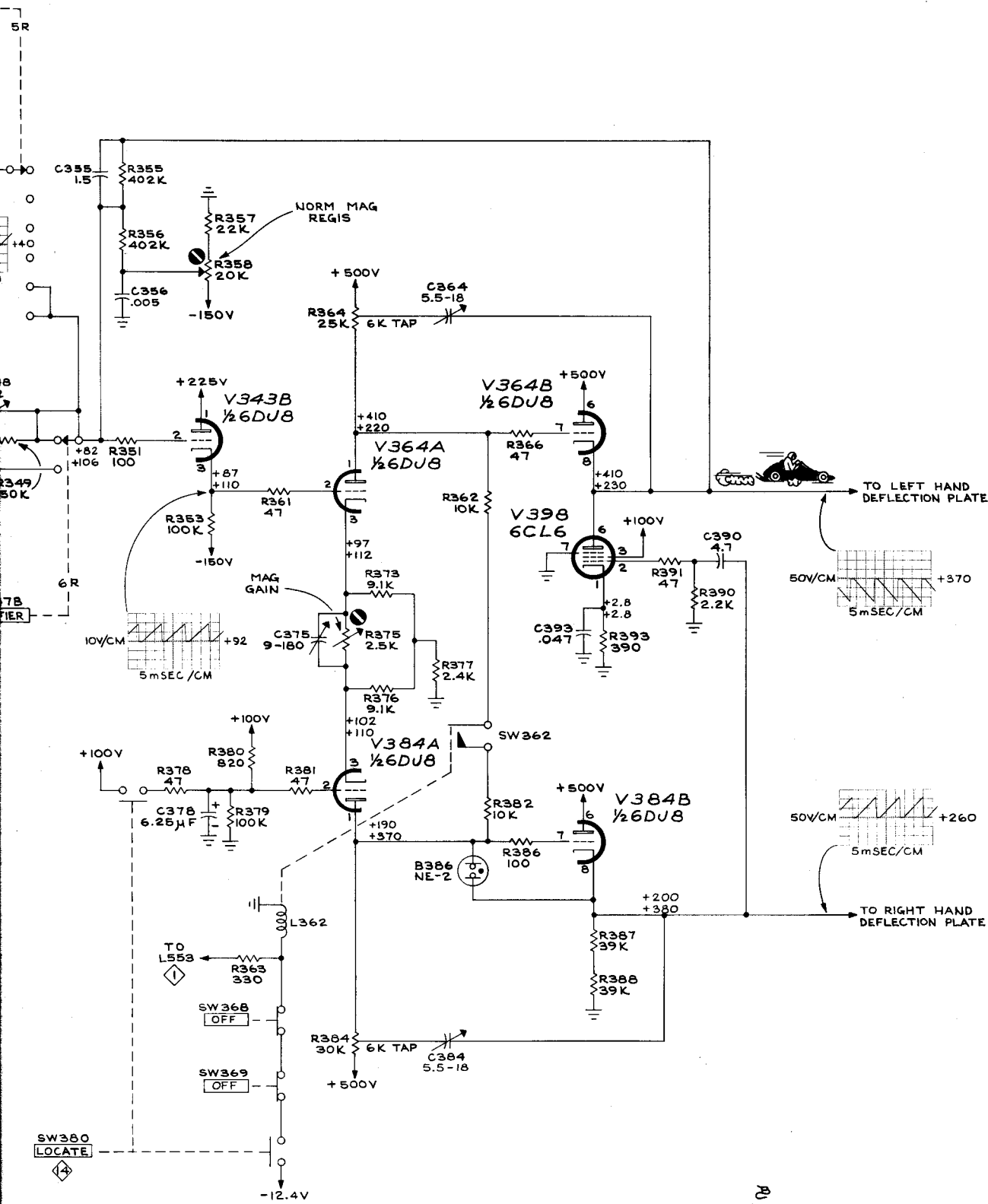
A

DRIVER CF

OUTPUT
AMPLIFIER

OUTPUT CF
& HF CAPACITANCE
DRIVER

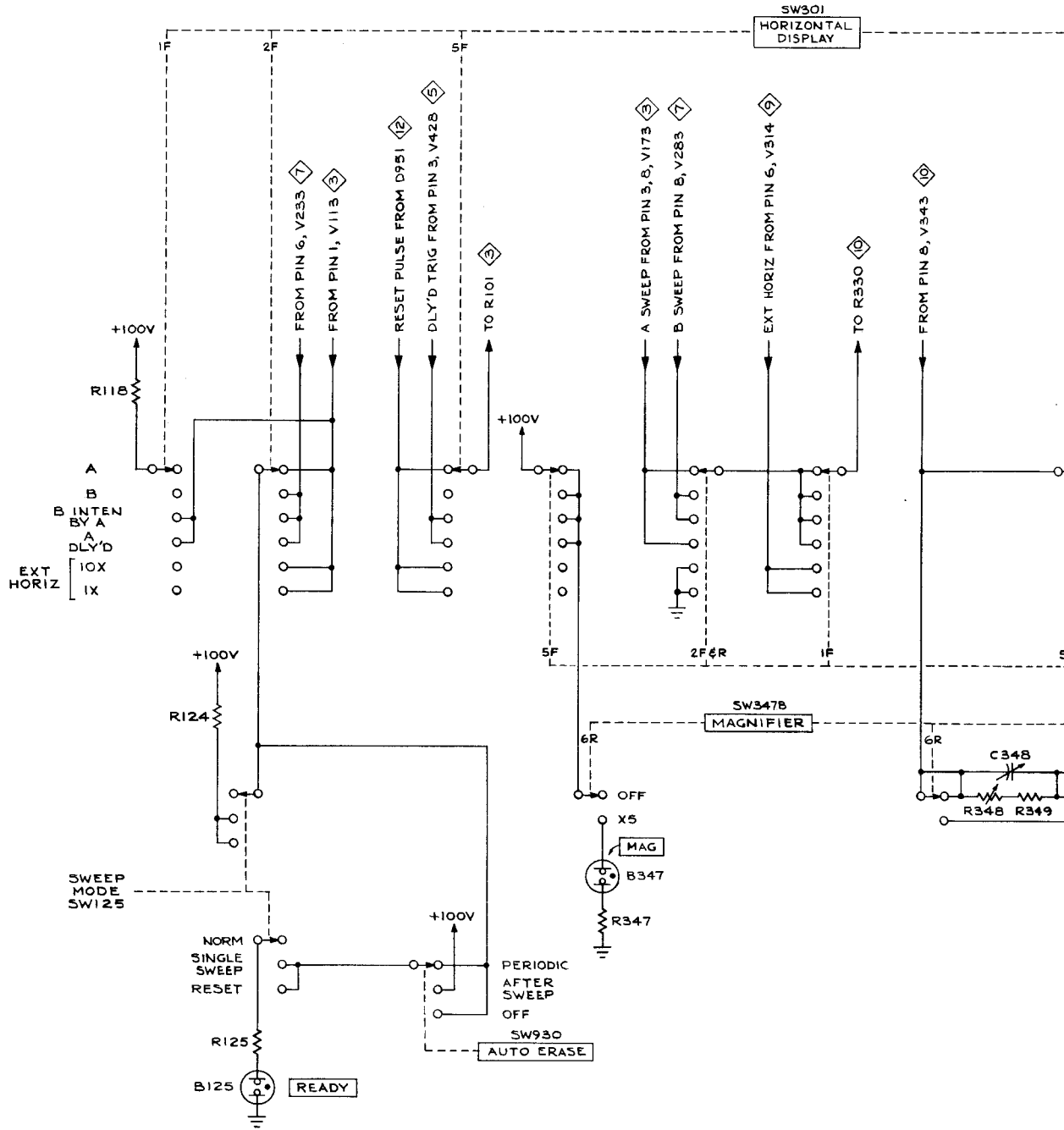
+



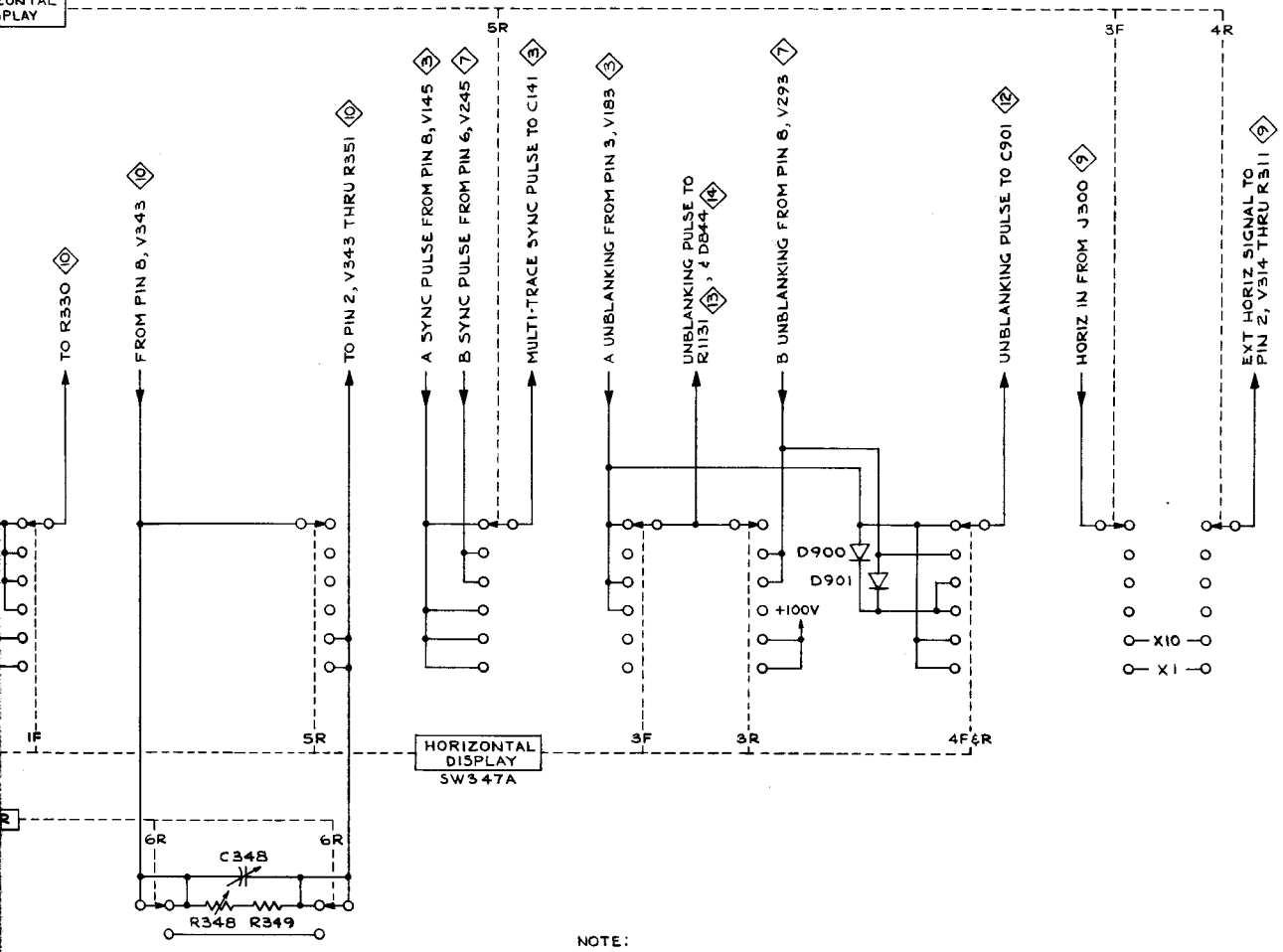
HORIZONTAL AMPLIFIER



A



SW301
HORIZONTAL
DISPLAY



HORIZONTAL
DISPLAY
SW347A

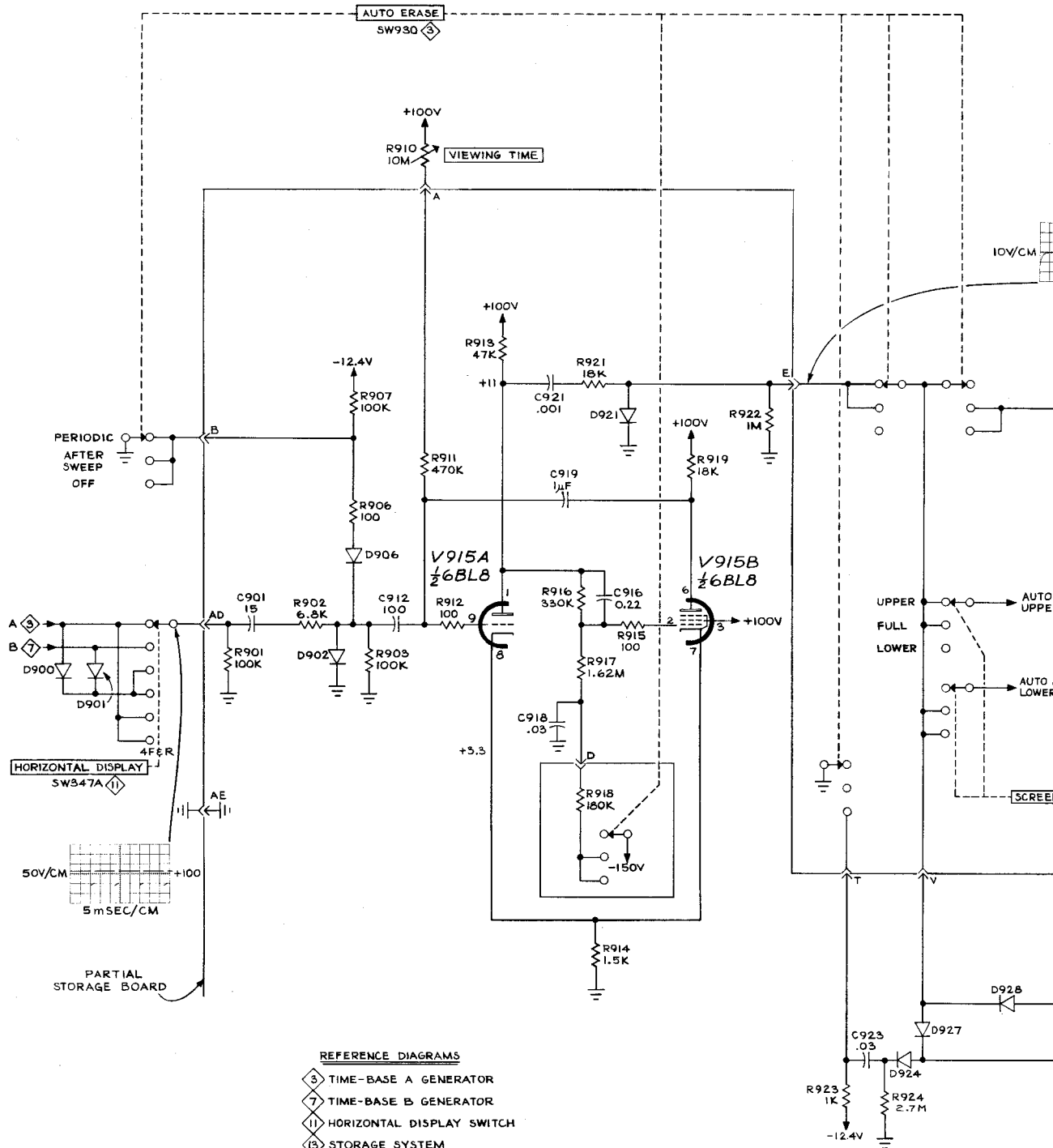
NOTE:
SW301 & SW347A ARE GANGED SWITCHES
& CONCENTRIC WITH SW347B

REFERENCE DIAGRAMS

- ③ TIME-BASE A GENERATOR
- ⑤ DELAY PICKOFF
- ⑦ TIME-BASE B GENERATOR
- ⑨ EXTERNAL HORIZONTAL AMPLIFIER
- ⑩ HORIZONTAL AMPLIFIER
- ⑫ AUTO ERASE CIRCUIT
- ⑬ STORAGE SYSTEM
- ⑭ CRT CIRCUIT

MRH
1165

HORIZONTAL DISPLAY SWITCH

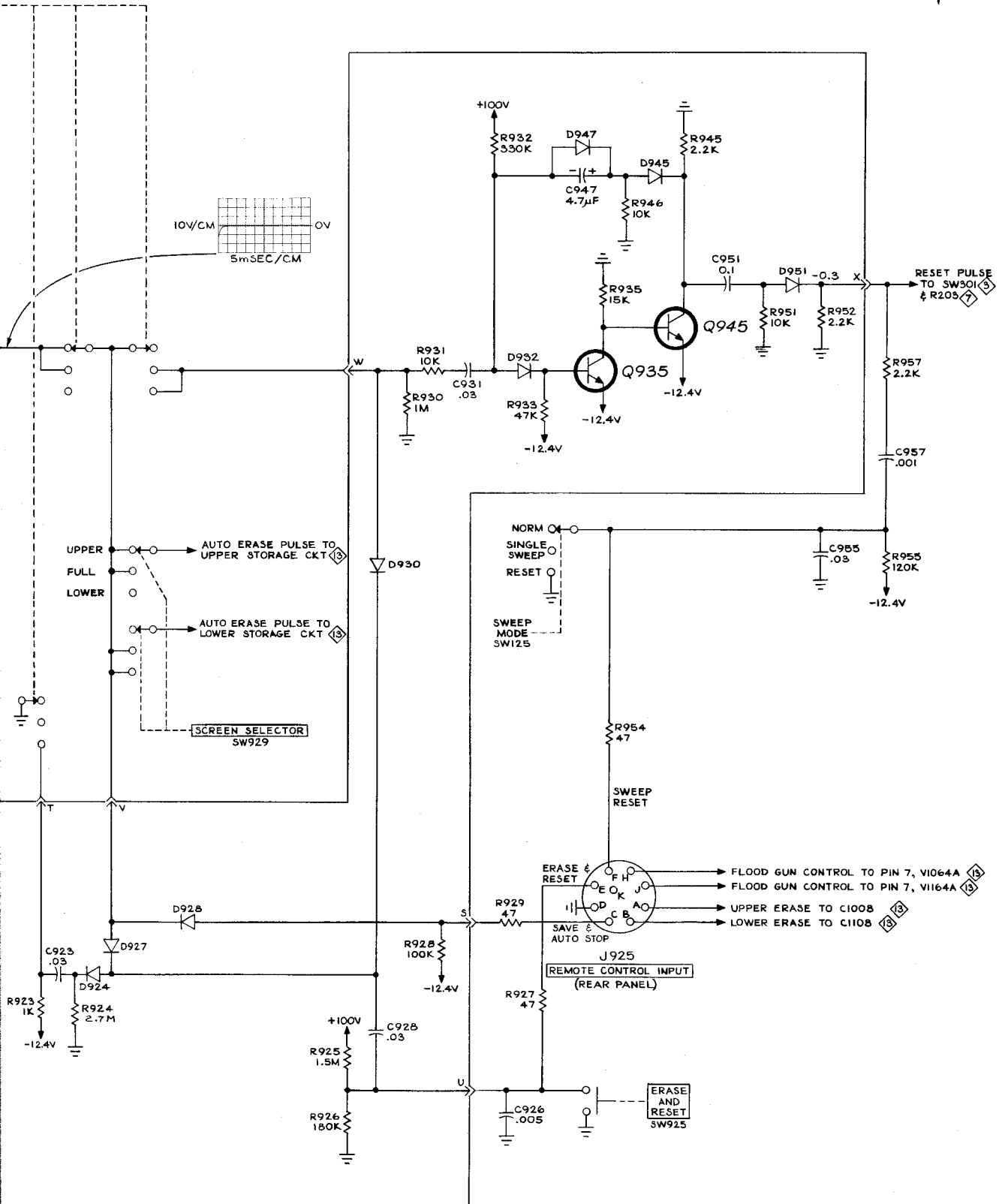


- REFERENCE DIAGRAMS**
- 3 TIME-BASE A GENERATOR
 - 7 TIME-BASE B GENERATOR
 - 11 HORIZONTAL DISPLAY SWITCH
 - 13 STORAGE SYSTEM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

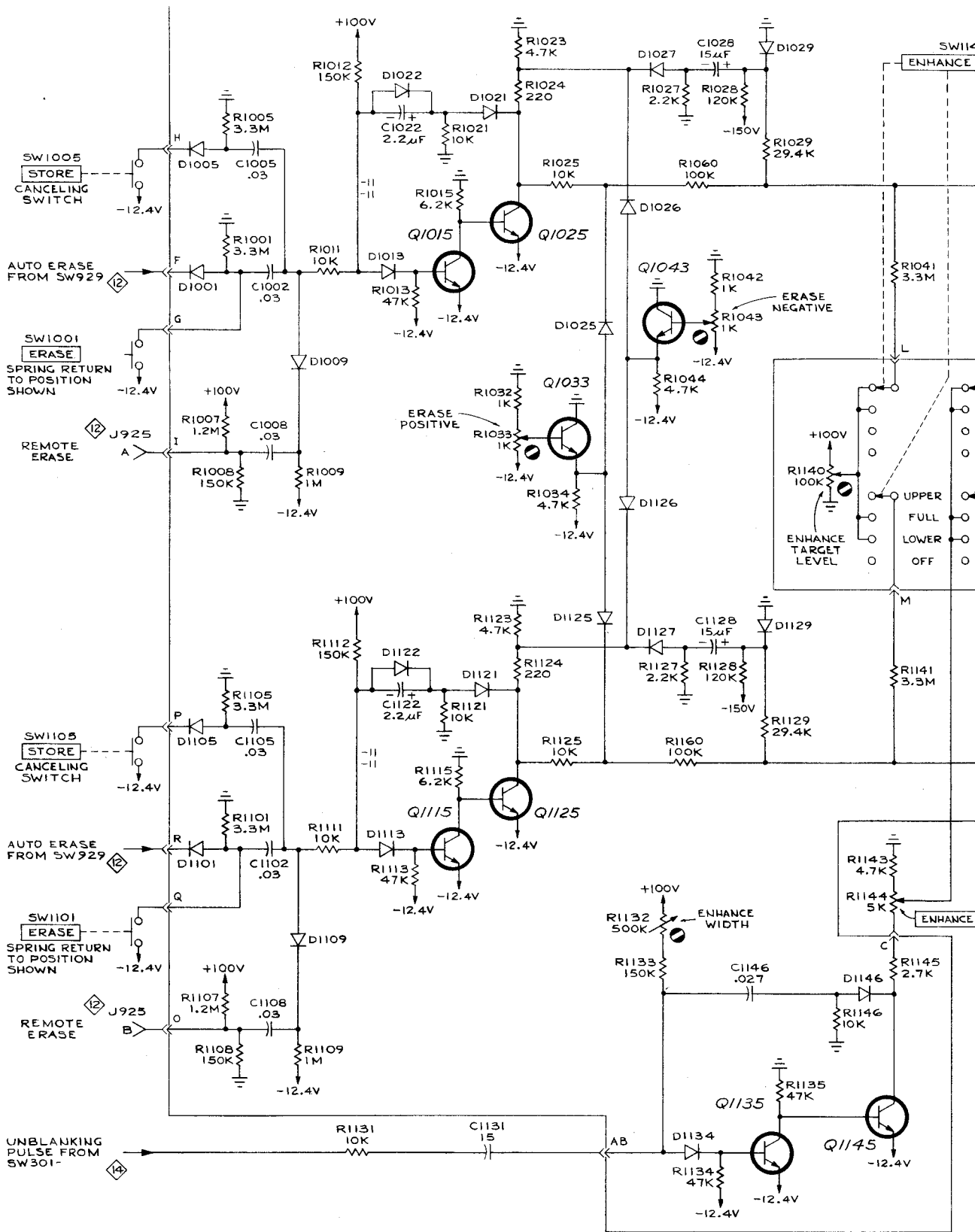
WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on diagram 2 except as follows:

Waveforms		
AUTO ERASE		PERIODIC STORE
UPPER and LOWER SCREEN STORAGE		OFF
Voltage Readings		
UPPER and LOWER SCREEN STORAGE		OFF
AUTO ERASE		OFF

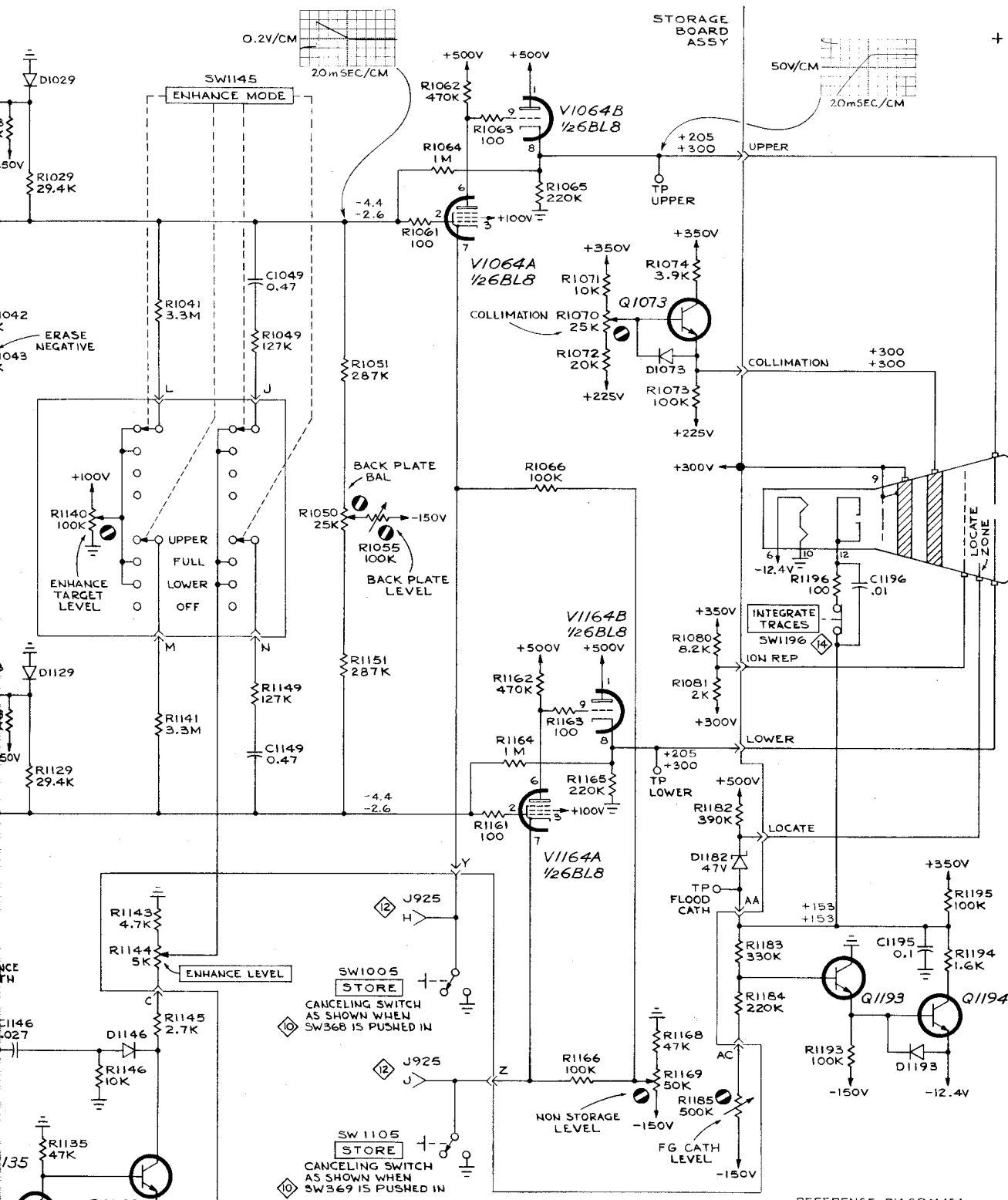


A₁

67
1065
AUTO ERASE CIRCUIT 12



TYPE 549 STORAGE OSCILLOSCOPE



WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on diagram (2) except as follows:

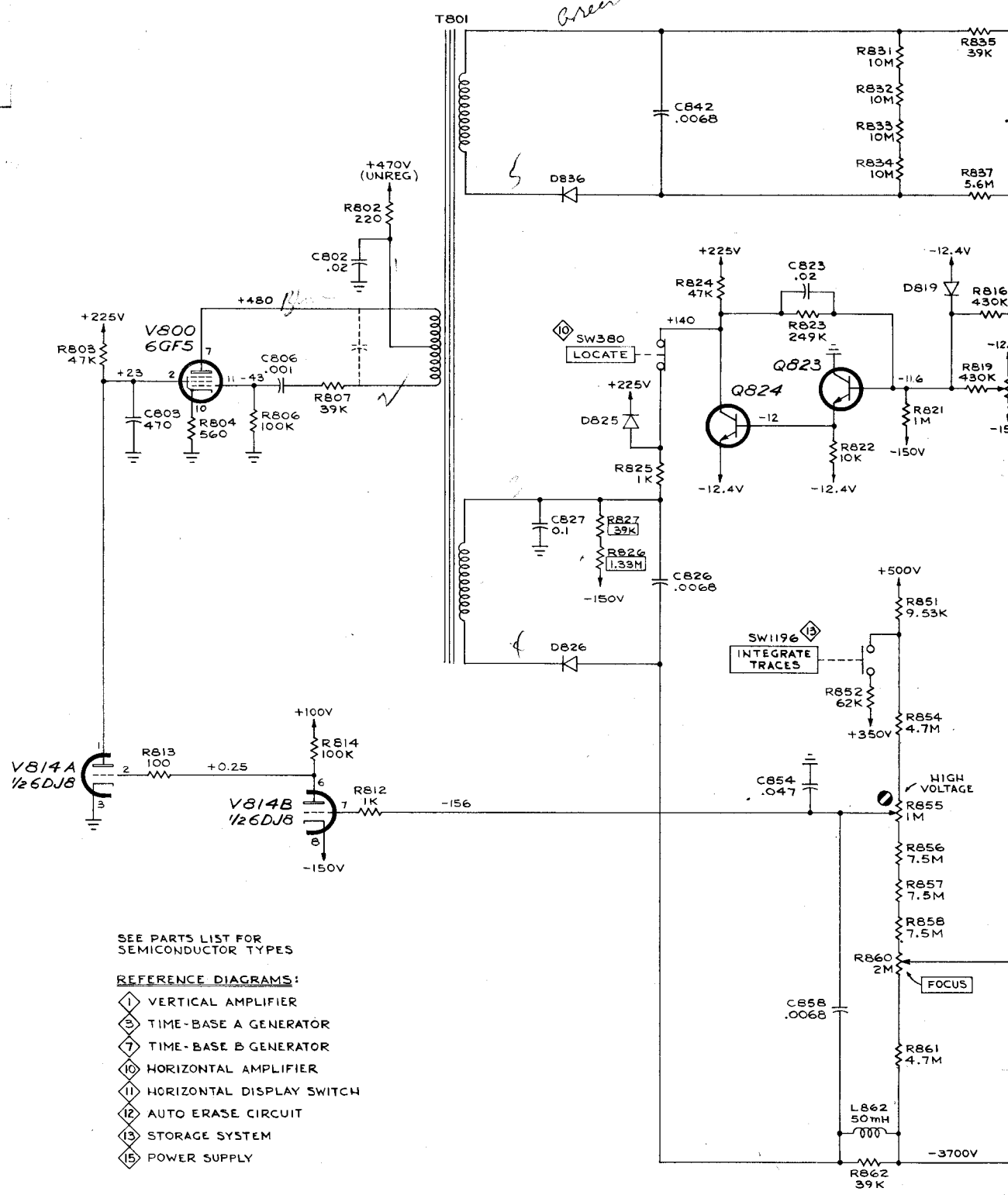
Waveforms	
AUTO ERASE	PERIODIC STORE
UPPER and LOWER SCREEN STORAGE	STORE
Voltage Readings (Upper)	
UPPER and LOWER SCREEN STORAGE	OFF
NORM-SINGLE SWEEP	SINGLE SWEEP
Voltage Readings (Lower)	
UPPER and LOWER SCREEN STORAGE	STORE
NORM-SINGLE SWEEP	SINGLE SWEEP

- REFERENCE DIAGRAMS:
- (10) HORIZONTAL AMPLIFIER
 - (2) AUTO ERASE CIRCUIT
 - (14) CRT CIRCUIT

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

MRH
1265

STORAGE SYSTEM (13)



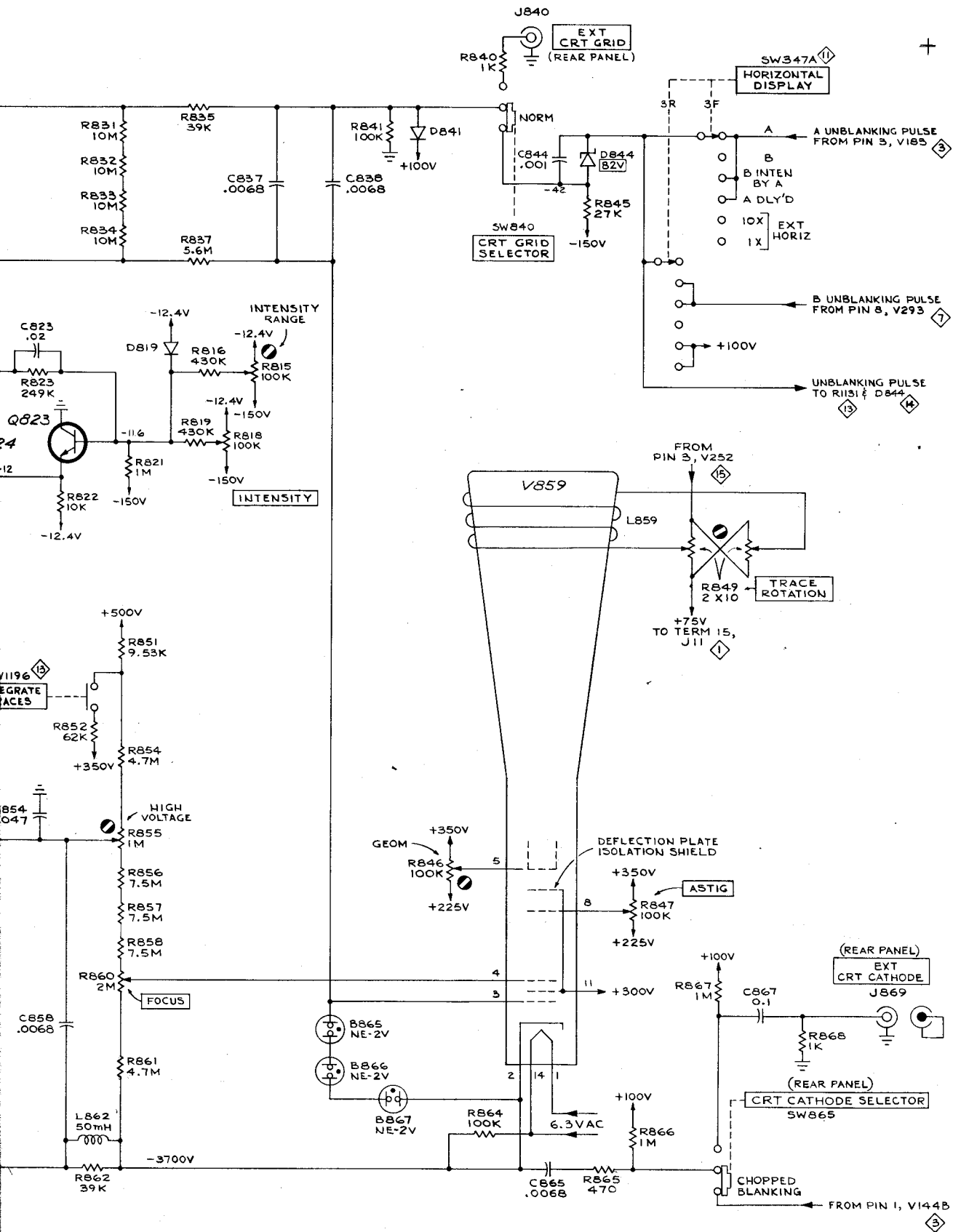
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

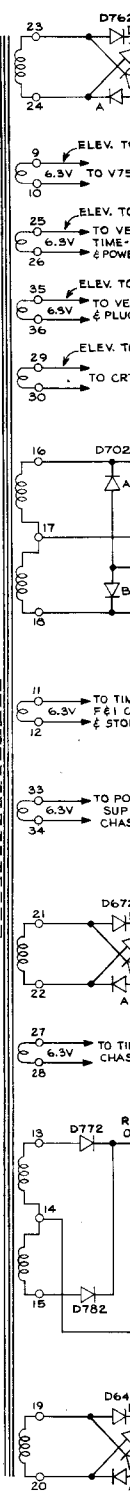
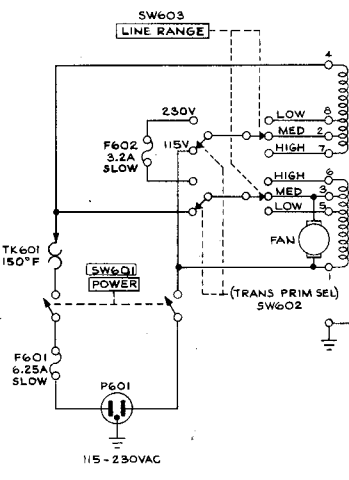
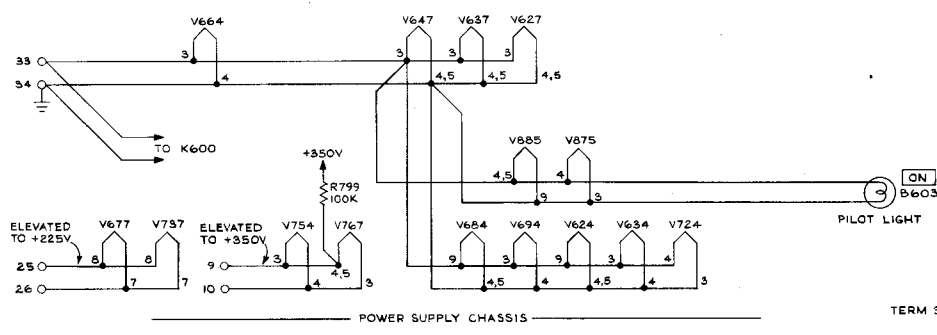
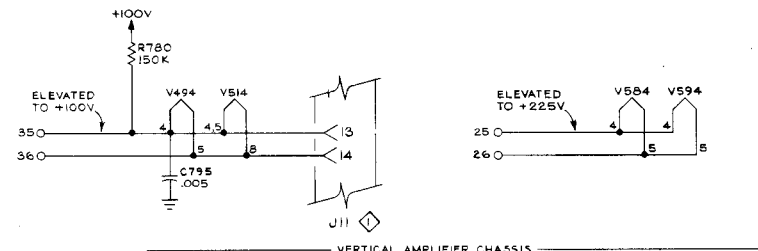
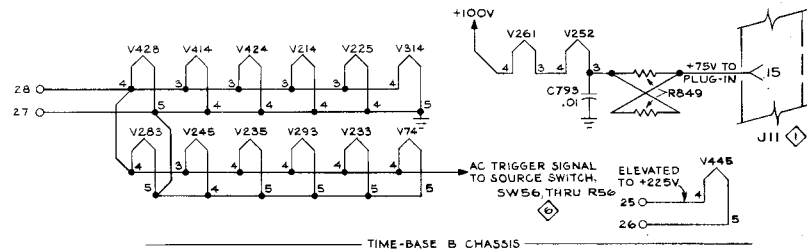
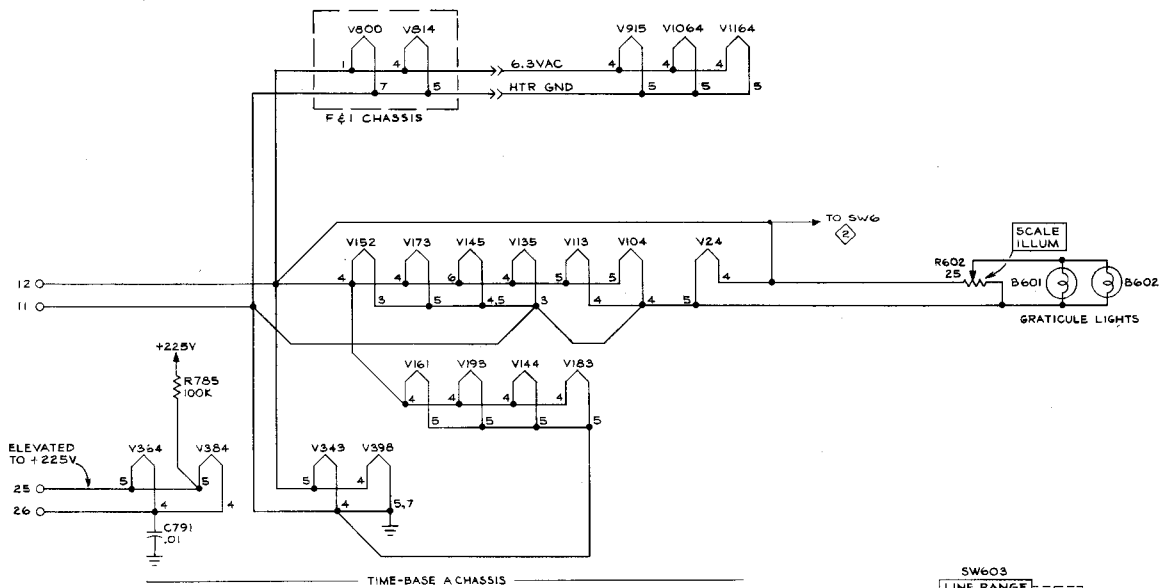
- ① VERTICAL AMPLIFIER
- ③ TIME-BASE A GENERATOR
- ⑦ TIME-BASE B GENERATOR
- ⑩ HORIZONTAL AMPLIFIER
- ⑪ HORIZONTAL DISPLAY SWITCH
- ⑫ AUTO ERASE CIRCUIT
- ⑬ STORAGE SYSTEM
- ⑮ POWER SUPPLY

VOLTAGE READINGS were obtained under conditions given on diagram ② except as follows:

INTENSITY	Counterclockwise
-----------	------------------



MR4
 1166
 CRT 14



VOLTAGE READINGS were obtained under conditions given on diagram (2)

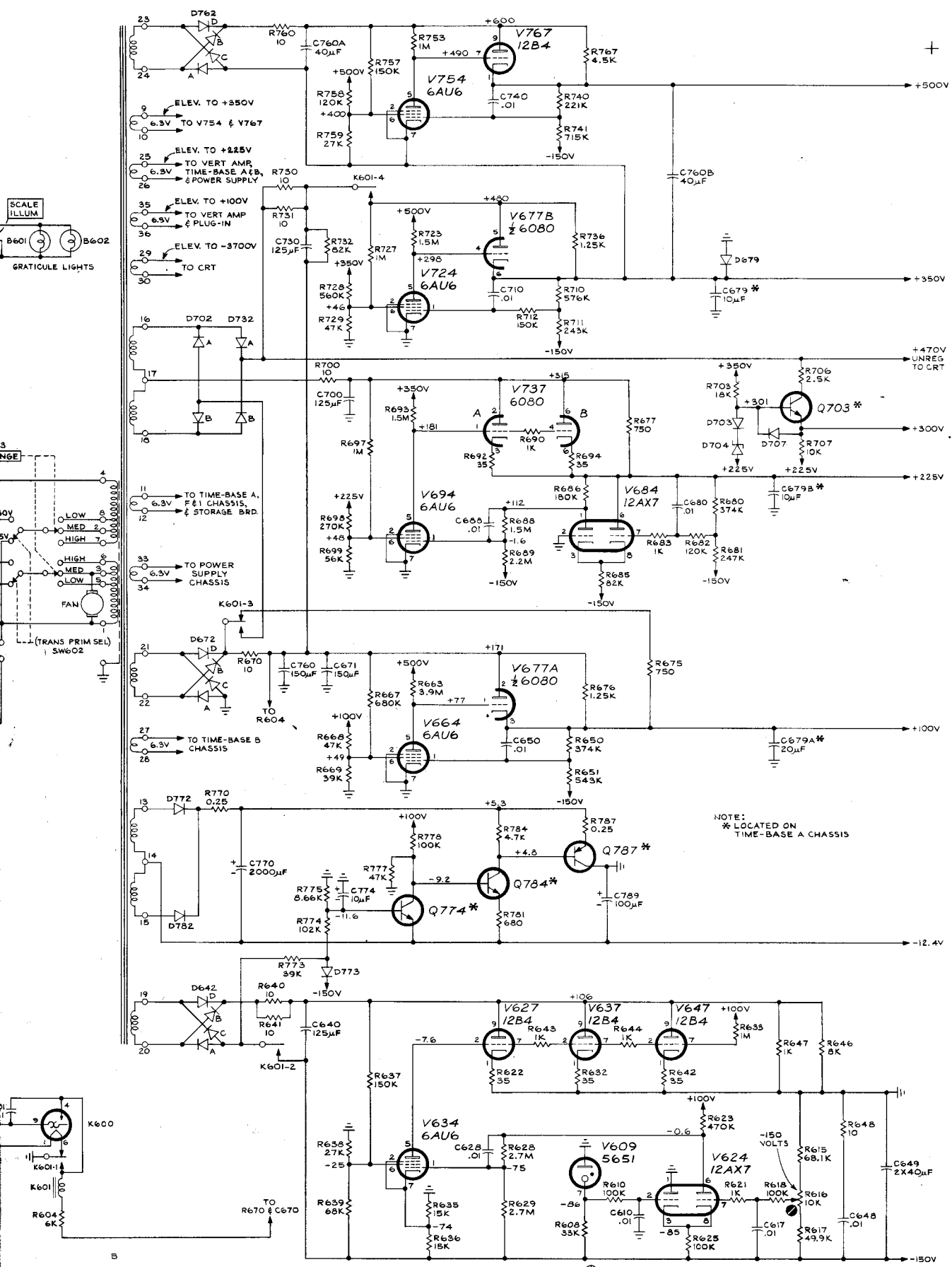
- REFERENCE DIAGRAMS**
- ① VERTICAL AMPLIFIER
 - ② TIME-BASE A TRIGGER
 - ③ TIME-BASE B TRIGGER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

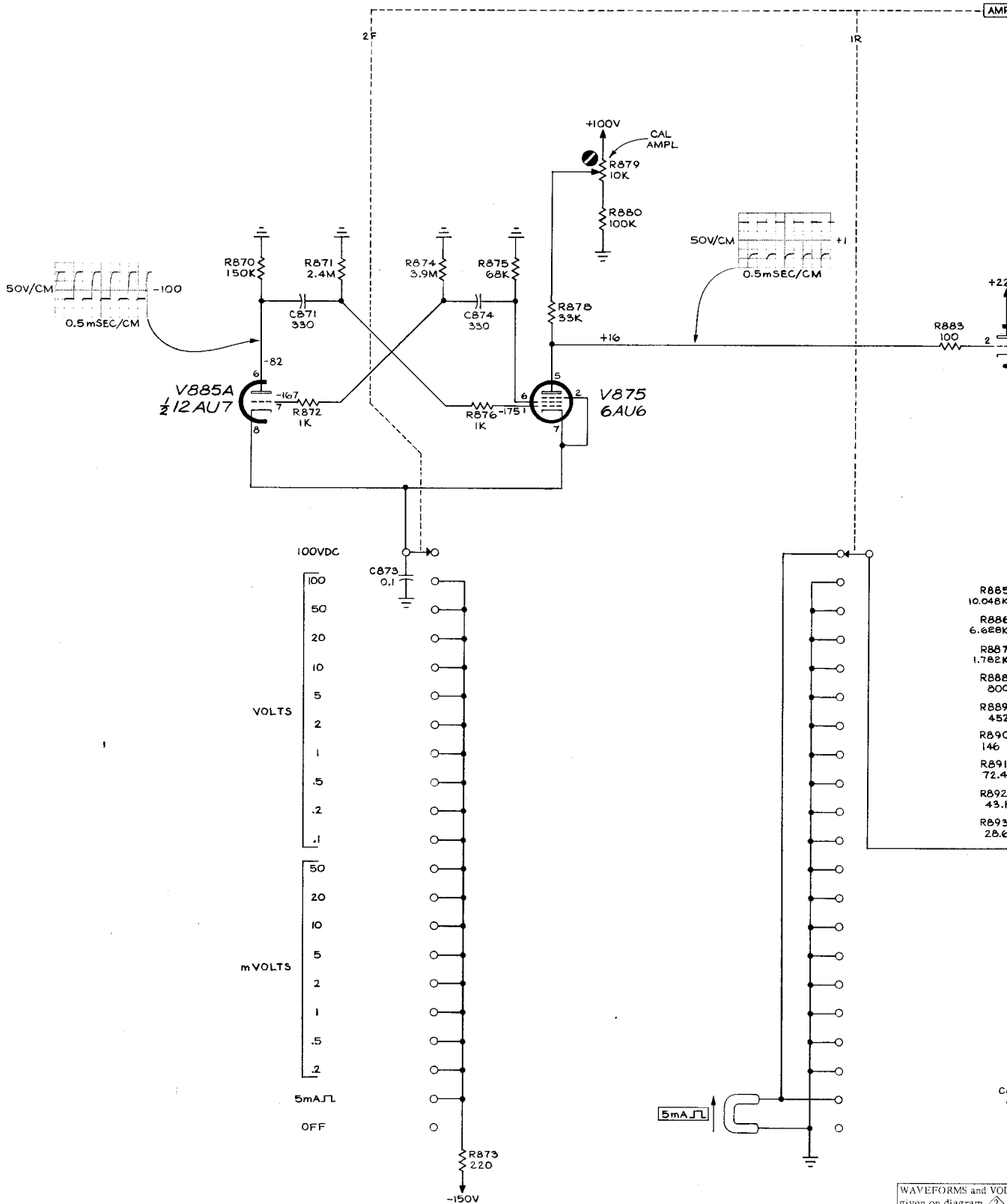
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

TYPE 549 STORAGE OSCILLOSCOPE



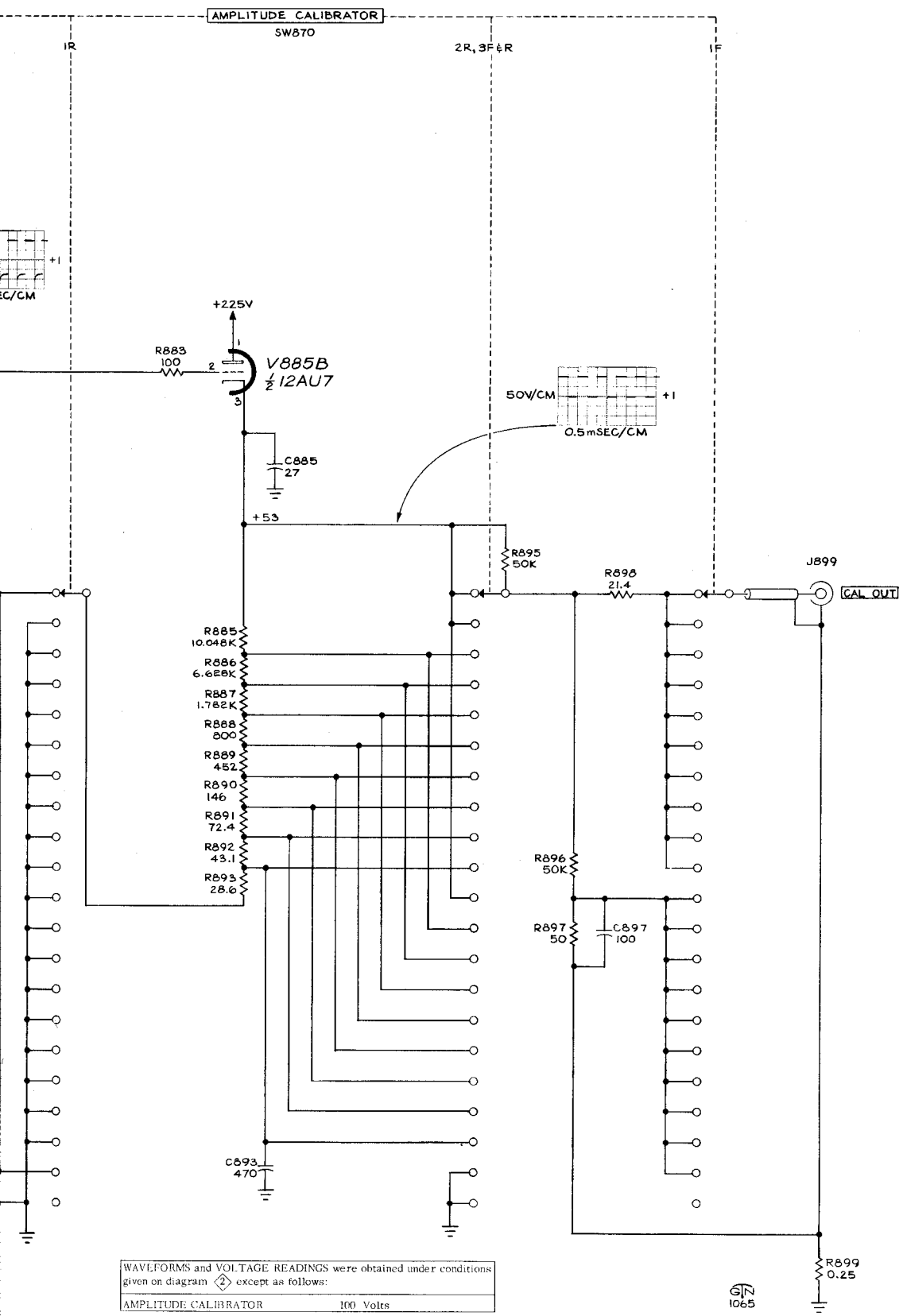


NOTE:
* LOCATED ON
TIME-BASE A CHASSIS



TYPE 549 STORAGE OSCILLOSCOPE

+

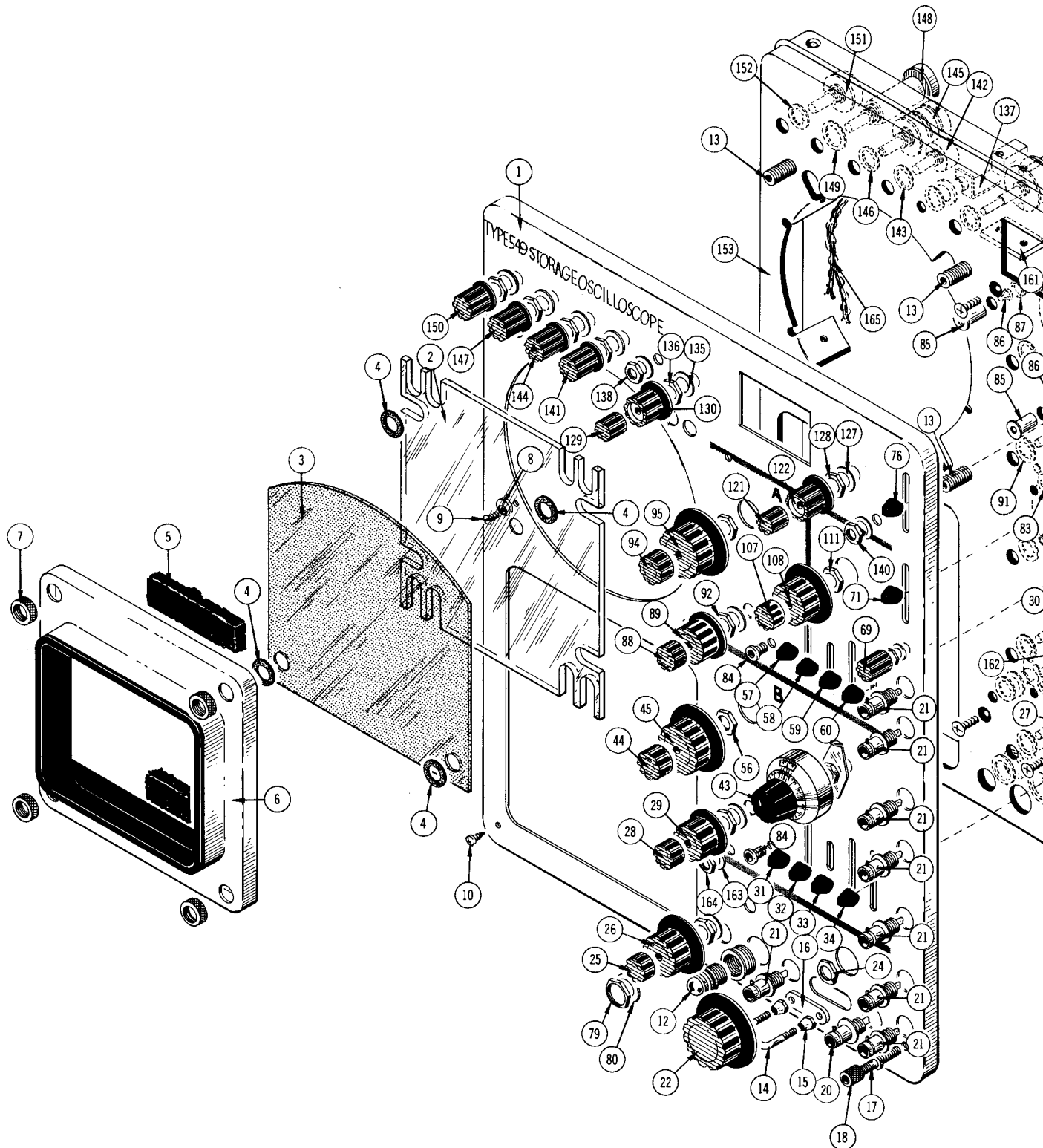


WAVEFORMS and VOLTAGE READINGS were obtained under conditions given on diagram (2) except as follows:
 AMPLITUDE CALIBRATOR 100 Volts

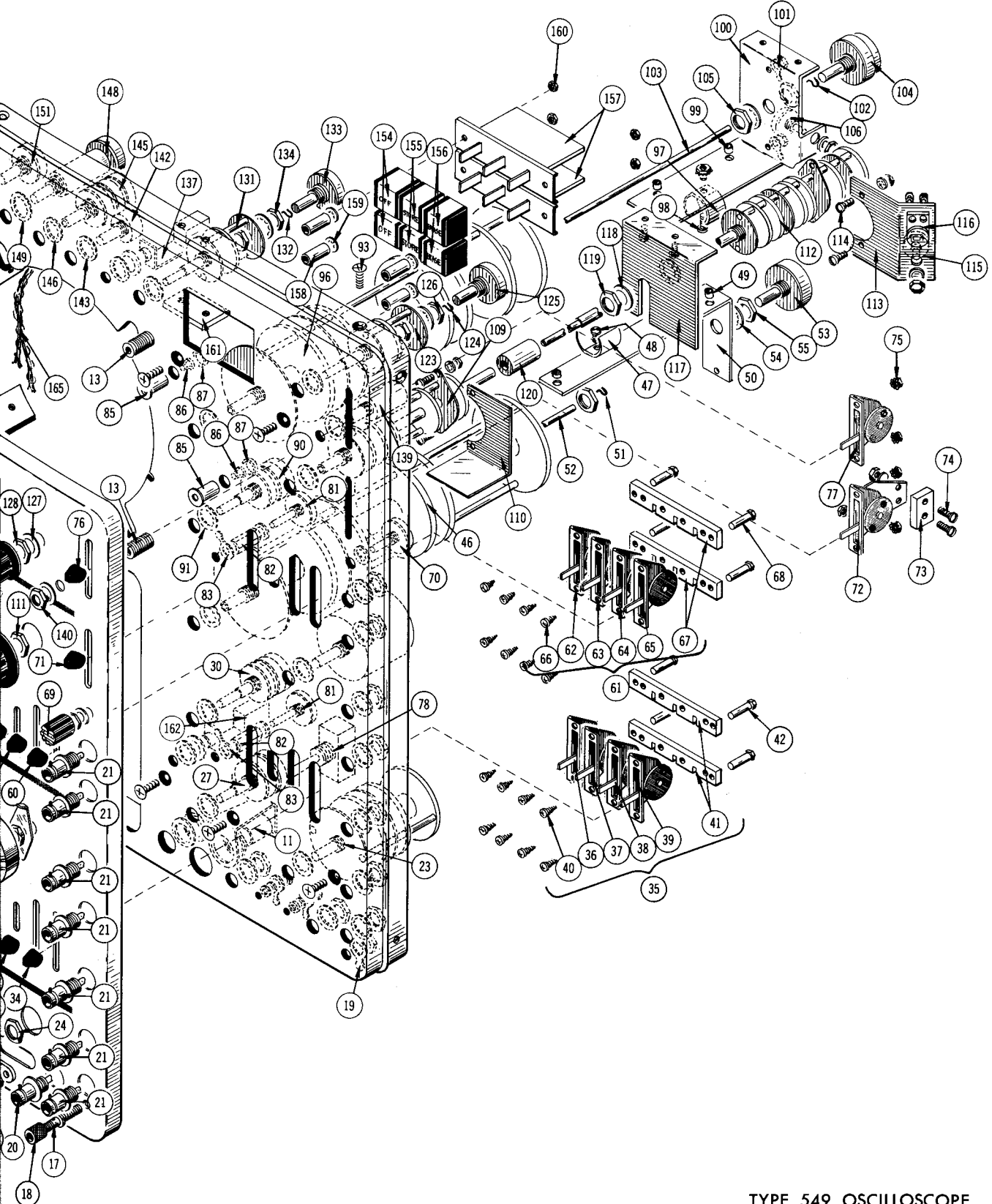
CALIBRATOR (6)

A₁

FIG. 1 FRONT AND SWITCHES

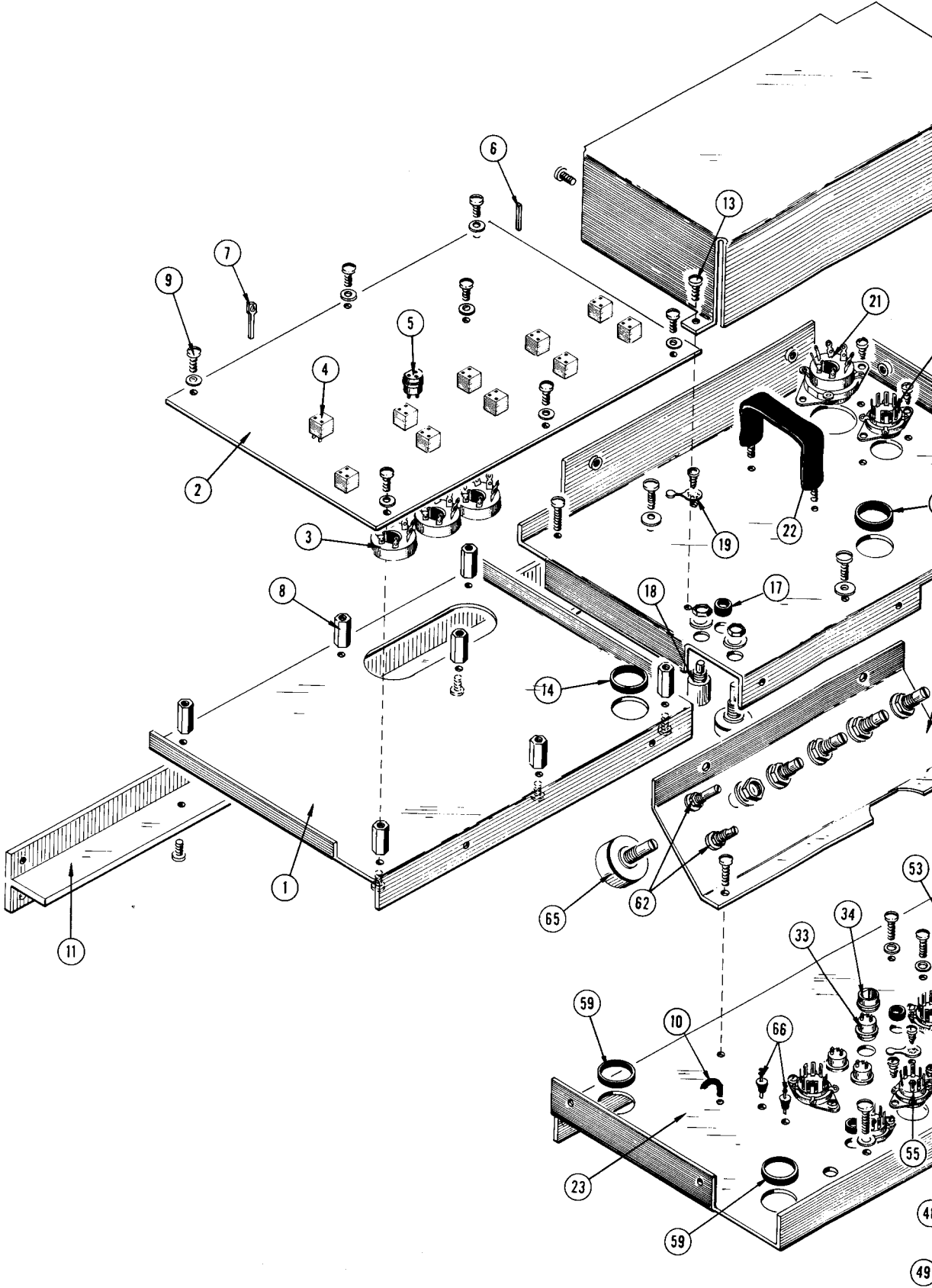


1 FRONT AND SWITCHES

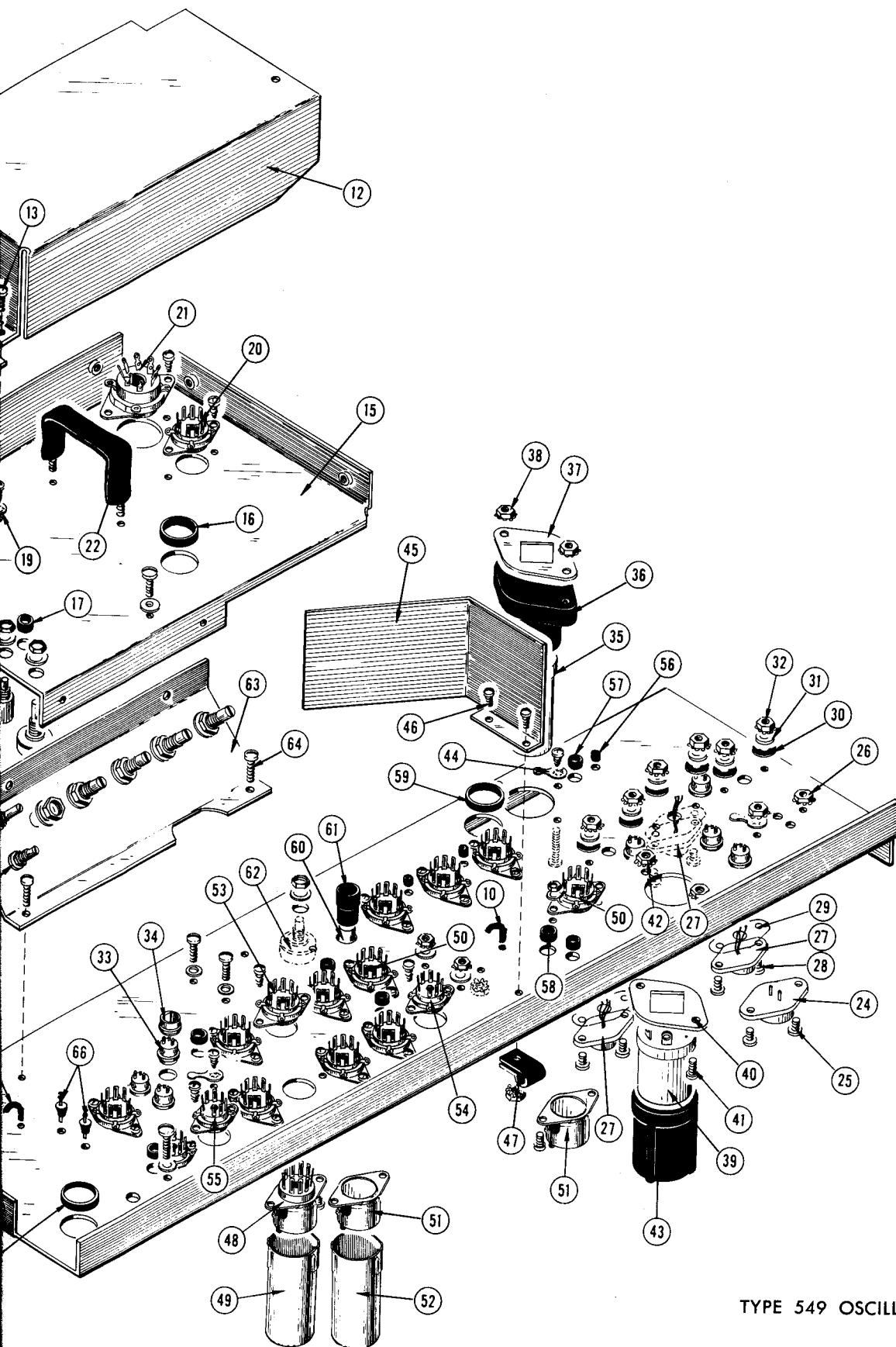


TYPE 549 OSCILLOSCOPE

FIG. 2 FOCUS & INTENSITY, HIGH VOLTAGE, STORAGE E

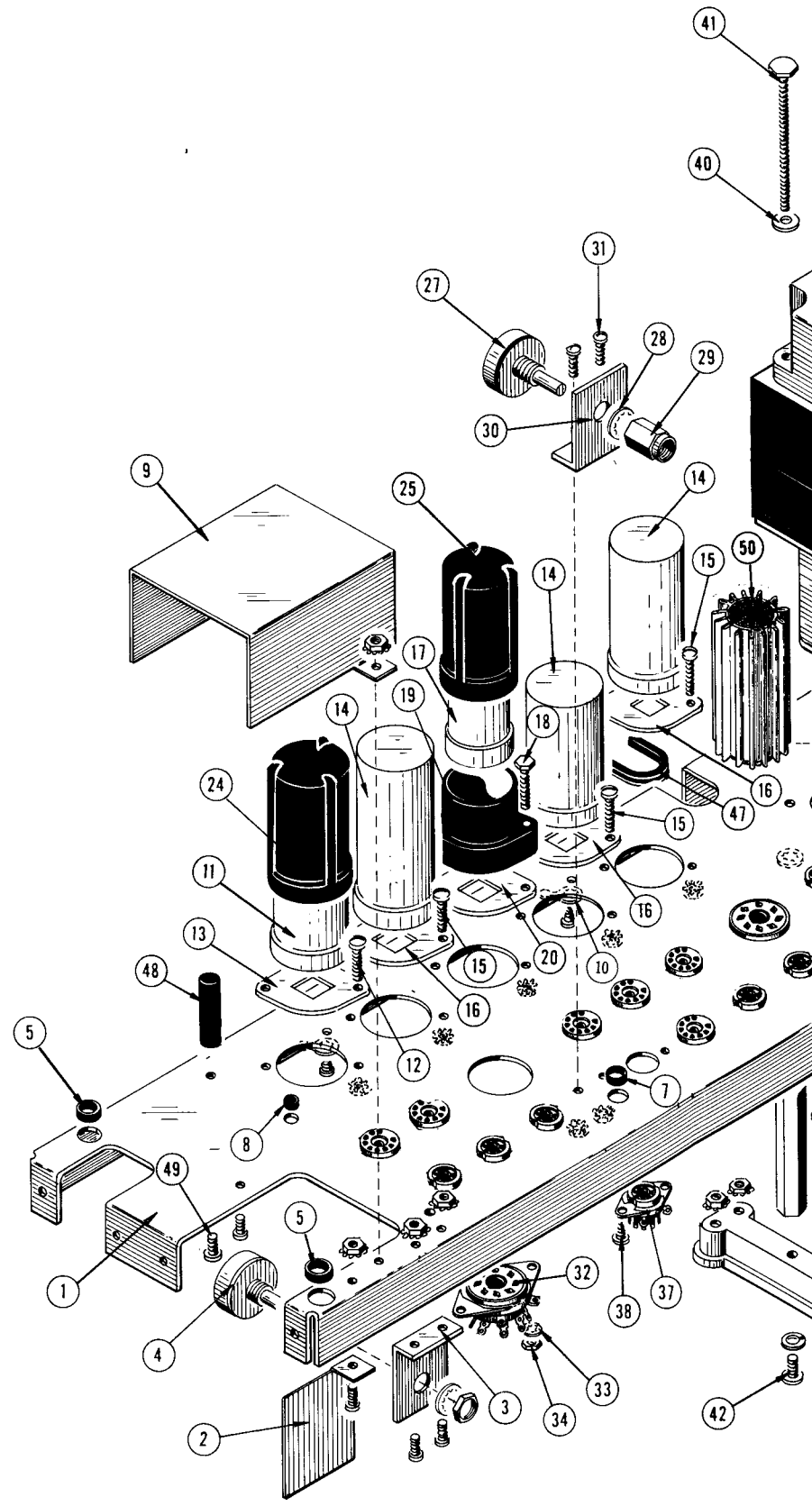


HIGH VOLTAGE, STORAGE BOARD AND A SWEEP

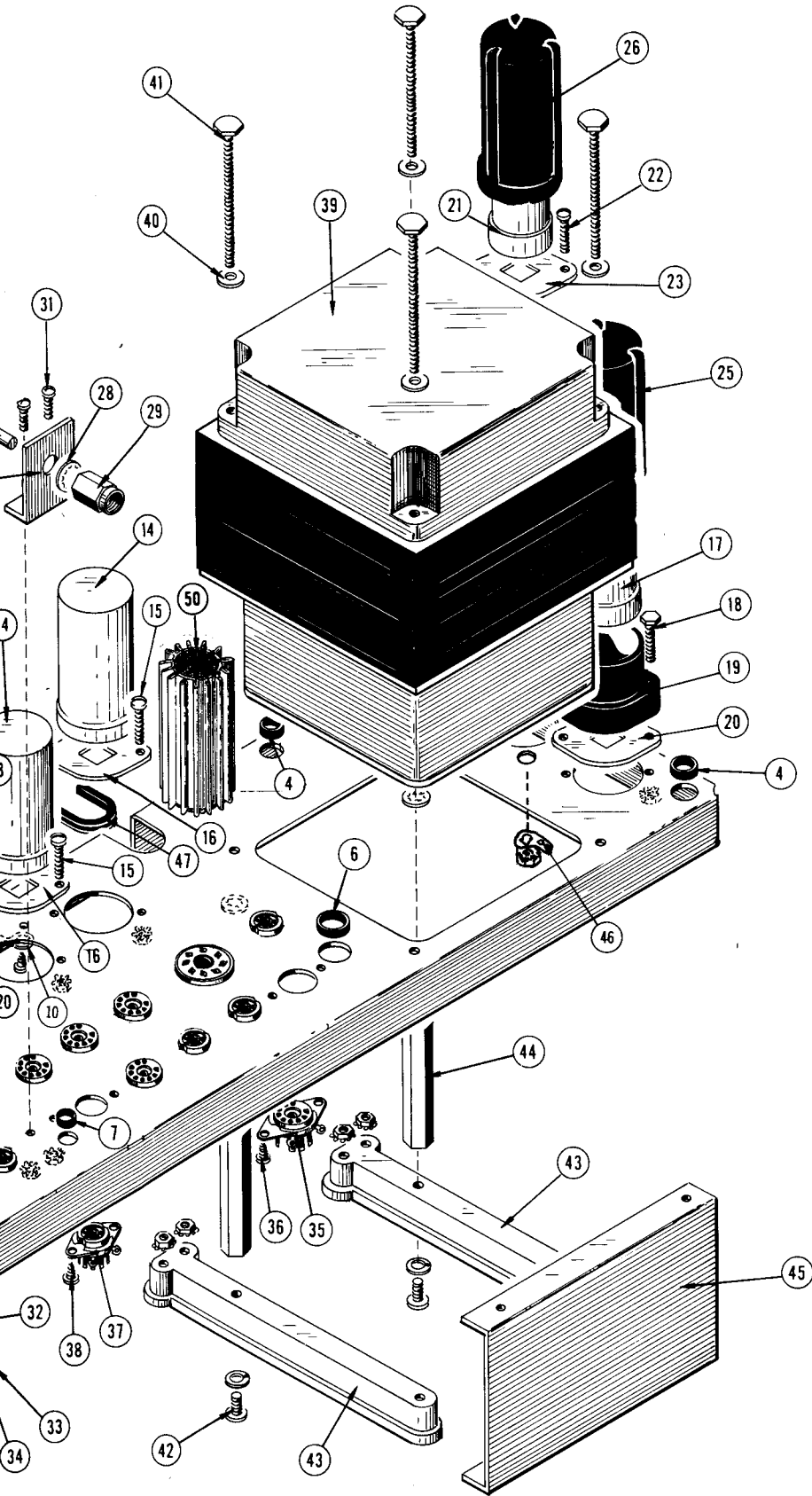


TYPE 549 OSCILLOSCOPE

FIG. 3 LOW VOLTAGE POW

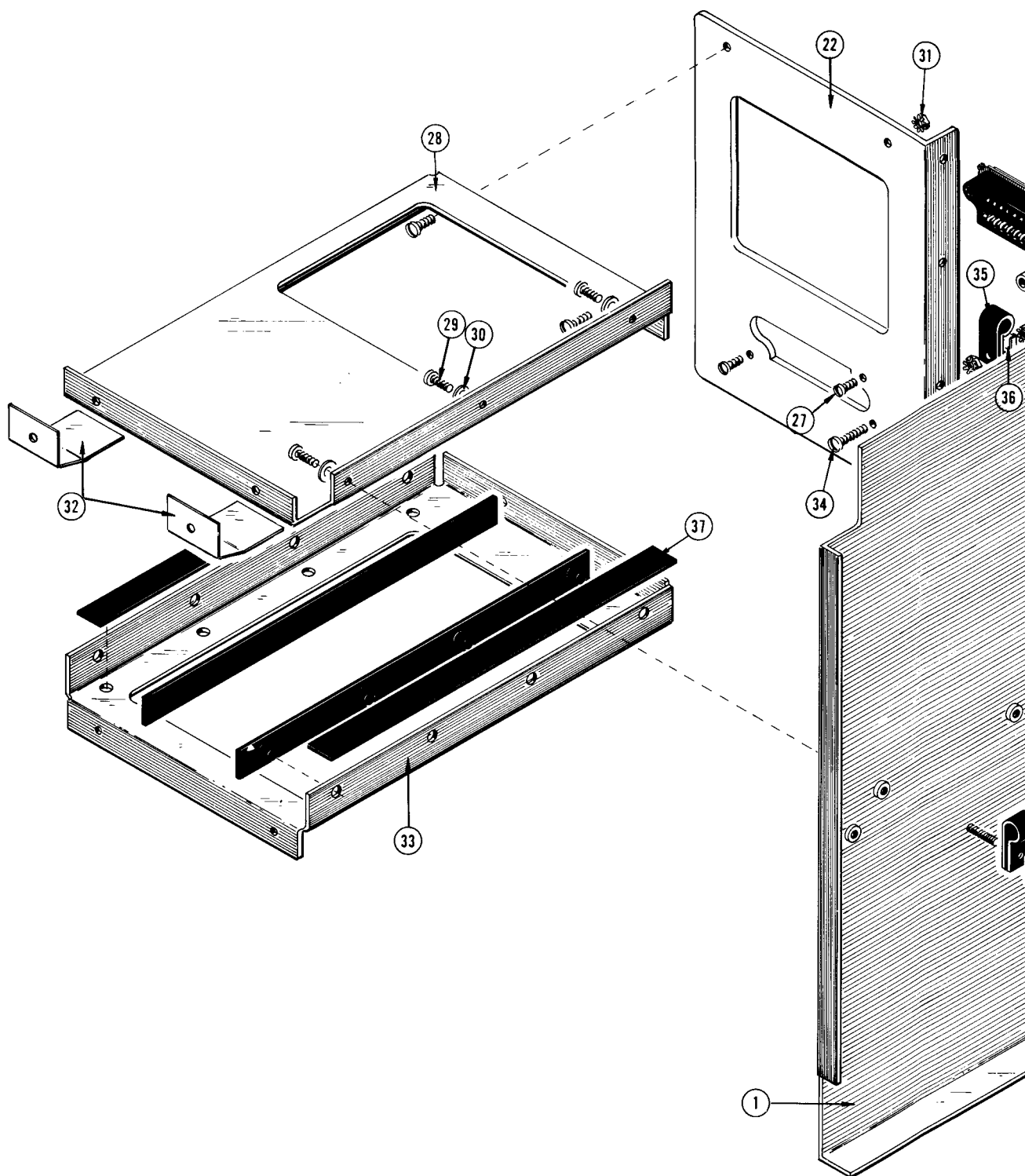


G. 3 LOW VOLTAGE POWER

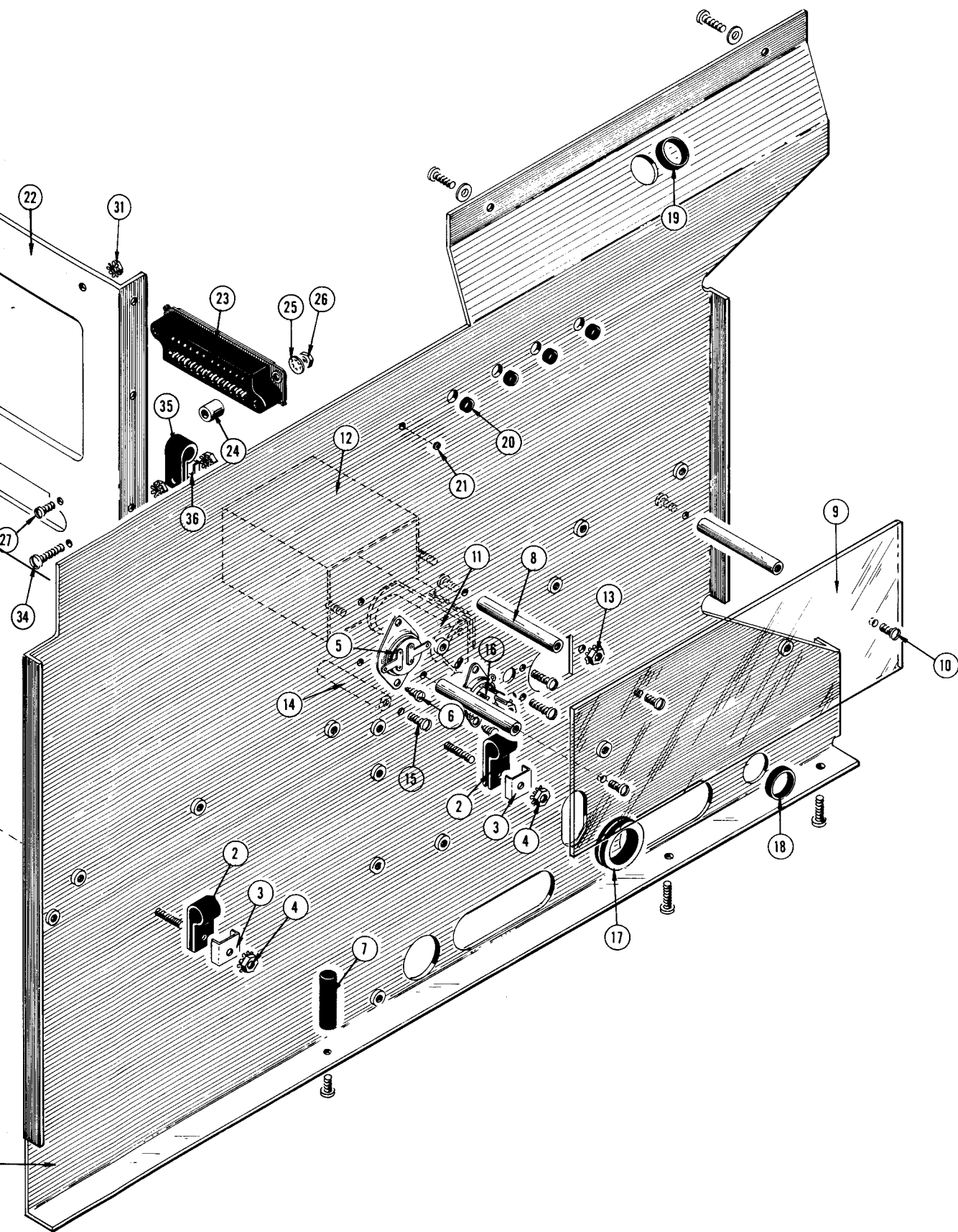


TYPE 549 OSCILLOSCOPE

FIG. 4 RECTIFIER MOUNTING



4 RECTIFIER MOUNTING PLATE



TYPE 549 OSCILLOSCOPE

FIG. 5 LOWER VERTICAL AMPLIFIER

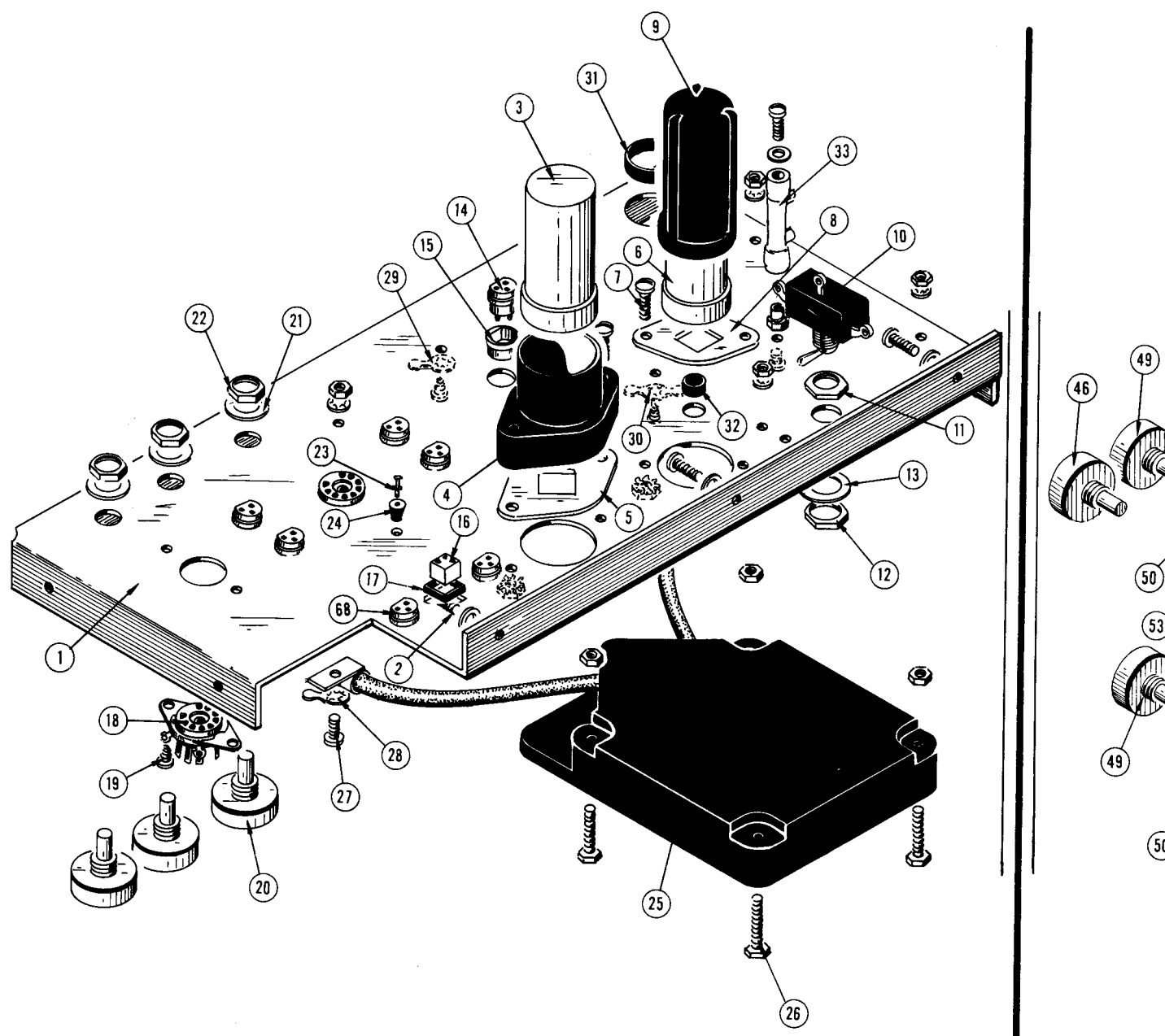
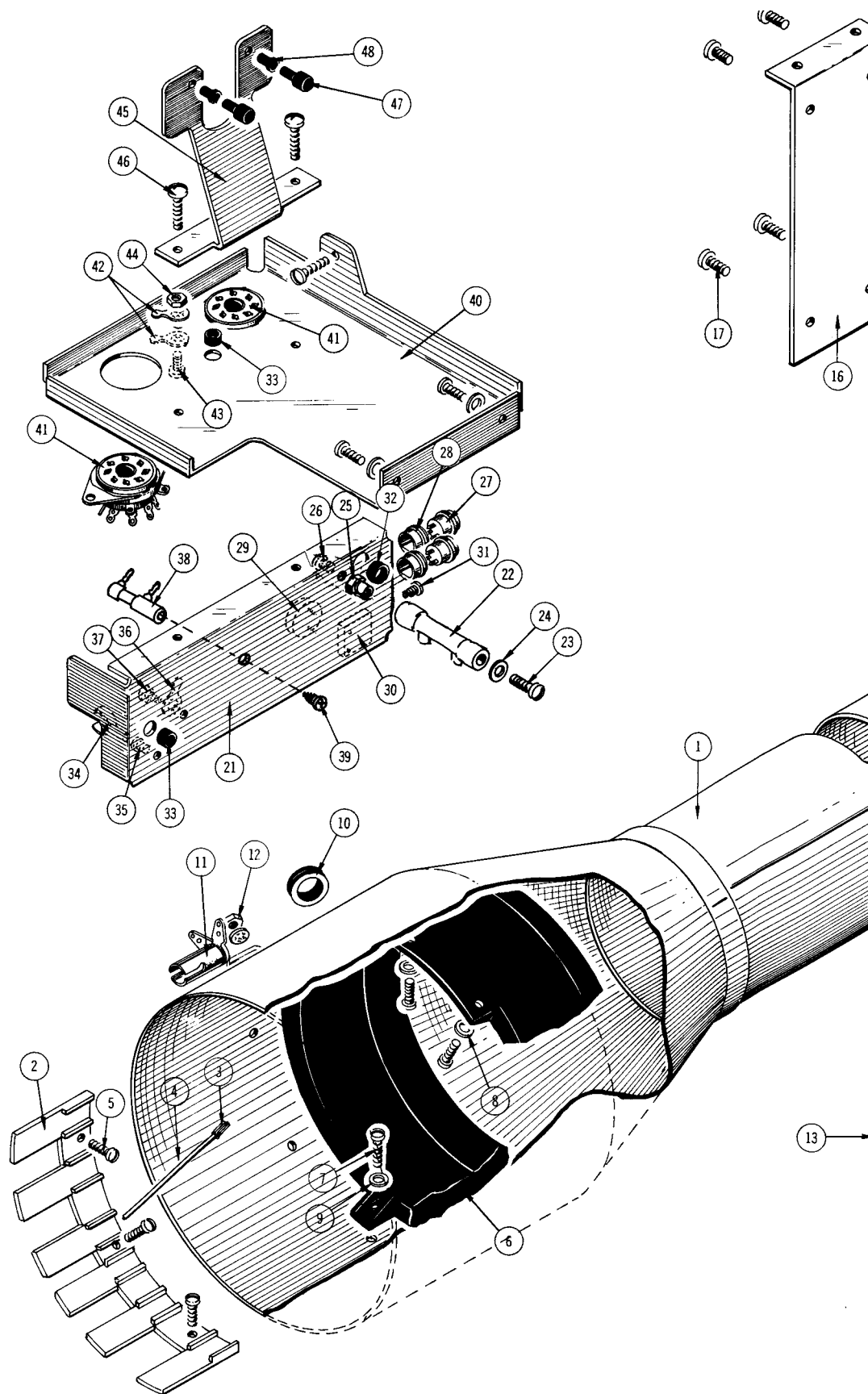


FIG. 6 CATHODE RAY TUBE SHIELD, MOUNTING BRACKET



LD, MOUNTING BRACKETS AND UPPER VERTICAL AMPLIFIER

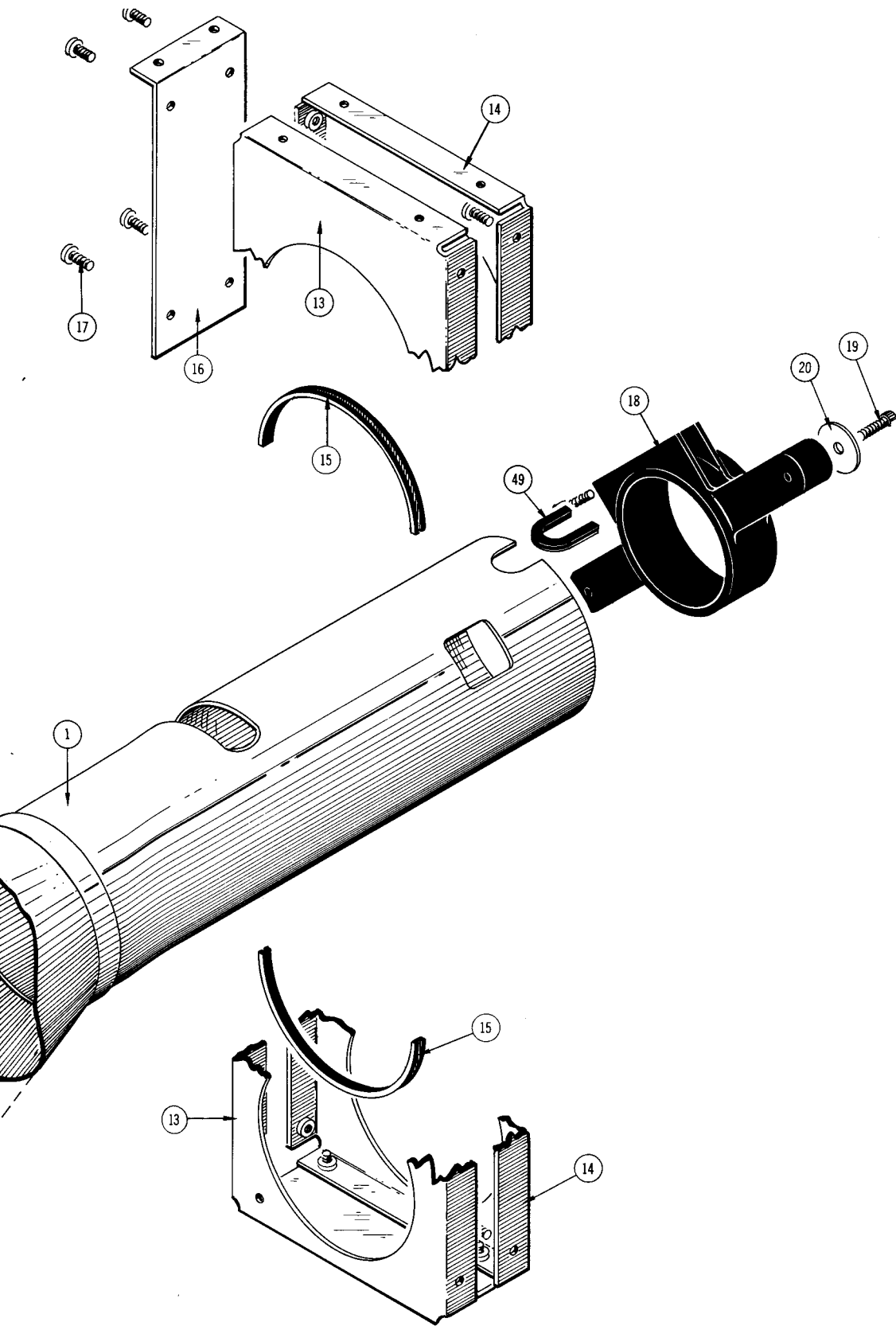
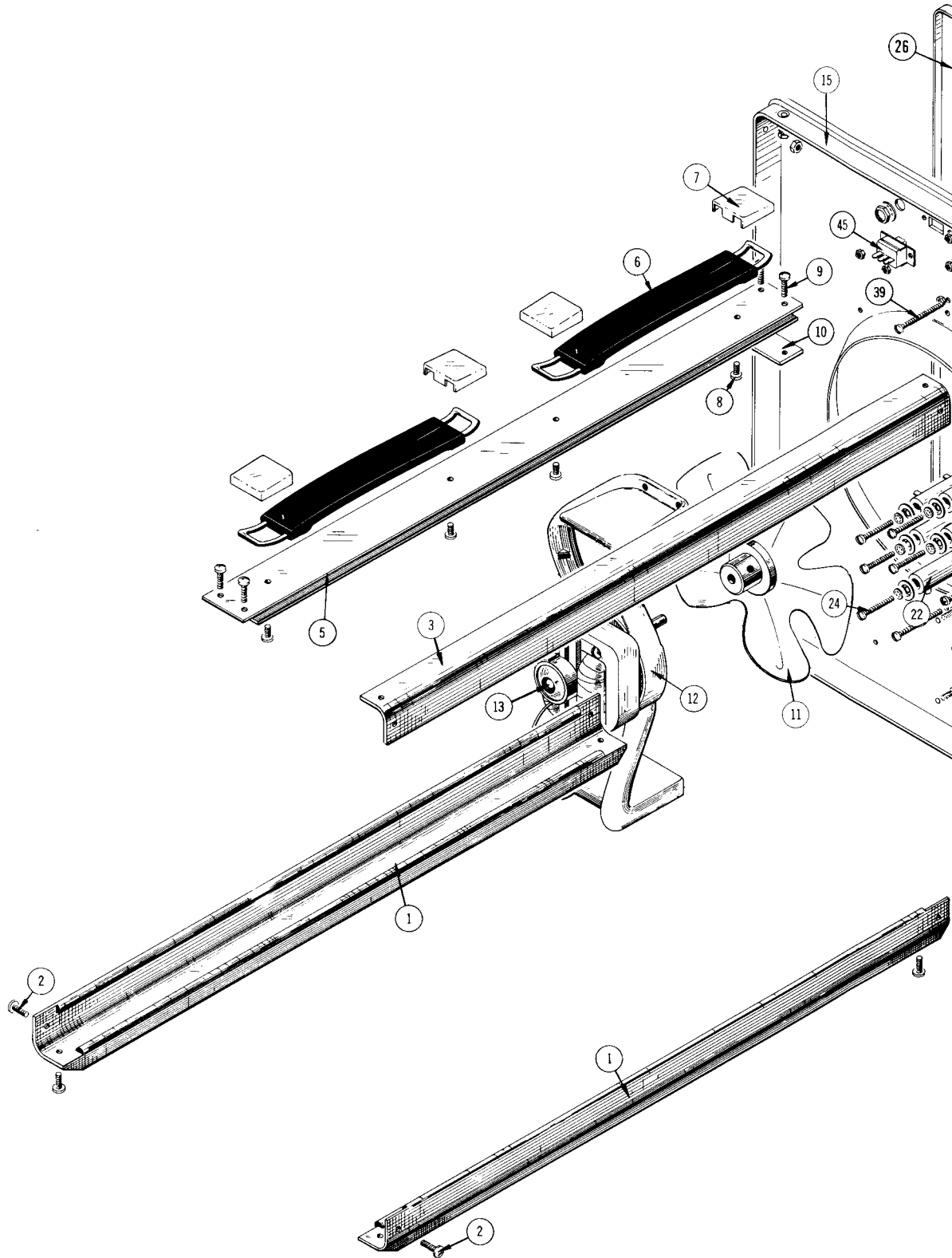
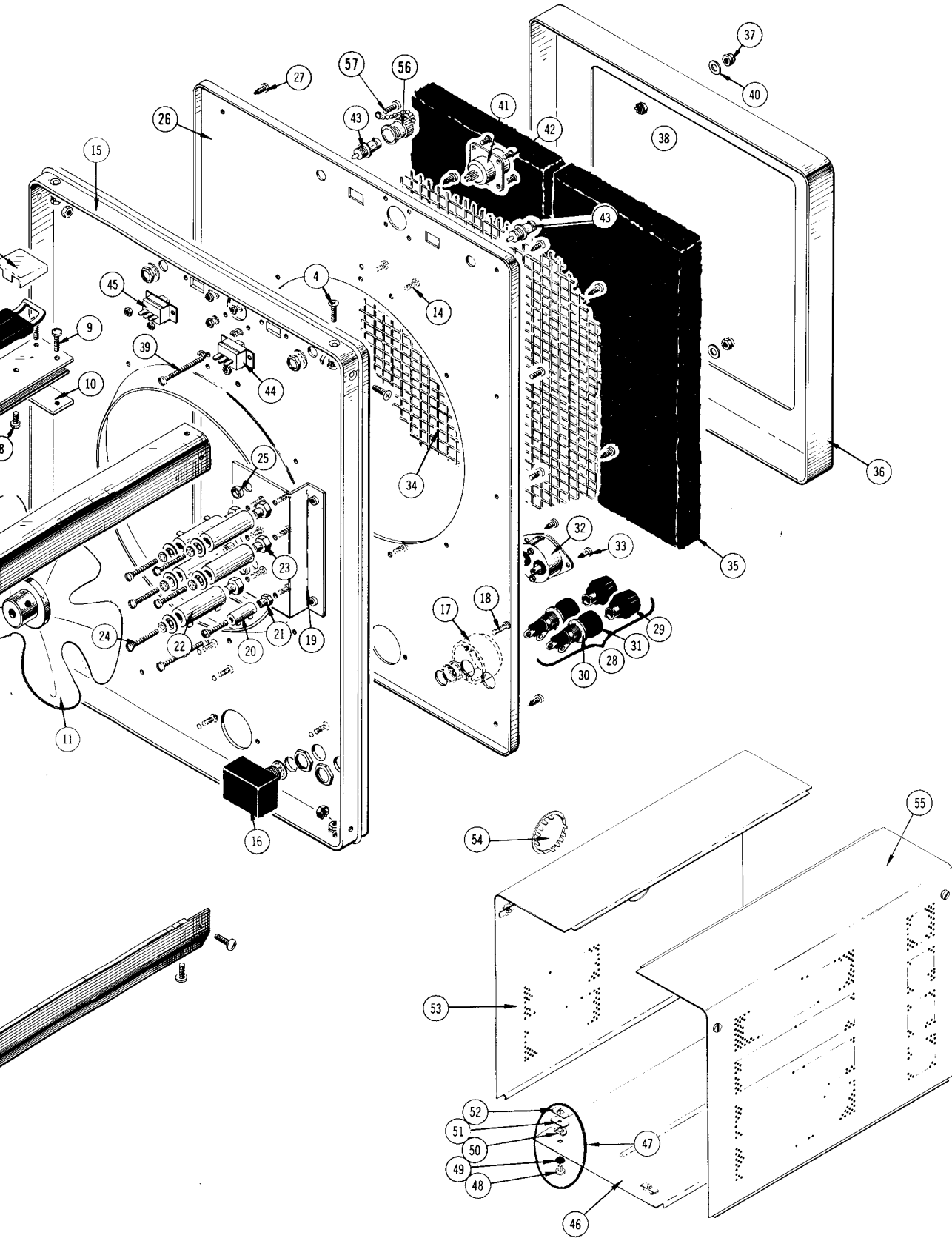


FIG. 7 RAILS AND REAR



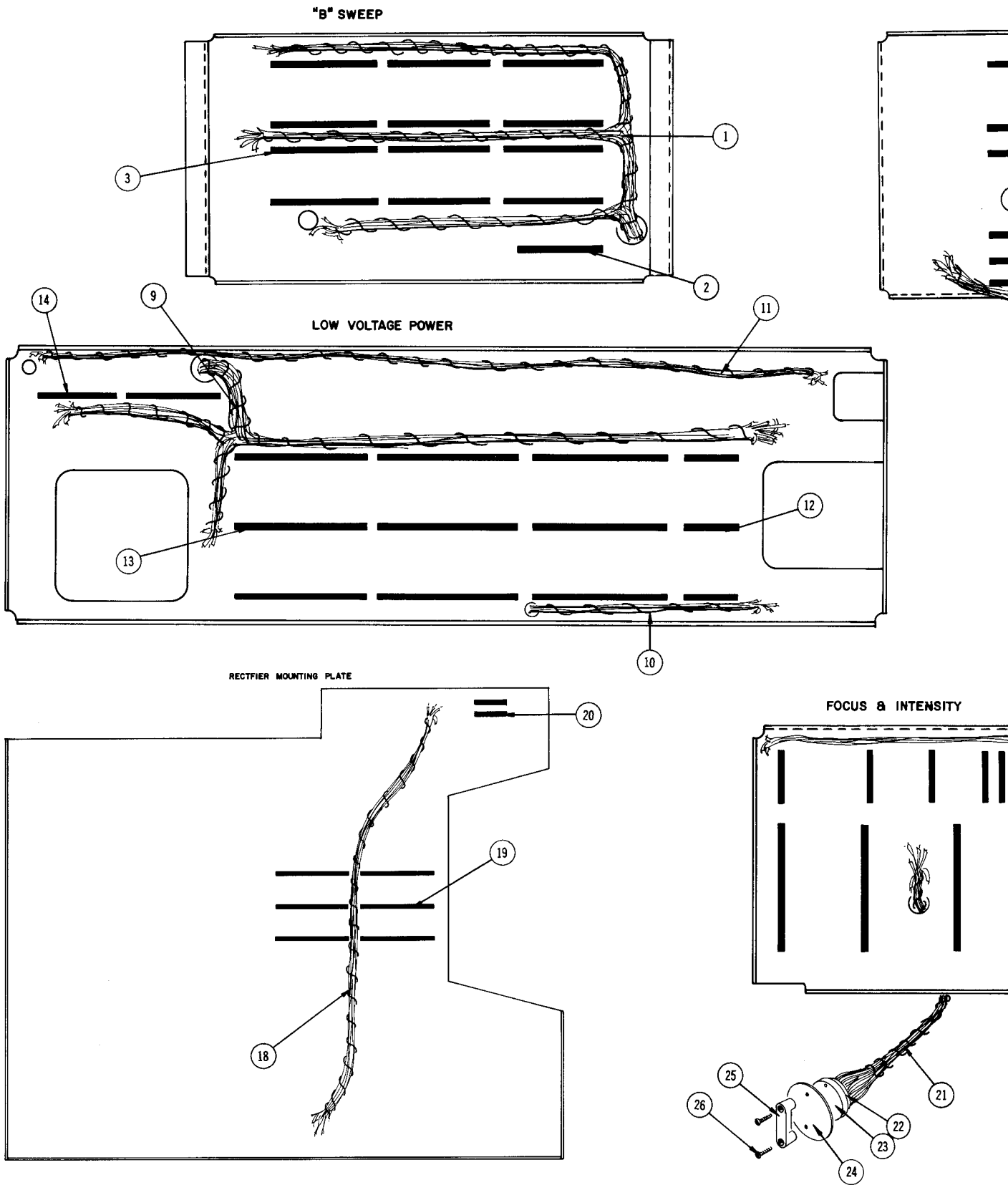
7 RAILS AND REAR

+



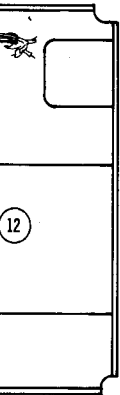
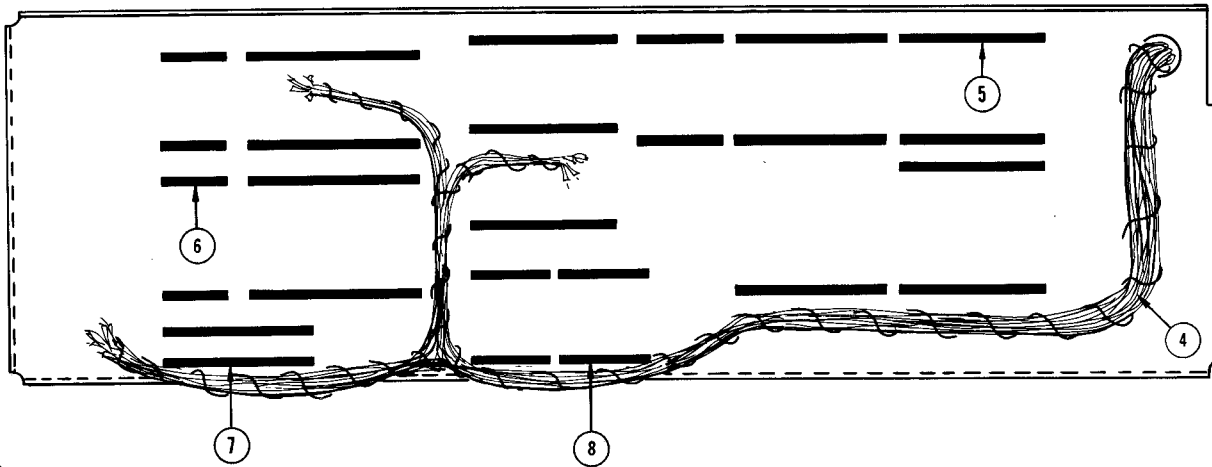
TYPE 549 OSCILLOSCOPE

FIG. 8 CERAMIC STRIPS AND CABLE HARNESS

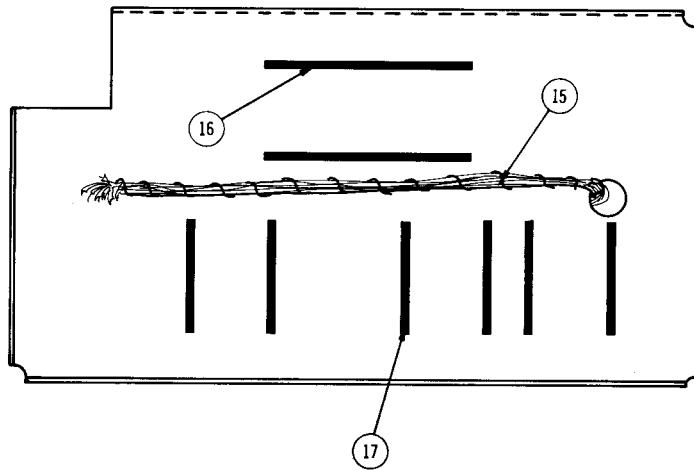


STRIPS AND CABLE HARNESS DETAIL

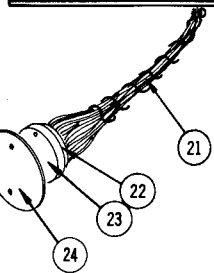
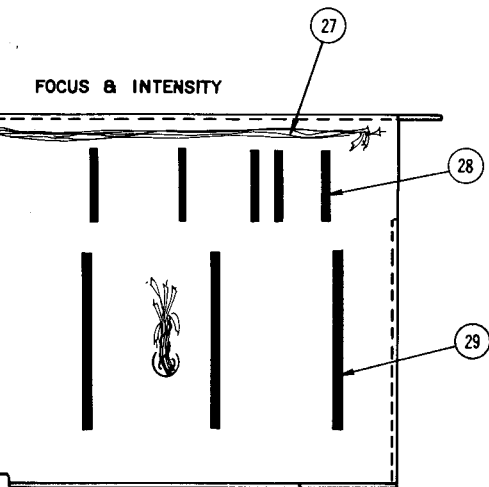
"A" SWEEP



LOWER VERTICAL AMPLIFIER



FOCUS & INTENSITY



UPPER VERTICAL AMPLIFIER

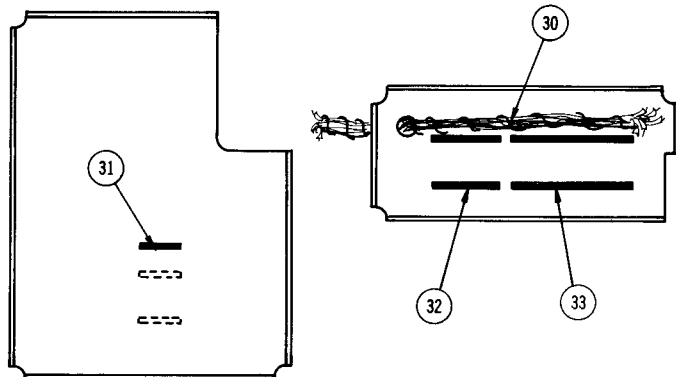


FIG. 9 STANDARD ACCESSORIES

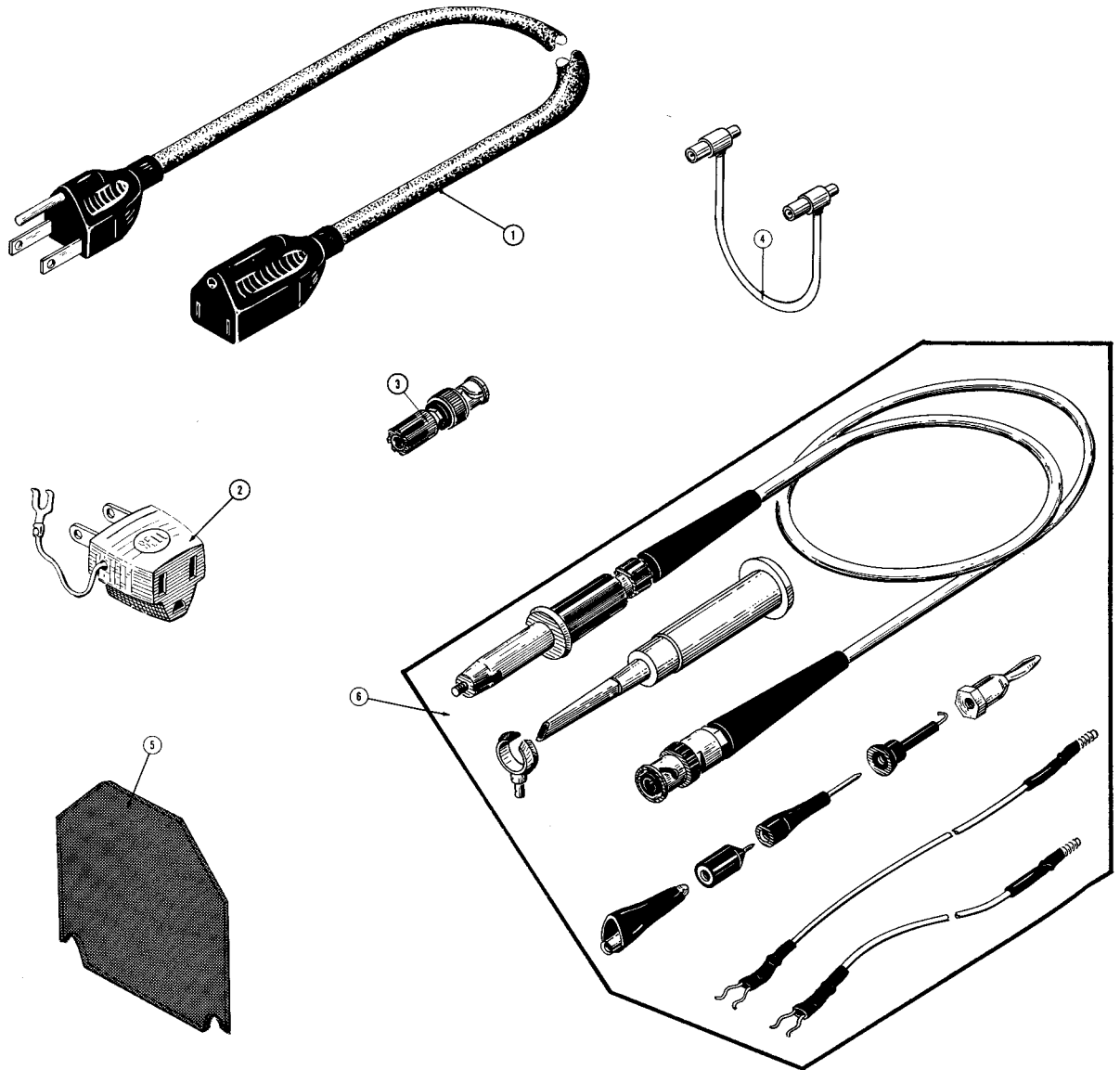


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
9-1	161-0010-00			1						CORD, power, 16 ga 8 ft., 3 wire
-2	103-0013-00			1						ADAPTER, power cord, 3 to 2 wire
-3	103-0033-00			1						ADAPTER, BNC to binding post
-4	012-0087-00			2						PATCH CORD, BNC to BNC, red, 18 inches long
-5	378-0567-00			1						FILTER, light, smoke gray
-6	010-0127-00			2						PROBE PACKAGE, P6006
	070-0508-00			2						MANUAL, instruction (not shown)

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 549

PARTS LIST CORRECTION

CHANGE TO:

R515	315-0360-00	36 Ω	1/4 W	5 %
R516	315-0360-00	36 Ω	1/4 W	5 %
R519	315-0510-00	51 Ω	1/4 W	5 %
R520	311-0372-00	750 Ω	Var	

TYPE 549

TEXT CORRECTION

Section 5 Performance Check

Page 5-9

Step 28. Check Vertical Amplifier Risetime

ADD: at the end of Step 28a:

NOTE

A side cover must be in place on the left side of the instrument for Steps 28, 29 and 30.

Section 6 Calibration

Page 6-37

Step 42. Adjust High Frequency Response

ADD: at the end of Step 42a:

NOTE

A side cover must be in place on the left side of the Type 549 when the high frequency response is being adjusted and checked in Steps 42 through 46. The adjustments described in Step 42c can be made if the right-hand side cover is used on the left side of the instrument. This allows access to the adjustments L554, L588, L589, L598, L599, C560, C568, C581 and R580 through the vent holes in the panel. (The panel will have to be raised slightly to gain access to L588 and L598.) After the calibration is completed be sure that the left side cover is replaced on the left side of the instrument. This is necessary to insure proper circulation of air through the instrument.

TYPE 549

TENT SN 1390

PARTS LIST CORRECTION

CHANGE TO:

V24, V74, V494

157-0122-00

6DJ8

TYPE 549

TENT SN 1450

PARTS LIST CORRECTION

CHANGE TO:

R855	311-0671-00	2 MΩ	Var	
R856	305-0685-00	6.8 MΩ	2 w	5 %
R860	311-0670-00	3 MΩ	Var	