K4XL's  BAMA

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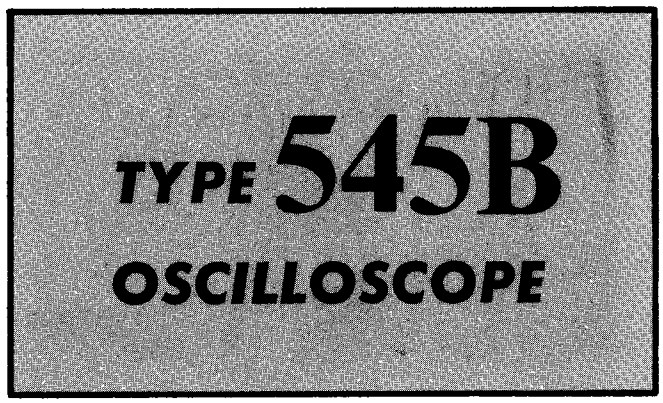
INSTRUCTION MANUAL

Serial Number _____



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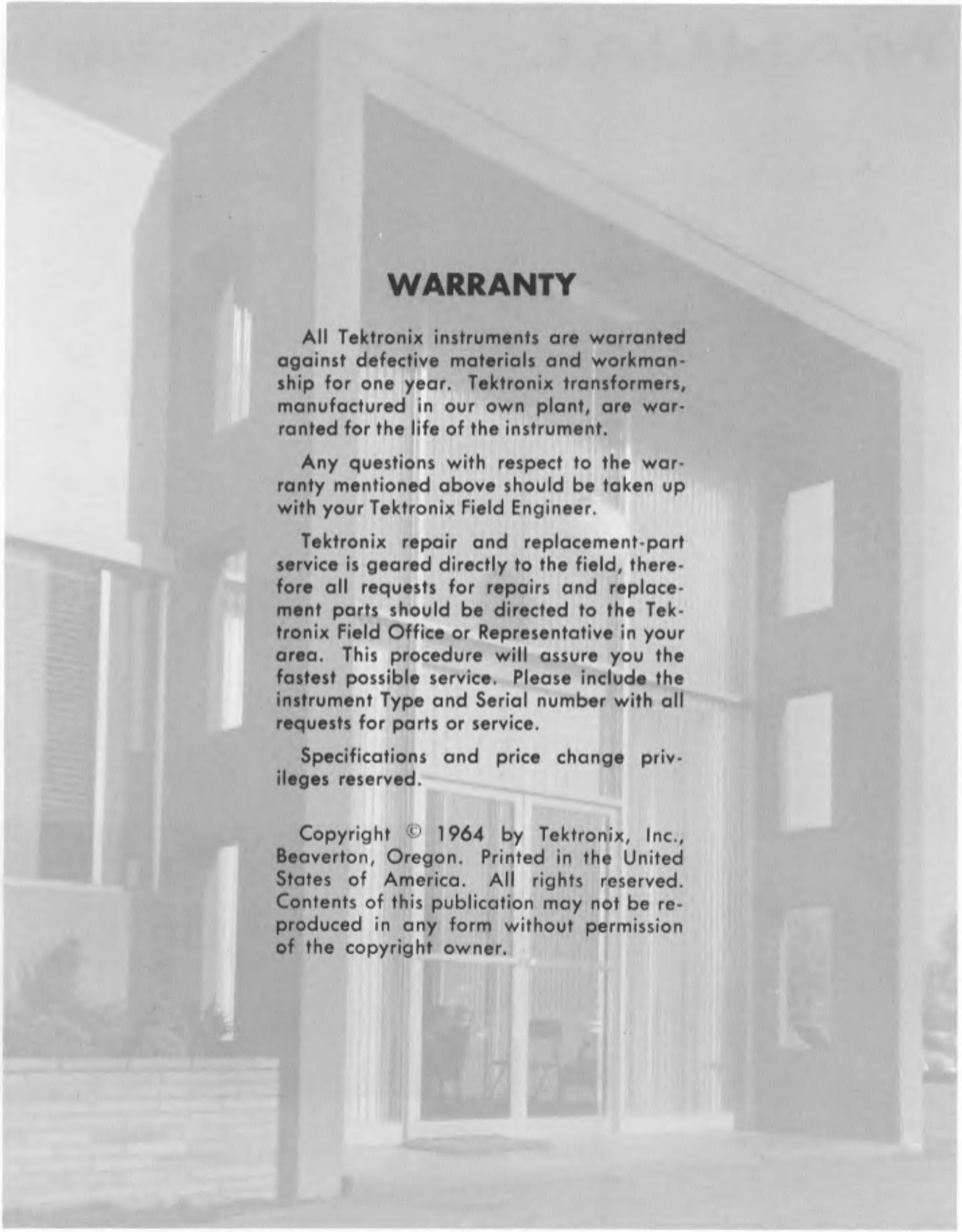
070-428



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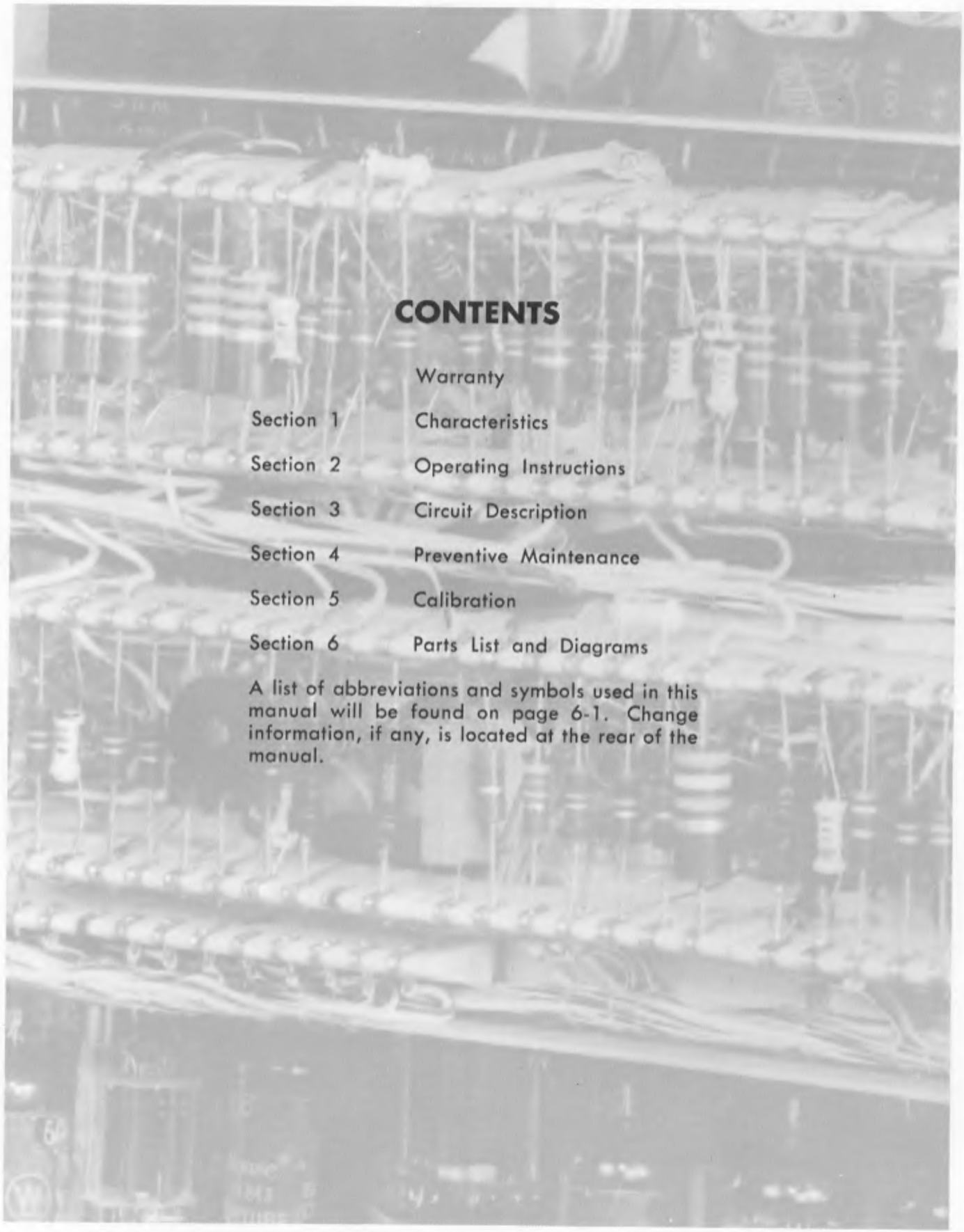


CONTENTS

A list of abbreviations and symbols used in this manual will be found on page 6-1. Change information, if any, is located at the rear of the manual.

The Type 545B Oscilloscope

SECTION 1
CHARACTERISTICS

Introduction

The Type 545B Oscilloscope is a versatile laboratory instrument designed for use with all Tektronix letter- or 1-series plug-in units. The instrument features two time-base generators.

The two time-base generators can be used in "delaying" and "delayed" sweep operation for highly accurate time measurements.

Vertical Deflection System

Refer to Table 1-1 for the characteristics.

Sweep Generation

Time Base A

Sweep Rates — 0.1 μsec/cm to 5 sec/cm in 24 calibrated steps. Displayed sweep-rate accuracy is ±3%. An uncalibrated variable sweep-rate control permits the sweep to be slowed to at least 0.4 times the indicated rate.

5× Sweep Magnification — Any sweep rate can be increased 5 times by expanding the center portion of the display horizontally. Sweep-rate accuracy is within ±3% in the magnified position.

Trigger Source Selection — Internal, external, and line.

Trigger Mode Selection — Automatic, dc, ac, and ac low-frequency rejection.

Trigger Signal Requirements — Internal (ac): Minimum deflection is 2 mm from 150 cps to 10 mc, rising to 1 cm at 30 mc with less than 1 mm of horizontal jitter at a sweep rate of 20 nsec/cm.

Internal (dc): Minimum deflection is 6 mm up to a frequency of 10 mc.

Internal (ac low-frequency rejection): Minimum deflection is 2 mm from 30 kc to 10 mc rising to 1 cm at 30 mc with less than 1 mm of horizontal jitter at a sweep rate of 20 nsec/cm.

Internal (automatic): 5 mm deflection at 150 cps. Will trigger from 50 cps to 10 mc with increased deflection.

External (ac): Minimum amplitude is 0.2 volt from 150 cps to 10 mc, rising to 1 volt at 30 mc with less than 1 mm of horizontal jitter at a sweep rate of 20 nsec/cm.

External (ac low-frequency rejection): Minimum deflection is 0.2 volt from 30 kc to 10 mc, rising to 1 volt at 30 mc with less

TABLE 1-1

Plug-In Characteristics for the Type 545B Oscilloscope

Plug-In Unit	Calibrated Deflection Factor	Minimum Bandpass	Risetime	Input Capacitance
Type 1A1*	50 mv/cm to 20 v/cm 5 mv/cm	dc to 33 mc dc to 23 mc	10.6 nsec 15.2 nsec	15 pf
Type 1A2*	50 mv/cm to 20 v/cm	dc to 33 mc	10.6 nsec	15 pf
Type B	0.005 v/cm to 20 v/cm 0.05 v/cm to 20 v/cm	2 cps to 12 mc dc to 20 mc	30 nsec 18 nsec	47 pf
Type CA*	0.05 v/cm to 20 v/cm	dc to 24 mc	15 nsec	20 pf
Type D	1 mv/cm to 50 v/cm	dc to 300 kc-2 mc	0.18 μsec	47 pf
Type E	50 μv/cm to 10 mv/cm	0.06 cps to 20 kc -60 kc	6 μsec	50 pf
Type G	0.05 v/cm to 20 mv/cm	dc to 20 mc	18 nsec	47 pf
Type H	5 mv/cm to 20 v/cm	dc to 15 mc	23 nsec	47 pf
Type K	0.05 v/cm to 20 v/cm	dc to 30 mc	12 nsec	20 pf
Type L	5 mv/cm to 2 v/cm 0.05 v/cm to 20 v/cm	3 cps to 24 mc dc to 30 mc	15 nsec 12 nsec	20 pf
Type M*	0.02 v/cm to 10 v/cm	dc to 20 mc	17 nsec	47 pf
Type N**	10 mv/cm	dc to 600 mc	0.6 nsec	50 Ω input Z
Type O**	0.05 v/cm to 20 v/cm	dc to 25 mc	14 nsec	47 pf
Type Q**	10 μstrain/cm to 10,000 μstrain/cm	dc to 6 kc	60 μsec	Adjustable
Type R**	0.5 ma/cm to 100 ma/cm			
Type S**	0.05 v/cm to 0.5 v/cm			
Type Z**	0.05 v/cm to 25 v/cm	dc to 13 mc	27 nsec	24 pf

*Multi-channel plug-in units.

**Special feature plug-in units. See your Tektronix catalog for more information on these units.

than 1 mm of horizontal jitter at a sweep rate of 20 nsec/cm.

External (dc): Minimum amplitude is 0.2 volt up to a frequency of 10 mc, rising to 1 volt at 30 mc with less than 1 mm of horizontal jitter at a sweep rate of 20 nsec/cm.

External (automatic): 0.5 v at 150 cps. Will trigger from 50 cps to 10 mc with increased signal.

Time Base B

Sweep Rates	2 μsec/cm to 1 sec/cm in 18 calibrated steps. Displayed sweep-rate accuracy is ±3%. Length control permits the sweep to be externally adjusted to between 4 and 10 cm in length.
5× Sweep Magnification	Any sweep rate can be increased 5 times by expanding the center portion of the display horizontally. Sweep-rate accuracy is within ±3% in the magnified position.
Trigger Source Selection	Internal, external, and line.
Trigger Mode Selection	Automatic, dc, and ac.
Trigger Signal Requirements	Internal (ac): Minimum deflection is 2 mm from 300 cps to 5 mc, rising to 1 cm at 10 mc with less than 1 mm of horizontal jitter. Internal (automatic): 5 mm deflection at 300 cps. Will trigger from 50 cps to 5 mc with increased deflection. External (ac): Minimum amplitude is 0.2 volt from 300 cps to 5 mc, rising to 1 volt at 10 mc with less than 1 mm of horizontal jitter. External (dc): Minimum amplitude is 0.2 volt up to a frequency of 5 mc, rising to 1 volt at 10 mc with less than 1 mm of horizontal jitter. External (automatic): 0.5 v at 300 cps. Will trigger from 50 cps to 5 mc with increased signal.
Sweep Delay	The time base A sweep can be delayed by the time base B sweep. Delay is continuously variable from 1 μsec to 10 sec with the DELAY TIME and DELAY-TIME MULTIPILER controls. Delay time is accurate to ±1% of indicated delay, ±2 minor divisions of the DELAY-TIME MULTIPLIER dial, at sweep rates from 1 μsec to 10 sec. Incremental delay accuracy is ±0.2%. Stated accuracies apply only when the VARIABLE control is set to CALIBRATED. Delay pickoff jitter is no greater than 1 part in 20,000 of the entire sweep duration.

Horizontal Deflection System

The following characteristics apply when the HORIZONTAL DISPLAY switch is set to the EXT positions.

Deflection Factor	A maximum of 0.2 volts/cm with the VARIABLE 10-1 control set fully clockwise and the HORIZONTAL DISPLAY switch set to EXT ×1. The VARIABLE 10-1 control provides at least a 10:1 attenuation of the input signal when turned fully counterclockwise.
Frequency Reponse	Dc to 350 kc at maximum gain (30% down).
Input Characteristics	1 megohm paralleled by approximately 55 pf.

Amplitude Calibrator

Output Voltages	0.2 mvolt to 100 volts peak-to-peak in 18 steps.
Frequency	Approximately a 1-kc square wave.
Amplitude Accuracy	Peak-to-peak amplitude accuracy is ±3% of indicated value. The calibrated output at the 0.5 (.1 v into 50 Ω) position is accurate to within ±3% of the indicated value.

Front-Panel Output Signals

+GATE B	Approximately a 20-volt peak-to-peak square-wave pulse having the same duration as the B sweep. Minimum dc load resistance is 5 k.
DLY'D TRIG	Approximately a 5-volt peak-to-peak pulse occurring at the end of the delay period.
SAWTOOTH A	Approximately a 130-volt, peak-to-peak sawtooth voltage having the same duration as the A sweep. Minimum allowable load resistance is 100 k.
+GATE A	Approximately a 20-volt peak-to-peak square-wave pulse having the same duration as the A sweep. Minimum dc load resistance is 5 k.
VERT SIG OUT	Vertical signal output connector. Output amplitude is at least 1.2 volts/cm of deflection on the crt. Output is ac coupled.

Cathode-Ray Tube

Type	T5470-31-2.
Unblanking	Dc coupled.
Accelerating Potential	10 kv.
Usable Viewing Area	6-cm high by 10-cm wide.
Focus	Vertical: 2 horizontal lines/mm distinguishable over the center 4 cm. 1.5 horizontal

	lines/mm distinguishable in the top and bottom 1 cm. Horizontal: 2 time markers/mm distinguishable over the middle 8 cm. 1.5 time markers/mm distinguishable in the first and tenth cm.
Phosphor	Type 31 phosphor is normally supplied. Other phosphors are available.
Graticule	Internal, adjustable edge lighted 6 × 10 cm with vertical and horizontal 1-cm divisions, and with 2-mm markings on the centerlines. Markings for measuring rise-time have been provided at the 2.5 cm points above and below the graticule centerline.

Power Supplies

Line Voltage	108, 115, 122, 216, 230, or 244 volts. Will regulate within ±10% of design-center voltage.
Line Frequency	50 to 60 and 400 cps.*

*With a line frequency of 400 cycles, a special fan modification is required; contact your local Tektronix Field Representative.

Power Consumption	600 watts maximum.

Mechanical

Construction	Front panel is anodized. Chassis is aluminum alloy.
Dimensions	13 inches wide × 24 inches long × 17 inches high.
Net Weight	65 pounds.

Accessories Included

	Tektronix Part No.
2 Instruction Manuals	070-428
2 P6006 Probes with BNC connectors	010-127
2 Adapters, BNC to Binding Post	103-033
1 Crt Protector Plate	387-918
1 Test Lead	012-031
1 50 Ω Cable, BNC, to BNC, 18 inches long	012-076
1 3-Wire Power Cord	161-010
1 3- to 2-Wire Adapter	103-015
1 Adapter, BNC to UHF	103-015

NOTES

SECTION 2

OPERATING INSTRUCTIONS

FUNCTION OF CONTROLS AND CONNECTORS

NOTE

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

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

STABILITY — Adjusts the oscilloscope for a stable displayed waveform. The STABILITY control can be set to the PRESET position and left there. This position provides for convenient triggering since only the TRIGGERING LEVEL control needs to be adjusted to obtain a stable display.

TRIGGERING MODE — AUTO: Permits normal triggering on simple waveforms with repetition rates higher than about 50 cps. With no trigger signal, or with a lower repetition rate, the trigger circuit free runs at approximately 40 cps and triggers the time base at this rate, providing a reference trace.

AC LF REJ: Attenuates trigger-signal frequencies below about 17 kc, allowing the trigger circuit to respond only to higher frequencies.

AC: Blocks the dc component of the triggering signal and allows triggering to take place only on the changing portion of the signal.

For frequencies below about 30 cps, use the DC position.

For best triggering at high frequencies, use an ac coupling position of the TRIGGERING MODE switch.

DC: Permits triggering on both high- and low-frequency (to dc) signals.

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

LINE: Uses a line-frequency signal as a trigger.

INT: Uses a portion of the signal applied to the vertical deflection plates of the crt as a trigger signal.

EXT: Provides external triggering on a signal applied to the TRIGGER INPUT connector.

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

TIME/CM VARIABLE (Time Base A) — Provides an uncalibrated sweep rate adjustment. The sweep rate can be slowed to at least 0.4× any setting of the TIME/CM switch. An UNCALIBRATED lamp lights when the VARIABLE control is not in the CALIBRATED position.

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

HORIZONTAL DISPLAY — A: Allows only Time Base A to display on the crt.

B: Allows only Time Base B to display on the crt.

'B' INTENSIFIED 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 BY 'B': One of the delayed sweep functions. In this position, Time Base A is displayed at the end of each delay period as determined by the B TIME/CM OR DELAY TIME and DELAY-TIME MULTIPLIER controls.

'A' SINGLE SWEEP: Allows the Time Base A generator to sweep once upon receipt of trigger signal and not sweep again until the circuit has been reset with the RESET button. Single sweep permits photographing nonrepetitive waveforms, which otherwise would not be photographed clearly.

EXT ×1 and ×10: Permit an external signal to be applied to the horizontal deflection circuit. Sensitivity is continuously variable (with the VARIABLE 10-1 control).

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

5× MAGNIFIER — Expands the sweep from the center of the graticule at any setting of the TIME/CM switch by 5 times.

DELAY-TIME MULTIPLIER 1-10 — Works in conjunction with the Time Base B TIME/CM OR DELAY TIME switch.

Varies sweep delay from 0 to 10 times the rate indicated by the Time Base B TIME/CM OR DELAY TIME switch.

HORIZONTAL POSITION and VERNIER — Positions the display along the horizontal axis of the crt.

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

POWER ON — Toggle switch for turning the instrument power on and off.

INTENSITY — Controls brightness of the display.

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 for obtaining a well-defined display.
TRACE ROTATION	Permits horizontal alignment of the trace with respect to the horizontal lines of the graticule. The TRACE ROTATION control is a screwdriver adjustment concentric with the ASTIGMATISM control.
SCALE ILLUM	Varies illumination of the graticule grid lines.
Beam Position	Four neon lamps with accompanying arrows indicate the direction when the display is deflected out of the viewing area.
TRIGGER INPUT (Time Base A and B)	Connector for applying an external trigger signal to the time base when its TRIGGER SLOPE switch is set to the EXT position.
HORIZ INPUT	Jack for applying external horizontal signal when the HORIZONTAL DISPLAY switch is set to either ×1 or ×10 EXT.
+GATE B	Supplies approximately a 20-volt square-wave pulse when Time Base B is operating. Pulse duration is approximately 10.5× the setting of the TIME/CM OR DELAY TIME switch.
DLY'D TRIG	Supplies a sharp positive-going trigger spike of about 5 volts at the end of the delay period as set by the TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER dial.
SAWTOOTH A	Supplies the sawtooth voltage of Time Base A. Peak amplitude is about +130 volts.
+GATE A	Same as +GATE B except applies to TIME BASE A.
VERT SIG OUT	Vertical signal output connector. Output amplitude is approximately 1.2 volts/cm of deflection.
CRT CATHODE SELECTOR (rear panel)	Provides blanking of 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 always be in the EXTERNAL CRT CATHODE position except when using the chopped mode.
EXTERNAL CRT CATHODE	With the ground strap disconnected, this connector applies Z-axis modulation signals to the crt cathode. The Z-axis signals should be at least 20 volts in amplitude to cause intensity modulation.

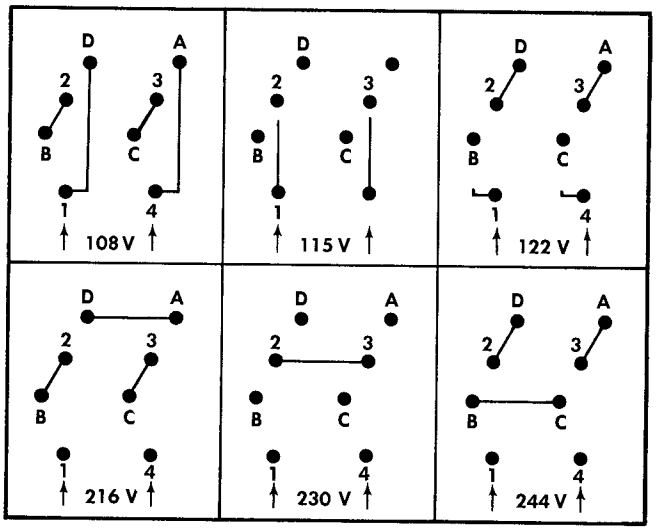


Fig. 2-1. Transformer connections for 108 to 244 volts, 50 to 60 cps and 400 cps operation.

Always have the ground strap connected except when applying Z-axis modulation signals.

POWER CONNECTIONS

Unless otherwise indicated, the Type 545B is shipped with the power transformer and fan wired for 115-volt ac input. A connection diagram on the side of the transformer and Fig. 2-1 show alternative connections for other input voltages to the power transformer. When the transformer is changed from a 108-122 volts to a 216-244 volts connection, the fan wiring must be changed. Fig. 2-2 shows the fan connections for each voltage range.

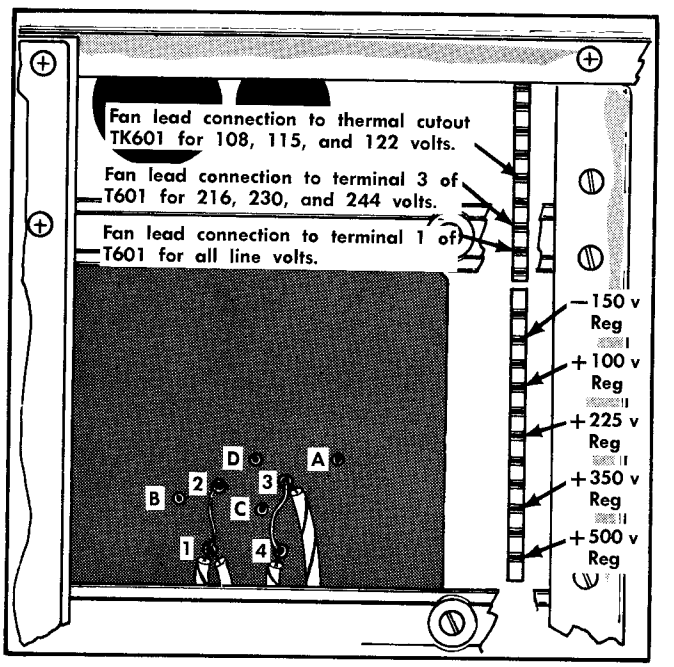


Fig. 2-2. Fan connection for 108 to 244 volts.

NORMAL (NON-DELAYED) SWEEP

The Type 545B Oscilloscope features two independent time-base circuits: Time Base A and Time Base B.

Sweep Triggering

Proper sweep triggering is essential for a stable presentation of an input signal. For a stable display, 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.

Selecting the Trigger Source

The TRIGGER SLOPE 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 TRIGGER SLOPE switch set at either + or — INT.

The LINE positions of the TRIGGER SLOPE switch connect a line-frequency signal to the triggering input. Line triggering is useful whenever the input signal is frequency-related to the line signal.

To trigger the time base from an external signal, set the TRIGGER SLOPE switch to an EXT position and connect the trigger signal to the TRIGGER INPUT connector. 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 an external trigger signal. With this arrangement, it is possible to observe the polarity, shaping and/or ampification of a signal at various points through the circuit without resetting the triggering controls for each new display.

Selecting Triggering Mode

Four means of trigger coupling are available with the TRIGGERING MODE switch. The different coupling positions permit you to accept or reject certain frequency components of the triggering signal.

With the switch set at DC, the time base can be triggered with all frequency components of the triggering signal within the trigger amplifier bandpass, including dc levels.

With the switch set at AC LF REJ, dc and low-frequency signals (below about 17 kc) are rejected or attenuated. Thus, the trigger circuit will respond best to the higher-frequency components of the triggering signal.

With the switch set to AUTO, proper triggering automatically takes place providing that the signal waveform is comparatively simple and approximately symmetrical. With no trigger signal, or with a lower repetition rate, the trigger circuit free runs at approximately 40 cps and triggers the time base at this rate, providing a reference trace.

In general, use AC coupling. However, it will be necessary to use DC coupling for very low-frequency signals. When line-frequency hum is mixed with the triggering signal, it is best to use AC LF REJ coupling so that triggering takes place only on the signal of interest (if the signal of interest contains frequency components above about 17 kc).

The AC LF REJ position is also useful when triggering internally from multi-channel plug-in units operated in the alternate dual-trace mode. AC LF REJ coupling has a faster recovery time when subjected to the alternate dc levels from the multi-channel plug-in unit.

Selecting Trigger Slope

The TRIGGER SLOPE switch determines whether the triggering circuit responds on the rising (+ setting) or the falling (— setting) portion of the triggering signal. When several cycles of a signal appear in the display, the setting of the TRIGGER SLOPE switch will probably be unimportant. However, if you wish to look at only a certain portion of a cycle, the TRIGGER SLOPE switch will help start the display on the desired slope of the input signal. Fig. 2-3 illustrates the effect of both the TRIGGER SLOPE and TRIGGERING LEVEL controls.

Setting Stability Control

In nearly all triggering applications, satisfactory operation can be obtained with the STABILITY control in the PRESET (fully counterclockwise) position. The PRESET position has the advantage of requiring no further adjustment of the STABILITY control when switching from one triggering signal to another. However, if stable triggering becomes difficult with the STABILITY control at PRESET, it will be necessary to adjust the control for proper triggering. To adjust the STABILITY control, place the TRIGGERING LEVEL 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.

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 respond at some higher positive amplitude on the triggering signal. Moving the TRIGGERING LEVEL control in the — direction causes the trigger circuit to respond at some higher negative amplitude on the triggering signal.

Selecting Time/Cm (Sweep Rate)

The TIME/CM and 5× MAGNIFIER switches control sweep rate. The 5× MAGNIFIER switch expands both time bases.

The TIME/CM and 5× MAGNIFIER switches allows you to view an applied signal at a wide variety of calibrated sweep rates. When making time measurements from the crt, be sure the VARIABLE control is set to CALIBRATED (Time Base A).

When the 5× MAGNIFIER switch is set to OFF, the TIME/CM switch indicates the true sweep rate. However, with the 5× MAGNIFIER switch set to ON, the setting of the

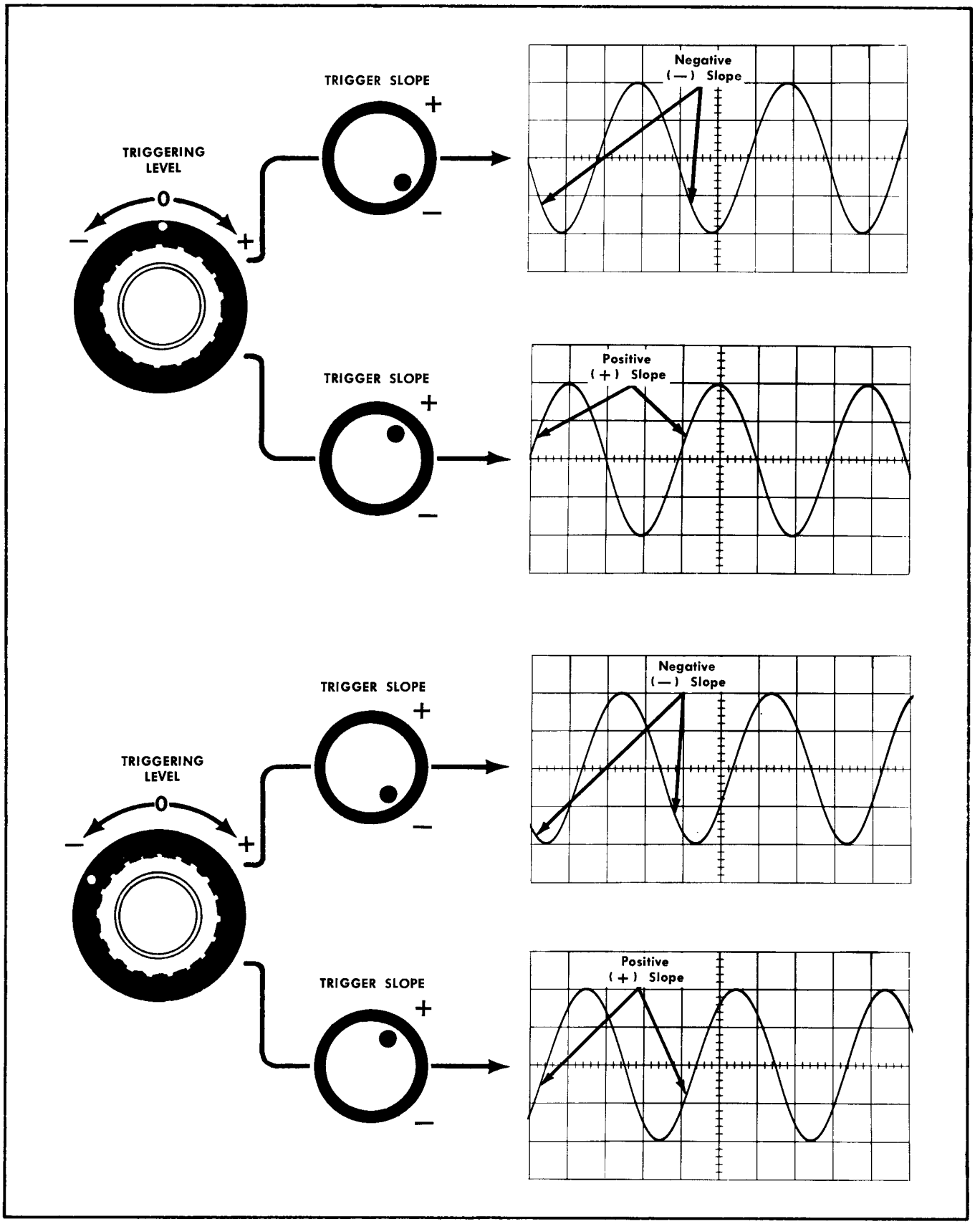


Fig. 2-3. Effects on the oscilloscope display produced by + and — settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the — region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising portion or the falling portion of the input waveform.

TIME/CM switch must be divided by 5 to determine the true sweep rate. For example, assume that the TIME/CM switch is set at 1 mSEC and the 5× MAGNIFIER is set to ON. In this case, the true sweep rate would be 1 msec divided by 5 (5× MAGNIFIER setting); resulting in a displayed sweep rate of 0.2 msec/div. Fig. 2-4 illustrates how to make time measurements from the graticule.

Single-Sweep Operation

In applications where the displayed signal is not repetitive or varies in amplitude, shape, or time, a photograph of a conventional repetitive display may produce a jumbled presentation. To avoid this, use the single-sweep feature of the Type 545B to photograph this type of display. To use single sweep, first make sure the trigger circuit will trigger on the event you wish to display. Do this in the conventional manner with the HORIZONTAL DISPLAY switch set to either time base. Then, after setting the HORIZONTAL DISPLAY switch to 'A' SINGLE SWEEP, press the RESET switch and release. When this is completed, the next trigger pulse will actuate the sweep and the Type 545B will display the event on a single trace. The READY lamp, near the HORIZONTAL DISPLAY switch, first lights when the sweep is ready to accept a trigger and then goes out after triggering has taken place. To ready the circuit for another single display, press the RESET switch and release. In single-sweep operation, make sure the TRIGGER MODE switch is not set to AUTO.

NON-TRIGGERED DELAYED SWEEP

The following procedures describe various measurements, the accuracy of those measurements, and other operations that can be performed using delayed sweep.

Insert a vertical plug-in unit and set the controls and switches on the instruments as listed in Table 2-1.

Set the HORIZONTAL POSITION control so the trace begins precisely at the left-hand edge of the graticule. Notice the position of the intensified segment in the trace.

Now set the TIME/CM OR DELAY TIME switch to .2 SEC and A TIME/CM switch to 20 mSEC. The intensified segment should be at the same position as with the previous sweep rates.

Connect the SAWTOOTH A output to the vertical plug-in unit input. Notice that the A sweep sawtooth and the intensified segment in the trace start and end at the same time. This display shows that Time Base A produces one sweep during the intensified segment of each B sweep. The A TRIGGERING LEVEL control has no effect.

The B sweep rate is 0.2 sec/cm. The intensified segment begins 5 cm after the beginning of the trace. Hence, the A sweep starts 1 sec after the B sweep (0.2 sec/cm × 5 cm).

The number of centimeters between the beginning of the trace and the beginning of the intensified segment is established by the setting of the DELAY-TIME MULTIPLIER dial. Therefore, with any dial setting, the time difference between the beginning of the A and B sweeps is the product of the TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER dial setting (see Fig. 2-5).

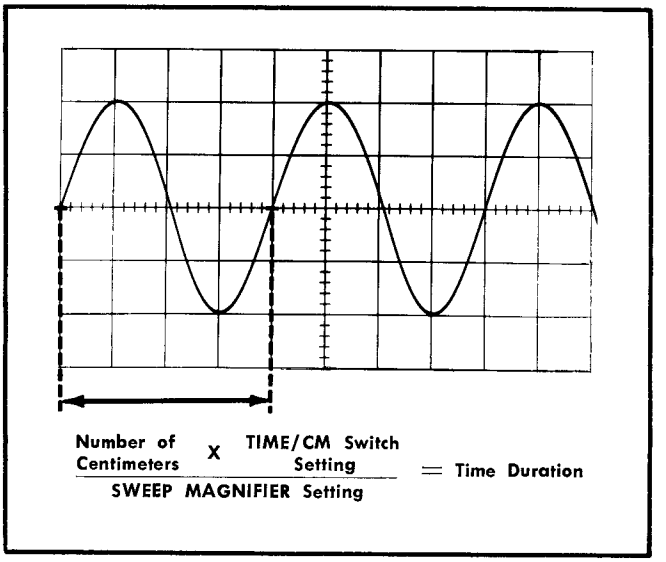


Fig. 2-4. Time measurement from the graticule.

TABLE 2-1

B TRIGGERING MODE	AC
B TRIGGER SLOPE	+INT
B TRIGGERING LEVEL	0
B STABILITY	Fully clockwise
B TIME/CM OR DELAY TIME	1 mSEC
B LENGTH	Fully clockwise
A TRIGGERING MODE	AC
A TRIGGER SLOPE	+EXT
A TRIGGERING LEVEL	0
A STABILITY	Fully clockwise
A TIME/CM	.1 mSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	'B' INTENSIFIED BY 'A'
SWEEP MAGNIFIER	OFF
DELAY-TIME MULTIPLIER	5.00
AMPLITUDE CALIBRATOR	10 Volts
HORIZONTAL POSITION	Centered
INTENSITY	So both intensity levels in the trace are easily seen.

Set the applicable controls and switches of the vertical plug-in unit as follows:

Volts/Div	5
Variable	Calibrated
Ac-Dc-Gnd	Dc
Position	Trace centered

The following procedures describe five common applications of the delayed-sweep feature. These applications are more accurate than time measurements taken directly from the crt display.

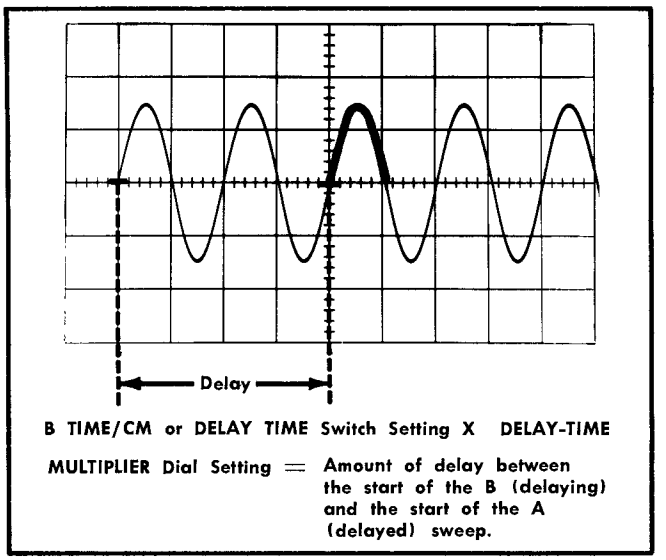


Fig. 2-5. Determining delay time.

Demonstration 1

This procedure describes how to measure pulse duration with the pulse triggering Time Base B.

Set the controls and switches as listed in Table 2-1 except at follows:

B TIME/CM OR DELAY TIME	.1 mSEC
A TIME/CM	1 μSEC

Apply the AMPLITUDE CALIBRATOR signal to the input of the vertical plug-in unit. Adjust the B triggering controls to obtain a stable display. The display should consist of nearly 1 cycle of the square-wave signal.

Turn down the intensity until the brightened portion of the trace is easily seen. Using the DELAY-TIME MULTIPLIER dial, position the brightened portion of the trace to the falling portion of the square wave. Record the setting of the DELAY-TIME MULTIPLIER dial. Now position the brightened portion to the adjacent rising portion of the square wave. Again record the setting of the DELAY-TIME MULTIPLIER dial.

Subtract the first DELAY-TIME MULTIPLIER dial setting from the second and multiply the result by the setting of the TIME/CM OR DELAY TIME switch. The figure obtained is the same as the interval measured.

Accuracy: Determined by the combination of all the following factors:

1. The basic accuracy of time measurements made by using the sweep delay is as stated in Section 1.
2. The Delay Pickoff and Time Base A generator circuits typically require a net total of about 75 to 100 nsec to respond to the signal event which triggers Delayed Sweep (A). This small inherent delay need not be considered unless it is a significant percentage of the measured time or when measuring time differences using the same sweep rate. When necessary, add the net circuit delay time to the measured time; that is, when measuring the time from the start of the B sweep.

Summary: The method described in Demonstration 1 provides a time measurement accuracy within 1% of reading, ±2 minor divisions of the DELAY-TIME MULTIPLIER dial.

By comparing the delay reading to an accurate external timing standard (such as a Tektronix Type 180A Time-Mark Generator) and applying a correction factor, an accuracy of ± 2 minor divisions of the DELAY-TIME MULTIPLIER dial can be achieved.

Demonstration 2

This procedure describes how to measure time between two pulses, neither of which triggers Time Base A.

Set the controls and switches as listed in Table 2-1 except as follows:

B TIME/CM OR DELAY TIME	.2 mSEC
A TIME/CM	2 μSEC

Apply the AMPLITUDE CALIBRATOR signal to the vertical input. Adjust the B triggering controls to obtain a stable display. The display should consist of about 2 cycles of the square wave. Set the DELAY-TIME MULTIPLIER dial so the square-wave rise located near the center of the display is intensified.

Turn down the intensity until the brightened portion of the trace is easily seen. Using the DELAY-TIME MULTIPLIER dial, position the start of the brightened portion to the 50% point on the square-wave rise for the first positive half-cycle. Record the setting of the DELAY-TIME MULTIPLIER dial. Now position the start of the brightened portion of the trace to the 50% point of the fall time for the first half-cycle of the square wave. Again record the setting of the DELAY-TIME MULTIPLIER dial.

Subtract the first dial setting from the second setting. The product of the difference times the TIME/CM OR DELAY TIME switch setting equals the time duration of the square-wave positive-going half cycle (between the 50% amplitude points). This measurement should indicate a time of about 0.5 msec.

Accuracy: Determined by the combination of the following factors:

1. The basic accuracy of the sweep delay as described in Demonstration 1.
2. The error added by the sweep-delay system linearity is ± 2 minor dial divisions. Hence, percentage of measurement error decreases as the numerical dial difference increases.

NOTE

When the separation between dial settings is 100 minor dial divisions or less, the time measurement can often be made more accurate by direct reading from a magnified crt display. See Demonstration 3: Magnification.

3. The accuracy of time measurements made in Demonstration 2 is independent of the inherent circuit delays, provided the B TRIGGERING LEVEL control setting is the same for each of the two dial readings.

Demonstration 3

Complex signals contain a number of individual events of different amplitudes. Since the trigger circuits of the Type 545B respond to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude. The A delayed by B mode permits the start of the A sweep to be delayed for a selected time after the signal event having the greatest amplitude. Any event within the series of events may then be displayed in magnified form as follows:

Set the controls and switches on the instrument as listed in Table 2-1. Apply the AMPLITUDE CALIBRATOR signal to the vertical input. If necessary, adjust the B triggering controls to obtain a stable display. The display should consist of several cycles of the square-wave signal. Set the DELAY-TIME MULTIPLIER dial to intensify one of the positive-going pulses.

Set the HORIZONTAL DISPLAY switch to 'A' DLY'D BY 'B'. The display should now include the same signal information as the intensified trace segment, but horizontally expanded (magnified) ten times.

Increase the A sweep rate to 1 μsec/div. The INTENSITY control may require readjustment. Set the DELAY-TIME MULTIPLIER dial to position a square-wave rise on the crt. The display now gives ×100 magnification of the intensified segment.

Slowly turn the DELAY-TIME MULTIPLIER dial. Note that any portion of the square wave can be brought into view in magnified form.

The DELAY-TIME MULTIPLIER dial reading corresponds to the number of centimeters between the beginning of the Time Base B trace and the beginning of the Time Base A (intensified) trace (e.g. 7.00 = 7 major graticule divisions).

The A delayed display will probably exhibit some horizontal jitter. The time jitter contributed by the delay system is less than 5×10^{-4} times the TIME/CM OR DELAY TIME switch setting. Since the sweep rate of the delayed sweep is now 1 μsec/cm, the jitter due to the delay system is less than one-half centimeter.

Accuracy: Depends solely on the B sweep-rate accuracy as listed in Section 1.

Demonstration 4

Ordinarily, the displayed signal is also used to trigger the oscilloscope sweep. In some situations, it may be desirable to reverse this situation. The sweep-related output pulses, available from the front-panel of the Type 545B, can be used as a triggering signal for an external device. The output signal of the external device can then produce a stable display while the oscilloscope sweep free runs.

To demonstrate one method of performing this operation, proceed as follows:

Set the controls and switches as listed in Table 2-1 except as follows:

B TRIGGER SLOPE	+EXT
DELAY-TIME MULTIPLIER	1.00
B TIME/CM OR DELAY TIME	10 μSEC
A TIME/CM	1 μSEC

Connect a lead from the DLY'D TRIG connector to the vertical input. The display should consist of a positive-going spike.

The oscilloscope display is the pulse that is available at the DLY'D TRIG connector at the end of each delay period. In a practical application, the pulse would not be applied to the vertical input but instead to some external device to be tested. The pulse would then serve as the trigger pulse or input signal from the external device, and the output of the device would provide a stable display on the oscilloscope, as though the oscilloscope were triggererd in the normal manner.

Demonstration 5

The +GATE B connector output signal can be used as a variable repetition rate, variable duty-factor pulse generator. To use the Type 545B in this manner, proceed as follows:

Set the controls and switches as listed in Table 2-1 except as follows:

HORIZONTAL DISPLAY	B
B TRIGGERING MODE	AUTO

Monitor the signal available at the +GATE connector on another oscilloscope and establish the desired pulse repetition rate by setting the TIME/CM OR DELAY TIME switch. Establish the desired duty factor by setting the LENGTH control.

TRIGGERED DELAYED SWEEP

Complex signals contain a number of individual events at different amplitudes. Since the trigger circuits in the Type 545B respond to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude.

The following instructions demonstrate that Time Base A can be triggered by any event within a series of events, regardless of relative amplitude.

Set the controls and switches on the instrument as listed in Table 2-1.

Connect the AMPLITUDE CALIBRATOR signal to the vertical input. Using the B triggering controls, obtain a stable display.

Turn the DELAY-TIME MULTIPLIER dial about 2 turns in either direction. Notice that the brightened segment in the display moves smoothly across the crt.

Set the DELAY-TIME MULTIPLIER dial so the brightened segment begins about in the middle of a pulse top. Now turn the HORIZONTAL DISPLAY switch to A and the TRIG-

GER SLOPE switch to +INT. Using the A triggering controls, obtain a stable display. Return the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A'. Notice that the brightened segment in the display has shifted to the next pulse on the right. (If the brightened segment is not present, or is unstable, readjust the A triggering controls.) Turn the DELAY-TIME MULTIPLIER dial several full turns. The brightened segment in the display should jump from one pulse to the next. Set the HORIZONTAL DISPLAY switch to 'A' DLY'D BY 'B' and note that the display now begins on the rising portion of the pulse. With the present display, turning the DELAY-TIME MULTIPLIER dial should not change the display since all of the AMPLITUDE CALIBRATOR pulses are the same shape. However, if the input signal consisted of a repeating series of several dissimilar pulses, turning the dial would provide a triggered display of each pulse in the series provided the A triggering controls are set for triggering on the smallest pulse.

The display is produced in the following manner:

Time Base A produces one sweep during each B sweep. The Time Base A sweep will begin some time after the start of B sweep. This time is the total of the TIME/CM OR DELAY TIME switch setting multiplied by the DELAY-TIME MULTIPLIER dial setting, plus the time between the end of this delay interval and the next event in the signal which can trigger Time Base B.

With the A triggering control set for triggered operation, the Time Base A sweep will occur only if A is armed and triggered before the B sweep ends. If Time Base A is not triggered, the scope waits.

Light Filter

The light filter provided with the Type 545B 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.

If the light filter is removed, the crt protector plate should be installed to prevent scratches to the crt face plate.

EXTERNAL HORIZONTAL DEFLECTION

For special applications, horizontal deflection can be produced with an externally derived signal. Thus, the oscilloscope system can be used to plot one function against another (e.g. Lissajous figures). However, the system is not intended for precise phase-angle measurements.

To use an external signal for horizontal deflection, connect the signal to the HORIZ INPUT connector. Set the HORIZONTAL DISPLAY switch to EXT ×10 or ×1. The signal is dc coupled to the deflection amplifier. The MAG switch is inoperative when the HORIZONTAL DISPLAY switch is set to either external horizontal position.

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 multchannel plug-in unit in conjunction with the Type 545B Oscilloscope are contained in the plug-in unit instruction manual.

When the multi-channel plug-in unit is operated in the 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.

INTENSITY MODULATION

The Type 545B crt display can be intensity modulated by an external signal to display additional information. This is done by disconnecting the grounding bar from the EXTERNAL CRT CATHODE connector at the rear of the instrument and connecting the external signal to this terminal. The CRT CATHODE SELECTOR switch must be in the EXERNAL CRT CATHODE position.

Very accurate time measurements can be made by intensity modulating the beam with time markers and measuring directly from the time markers on the crt. A positive signal of approximatly 20 volts is required to cut off the beam from normal intensity. The low-frequency cutoff point for Z-axis modulation is 600 cps.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section describes the operation of the various circuits in the Type 545B. A simplified block diagram description is given first to explain the general operation of each circuit, then the operation of each circuit is covered in detail.

BLOCK DIAGRAM DESCRIPTION

Low-Voltage Power Supply

The low-voltage power supply produces all operating voltages for the oscilloscope with the exception of parts of the crt circuit. The low-voltage supply provides regulated −150, +100, +225, +350, and +500 volts. It also provides heater voltages and an unregulated +325-volt output.

Vertical Plug-In Preamplifier

Any Tektronix letter- or 1-series vertical plug-in preamplifier can be used with the Type 545B. 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 output amplifier. The delay line is a specially braided 186 Ω line which delays the application of the vertical signal to the vertical output amplifier for 200 nsec. This provides time for unblanking the crt and starting 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. The delay line requires no adjustment because of the precision construction.

Vertical Output Amplifier

The vertical output amplifier is a push-pull cascode amplifier that takes the output of the delay line and amplifies it 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 trigger is picked off at the output of the vertical input amplifier.

Time Base A Generator

The Time Base A generator provides accurate ramp voltages for the horizontal deflection system, unblanking for the crt, and a +gate to a front-panel connector. 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 may be used to arm or trigger Time Base A, and is also available at a front-panel connector.

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 input 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 provide horizontal deflection factors from about 0.2 to 15 volts/cm.

Crt Power Supply

The crt power supply provides the high voltages for operating the crt. The power supply is of the rf type, using a 50 kc Hartley oscillator. Secondary windings on the oscillator transformer supply voltages to the high-voltage rectifiers.

Cathode-Ray Tube (Crt)

The cathode-ray tube used in the Type 545B is a flat-faced, internal graticule, 5-inch tube with 6 cm of usable vertical scan area. The tube is designed for low-input capacitance to the vertical deflection plates and minimum x-axis center-to-edge defocusing.

Calibrator

The calibrator in the Type 545B is a multivibrator and cathode follower that provides a square-wave output with a maximum amplitude of 100 volts at a nominal 1 kc. A step attenuator permits switching the output amplitude from the front panel.

CIRCUIT DESCRIPTION

The following is a detailed discussion of the operation of each circuit in the Type 545B. While reading through the description of a particular circuit, refer to the proper schematic diagram in Section 6.

Low-Voltage Power Supply

The low-voltage power supply in the Type 545B (see Power Supply schematic diagram) actually consists of five interrelated supplies that operate together as a system. This system delivers filtered and regulated voltages of —150, +100, +225, +350, and +500 volts as well as an unregulated dc voltage of +325 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. Unless otherwise specified, the Type 545B is shipped with T601 wired for 115-volt ac input. A connection diagram on the side of the transformer shows alternative connections for other input voltages. An optional ac converter is available to provide 60-cycle power for the fan motor if it is desired to operate the oscilloscope on line frequencies from 50 to 60 cycles and 400 cycles.

The 115-volt ac input power is applied to T601 through POWER ON switch SW601. Overload protection is provided by fuse F601. 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; and to shorten the cooling time, the fan continues to run while TK601 is open (except when T601 is connected for 216-, 230- or 244-volt operation). Thermal time-delay relay K600 provides a filament warmup time of approximately 30 seconds before the dc power supplies are activated. The heater of K600 is rated at 6 volts and is connected to 6.3 volts on the T601 secondary winding. During heater warmup time, contacts 4 and 9 of K600 remain open. At the end of heater warmup time, contacts 4 and 9 close and apply power to magnetic relay K601. Contacts K601-1 of K601 remove the heater power from K600, but before K600 can open, contacts K601-1 lock the holding circuit to the coil of K601. 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 thus activate their respective dc supplies.

—150-Volt Supply. The —150-volt supply in the Type 545B is the reference voltage source for the other supplies and must be very stable. The —150-volt supply includes a high-gain electronic voltage regulator designed to give good regulation under extreme operating conditions. This regulator circuit contains a series regulator, a glow-discharge tube reference source, an error detector, and an amplifier.

In operation, the input power to the —150-volt supply is supplied by one secondary winding (pins 6-11) of T601. The ac output of the secondary winding is rectified by silicon diode rectifier bridge D642 and filtered by C640. In series with the positive side of the supply and ground are series regulators V627, V637, and V647, paralleled by shunting resistor R647. The output of the —150-volt supply is taken from the negative side.

Error sensing in the voltage-regulator circuit is accomplished by comparator V624. Current through V624 is established by the setting of the tap on R616 in the voltage divider R615, R616, and R617. The voltage on the grid of V624A is held at approximately —85 volts by reference stage V609. Assuming that the output voltage of the —150-volt supply increases, (e.g. increased line voltage) the voltage increase appears on the cathodes of V624 and, through the tap on R616, on the grid of V624B. Due to the voltage divider, only a part of the voltage increase appears between the grid and cathode of V624B, but the full change appears on the grid and cathode of V624A. The increase is in the negative direction, therefore, V624A increases its conduction to maintain the proper bias between grid and cathode. Thus, both cathodes are held nearly fixed while the grid of V624B is pulled negative by the increasing negative voltage across the voltage divider. The increasing negative voltage on the grid of V624B causes a decrease in current; thus the plate voltage goes positive.

The positive change in plate voltage is amplified and inverted to a negative change by amplifier V634. The amplified error signal from V634 is applied to the grids of series regulators V627, V637, and V647. The negative-going error signal on the grids of V627, V637, and V647 decreases the current through the tubes, effectively increasing their resistance and the voltage drop across them. The voltage necessary to provide the increased drop across the series regulator tubes and shunt resistor can only be obtained by subtracting it from the negative side of the supply, so the undesired increase in negative voltage is absorbed in the series regulators and shunt resistor.

If the output of the —150-volt supply decreases instead of increases, then the error voltage applied to the grids of the series regulators would be positive-going. The positive-going error voltage on the grids of the series regulators would lower their resistance, and the voltage drop across them would decrease, leaving more voltage for the negative side of the supply. Since the output voltage of the —150-volt supply depends upon the relationship of the voltage on the tap of R616 and the reference voltage from V609, accurate adjustment of the output voltage is provided by making R616 variable.

Filter capacitor C640 does not remove all the ripply from the output of the bridge rectifier, and the series regulator circuit also reduces the output ripple voltage. Any ripple between the —150-volt output point and ground reaches the grid of V624B via C617. This input ripple voltage is amplified by V624 acting as a cathode-coupled amplifier. The ripple output voltage at the plate of V624 has the same polarity as the ripple voltage at the —150-volt output. C628 couples this ripple voltage to the grid of V634 where it is further amplified and applied to the grids of the series regulator tubes with a polarity that opposes the original ripply voltage. Ripple in the positive side of the —150-volt supply is coupled through R637 to a degenerative feedback loop and the screen of V634.

Some of the components in the —150-volt supply are not necessary in normal operation but are included to insure proper operation of the circuit under adverse conditions. R640 and R641 protect against large surge currents, while C649 suppresses sudden load changes that fall outside the bandwidth of the regulator circuit.

+100-Volt Supply. The input to the +100-volt supply is the output of the secondary winding (pins 8-15) 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 545B 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 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 V677A is a series regulator tube. The error-feedback circuit, R650 and R651, is connected to the grid of V664. The top end of R650 is connected to the regulated +100-volt output and the lower end of R651 provides a reference voltage from the regulated —150-volt supply. With normal line voltages and loads, the bias voltage at the grid of V664 is about —1.7 volts.

If the load current, output voltage, or the input voltage changes (including changes due to ripple), the output of the regulated +100-volt supply starts to change also, but any change appears across R650 and R651 and is applied to the grid of V664 as a change in operating bias. Assuming that the output of the regulated +100-volt supply tries to decrease, the reduced voltage at the top of R650 permits the voltage at the junction of R650 and R651 to go more negative than the normal —1.7-volt level. The increase in negative bias on the grid of V664 reduces the plate current of V664. The voltage drop across plate-load resistor R663 decreases and the plate voltage of V664 and the grid bias of V677A go more positive. As the grid of V677A goes more positive, the resistance of V677A is decreased and the output voltage rises, compensating for the drop in output voltage. 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 out the ripple appearing at the plate of V677A.

Unregulated +325-volt Supply. The voltage source for the unregulated +325-volt supply differs somewhat from the voltage sources for the —150- and +100-volt supplies. The secondary of T601 (pins 5, 7, 10, and 14) and D702 and D732 form a center-tapped bridge rectifier circuit. The negative side of the bridge rectifier is connected back to ground through the rectifier circuit of the +100-volt supply; thus elevating this point and the output of the bridge rectifier circuit by the unregulated output voltage of the +100-volt rectifier circuit. The unregulated output of the +100-volt rectifier circuit 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 unregulated output of the +180-volt supply, the total output of this circuit is +470 volts. (This total output is the unregulated source for the regulated +350-volt supply.) However, the unregulated +325-volt output, obtained from the center tap of the bridge rectifier (+145 volts), elevated by the unregulated output of the +100-volt supply, provides a total unregulated output of +325 volts.

+225-Volt Supply. The voltage source for the regulated +225-volt supply is the unregulated +325-volt supply described in the preceding paragraphs. The regulator circuit is similar to the regulator circuit in the —150-volt supply; the main difference being that instead of using a glow discharge tube as a reference voltage source, the reference voltage is from the —150-volt supply. The error signal is picked off the junction of precision resistors R680 and R681. The upper end of R680 is connected to the +225-volt output, and the lower end of R681 is connected to the regulated —150-volt supply. The voltage at the junction between R680 and R681 is approximately —0.1 volt which is applied through R682 and R683 to the grid of V684B. The cathodes of V684 are long-tailed to the —150-volt supply through R685. The grid of V684A is grounded. The error signal is fed from the grid of V684B through the common-cathode circuit to the A side of the tube. Notice that this comparator is somewhat different from the comparator used in the —150-volt supply; the output is taken from the A side. The error signal is amplified by V684 and fed, unchanged and in phase, to the voltage divider in the grid of V694. V694 also amplifies and inverts the error signal and applies it out of phase with any change in the +225-volt output, to the grids of series regulators V677B and V737B.

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 grids of series regulators V677B and V737B. The result is that the same ripple appears simultaneously on the grids and plates of V677B and V737B, but 180° out of phase; thus the ripple cancels out.

+350-Volt Supply. The input to the +350-volt supply is the full voltage output of the center-tapped bridge (see description of unregulated +325-volt supply) added to the unregulated side of the +100-volt supply. The operation of the regulator circuit is very similar to the operation of the +100-volt regulator except for different component values.

+500-Volt Supply Rectified voltage from terminals 20 and 21 of T601 via D762 is added to the regulated voltage of the +350-volt supply to provide the necessary voltage for the +500-volt supply. The operation of the regulator circuit is similar to that of the +100-volt regulator except for different component values.

Crt Circuit

The crt circuit (see Crt schematic diagram) includes the crt, the high-voltage power supply, and the controls necessary to focus and orient the display. The crt (Tektronix Type T5470-31-2) is an aluminized, 5-inch, flat-faced, glass crt with a helical post-accelerator and electrostatic focus and deflection. The crt circuit provides connections for externally modulating the crt cathode. The high-voltage power supply is composed of a dc-to-50-kc power converter, a voltage regulator circuit, and three high-voltage outputs. Front-panel controls in the crt circuit adjust the trace rotation (screwdriver adjustment), intensity, focus, and astigmatism. Internal controls adjust the geometry and high-voltage output level.

High-Voltage Power Supply. The high-voltage power supply is an oscillator operating at approximately 50 kc with the transformer providing three high-voltage outputs. A modified Hartley oscillator converts dc from the +325-volt unregulated supply to the 50-kc input required by high-voltage transformer T801. C808 and the primary of T801 form the oscillator resonant tank circuit. No provisions are made for precise tuning of the oscillator tank since the exact frequency of oscillation is not important.

Voltage Regulation. Voltage regulation of the high-voltage outputs is accomplished by regulating the amplitude of oscillations in the Hartley oscillator. The —1700-volt output is referenced to the +350-volt regulated supply through a voltage divider composed of R841, R842, R843, R845, R847, R853, and variable resistors R840 and R846 Through a tap on the voltage divider, the regulator circuit samples the —1700-volt output of the supply, amplifies any errors and uses the amplified error voltage to adjust the screen voltage of Hartley oscillator V800. If the —1700-volt output changes, the change is detected at the grid of V814B The detected error is amplified by V814B and V814A. The error signal at the plate of V814A is direct coupled to the screen of V800 by making the plate-load resistor of V814A serve as the screen-dropping resistor for V800. Any change in the —1700-volt output thus changes the screen voltage of V800 and the amplitude of the 50-kc oscillations. R840 provides a means of controlling the high-voltage output through controlling oscillation amplitude.

Crt Grid Supply. The approximate 1700-volt output of the high-voltage power supply is the rectified output of one of the two high-voltage secondaries on T801. To provide dc-coupled unblanking signals to the crt grid, the crt grid supply is floating (the dc voltage on the components shift in accordance with the unblanking signals). The positive side of the crt grid supply is returned to the —150-volt supply through the unblanking cathode-follower load resistor of the selected sweep generator. The negative side of the crt grid supply is applied through the INTENSITY control to the crt grid.

At the fastest sweep rates, the stray capacitance of the floating crt grid circuit makes it difficult for the crt grid to rise fast enough to unblank the crt in the required time. An isolation network consisting of R827, C829, and C830 isolates the capacitive loading. By this arrangement the fast leading edge of the unblanking pulse is coupled through C830 and C829 to the grid of the crt. For short-duration unblanking pulses such as those that occur at the fastest sweep rates, the dc levels on the rectifier and secondary winding are not appreciably affected. Longer unblanking pulses such as those that occur at the slower sweep rates, charge the stray capacitance in the 1700-volt output through R827. This pulls up the floating crt grid circuit and holds the crt grid at the unblanked potential for the duration of the unblanking pulse.

+8300- and —1700-volt Outputs. Both the +8300- and the —1700-volt outputs are derived from the same secondary winding on T801. The full secondary voltage of approximately 2900 volts is applied to a voltage tripler consisting of rectifiers V832, V842, and V852 and associated capacitors. A tap on the secondary provides the input for half-wave rectifier V862 in the —1700-volt output. The 1700-volt supply is referenced to the regulated +350-volt supply through a voltage divider network. The +8300-volt output is connected to the crt post-deflection-accelerator anode and the —1700-volt output is connected to the crt cathode via R857 to provide a total accelerating voltage of 10,000 volts.

Crt Circuit Controls and Connectors. Optimum size and shape of the fluorescent spot on the crt is obtained by adjusting the front-panel FOCUS and ASTIGMATISM controls. FOCUS control R846 provides the correct voltage for the second anode (focus ring) in the crt. Proper voltage for the third anode is obtained by adjusting ASTIGMATISM control R864. To obtain optimum spot size and shape, both the FOCUS and ASTIGMATISM controls are adjusted to provide the proper electronic lens configuration in the region of the second and third anodes of the crt. Spot intensity is adjusted by means of front-panel INTENSITY control R826. Varying the INTENSITY control changes the voltage on the crt grid, which in turn varies the beam current. Internal GEOMETRY control R861 adjusts the isolation shield voltage in the crt, and is adjusted to minimize "bowing" or "tilting" of the display. Front-panel TRACE ROTATION control R778 permits minor adjustments in trace orientation. By adjusting the TRACE ROTATION control, the trace can be made parallel with the horizontal lines on the graticule.

An input binding post on the rear panel of the Type 545B provides an input for externally modulating the crt cathode. The input binding post is normally grounded by a link. If it is desired to intensity modulate the display from an external source, the link is opened, and the modulating signal is coupled to the crt cathode through C858.

When the Type 545B is used with a multi-channel vertical plug-in preamplifier that provides dual-trace chopped blanking pulses, the blanking pulses are applied to rear-panel CRT CATHODE SELECTOR switch SW858. With the vertical plug-in preamplifier operating in the chopped mode and SW858 set to the CHOPPED BLANKING position, a positive pulse of approximately 20-volts amplitude is applied through C858 to the cathode of the crt. At normal intensity levels, this pulse is sufficient to cut off the crt during the time the amplifier channels in the vertical plug-in preamplifiers are being switched.

Vertical Amplifier System

The vertical amplifier system in the Type 545B consists of an appropriate vertical plug-in preamplifier, a push-pull cathode-follower input stage, a push-pull hybrid delay-line driver, a 186 Ω delay line, and a push-pull hybrid output

amplifier. In addition, the trigger-pickoff circuit functions as a part of the vertical amplifier by providing reverse termination for the delay line.

Vertical Input Amplifier. 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 T500 are parasitic suppressors. The cathodes of cathode followers V494A and V494B are returned to ground through vertical DC BAL control R495, which is adjusted to equalize the dc voltage (about +68.5 volts) on the bases of delay-line driver transistors Q514 and Q524. The DC SHIFT control R502 varies operating voltage and compensates for errors of thermal balance in Q514 and Q524 as well as Q584 and Q594.

The balanced delay-line driver stage is a push-pull cascode amplifier with an adjustable vertical gain control (R520) connected in the emitter circuit of the two transistors. Gain is adjusted by controlling the amount of degeneration in the emitter circuit of the transistors. R532 and R533 set the operation points of Q513 and Q523 which provide the reverse termination for the delay line.

The RC networks in the collectors of Q514, Q524, Q584, and Q594 set the individual transistor operating points for thermal balance.

Vertical Output Amplifier. The vertical output amplifier must properly terminate the 186 Ω delay line and provide broadband amplification of the vertical signals. The delay line is properly terminated by adjusting C568, L554, and L560.

The output amplifier is a wideband amplifier stage consisting of Q584, Q594, V584 and V594 and associated elements. High-frequency compensation in this stage is provided by peaking coils L588, L589, L598, and L599 in the plate circuits of V584 and V594. The high-frequency response is varied by adjusting C581 and R580, which provide variable high-frequency degeneration in the emitter circuit of Q584 and Q594.

The output stage of the vertical amplifier is a hybrid push-pull cascode amplifier. This circuit configuration is used to match the low impedance of the transistorized vertical-amplifier system to the higher impedance required at the crt vertical deflection plates.

Trigger-Pickoff Circuit. The trigger-pickoff transistor amplifier Q543 provides trigger signals to the two time bases, and also supplies the VERT SIG OUT connector with a vertical signal.

Beam-Position Indicators. The beam-position indicators B538 and B539 driven by Q534 (located on the front panel above the crt) indicate the relative vertical position of the trace with respect to the center of the graticule. When the beam is centered vertically, the potential is insufficient to light either neon. The current through Q534, and thus the voltage across the neons, will change as the beam is positioned up or down on the crt. The voltage across one noen will increase, causing it to light, and the voltage across the other neon will decrease, causing it to remain extinguished. The neon that lights will indicate the direction in which the beam has been moved.

Time Base A

The Time Base A consists of the A sweep trigger and the A sweep generator circuits. The A sweep trigger circuit includes controls for selecting the type, source, and level of the trigger to be used, and circuit elements for regenerating the selected trigger into a pulse suitable for triggering the A sweep generator. The A sweep generator is basically a Miller-runup circuit. The A sweep generator provides ramp voltages for the horizontal deflection system and the SAWTOOTH A connector, unblanking pulses, and +gate pulses.

Trigger Generator. The input to the A sweep trigger circuit is selected by TRIGGER SLOPE switch SW10A from the trigger-pickoff circuit in the vetrical amplifier, the power transformer for line triggering, or from the front-panel TRIGGER INPUT connector. TRIGGERING MODE switch SW10B permits further selection of the type of triggering signal; either automatic, ac low-frequency reject, ac or dc. Once the type and source of triggering signal has been selected, the slope on which triggering is desired is selected by TRIGGER SLOPE switch SW10A. The level of the triggering signal required by the A sweep trigger circuit is selected by adjusting TRIGGERING LEVEL control R17. After this triggering signal has been selected by the preceding control and switches, it is applied to trigger input amplifier V24.

The trigger-input amplifier provides a source of positive-going signal to drive the following stage and, by means of the TRIGGERING LEVEL control, enables the operator to select the point on the signal at which triggered operation will occur.

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

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

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

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

D29 and D30 are limiters and allow the trigger circuit to count down to provide triggers at a slow enough rate for the sweep gating multivibrator to react. The quiescent voltage level on the base of Q35 is set by the collector of Q34 whose base voltage is set by R39 (TRIG LEVEL CENTERING).

The amplitude of the triggering signal necessary to cause operation of the trigger multivibrator is determined by the setting of the TRIGGERING LEVEL control.

Trigger amplifier Q34 provides additional amplification to the trigger signal before applying the signal to the base of Q35. The additional stage of amplification requires that the input triggering signal be applied to the opposite section of the trigger-input amplifier than is done in the B trigger generator.

In the quiescent state, ready to receive a signal, Q35 of the trigger multivibrator is conducting and the collector voltage is down. Since the collector is dc coupled to the base of Q45, that base is held below cutoff. With Q45 cut off its collector voltage is up and no output is developed.

The negative-going portion of the signal from the trigger amplifier is required to drive the base of Q35 down. As the Q35 base is driven negative, the current flow through the transistor is restricted and the voltage at the collector starts to rise.

The rise in voltage at the collector of Q35 carries the base of Q45 in the positive direction.

The emitters of both transistors are coupled together, and follow the action of the bases. With the Q45 base going in a positive direction, and the emitter in a negative direction, Q45 starts to conduct. As Q45 starts to conduct, the emitters of both transistors follow the action of the Q45 base, hence the emitter voltage starts to rise.

As the base goes down and the emitter goes up, Q35 stops conducting. As Q45 conducts, its voltage drops, creating a negative step at the output. This transition occurs rapidly, regardless of how slowly the base falls.

When the signal applied to the base of Q35 goes in a positive direction, the action described in the previous paragraphs reverses itself. That is, Q35 will start to conduct once more, while Q45 will be cut off.

In the AUTO position of the TRIGGERING MODE switch the trigger multivibrator is converted from a bistable to a recurrent configuration. This is accomplished by disconnecting +100 volts from the junction of D49 and R38, thereby allowing C49 to charge and discharge.

In this mode of operation, the trigger mulitivibrator will run in the absence of a triggering signal. For example, assume that the base of Q35 is just being driven into cutoff. The voltage at the collector of Q35 will rise, carrying with it the base of Q45. As the voltage at the base of Q45 starts to rise, Q45 starts to conduct. The falling voltage at the collector of Q45 is coupled to the base of Q34.

Since the voltage at the base of Q34 is falling, the collector voltage is rising. This rising collector voltage of Q34 is then coupled to the base of Q35. The base of Q34 is prevented from falling immediately by the action of C49, which must discharge sufficiently to lower the voltage at the base of Q34 into cutoff.

As the collector voltage of Q34 raises the base of Q35 sufficiently to bring Q35 out of cutoff, its collector voltage will in turn lower. The lowering collector voltage of Q35 is coupled through D43 to the base of Q45, thus causing Q45 to cut off. When Q45 reaches cutoff, the circuit has completed one cycle of an approximately 40-cycle repetition rate.

During calibration, the repetition rate for the AUTO mode is adjusted by R47 (TRIG SENS), which comprises part of the discharge path for C49.

Sweep Generator. The time-base generator consists of three main circuits: the sweep gating multivibrator, the Miller-runup circuit, and the holdoff circuit.

The time-base trigger circuit furnishes the waveform which initiates a cycle of action in the time-base generator. Square waves from the output of the trigger multivibrator are fed to the time-base generator where they are differentiated and used as trigger pulses. To explain the action of the time-base generator assume it is in the quiescent state, just before the arrival of a suitable trigger pulse, with V135A conducting.

Square waves, generated by the time-base trigger circuitry, are differentiated by the C131-R131 network.

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

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

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

The voltage rise at the cathode of V135B drives the grid of V145 above cutoff. As V145 begins to conduct, its plate voltage drops rapidly. Any spiking which may occur is attenuated by the C150-R150 network.

When V145 is conducting at the maximum determined by circuit parameters, the sweep gating multivibrator has reached its other stable state and the action of the Miller runup circuit has been initiated.

The Miller runup 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 runup cathode follower V173 and opposes the attempt of the grid to go negative. Because the gain of the Miller tube is high, (approximately 200) it is possible to maintain an essentially linear rate of charge on the timing capacitor.

In the quiescent state of the time-base generator, the voltage at the plate of the Miller tube is determined by the voltage drop across the dc network formed by neon lamp B167, the runup 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, and hence 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. In the quiescent state of the time-base generator, the grid of the Miller tube is held slightly negative but well above cutoff by the flow of the current through the A section of the 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 runup 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 of 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 follows the action of the grids closely. This results in a linear rise in the voltage at the upper end of timing capacitor C160. Since the charge on the capacitor cannot change instanteously, this voltage is coupled to the grid of the Miller tube in a direction to correct for the attempt of the Miller-tube grid to go negative.

Current to charge timing capacitor is supplied through timing resistor R160. Since the voltage across the timing resistor is virtually constant, a constant current source is thus provided for charging the timing capacitor.

The linear voltage rise at the cathode of V173 is used as the time-base sawtooth. This voltage rise continues until a positive step from the sweep gating multivibrator raises the plate voltage 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 and causes that circuit to revert to its other state. It is kept from acting on further trigger pulses by the action of the holdoff circuit.

The waveform coupled to the time-base generator from the time-base trigger circuit contains both positive- and negative-going pulses. To prevent a negative-going pulse from triggering the sweep gating multivibrator before the action of the time-base generator is completed, the grid of V135A must be held above cutoff.

The holdoff circuit keeps the grid of V135A above cutoff until the capacitances in the time-base gererator have had time to reach their quiescent state. The point at which the holdoff circuit will allow the sweep-gating multivibrator to return to its quiescent state is determined by the adjustment of R176 (SWEEP LENGTH).

The sawtooth present at the cathode of the runup cathode follower is coupled to the grid of V183A through R176. During calibration, R176 is adjusted so that the time base terminates after it has passed the right-hand limit of the graticule. R176 adjusts the voltage at the grid of V183A and consequently at the cathode of V183A and also on capacitor C180, thus determing when the sweep ends.

The positive-going pulse from the cathode of V183A is coupled to the grid of V133B. The action of capacitor C180 retards the voltage at the grid of V133B. The value of C180 is chosen so that its capacitance will prevent the voltage at the grid of V133B from falling until all capacitance in the time-base generator have returned to their quiescent level.

Unblanking Circuit. In the quiescent state of the time-base generator, the crt beam is cut off. To allow the crt beam to be seen, the potential at the control grid of the crt must be raised. The voltage rise appearing at the cathode of V135A in the time-base generator is used to drive cathode follower V183B. The signal on the cathode of V183B unblanks the beam during the time a sawtooth is generated, permitting the left-to-right motion on 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.

Output Waveforms. The time-base sawtooth from the cathode of V173 is fed through cathode-follower V193B and is available at the SAWTOOTH A front-panel connector.

The same pulse that is fed to the grid of V183B for unblanking purposes is also fed to cathode-follower V193A which makes the pulse available at the +GATE A front-panel connector.

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

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

Depressing the RESET switch grounds C102 and R102. The resulting positive pulse at the grid of V114 forces the lockout multivibrator into its other stable state with V125 conducting and V133A cut off. With V133A cut off, its plate voltage rises and lights the READY lamp. With V125 conducting, the STABILITY control regains control over the grid level of V135A.

Depending on the adjustment of the STABILITY control, a sweep can now be produced in one of two ways. If the STABILITY control is turned fully clockwise, the grid of V135A will be pulled down and cause 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 V133B by the holdoff action previously described. As the cathode of the lockout multivibrator follows the cathode if V133B up, V125 cuts off and V133A conducts. As the cathodes continue to rise (following the rise in the sawtooth sweep voltage) V133A cuts off again.

Both tubes are then held cut off for the remainder of the sweep and the READY lamp stays on. When the grid of V135A rises to the point at which the sweep gating multivibrator reverts, the sweep is terminated.

As hold-off capacitor C180 discharges, the cathodes of the lockout multivibrator starts to fall. The grid level of V133A is such that this tube comes out of cutoff first, thus V133A conducts and V125 remains in cutoff. As V133A conducts, its plate drops and extinguishes the READY lamp. A new sweep cannot be initiated until the RESET switch is pressed again.

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

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

Time Base B

Time Base B is very similar to Time Base A. The major difference is the lack of the bootstrap capacitor in Time Base B and no sawtooth-output cathode follower or output connector on the front panel.

Trigger Generator. The input to the B sweep trigger circuit is selected by TRIGGER SLOPE switch SW60A either from the trigger-pickoff circuit in the vertical amplifier, the power transformer for line triggering, or from the front-panel TRIGGER INPUT connector. TRIGGERING MODE switch SW60B permits further selection of the type of triggering signal; either automatic, ac or dc. Once the type and source of triggering signal has been selected, the slope on which triggering is desired is selected by TRIGGER SLOPE switch SW60A. The level of the triggering signal required by the B sweep trigger circuit is selected by adjusting TRIGGERING LEVEL control R67. After the triggering signal has been selected by the preceding controls and switches, it is applied to trigger-input amplifier V74.

The trigger-input amplifier is a polarity-inverting cathode-coupled amplifier which serves two basic functions. First, it provides a source of negative-going signal to drive the following stage. Secondly, it enables the operator to select the point on the signal at which triggered operation will occur with the TRIGGERING LEVEL control.

To trigger from a negative-going signal, the grid of the V74A section is connected to the input-signal source. The grid of the V74B section is connected to a dc-bias source, which is adjustable with the TRIGGERING LEVEL control. This bias voltage establishes the voltage present at the plate under no-signal conditions.

The voltage at the grid of V74A and the voltage at the plate of V74B are in phase with each other; that is, they both go through ac zero in the same direction at the same time. Thus, the V74A section acts as a cathode follower, and the signal voltage developed across the cathode resistors becomes the input signal to the V74B section.

To trigger from a positive-going signal, the grid of the V74A section is connected to the TRIGGERING LEVEL control, and the grid of V74B is connected to the input signal. With this configuration, the voltage at the plate of the V74B section will be 180 degrees out of phase with the input-signal voltage.

In each of the cases described previously, a negative-going signal is produced at the plate of the V74B section of the Trigger-Input Amplifier regardless of the polarity of the input signal.

D81 and D82 are limiters and allow the trigger circuit to count down to provide triggers at a slow enough rate for the sweep gating multivibrator to react. The quiescent voltage level on the base of Q85 is set by TRIG LEVEL CENTERING R82. The amplitude of the triggering signal necessary to cause operation of the trigger multivibrator is determined by the setting of the TRIGGERING LEVEL control.

In the quiescent state, ready to receive a signal, Q85 of the trigger multivibrator is conducting and the collector voltage is down. The Q85 collector is dc coupled to the base of Q95, thus Q95 is held below cutoff. With Q95 cut off, its collector voltage is up and no output is developed. The negative-going portion of the signal from the trigger-input amplifier is required to drive the base of Q85 down. As the Q85 base is driven negative, the curent flow through the transistor is restricted and the voltage at the collector starts to rise. The rise in voltage at the collector of Q85 carries the base of Q95 in the positive direction. The emitters of both transistors are coupled together and follow the action of the bases. With the Q95 base going in a positive direction, and the emitter in a negative direction, Q95 starts to conduct. As Q95 starts to conduct, the emitters of both transistors follow the action of the Q95 base; hence the emitter voltage starts to rise. As Q85 stops conducting the base goes down and the emitter goes up. As Q95 conducts, its voltage drops, creating a negative step at the output. This transition occurs rapidly, regardless of how slowly the base falls. When the signal applied to the base of Q85 goes in a positive direction, the action described in the previous paragraphs reverses itself. That is, Q85 will start to conduct while Q95 will be cut off.

In the AUTO position of the TRIGGERING MODE switch, the trigger multivibrator is converted from a bistable to a recurrent configuration. This is accomplished by ac coupling the +100 volts to the collector of Q95. In this mode of operation the trigger multivibrator will run in the absence of a triggering signal. For example, assume that the base of Q95 is just being driven into cutoff. The collector of Q95 starts to rise causing C90 and C95 to start charging. The charging of C90 and C95 prevents the base of Q95, which is connected back to its collector, from rising immediately. The emitter of Q95 which follows the base is going negative as Q95 cuts off. The negative-going emitter of Q95 is directly coupled to the emitter of Q85, thus pulling it negative and turning on Q85. When the capacitors have charged sufficiently to allow the base of Q95 to rise and turn on Q95, one cycle of an approximately 40-cycle repetition rate will have been completed.

Delay-Pickoff Circuit. Delayed triggers can be applied to sweep generator A in the 'B' INTENSIFIED BY 'A' and 'A' DLY'D BY 'B' positions of the HORIZONTAL DISPLAY switch. The trigger pulses are applied to the sweep generator from delayed trigger amplifier V114 through V133A which acts as a coupling cathode follower to apply delayed triggers to the sweep gating multivibrator. Delayed trigger pulses are applied to the grid of V114 from the cathode of V428B.

These pulses are shaped and amplified in the delay pickoff circuit composed of V414, V424, V445, and V428. V414 and V424 are combined to form a difference amplifier which picks off a sample of the sawtooth output from sweep generator A or B and converts it into a positive step pulse. Before the pickoff time, V414 is cut off and V424 is conducting. Since the cathodes of V414 and V424 are tied together, V424 determines the common-cathode voltage.

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

Plate current through R424 and L424 remains very nearly constant while V424 is conducting, regardless of the grid voltage set by DELAY-TIME MULTIPLIER R433. This is important since the plate voltage of V424 holds the grid voltage of shaper stage V445A near the triggering points.

The positive-going delayed sweep sawtooth raises the grid of V414 toward its cathode voltage. When the grid rises past the cathode voltage set by the DELAY-TIME MULTIPLIER control, R414 conducts and V424 cuts off. When V424 cuts off, its plate rises, carrying the grid of trigger shaper V445A positive past its transition point. The trigger-shaper stage is regenerative to produce a fast transition. The regulating positive step at the plate of V445B is differentiated through C454 and used to arm or to trigger the Time Base A sweep circuits. The sharp differentiated pulse is transmitted to the succeeding circuits through cathode follower V428B.

The DELAY START and DELAY STOP controls (located on the swingout gate of the oscilloscope) precisely adjust the upper and lower grid voltage limits of V424 as set by the DELAY-TIME MULTIPLIER so that delay can be read accurately from the DELAY-TIME MULTIPLIER dial.

Horizontal Amplifier

The Horizontal Amplifier converts the single-ended sawtooth output of the time-base generator into a push-pull signal suitable for driving the horizontal plates of the crt.

The gain of the amplifier may be varied by a factor of five with the 5× MAGNIFIER switch. Controls are also provided for horizontal positioning and adjustment of the horizontal linearity.

The sawtooth waveform from the time-base generator is coupled to the input cathode follower through the R330, C330, network. This network attenuates the input signal and provides a means of compensating the input circuitry for optimum frequency response.

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

Coupling between the input cathode follower and the driver cathode follower is made by the 5× MAGNIFIER switch. When the 5× MAGNIFIER switch is in the OFF position, the signal from the input cathode follower must pass through the network formed by C348 in parallel with the series combination of R348 and R349. Variable resistor R348 adjusts the length of the time base by varying the attenuation applied to the signal. Variable capacitor C348 is adjusted to provide optimum linearity on the time base. The R348, R349, C348 network attenuates the signal by a factor of five. To provide magnification of the sweep, the network is removed when the 5X MAGNIFIER switch is turned to the ON position.

The gain of the horizontal amplifier is controlled by a negative-feedback circuit. The signal appearing at the left-hand deflection plate is fed back to the input of driver cathode follower V343B. NORM/MAG REGIS R358 varies the dc voltage applied to the feedback loop.

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

The output waveform from the horizontal amplifier is taken from V364A and V384A. The cathodes of these tubes are connected through a network which includes the MAG GAIN control. The MAG GAIN control adjusts the gain of the horizontal amplifier when the 5× MAGNIFIER switch is in the ON position. C375, in parallel with the MAG GAIN control, effects the linearity at the beginning of the sweep for high sweep rates.

Part of the signal appearing at the plates of the output amplifiers is used to drive the output cathode followers. Note that the cathode of V364B is connected to the plate of V398. The function of the output cathode followers is to drive the capacitance of the horizontal deflection plates and the associated wiring. To assure a sufficient flow of current at fast sweep rates, V398 is used to supply current to the output cathode follower which drives the negative-going, or left-hand deflection plate. The pulse to drive the grid of V398 is derived from the waveform at the right-hand deflection plate. This waveform is differentiated by the C390, R390 network before being applied to the grid. Thus, its amplitude is proportional to the sweep rate.

Bootstrap capacitors C364 and C384 are used to help supply the necessary charging current for fast sweep rates.

Beam-Position Indicators. The beam-position indicators B397 and B398 located on the front panel above the crt indicate the relative horizontal position of the spot or center of the trace with respect to the center of the graticule. When the spot or trace is centered horizontally, the potential across either neon is insuficient to light it. As the beam is positioned left or right on the crt, the voltage across the neons will change. The voltage across one neon will increase, causing it to light, and the voltage across the other neon will decrease, causing it to remain extinguished. The neon that lights will indicate the direction in which the spot or trace has been moved.

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 HORIZ INPUT connector to an auxiliary amplifier whose output is then fed to the horizontal amplifier.

External signals are either 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 amplifier gain can be adjusted by varying VARIABLE 10-1 R314 which determines the amount of cathode coupling. The two cathodes must be at the same dc voltage, or varying R314 will change the dc level. EXT HORIZ DC BAL R317 can be adjusted so that the cathodes of V314A and V314B are at the same voltage.

Plate 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 is a square-wave generator with approximately a 1-kc output available at the front-panel CAL OUT connector. The amplitude calibrator consists of multivibrator V875 and V885A connected to switch cathode follower V885B between two operating states: cutoff and conduction.

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

Cathode follower V885B has a precision tapped divider for its cathode resistor. When the CAL ADJ control is properly adjusted, the cathode of V885B is at +100 volts when V875 is cut off. 18 output voltages from 0.2 mvolts to 100 volts are available through tapped divider, R885, R893, and 1000/1 divider R896-R897. C885, connected between the cathode of V885B and ground, corrects the output waveform for overshoot.

The amplitude calibrator provides a 0.1-volt output when the AMPLITUDE CALIBRATOR switch is set to 0.5 volt and a 50 Ω load is connected to the CAL OUT connector.

SECTION 4

PREVENTIVE MAINTENANCE

Panel Removal

The side and bottom panels of the Type 545B 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 of each panel to insure proper air flow throughout the instrument.

For instructions on removing the cabinet from the Type RM545B see the rackmounting instructions at the rear of Section 6.

Recalibration

To insure accurate measurements, check the calibration of the instrument after each 500 hours of operation or every six months if used intermittently. Complete calibration instructions are given in Section 5.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases minor troubles, not apparent during normal use, may be revealed and/or corrected by recalibration.

Visual Inspection

The Type 545B should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated tubes or transistors, and heat-damaged parts.

The remedy for most visible defects is obvious; however, particular care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of over-heating before the heat-damaged parts are replaced; otherwise, the damage may be repeated.

Cleaning

The Type 545B should be cleansed as often as operating conditions require. Accumulations of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides a conduction path for electricty. Dirt in the air filter chokes the flow of cooling air and results in excessive operating temperature.

Air Filter. The air filter should be visually checked every few weeks and cleaned if dirty. More frequent inspections and cleaning are required under severe operating conditions. To clean the filter, wash it out in the same manner as a plastic sponge. Rinse the filter thoroughly and let it dry. Coat the dry filter with fresh "Filter Kote" (Tektronix Part No. 006-580) or "Handi-Koter" (available locally through most air conditioner suppliers). Let the filter dry thoroughly before reinstalling.

Exterior. Loose dust accumulating on the outside of the Type 545B can be removed with a cloth or small paint brush. The paint brush is particularly useful for dislodging dust on and around the front-panel controls. Stubborn dirt can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

Clean the face of the crt with a soft, lint-free cloth dampened with denatured alcohol.

CAUTION

Avoid the use of chemicals which might damage the plastics used in this instrument, particularly the lucite plastic crt faceplate. Avoid chemicals such as benzene, toluene, xylene, acetone or similar solvents.

Interior. Although air entering the Type 545B is filtered, some dust may penetrate into the interior of the instrument. This dust must be removed occasionally due to its conductivity under high humidity conditions. The best way to clean the interior of the instrument is to first carefully vacuum all accessible areas and then blow away the remaining dust with dry, low-pressure air. Avoid the use of high-velocity air which might damage some of the components. Remove any dirt which remains with a soft paint

Fig. 4-1. Fan motor lubrication points.

brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips and etched wiring boards.

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.

Lubrication

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

CORRECTIVE MAINTENANCE

Soldering

Special silver-bearing solder is used to establish a bond to the ceramic terminal strips in Tektronix instruments. This bond can be broken by repeated soldering (especially if ordinary tin-lead solder is used) or by excessive heating. Solder containing about 3% silver is recommended. A small supply of this solder is provided on a spool mounted inside the Type 545B. Additional silver-bearing solder can usually be purchased locally; however, is may be purchased through your Tektronix Field Engineer or Field Office—specify Tektronix Part No. 251-514.

The following procedure is recommended when soldering to ceramic terminal strips:

1. Use a wedge-shaped soldering-iron tip about 1/8-inch wide. This allows heat to be applied directly to the solder in the terminal strip, thereby reducing the amount of heat required.
2. Maintain a clean, properly tinned tip.
3. Use a hot iron for a short time. A 50- to 75-watt iron having good heat transfer and storage characteristics is adequate.
4. Avoid putting pressure on the strip. Excess pressure may crack or chip the strip.
5. Apply only enough heat to make the solder flow freely.
6. Do not attempt to fill the notch on the strip with solder; instead apply only enough solder to cover the wires adequately and establish a solid solder joint. Overfilling the notches may result in cracked terminal strips. If the lead extends beyond the solder joint, clip the excess as close to the joint as possible. Remove all wire clippings from the chassis.

Ceramic Terminal Strips

Fig. 4-2 shows an assembled ceramic terminal strip. Replacement strips with studs attached are supplied under one part number; the spacers are supplied under a separate part number. However, the old spacers may be reused if not damaged.

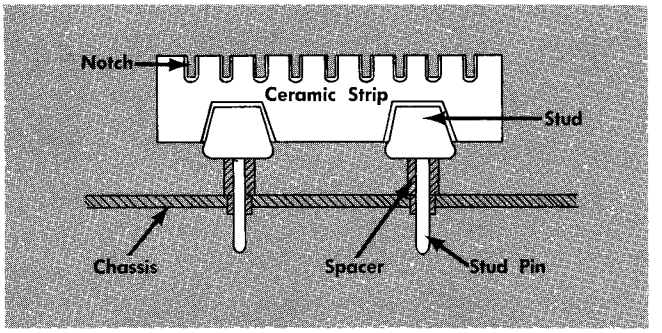


Fig. 4-2. Ceramic strip assembly.

Usually a strip can be pried out of the chassis or pulled out with a pair of pliers. If desired, a hammer and punch may be used to drive out the studs from the opposite side of the chassis.

When the damaged strip has been removed, place the new or used but undamaged spacers in the chassis holes. Then, carefully force the studs of the new strip into the spacers until they are completely seated. If necessary, use a soft-faced mallet and tap lightly, directly over the stud area of the strip.

Component Replacement

Certain parts in the instrument are easiest to replace by following a definite procedure. The procedures for replacing these parts are outlined in the following paragraphs.

Many electrical components are mounted in a particular manner to reduce or control stray capacitance or inductance. Duplicate the original location and mounting when replacing components. When selecting replacement parts, remember that the physical nature of a component can affect its performance at high frequencies. After repair, check the instrument calibration.

NOTE

Turn off the instrument power before replacing transistors or other components.

Standard Parts

Many of the components in this instrument are standard electronic parts that can be purchased locally. However, all parts in the instrument can be obtained through your Tektronix Field Engineer or Field Office. Before purchasing or ordering parts, check the parts list in Section 6 to determine the value, tolerance, and rating required.

Special Parts

Some of the parts in the instrument are manufactured or selected by Tektronix to meet specific requirements, or are manufactured for Tektronix to our specifications. These parts and most mechanical parts should be ordered through your Tektronix Field Engineer or Field Office. See "Parts Ordering Information" and "Special Notes and Symbols" in Section 6.

Tubes and Transistors

Tubes or transistors should not be replaced unless they are actually defective. If tubes or transistors are removed and found to be acceptable, be sure to return them to their original sockets. Tube- or transistor-tester checks on the tubes or transistors used in the Type 545B are not recommended. Testers may indicate a tube or transistor to be defective when it is operating satisfactorily in a circuit, or may fail to indicate tube or transistor defects which affect the performance of the circuits. It is recommended that tubes and transistors be checked by substitution. If the tube or transistor is good, return it to its socket. Unnecessary replacement of tubes or transistors is not only expensive but may also result in needless recalibration of the instrument.

Wafer Switches

Individual wafers are normally not replaced in the switch assemblies. Replacement switches may be ordered from Tektronix either wired or unwired; see the parts list for the part numbers.

When soldering a switch assembly, do not let the solder flow around and beyond the terminal rivet since this may destroy the spring tension of the contact.

Cathode-Ray Tube

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

WARNING

Be careful when handling a crt. Avoid striking it on any object that might cause it to crack and implode. Flying glass from an imploding crt can cause serious injury. Use safety glasses or a plastic face mask for protection.

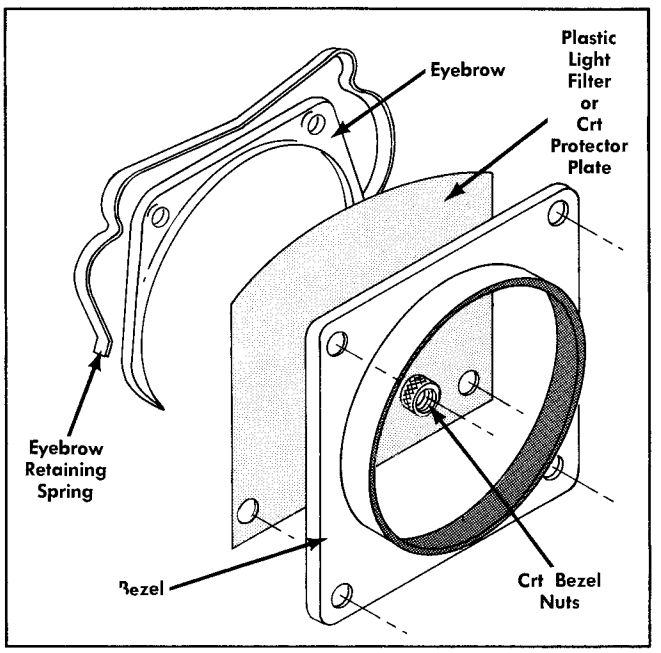


Fig. 4-3. Crt bezel and eyebrow arrangement.

1. Remove crt bezel nuts, bezel and plastic light filter or crt protector plate (see Fig. 4-3).
2. Remove plastic eyebrow and retaining spring from the top of the crt (see Fig. 4-3).
3. Remove crt anode lead and disconnect all leads from the neck of the crt.
4. Using a phillips screwdriver, loosen crt base clamp (see Fig. 4-4) so that the crt base is loose in the base clamp.
5. With a chisel-tipped plastic or wooden dowel, carefully work the crt socket loose from the crt base.
6. Grasp the face of the crt with the right hand. Push the crt carefully toward the front of the Type 545B with the left hand. Be careful not to bend the neck pins. Remove the crt through the front of the oscilloscope.
7. Before reinstalling the crt, dust talcum powder on the crt base. This prevents the base of the crt from sticking to the neoprene bushing inside the base clamp.
8. Carefully insert the new tube into the shield and the tube base clamp. Keep the anode button in line with the anode connector hole so that the button is aligned with the hole when the crt is fully inserted.
9. Reconnect the crt socket to the tube base.
10. Turn the crt so that the horizontal graticule lines are parallel with the top of the front panel.

NOTE

If the crt face is not aligned with the front of the oscilloscope, use a $^{7}/_{64}$" hexagonal wrench to loosen the two socket head mounting screws that fasten the base clamp to the mounting bracket (see Fig. 4-4). Move the base clamp and crt radially to align the face of the crt with the front panel of the instrument.

11. Install eyebrow and eyebrow retainer spring. Position the crt so that the crt faceplate and eyebrow are flush.
12. Tighten the base clamp.
13. Reconnect the anode and neck-pin leads (observe color code).
14. Turn on the oscilloscope and obtain a free-running sweep on the crt.
15. Check the trace alignment with the graticule lines. If the trace is not parallel with the graticule lines, adjust the TRACE ROTATION control to realign the trace.
16. Remove all smudges and dirt from the crt face with a soft lint-free cloth dampened with denatured alcohol.
17. Replace light filter (or crt protector plate), crt bezel, and bezel nuts.

TROUBLESHOOTING AIDS

Schematic Diagrams

Schematic diagrams for each circuit in this instrument are located in Section 6. In addition, a block diagram provides an overall picture of instrument operation. The circuit re-

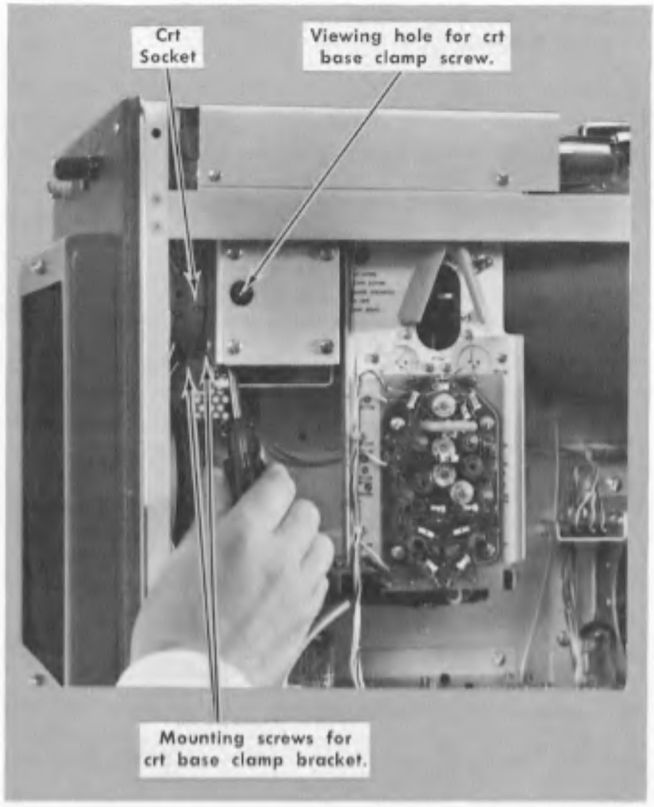


Fig. 4-4. Loosening the crt base clamp.

ference designation for each electronic component in the instrument is shown on the circuit diagrams along with important voltages and waveforms. The following list shows the circuit numbers and their associated circuit in this instrument:

1 — 49 .....Time-Base A Trigger
50 — 99 .....Time-Base B Trigger
100 — 199.....TIME-BASE A Generator
200 — 299.....TIME-BASE B Generator
300 — 329.....External Horizontal Amplifier
330 — 399.....Horizontal Amplifier
400 — 459.....Delay Pickoff
460 — 599.....Vertical Amplifier
600 — 799.....Power Supply
800 — 869.....Crt Circuit
870 — 899.....Calibrator

Switch Wafers

Switch wafers shown on the schematic diagrams are coded to indicate the position of the wafer in the complete switch assembly. The number portion of the code refers to the wafer number counting from the front or mounting end of the switch toward the rear. The letters 'F' and 'R' indicate whether the front or rear of the wafer is used to perform the particular switching function.

Wiring Color-Code

All wiring in the Type 545B is color-coded to facilitate circuit tracing. The widest color stripe identifies the first color of the code. The background color indicates the following: white—positive voltage, tan—negative voltage, gray—unregulated voltage.

The regulated power-supply wiring is identified by the following code.

+500 volts.....Green-black-brown on white background.
+350 volts.....Orange-green-brown on white background.
+225 volts.....Red-red-brown on white background.
+100 volts.....Brown-black-brown on white background.
—150 volts.....Brown-green-brown on tan background.

The heater wiring is indicated by a white background and a blue first stripe. The remainder of the wiring in the Type 545B is not color-coded in any particular manner; the color used is to facilitate point-to-point circuit tracing within the instrument.

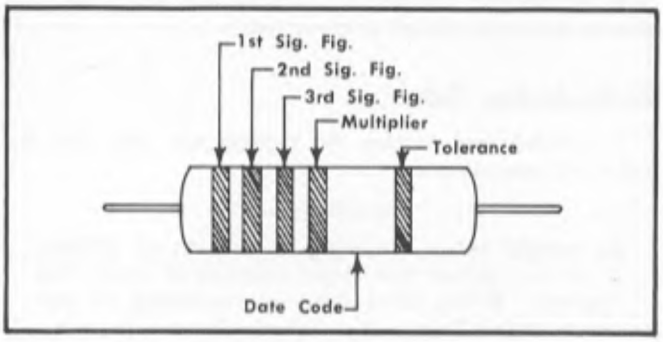


Fig.4-5. Standard EIA color code for metal-film resistors.

Resistor Color-Code

Some stable metal-film resistors are used in this instrument. These resistors can be indentified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it will be color-coded according to the EIA standard. If it has a value indicated by four significant figures and a multiplier, the value will be printed on the body of 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. 4-5, and Table 4-1.

Composition resistors used in this instrument are color-coded according to the EIA color code.

TROUBLESHOOTING

General Information

The following information is provided to facilitate troubleshooting of the Type 545B if troubles develops. During troubleshooting, information contained in this section of the manual should be used with information obtained from other portions of the manual.

TABLE 4-1
Color Code Sequence

Color	1st Sig. Fig.	2nd Sig. Fig.	3rd Sig. Fig.	Multiplier	(±) % Tolerance
Black	0	0	0	1	
Brown	1	1	1	10	1
Red	2	2	2	100	2
Orange	3	3	3	1,000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	0.50
Blue	6	6	6	1,000,000	0.25
Violet	7	7	7	10,000,000	0.10
Gray	8	8	8	100,000,000	0.05
White	9	9	9	1,000,000,000	
Gold				0.1	5
Silver				0.01	
No Color					10

In general, troubleshooting an instrument can be divided into two parts: isolating the trouble to the originating circuit, and the actual location of the defective component. The following general procedures should help isolate the trouble to the defective circuit. Then the circuit troubleshooting information should be used to locate the defective component.

Circuit Isolation

The Type 545B can be divided into 11 major circuits, as follows:

1. Time-Base A Trigger
2. Time-Base B Trigger
3. Time-Base A Generator
4. Time-Base B Generator
5. External Horizontal Amplifier
6. Horizontal Amplifier
7. Delay Pickoff
8. Vertical Amplifier
9. Power Supply
10. Crt Circuit
11. Calibrator

Although the Type 545B is a stable instrument, it is possible for circuits to get out of calibration, thereby producing an apparent trouble. Before proceeding with any detailed trouble analysis, be sure that the trouble cannot be corrected by means of a normal calibration adjustment. If there is any doubt, recalibrate the entire suspected circuit using the procedure given in Section 5.

When a trouble occurs in the instrument, first recheck the settings of all controls to see that they are set properly. Then turn the front-panel controls throughout their range to see what effect, if any, they have on the trouble symptom. The normal or abnormal operation of each control may help to indicate the circuit in which the trouble is located.

When vertical-system troubles are encountered, isolate the trouble to the Type 545B or the vertical plug-in unit. One way to do this is by substituting another vertical plug-in unit. If the trouble appears to be in the plug-in unit, refer to the Maintenance section of the plug-in unit instruction manual.

If the instrument does not operate at all, check the obvious things first. Check to see the instrument is plugged in and there is power at the socket. Check the line fuse. Check that the pilot lamp and tube heaters are lit. When the obvious indications of trouble have been checked, proceed to a more detailed analysis of the trouble.

Unusual troubles may often occur due to a failure in one of the low-voltage power supplies. Also, the circuits of the Type 545B make it possible for an incorrect voltage to affect one circuit more than another. Consequently, a power supply trouble should be considered as a possibility in virtually any type of failure which may occur within the instrument. If there is any doubt as to whether a power supply may be causing the trouble, the regulated output and ripple of that supply should be checked before proceeding further with the troubleshooting procedure. If the output voltage and ripple of a regulated power supply are correct, that supply can be assumed to be operating properly.

Circuit Troubleshooting

After the trouble has been isolated to a particular circuit, perform a complete visual check of that circuit. Many troubles can be found most easily by visual means. If a visual check fails to detect the cause of the trouble, check the tubes or transistors used in that circuit by replacing them with tubes or transistors known to be good. Most of the troubles which occur in Tektronix instruments result from tube or transistor failures. Be sure to return any tubes or transistors found to be good to their original sockets. If the trouble is not the result of a tube or transistor failure use the following procedure:

1. Isolate the trouble to a portion of the circuit if possible.
2. Recheck the reaction of the front-panel controls and calibration adjustment on the affected circuit.
3. Check the voltage in the circuit. Typical operating voltages are given on the schematic diagrams.
4. Check waveforms in the circuit with another oscilloscope. Typical waveforms are given on the schematic diagrams.
5. Check the components in the circuit (i.e., check for faulty capacitors, off-tolerance resistors, etc.).

NOTES

SECTION 5

CALIBRATION

Introduction

The Type 545B Oscilloscope is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors, or other components are replaced.

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

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

Equipment Required

The following equipment is necessary for a complete calibration of the Type 545B Oscilloscope.

1. Dc voltmeter having a sensitivity of at least 5000 Ω/v and calibrated for an accuracy of at least 1% at 100, 150, 225, 350, and 500 volts, and for an accuracy of at least 3% at 1700 volts. Portable multimeters should be regularly checked against an accurate standard and corrected readings noted, where necessary, at the above listed voltages.
2. An accurate rms-reading ac voltmeter, having a range of 0-150 volts (0-250 or 0-300 for 230-volt operation).
3. Variable auto-transformer having a rating of at least 6.25 amperes.
4. Time-mark generator, Tektronix Type 180A or equivalent, having markers at 1 μsec, 10 μsec, 50 μsec, 100 μsec, 1 msec, 5 msec, 10 msec, 100 msec, 1 sec, and 5 sec, and sinewave outputs of 10 mc and 50 mc, all having an accuracy of at least 1%.
5. Test load unit, Tektronix Type TU-7. Contains a pulse generator capable of producing pulses with a risetime of 3 nsec or faster. This multi-purpose test-load unit is the only plug-in needed to perform a complete calibration of the oscilloscope.
6. Low-bandwidth test oscilloscope with a 1× attenuator probe. Bandwidth of dc to 350 kc or better.
7. Two coaxial cables, 50-ohm nominal impedance, 42" long with BNC connectors on each end. Tektronix Part No. 012-057.
8. Adapter, single binding post fitted with a BNC connector. Tektronix Part No. 103-033.
9. Coaxial connector adapter with BNC and UHF connector fittings. Tektronix Part No. 103-015.
10. Jumper clip lead, about 4" long. Equipped with miniature alligator clips on each end.
11. Two interconnecting leads, 18" long, with combination plug-and-jack banana-type connectors on each end. Tektronix Part No. 012-031.
12. BNC T connector. Tektronix Part No. 103-332.
13. Miscellaneous Items

    1-Screwdriver, 3/16" wide bit, shank about 3" long.

    1-Screwdriver, 3/32" wide bit, shank about 2" long.

    1-Jaco No. 125 insulated low-capacitance-type screwdriver with a 1 1/2" long shank and 1/8" wide metal tip. Total length is 5". Tektronix Part No. 003-000.

    1-Low-capacitance alignment tool consisting of a handle (Tektronix Part No. 003-007), a gray nylon insert with a metal screwdriver tip (Tektronix Part No. 003-334), a 5/64" hexagonal wrench insert (Tektronix Part No. 003-310).

    1-Hexagonal wrench, 1/16". For respositioning, if necessary, the TRIGGERING LEVEL control knobs.

PRELIMINARY INSTRUCTIONS

Remove the cover(s) from the instrument to be calibrated and install the Type TU-7 Unit.

Set the front-panel controls as follows:

Crt Controls

INTENSITY	0
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	5

Time Base A

TRIGGERING LEVEL	Fully clockwise
STABILITY	Fully clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC

Horizontal Display

HORIZONTAL DISPLAY	A
5× MAGNIFIER	OFF

Time Base B

TRIGGER LEVEL	Fully clockwise
STABILITY	Fully clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
LENGTH	10 cm
TIME/CM	.5 mSEC

Other Controls

DELAY-TIME MULTIPLIER	1.00
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	OFF

Before installing the Type TU-7 and applying power to the instrument, the resistances of the power supplies should be checked. The typical resistances of the supplies may be found in the chart below.

Norminal Resistances of Power Supplies

Supply	Approx. Resistance to Ground
—150	2 k
+100	2 k
+225	2 k
+350	1 k
+500	15 k

Install the Type TU-7 and preset its controls as follows:

Vertical Position	Centered
Test Function	Low Load
Other Controls	As is

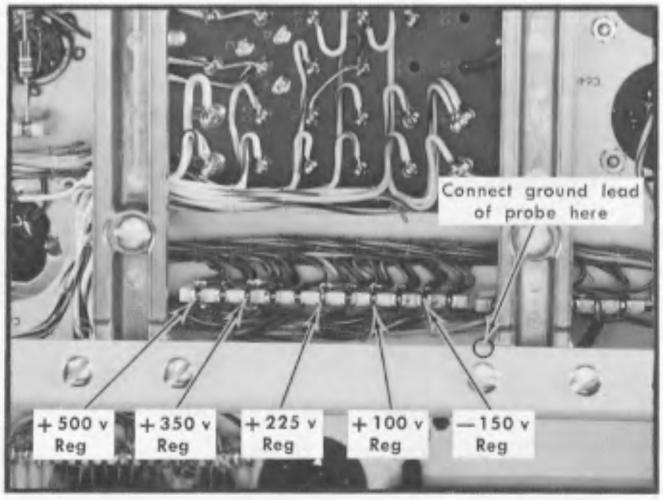


Fig. 5-1. Low-voltage power supply test point locations.

Connect the power cord and the ac voltmeter to the output of the autotransformer. Turn the power switch to the ON position and adjust the autotransformer for an output voltage to match the design center voltage of the oscilloscope. Allow the instrument to warm up for several minutes before proceeding with the calibration adjustments. During calibration, periodically check the input voltage to the instrument and adjust the autotransformer as necessary to maintain the voltage at the design center voltage except when the power supply regulation is being checked.

CAUTION

Do not reset the —150 v control unless the power supply voltages are actually out of tolerance or you are planning to perform a complete calibration of the instrument.

Check the delay time of the delay relay. The relay armature should pull in with a "click" sound after 15 to 60 seconds time has elapsed.

PROCEDURE

1. Low-Voltage Power Supplies

Measure the output voltage of the —150 v, +100 v, +225 v, +350 v, and +500 v regulated supplies at the points indicated in Fig. 5-1. The output voltage of the —150 v and the other regulated supplies must be within 3% of their rated values. You should set the —150 v control (see Fig. 5-2) so that all of these voltages are within the specified tolerance.

To check the regulation of the power supplies, set the Test Function switch of the Type TU-7 to High Load and adjust the line voltage for a voltage 10% lower than your design center voltage. Now check the voltage of each supply. The —150 v, +100 v, +225 v, and +350 v supplies should still be within 3% of their proper values. The +500 v supply should still be within 5% of its proper value.

The power supply ripple is checked by connecting a 1× probe from the test oscilloscope to the supply being checked. The table below gives the approximate ripple amplitudes of each power supply.

After the power supplies have been checked on low line voltage, the line voltage should be raised 10% above design center voltage and the Test Function switch of the Type TU-7 set to Low Load. Repeat the voltage and ripple checks. The same limits apply.

When the power supply regulation checks are completed, return the line voltage to the design center voltage.

Typical Ripple Amplitudes

Supply	Typical Ripple
—150	5 mv
+100	10 mv
+225	5 mv
+350	20 mv
+500	20 mv

2. AMPLITUDE CALIBRATOR Adjustments

The CAL ADJ (R879) should be set to provide exactly +100 volts at the CAL TEST PT when the AMPLITUDE CALIBRATOR

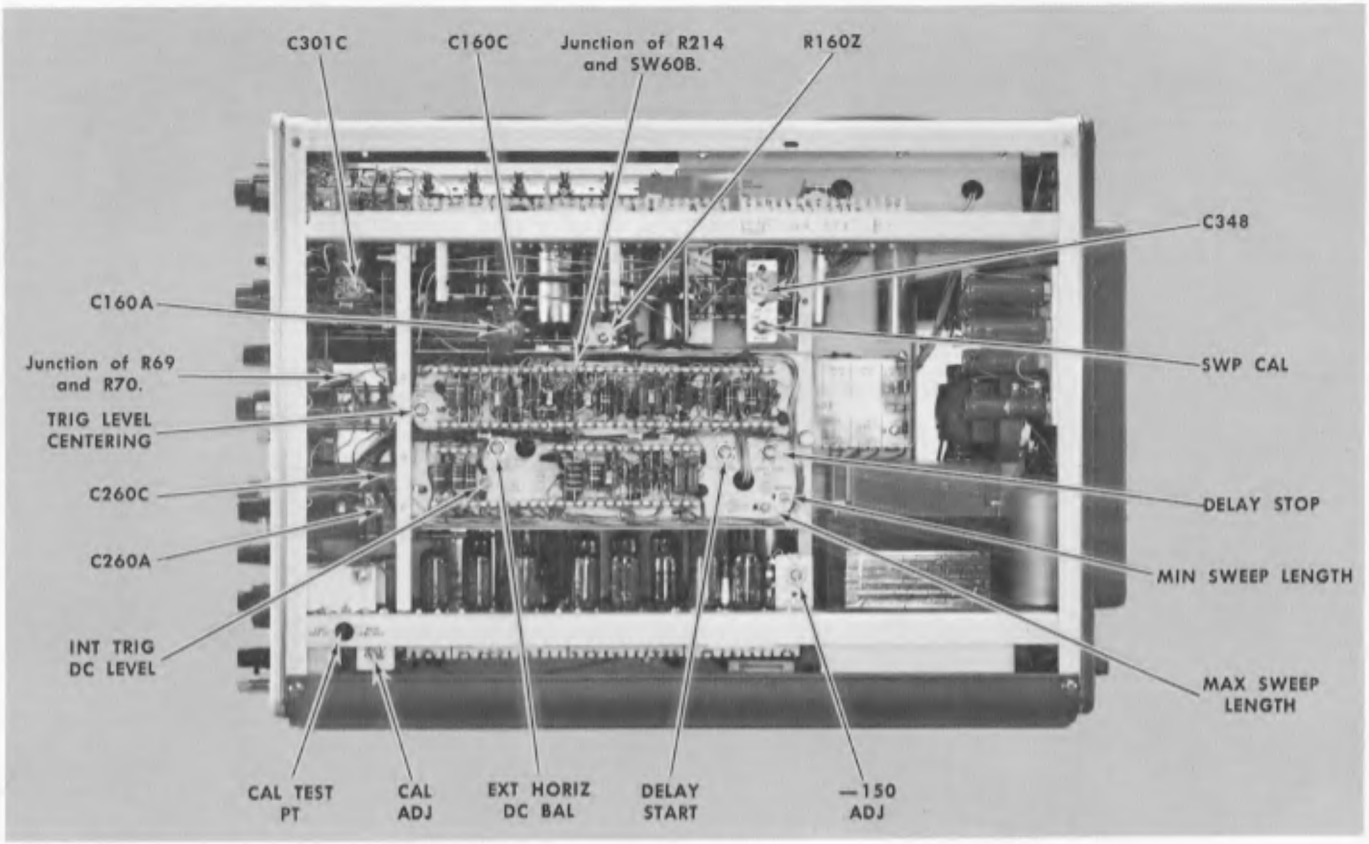


Fig. 5-2. Location of internal adjustments and test points for Time-Base B, Power Supply, and Amplitude Calibrator.

switch is in the OFF position. Under these conditions, the CAL OUT voltages should be within 3% of the front-panel readings.

To make this adjustment, connect the voltmeter between the CAL TEST PT jack and ground (see Fig. 5-2), and adjust the CAL ADJ (R879) for a reading or exactly +100 volts. To assure suitable symmetry of the calibrator waveform, the reading at this point should not be less than 45 v nor more than 55 v when the calibrator is turned on. Readings outside this range are generally caused by unbalanced multivibrator tubes (V875 or V885A).

3. High-Voltage Power Supply Adjustment

Connect the voltmeter between ground and the high-voltage check point (see Fig. 5-3), and set the HIGH VOLTAGE control (see Fig. 5-3) for a meter reading of exactly —1700 volts. Disconnect the voltmeter.

Check the regulation of the high-voltage power supply by turning the INTENSITY control to 7 and defocusing the trace with the FOCUS and ASTIGMATISM controls. Place the HORIZONTAL DISPLAY switch to EXT ×10 and position the defocused spot to the left side of the crt. Now observe the spot while adjusting the line voltage 10% above and below the design center voltage. The spot should not have shown any "blooming".

4. Trace Alignment

Position the HORIZONTAL DISPLAY switch to A and adjust the INTENSITY, FOCUS, and ASTIGMATISM controls to obtain a focused trace of normal intensity.

Position the trace behind the center horizontal graticule line. If the trace and graticule line do not coincide over the width of the graticule, adjust the TRACE ROTATION control until they do.

5. Geometry Adjustment

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

Connect 500-μsec markers from the Type 180A to the Ext Input connector of the Type TU-7 and position the base line of the markers below the bottom of the crt face so it is not visible. Adjust the Type TU-7 Variable control so that the markers over-scan the crt. Obtain a stable display with the A triggering controls, and adjust the GEOMETRY control (see Fig. 5-3) for straight vertical lines running parallel to the left and right edges of the graticule (see Fig. 5-4).

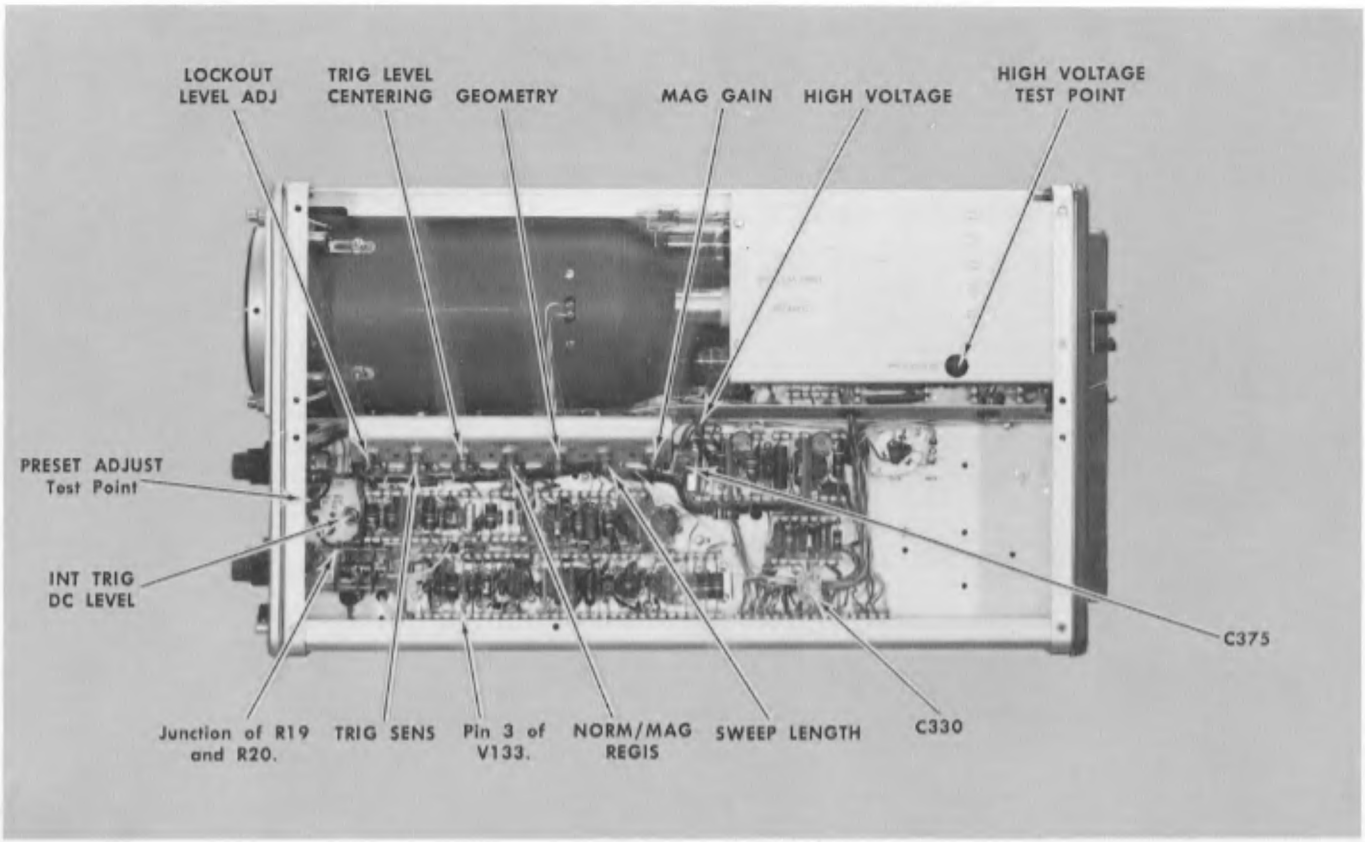


Fig. 5-3. Location of internal adjustments and test points for Time Base A and Crt Circuit.

NOTE

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

6. Vertical Amplifier Low-Frequency Adjustments

Set the Test Function switch of the Type TU-7 to Common Mode and adjust R495 (DC BAL) until the trace is superimposed on the center graticule line.

Now set the Test Function switch to Gain Set and the AMPLITUDE CALIBRATOR to 100 VOLTS. Connect a jumper from the CAL OUT connector to the Ext Input connector of the Type TU-7. Adjust R520 (GAIN) for exactly 4 cm of vertical separation between the two traces. Be sure measurements are always made from the same side of the trace. Vary the line voltage 10% above and below design center line voltage. The gain should not change more than 3%.

Adjust the AMPLITUDE CALIBRATOR to 2 VOLTS and set the Type TU-7 Test Function switch to Low Load. Adjust the Type TU-7 Variable control for a 2-cm vertical separation between the two traces. This adjustment is made using the center 2-cm area of the crt.

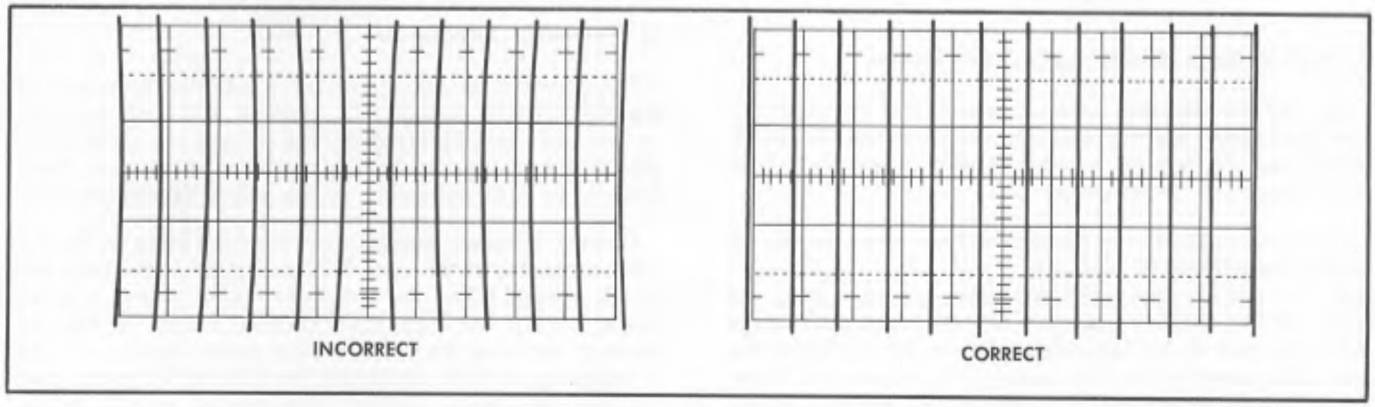


Fig. 5-4. Adjustment of the GEOMETRY control.

Move the display up and down, and measure any changes in apparent sensitivity at different points. The signal must not be compressed or expanded more than 1.5 mm at either the top or bottom extremes of the graticule.

Disconnect the jumper from the CAL OUT connector to the Ext Input connector and center the trace. Vary the line voltage 10% above and below the design center line voltage. From the stable trace position at low-line voltage to a possible new stable position at high-line voltage, the trace should not drift more than 0.5 cm.

7. Checking Alternate Trace and Chopped Blanking

Set the AMPLITUDE CALIBRATOR to 20 VOLTS and the Type TU-7 Test Function switch to Alternate. Center the display with the Vertical Position control and check each sweep rate of the A TIME/CM switch for the alternating traces.

When observing slow sweep rates, the spot will consist of a single dot when the upper trace crosses the crt. However, the spot will consist of two dots, one above the other, when the lower trace crosses the crt.

Set the HORIZONTAL DISPLAY switch to B and again check each sweep rate as was done above.

Set the Type TU-7 Test Function switch to Chopped and the B TIME/CM control to 5 μSEC. Adjust the B triggering controls for a stable display. Switch the CRT CATHODE SELECTOR to DUAL TRACE CHOPPED BLANKING and observe that the vertical lines (chopped transients) disappear. Return the CRT CATHODE SELECTOR switch to the EXTERNAL CATHODE position and reset the oscilloscope and Type TU-7 controls according to Table 5-1.

TABLE 5-1

Set the front-panel controls as follows before proceeding to step 8.

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base A	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AUTO
TRIGGER SLOPE	+EXT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC
Horizontal Display	
HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
Time Base B	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
LENGTH	10 CM
TIME/CM	.5 mSEC
Other Controls	
DELAY-TIME MULTIPLIER	1.00
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	100 VOLTS
TU-7	
Vertical Position	Centered
Test Function	Gain Set
Other Controls	As is

A TRIGGERING ADJUSTMENTS

8. A Trigger Sensitivity

With no input leads connected to the Type TU-7 and the front-panel controls set as in Table 5-1, connect a probe from the test oscilloscope to the junction of C131 and R49 and a jumper from the TRIGGER INPUT connector to ground. Set the time/cm control of the test oscilloscope to 10 msec, the vertical contols for ac coupling and input signal of 5 volts in amplitude, and the triggering controls for a stable display.

Adjust the TRIG SENS control until one cycle of the waveform occupies about 2.5 cm of the sweep. Disconnect the jumper between the TRIGGER INPUT connector and ground.

9. A Trigger Level Centering

Set the TRIGGER SLOPE control to +INT and the TRIGGERING MODE switch to AC. Connect a test lead from the CAL OUT connector to the Ext Input connector on the Type TU-7. A signal with an amplitude of 4 cm should be observed. If this signal amplitude is not present recheck steps 2 and 6. After observing the 4-cm signal, reduce the AMPLITUDE CALIBRATOR signal to 5 volts to obtain a calibrated 2-mm signal for use in the following procedure.

Center the trace vertically on the crt and adjust the INTENSITY, FOCUS, and ASTIGMATISM controls for best definition. Then ground the junction of R19 and R20 with a short clip lead. This junction is located on top of the trigger switch (see Fig. 5-3).

Preset the TRIG LEVEL CENTERING control fully clockwise. Turn the STABILITY control counterclockwise until the trace just disappears from the crt, then two or three degrees further counterclockwise.

Turn the TRIG LEVEL CENTERING control counterclockwise until the display reappears on the screen. Then switch the TRIGGER SLOPE control to —INT; it may be necessary to turn the TRIG LEVEL CENTERING control clockwise slightly to obtain a stable display. Then while switching back and forth between +INT and —INT, slightly readjust the TRIG LEVEL CENTERING control for stable triggering in both positions.

10. A Internal Triggering Dc Level

Set the Type TU-7 Test Function switch to Low Load and the oscilloscope AMPLITUDE CALIBRATOR to 1 VOLT. Use the Type TU-7 Variable control to reduce the signal amplitude to 6 mm.

Center the display vertically, and turn the TRIGGERING MODE switch to the DC position. While switching the TRIGGER SLOPE control back and forth between +INT and —INT, adjust the INT TRIG DC LEVEL ADJ control for stable triggering in both positions. It may be necessary to slightly readjust the TRIG LEVEL CENTERING control to obtain stable triggering.

11. A Trigger Level

Remove the jumper and turn the TRIGGERING LEVEL control until the waveform is triggered at the same point as that observed when the shorting lead was connected. The white dot on the TRIGGERING LEVEL knob should point at 0. If it does not, loosen the knob and move it to this position. Remove the test lead between the CAL OUT and Ext Input connectors.

12. A Preset Adjust

Place the A TRIGGERING MODE switch at AUTO and the TRIGGER SLOPE switch to +LINE. Connect the dc voltmeter between the PRESET ADJUST potentiometer wiper arm (see Fig. 5-3) and ground and rotate the potentiometer fully counterclockwise. Turn the control slowly clockwise until a trace first appears and note the meter reading at this point. Continue to turn this control until the trace brightens and again note the meter reading. Finally, set the PRESET ADJUST control to obtain a meter reading midway between the two previously noted meter readings.

B TRIGGERING ADJUSTMENTS

13. B Trigger Level Centering

Set the oscilloscope and plug-in controls as in Table 5-1, except the HORIZONTAL DISPLAY switch. Set HORIZONTAL DISPLAY to B.

Connect a test lead from the CAL OUT connector to Ext Input connector on the Type TU-7. A signal with an amplitude of 4 cm should be observed. If this signal amplitude is not present recheck steps 2 and 6. After observing the 4-cm signal, reduce the AMPLITUDE CALIBRATOR signal to 5 volts to obtain a 2-mm signal.

Center the trace vertically on the crt and adjust the INTENSITY, FOCUS, and ASTIGMATISM controls for best definition. Then ground the junction of R69 and R70 with a short clip lead. This junction is located on top of the trigger switch (see Fig. 5-2).

Preset the TRIG LEVEL CENTERING control fully clockwise. Turn the STABILITY control counterclockwise until the trace just disappears from the crt screen, then two or three degrees further counterclockwise.

Turn the TRIG LEVEL CENTERING control counterclockwise until the display reappears on the screen. Then switch the TRIGGER SLOPE control to —INT; it may be necessary to turn the TRIG LEVEL CENTERING control clockwise slightly to obtain a stable display. Then while switching back and forth between +INT and —INT, slightly readjust the TRIG LEVEL CENTERING control for stable triggering in both positions.

14. B Internal Triggering Dc Level

Set the Type TU-7 Test Function switch to Low Load and the oscilloscope AMPLITUDE CALIBRATOR to 1 VOLT. Use the Type TU-7 Variable control to reduce the signal amplitude to 6 mm.

Center the display vertically, and turn the TRIGGERING MODE switch to the DC position. Then, while switching the TRIGGER SLOPE control back and forth between +INT and —INT, adjust the INT TRIG DC LEVEL ADJ control for stable triggering in both positions. It may be necessary to slightly readjust the TRIG LEVEL CENTERING to obtain stable triggering.

15. B Trigger Level

Remove the jumper and turn the TRIGGERING LEVEL control until the waveform is triggered at the same point as that observed when the shorting lead was connected. The white dot on the TRIGGERING LEVEL knob should now point at 0. If it does not, loosen the knob and move it to this position. Remove the test lead between the CAL OUT and Ext Input connectors.

16. B Preset Adjust

Place the B TRIGGERING MODE switch at AUTO and the TRIGGER SLOPE switch at +LINE. Connect the dc voltmeter between ground and the junction of R214 and SW60B (see Fig. 5-2) and rotate the PRESET ADJUST control fully counterclockwise. Now, rotate the control slowly clockwise until a trace first appears and note the meter reading at this point. Next, continue to turn this control until the trace brightens and again note the meter reading. Finally, set the PRESET ADJUST control to obtain a meter reading midway between the two previously noted meter readings.

TABLE 5-2

Front-panel controls should be set as below, before proceeding with step 17.

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base A	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	1 mSEC

Horizontal Display

HORIZONTAL DISPLAY	B
5× MAGNIFIER	ON

Time Base B

TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
LENGTH	10 CM
TIME/CM	1 mSEC

Others Controls

DELAY-TIME MULTIPLIER	1.00
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	OFF

TU-7

Vertical Position	Centered
Test Function	Low Load
Variable	Adjust for desired amplitude
Other Controls	As is

HORIZONTAL ADJUSTMENTS

17. Adjust 5X Magnifier gain

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

18. Adjust Sweep Magnifier Registration

With the 5× MAGNIFIER on, position the display so that the first time marker is directly behind the center graticule line. Turn the MAGNIFIER off and adjust NORM/MAG REGIS (see Fig. 5-3) so that the first time marker again falls directly behind the center graticule line.

19. Adjust Sweep Calibration

Reset these controls:

5× MAGNIFIER	OFF
Variable (TU-7)	Adjust for desired amplitude

Apply 1 msec markers from the Type 180A to the vertical input and adjust B triggering controls for a stable display. Now adjust SWP CAL (see Fig. 5-2) for 1 time-marker per centimeter display.

NOTE

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

20. Adjust Time Base A to Time Base B

Switch HORIZONTAL DISPLAY to A and adjust A triggering controls for a stable display. Adjust R160Z (see Fig. 5-2) for the same timing as that obtained for the B sweep in step 19 above, ±0.5 mm.

21. Adjust Time Base A Sweep Length

With controls as in step 20 above, adjust the SWEEP LENGTH control (see Fig. 5-3) for a sweep length of 10.5 cm.

22. Check Time Base B Sweep Rates

Set the HORIZONTAL DISPLAY switch to B, trigger the display and check Time Base B sweep rates according to the following table:

Time Base B	Type 180A	Markers Displayed
1 mSEC	1 msec	1/cm
2 mSEC	1 msec	2/cm
5 mSEC	5 msec	1/cm
10 mSEC	10 msec	1/cm
20 mSEC	10 msec	2/cm
50 mSEC	50 msec	1/cm
.1 SEC	100 msec	1/cm
.2 SEC	100 msec	2/cm
.5 SEC	500 msec	1/cm
1 SEC	1 sec	1/cm

23. Check Time Base A Sweep Rates

Starting with conditions as in step 20 above, check Time Base A sweep rates according to the following table:

Time Base A	Type 180A	Markers Displayed
1 mSEC	1 msec	1/cm
2 mSEC	1 msec	2/cm
5 mSEC	5 msec	1/cm
10 mSEC	10 msec	1/cm
20 mSEC	10 msec	2/cm
50 mSEC	50 msec	1/cm
.1 SEC	100 msec	1/cm
.2 SEC	100 msec	2/cm
.5 SEC	500 msec	1/cm
1 SEC	1 sec	1/cm
2 SEC	1 sec	2/cm
5 SEC	5 sec	1/cm

24. Check Time Base A—Variable Time/Cm Control and Uncalibrated Neon.

The VARIABLE control provides for a complete range of control between the calibrator TIME/CM steps. To check operation of this control, set TIME/CM to 1 mSEC — CALIBRATED, connect 5-msec markers from the Type 180A to the vertical input connector and trigger the oscilloscope for a stable display consisting of 1 marker for each 5 cm. Next, turn the VARIABLE control fully counterclockwise. The display should now consist of markers every 2 cm or less. Check to see that the UNCALIBRATED neon indicator lamp is lit in all positions of the VARIABLE control except when switched to the CALIBRATED position.

TABLE 5-3

Set the front-panel controls as below, before proceeding with step 25.

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base A	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.1 mSEC
Horizontal Display	
HORIZONTAL DISPLAY	A
5× MAGNIFIER	OFF
Time Base B	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
LENGTH	10 CM
TIME/CM	.5 mSEC
Other Controls	
DELAY-TIME MULTIPLIER	1.00
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	OFF
TU-7	
Vertical Position	Centered
Test Function	Low Load
Variable	Adjust for desired amplitude
Other Controls	As is

25. Adjust Time Base A Sweep Rates (50 μsec/cm to .02 μsec/cm).

Apply 10-μsec markers from the Type 180A to the vertical input connector, and adjust the triggering for a stable display. Turn the 5× MAGNIFIER to ON and horizontally position the trace so that the first time marker is aligned with the center graticule line. Then switch the TIME/CM switch to 50 μSEC and check for horizontal shift of the first marker. If shift occurs, adjust C330 (see Fig. 5-3) until the first marker of both the .1 mSEC and 50 μSEC positions occur at the same point.

Turn the 5× MAGNIFIER to OFF, Time Base A TIME/CM to 10 μSEC and proceed with the following adjustments:

TIME/CM	Type 180A	Adjustments	Observe
10 μSEC	10 μsec	C160E	1 marker/cm
1 μSEC	1 μsec	C160C	1 marker/cm
.5 μSEC	1 μsec	C160A	1 marker/2 cm. Position 2nd marker to 2nd graticule line.
.1 μSEC	10 mc	*C375 for linearity and C348 for timing.	1 cycle/cm
2 μSEC	1 μsec	Check timing range.	2 markers/cm
5 μSEC	5 μsec	Check timing range.	1 marker/cm
.1 μSEC	50 mc**	Check timing and linearity.	1 cycle/cm

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

**It may be necessary to readjust C375 slightly to obtain best possible linearity. 5× MAGNIFIER must be on for this check.

26. Check B Sweep Length

Place the HORIZONTAL DISPLAY switch at B, the 5× MAGNIFIER to OFF. Rotate the LENGTH control and check that the sweep length changes between approximately 3.5 and 10.5 cm. If the sweep length range is incorrect, adjust R273 and R277 until the LENGTH control changes the sweep length from 3.2-4.0 to 10-10.8 cm.

27. Set Delay Start and Delay Stop Adjustments

Set the HORIZONTAL DISPLAY switch at 'B' INTENSIFIED BY 'A'. Apply 500 μsec markers from the time-mark generator to the oscilloscope vertical input. Set the A TIME/CM switch at 50 μSEC and adjust the B triggering controls for a stable display. Turn the A STABILITY control fully clockwise. A portion of the display will be brightened. With the DELAY-TIME MULTIPLIER control set at 1.00, adjust the DELAY START (see Fig. 5-2) control until the brightened portion starts at the first time mark (1 cm from the start of the trace). Set the DELAY-TIME MULTIPLIER control at 9.00 and adjust

the DELAY STOP (see Fig. 5-2) control until the brightened portion starts at the ninth time mark (9 cm from the start of the trace). Repeat the DELAY START and DELAY STOP adjustments until a satisfactory setting is obtained for both controls. Set the DELAY-TIME MULTIPLIER control to 1.00 and place the HORIZONTAL DISPLAY switch at 'A' DLY'D BY 'B'. Adjust the DELAY START control so that the leading edge of the time mark is at the start of the trace. Set the DELAY-TIME MULTIPLIER control at 9.00 and adjust the DELAY STOP control until the leading edge of the time mark is at the start of the trace.

28. Adjust Time Base B Sweep Rates

Place the HORIZONTAL DISPLAY switch at 'B' INTENSIFIED BY 'A'. Set the A TIME/CM switch to 5 μSEC and the B TIME/CM switch at 50 μSEC. Connect 50 μSEC time markers to the oscilloscope vertical input and adjust the B triggering controls for a stable display. Turn the A STABILITY control fully clockwise. Adjust the DELAY-TIME MULTIPLIER control to place the start of the brightened portion of the trace at the first marker (1 cm from the start of the trace). Place the HORIZONTAL DISPLAY at 'A' DLY'D BY 'B' and adjust the DELAY-TIME MULTIPLIER control so that the leading edge of the time marker is at the start of the trace. Record the DELAY-TIME MULTIPLIER control setting. Adjust the DELAY-TIME MULTIPLIER control for a setting 8.00 higher than the setting recorded. Adjust C260C (see Fig. 5-2) until the leading edge of the ninth time marker is at the start of the trace.

Repeat the procedure outlined in the previous paragraph with the A TIME/CM switch at .5 μSEC, the B TIME/CM switch at 5 μSEC, and 5 μsec markers connected to the oscilloscope. The adjustment should be made with C260A.

29. Set Lockout Level Adjust

Set the HORIZONTAL DISPLAY switch at 'A' DLY'D BY 'B' the B STABILITY control fully clockwise, and the A TIME/CM switch at .1 mSEC. Slowly adjust the A STABILITY control until the sweep first appears. Connect the test oscilloscope through a 10× probe to pin 3 of V133 using dc coupling. Adjust the test oscilloscope so that the displayed waveform has a vertical amplitude of 4 divisions. Adjust the LOCKOUT LEVEL ADJ (see Fig. 5-3) until the square-wave portion of the displayed waveform is 2.2 divisions in amplitude. During adjustments, the A STABILITY control should be checked frequently to be sure that it is set to where the sweep just runs. At the completion, the square-wave portion should be 2.2 cm in amplitude, the sawtooth portion should be 1.8 cm in amplitude.

30. Adjust External Horizontal DC Balance

Connect a jumper from the SAWTOOTH A to the vertical input, switch the HORIZONTAL DISPLAY to EXT ×1 and turn A STABILITY fully clockwise. Turn the HORIZONTAL POSITION control counterclockwise to position a vertical trace to the left vertical graticule line. Now, adjust the EXT HORIZ DC BAL (see Fig. 5-2) control for no horizontal shift of the trace while turning the horizontal VARIABLE 10-1 front-panel control.

31. Check External Horizontal Input Deflection Factor

With conditions as in step 30, above, connect a jumper from CAL OUT to HORIZ INPUT, set AMPLITUDE CALIBRATOR for .2 VOLTS and turn VARIABLE 10-1 control fully clockwise. At least 1 cm of horizontal deflection must be observed between the two vertical lines. Increase the AMPLITUDE CALIBBRATOR to 2 VOLTS and adjust VARIABLE 10-1 for exactly 10 cm of horizontal deflection between the vertical lines. Switch HORIZONTAL DISPLAY to EXT ×10. Horizontal deflection should be 1 cm (attenuator accuracy ±3%).

32. Adjust External Horizontal Input Compensation

Connect a jumper from SAWTOOTH A to the vertical input. Feed .5 VOLTS from CAL OUT to both HORIZ INPUT and A TRIGGER INPUT. Set the controls as follows:

HORIZONTAL DISPLAY	EXT ×1
TRIGGER SLOPE (A)	—EXT
TIME/CM (A)	1 mSEC
VARIABLE (Plug-In)	Adjust to display 2 cycles of square wave vertically

Adjust A STABILITY and TRIGGERING LEVEL controls for a stable square wave, displayed vertically. Observe the shape of the waveform. Now switch the HORIZONTAL DISPLAY to EXT ×10, increase AMPLITUDE CALIBRATOR signal to 5 VOLTS, and adjust C301C (see Fig. 5-2) for a display that will match the one observed in the EXT ×1 position of the HORIZONTAL DISPLAY switch.

VERTICAL ADJUSTMENTS

TABLE 5-4

Set the oscilloscope and plug-in controls as below, before proceeding with step 33.

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base A	
TRIGGER LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC
Horizontal Display	
HORIZONTAL DISPLAY	A
5× MAGNIFIER	OFF
Time Base B	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
LENGTH	10 CM
TIME/CM	1 mSEC

Other Controls

DELAY-TIME MULTIPLIER	1.00
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
AMPLITUDE CALIBRATOR	OFF

TU-7

Vertical Position	Centered
Test Function	+Pulse
Amplitude	Adjust for 6 cm of signal
Reptition Rate	Low
Other Controls	As is

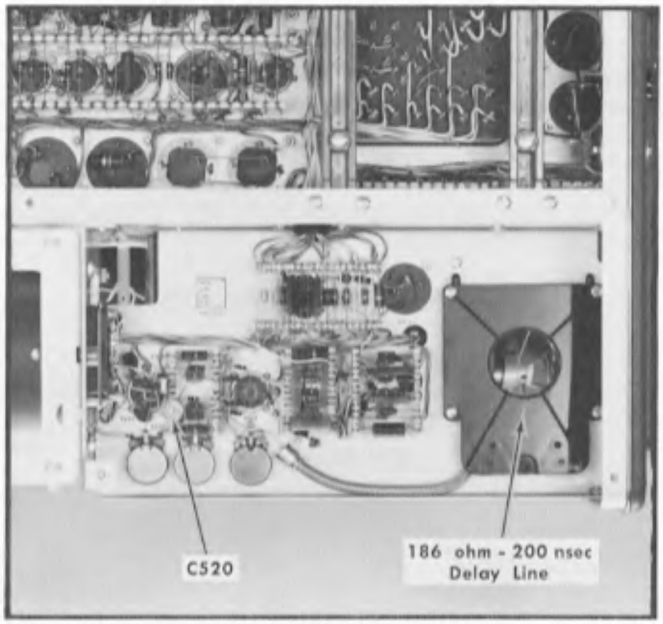


Fig. 5-5. Location of internal adjustments for Vertical Input Amplifier.

33. Vertical Amplifer High-Frequency Adjustments

Using the A triggering controls obtain a stable display. While observing the top of the displayed signal, adjust R502 (DC SHIFT) for minimum tilt.

Set the Repetition Rate to High and the A TIME/CM control to .1 μSEC. Adjust, L588, L589, L598, L599, C520 and R580 for minimum rolloff, overshoot, or ringing on the front corner of the waveform. When making these adjustments be careful that the front corner remains level with the remainder of the waveform.

Switch the A TIME/CM control at .1 or .2 μSEC and adjust L554 and C581 for minimum rolloff or overshoot on the front corner area. Again, be sure that the front corner does not begin to tilt up or down.

With the A TIME/CM switch at .2 μSEC adjust C568 and L560 for minimum ringing on the front corner area of the waveform.

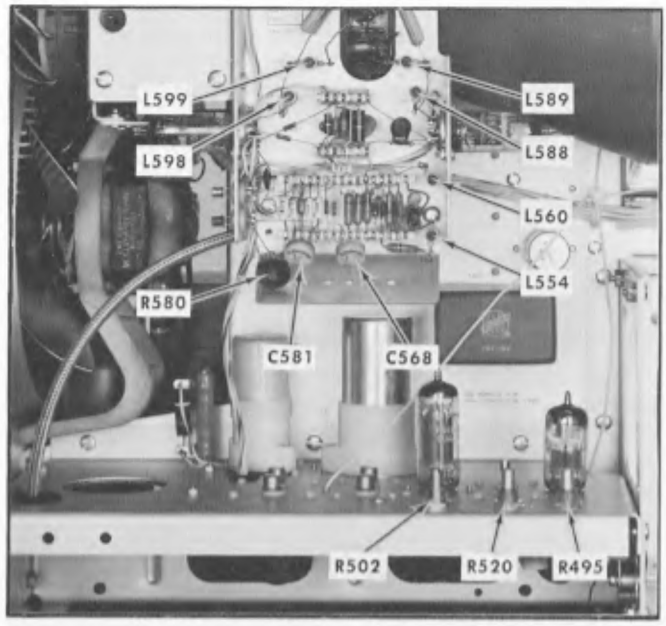


Fig. 5-6. Location of internal adjustments for Vertical Output Amplifier.

Some of the high-frequency adjustments just made will affect the vertical gain. It is therefore necessary to check the vertical gain. Refer to step 6 for gain setting instructions.

34. Checking Risetime

With all controls left as they were above, set the 5× MAGNIFIER to ON. With the 5× MAGNIFIER on and the TIME/CM control set to .1 μsec, each cm of horizontal deflection on the graticule represents 20 nsec.

Adjust the Type TU-7 Amplitude control for a display amplitude of 5 cm. Using the Vertical Position control, place the top of the display on the long dash line which is at the 2.5-cm point above the center graticule line. The bottom of the display should now be on the long dash line 2.5-cm below the center graticule line.

With the HORIZONTAL POSITION control, move the point at which the lower part of the waveform crosses the small dash lines to a point near the center of the graticule where a

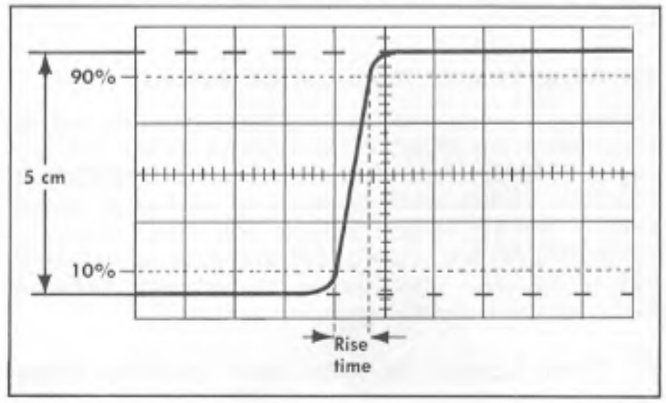


Fig. 5-7. Measuring risetime.

horizontal and vertical graticule line intersect (see Fig. 5-7). Now using the above intersection as the starting point (10% point) follow the vertical graticule line up to the small dash line, then follow the small dash line to the right until it intersects the waveform. This is the 90% point of the waveform. The distance from the vertical graticule line to the intersection of the small dash and waveform times 20 nsec give the risetime of the waveform. The risetime should be 10 nsec or less. Refer to Fig. 5-7.

Turn the TRIGGER SLOPE to —INT and the Test Function switch to —Pulse. To measure the risetime of a negative pulse the same technique as above is followed. The exception is that the top part of the pulse is lined up with an intersection of a horizontal and vertical graticule line to establish the starting point (10% point). The vertical graticule line is then followed down and to the right to find the 90% point. The normal specified risetime for the positive and negative pulses is the same.

NOTES

SECTION 6
PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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

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 including any suffix, instrument type, serial number, and modification number if applicable.

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

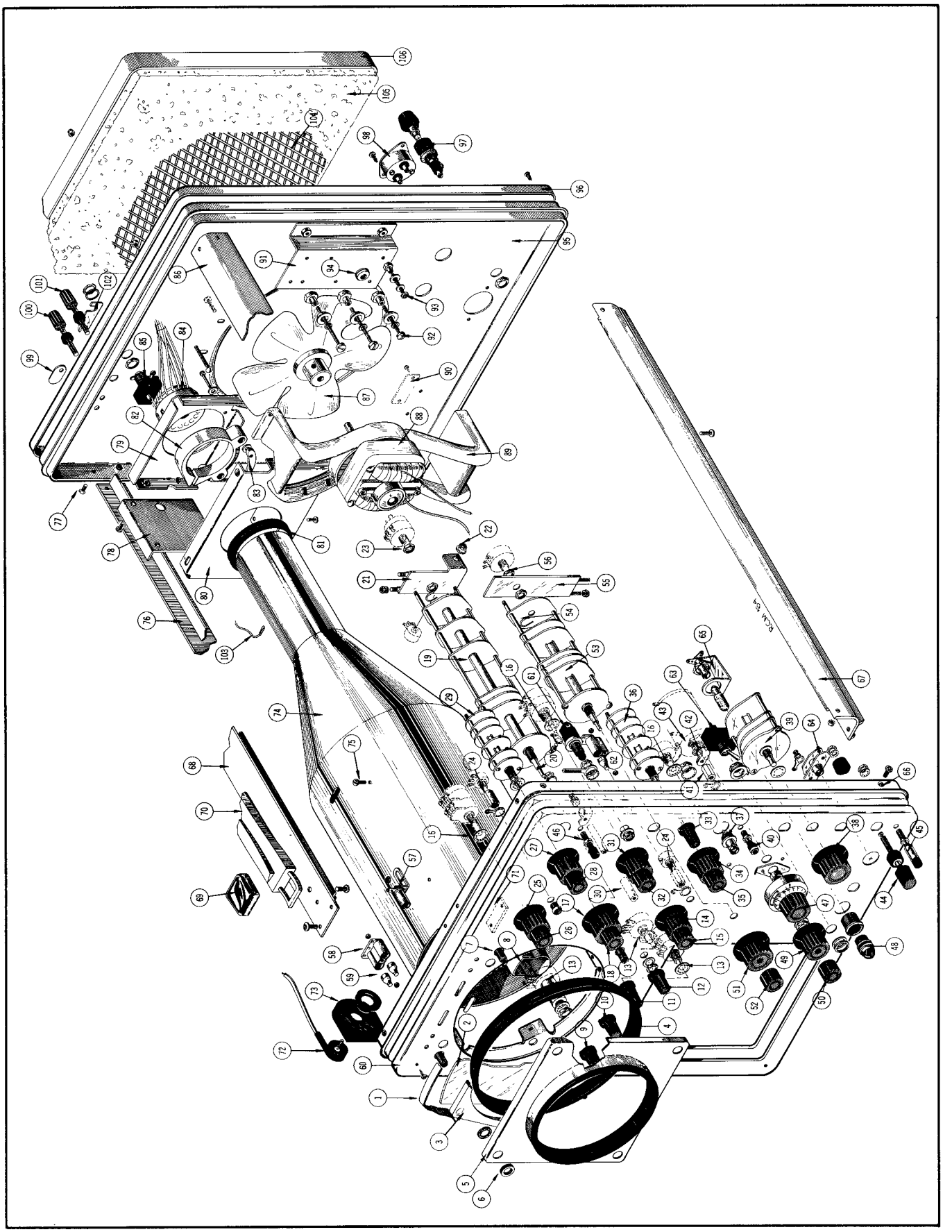
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

FRONT AND REAR



FRONT & REAR

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	214-433			1	SPRING, eyebrow hold down
2	378-546			1	FILTER, light
3	378-917			1	PLATE, eyebrow
4	354-204			1	RING, shockmount
5	200-382			1	COVER, graticule
	- - - -			-	Includes:
	354-116			1	RING, ornamental
	- - - -			-	Mounting Hardware: (not included)
	210-816			4	WASHER, rubber
6	210-424			4	NUT, knurled, 5/8-24 x 9/16 inch
7	355-043			4	STUD, graticule
	- - - -			-	Each includes:
	212-507			1	SCREW, 10-32 x 3/8 Inch BHS
	210 010			1	LOCKWASHER, internal, #10
8	200-269			2	COVER, pot
9	366-220			1	KNOB, charcoal—INTENSITY
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
10	366-220			1	KNOB, charcoal—FOCUS
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
11	366-254			1	KNOB, charcoal—ASTIGMATISM
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
12	366-220			1	KNOB, charcoal—SCALE ILLUM
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
13	- - - -			-	Mounting Hardware For Each Pot:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-590			1	NUT, hex, 3/8-32 x 7/16 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
14	366-159			1	KNOB, charcoal—TRIGGERING LEVEL "B"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
15	366-039			1	KNOB, red—STABILITY "B"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
16	- - - -			-	Mounting Hardware For Each Pot:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
17	366-144			1	KNOB, charcoal—TIME/CM "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
18	366-038			1	KNOB, red—VARIABLE "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
19	262-245			1	SWITCH, wired—TIME/CM "A"
	- - - -			-	Includes:
	260-230			1	SWITCH, unwired—TIME/CM "A"
	210 449			2	NUT, hex, 5-40 x 1/4 inch
	376-014			1	COUPLING, pot wire steel
20	384-162			1	ROD, extension, 1/8 x 87/16 inches

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
21	406-449			1	BRACKET, switch
	- - - -			-	Mounting Hardware: (not included
	210-202			1	LUG, solder, SE #6 with 2 wire holes
	210-203			1	LUG, solder, SE #6 long
	210-407			2	NUT, hex, 6-32 x 1/4 inch
22	- - - -			-	Pot Mounting Hardware:
	210-046			1	LOCKWASHER, internal, 1/4 inch
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
23	- - - -			-	Pot Mounting Hardware:
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
	- - - -			-	Mounting Hardware For Switch:
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-457			2	NUT, keps, 6-32 x 5/16 inch
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-803			4	WASHER, 6L x 3/8 inch flat
24	- - - -			-	Mounting Hardware For Each Pot:
	210-046			1	LOCKWASHER, internal, 1/4 inch
	210-223			1	LUG, solder, 1/4 inch
	210-471			1	NUT, hex, 1/4-32 x 5/16 x 19/32 inch long
	358-054			1	BUSHING, banana jack, 1/4-32 x 13/32
25	366-159			1	KNOB, charcoal—TRIGGERING LEVEL "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
26	366-039			1	KNOB, red—STABILITY "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
27	366-160			1	KNOB, charcoal—TRIGGER SLOPE "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
28	366-038			1	KNOB, red—TRIGGERING MODE "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
29	262-657			1	SWITCH, wired—TRIGGER "A"
	- - - -			-	Includes:
	260-619			1	SWITCH, unwired—TRIGGER "A"
	- - - -			-	Mounting Hardware For Switch:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
30	385-135			1	ROD, delrin, 5/16 x 15/16 inch
	- - - -			-	Mounting Hardware: (not included)
	213-068			1	SCREW, thread forming, 6-32 x 5/16 inch FHS
31	366-160			1	KNOB, charcoal—HORIZONTAL DISPLAY
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
32	366-038			1	KNOB, red—5X MAGNIFIER
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
	262-655			1	SWITCH, wired—HORIZONTAL DISPLAY (front) (not shown)
	- - - -			-	Includes:
	260-502			1	SWITCH, unwired—HORIZONTAL DISPLAY (front) (not shown)
	337-279			1	SHIELD, switch
	- - - -			-	Mounting Hardware:
	210-004			1	LOCKWASHER, internal, #4
	210-201			1	LUG, solder, SE #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-007			2	SCREW, 4-40 x 3/16 inch BHS
	- - - -			-	Mounting Hardware For Switch:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
32 cont.	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	376-007			1	COUPLING, shaft, 1 inch long (not shown)
	262-656			1	SWITCH, wired—HORIZONTAL DISPLAY (rear) (not shown)
	- - - -			-	Includes:
	260-503			1	SWITCH, unwired—HORIZONTAL DISPLAY (rear) (not shown)
	406-450			1	BRACKET, mag. switch
	- - - -			-	Mounting Hardware:
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
	- - - -			-	Mounting Harware For Capacitor:
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-013			2	SCREW, 4-40 x 3/8 inch RHS
	- - - -			-	Mounting Hardware For Pot
	210-046			1	LOCKWASHER, internal, 1/4 inch
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
33	366-220			1	KNOB, charcoal—VARIABLE 10-1
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
34	366-160			1	KNOB, charcoal—TRIGGER SLOPE "B"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
35	366-038			1	KNOB, red—TRIGGERING MODE "B"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
36	262-658			1	SWITCH, wired—TRIGGER "B"
	- - - -			-	Includes:
	260-261			1	SWITCH, unwired—TRIGGER "B"
	- - - -			-	Mounting Hardware For Switch:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
37	131-126			2	CONNECTOR, coax. single contact
38	366-115			1	KNOB, charcoal—AMPLITUDE CALIBRATOR
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
39	262-654			1	SWITCH, wired—AMPLITUDE CALIBRATOR
	- - - -			-	Includes:
	260-253			1	SWITCH, unwired—AMPLITUDE CALIBRATOR
	210-207			1	LUG, solder, plain 3/8 inch
	- - - -			-	Mounting Hardware For Switch:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
40	200-103			1	CAP, knurled
	355-507			1	STEM, binding post
	- - - -			-	Mounting Hardware: (not included)
	210-223			1	LUG, solder, 1/4 inch
41	385-142			1	ROD, hex, 3/8 x 5/8 inch
42	343-004			1	CLAMP, cable, 5/16 inch plastic
	- - - -			-	Mounting Hardware: (not included)
	210-803			1	WASHER, 6L x 3/8 inch flat
43	211-504			1	SCREW, 6-32 x 1/4 inch BHS
44	129-063			6	POST, binding
	- - - -			-	Mounting Hardware For Each: (not included)
	220-410			1	NUT, keps, 10-32 x 3/8 inch
	358-169			1	BUSHING, nylon

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
45	129-051			1	POST, binding assembly
	- - - -			-	Consisting Of:
	200-182			1	CAP, knurled
	210-011			1	LOCKWASHER, internal, 1/4 inch
	210-445			1	NUT, hex, 1/4-28 x 3/8 x 3/32 inch
	355-507			1	STEM
46	129-035			1	POST, binding assembly
	- - - -			-	Consisting Of:
	200-103			1	CAP, knurled
	210-011			1	LOCKWASHER, internal, 1/4 inch
	210-455			1	NUT, hex, 1/4-28 x 3/8 x 3/32 inch
	355-507			1	STEM
47	331-091			1	DIAL, duo dial
48	378-518			1	JEWEL, light, red
49	366-160			1	KNOB, charcoal—HORIZONTAL POSITION
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
50	366-038			1	KNOB, red—VERNIER
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
	- - - -			-	Pot Mounting Hardware:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
51	366-144			1	KNOB, charcoal—TIME/CM OR DELAY TIME "B"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
52	366-038			1	KNOB, red—LENGTH
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
53	262-208			1	SWITCH, wired—TIME/CM OR DELAY TIME "B"
	- - - -			-	Includes:
	260-260			1	SWITCH, unwired—TIME/CM OR DELAY TIME "B"
54	376-014			1	COUPLING, pot wire steel
	384-180			1	ROD, extension, 1/8 x 5 5/8 inches
55	406-497			1	BRACKET, switch
	- - - -			-	Mounting Hardware:
	210-017			2	LOCKWASHER, spring, #5
	210-407			2	NUT, hex, 6-32 x 1/4 inch
56	- - - -			-	Pot Mounting Hardware:
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
	- - - -			-	Mounting Hardware For Switch:
	210-457			2	NUT, keps, 6-32 x 5/16 inch
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	210-803			4	WASHER, 6L x 3/8 inch flat
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
57	136-001			2	SOCKET, graticule lamp
	- - - -			-	Mounting Hardware For Each: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	210-803			1	WASHER, 6L x 3/8 inch flat
	211-534			1	SCREW, 6-32 x 5/16 inch PHS with lockwasher

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
58	352-064			3	HOLDER, neon double
	- - - -			-	Mounting Hardware For Each: (not included)
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-031			1	SCREW, 4-40 x 1 inch FHS
59	378-541			9	FILTER, lens, neon light
60	333-831			1	PANEL, front 545B
	- - - -			-	Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
61	260-017			1	SWITCH, unwired—RESET
	- - - -			-	Mounting Hardware: (not included)
	210-840			1	WASHER, .390 ID x 9/16 inch OD
	210-207			1	LUG, solder, plain
	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
62	352-067			3	HOLDER, neon single
	- - - -			-	Mounting Hardware For Each: (not included)
	211-031			1	SCREW, 4-40 x 1 inch FHS
	210-406			2	NUT, hex, 4-40 x 3/16 inch
63	260-199			1	SWITCH, unwired—POWER ON
	- - - -			-	Mounting Hardware: (not included)
	210-414			1	NUT, hex, 15/32 x 9/16 inch
	210-473			1	NUT, switch, 15/32-32 x 5/64 inch
	210-902			1	WASHER, .470 ID x 21/32 inch OD
	354-055			1	RING, locking switch
64	131-279			1	CONNECTOR, chassis mount, BNC
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	210-812			2	WASHER, fiber, #10
	210-961			1	WASHER, plastic, 13/16 OD x 3/8 inch ID
	211-025			2	SCREW, 4-40 x 3/8 inch FHS 100°
	406-244			1	BRACKET, nylon, 3/4 x 1 3/8 inches, insulator
65	136-025			1	SOCKET, light
66	387-944			1	PLATE, front sub-panel
	- - - -			-	Includes:
	354-056			1	RING, ornamental
67	122-108			2	ANGLE, rail, bottom
	- - - -			-	Mounting Hardware For Each: (not included)
	210-458			4	NUT, keps, 8-32 x 11/32 inch
	212-039			4	SCREW, 8-32 x 3/8 inch THS phillips
68	381-217			1	BAR, top support
	- - - -			-	Includes:
69	344-098			4	CLIP, handle
	- - - -			-	Mounting Hardware:
	212-507			4	SCREW, 10-32 x 3/8 inch BHS
	210-010			4	LOCKWASHER, internal, #10
70	367-037			2	HANDLE
	- - - -			-	Mounting Hardware: (not included)
	212-039			4	SCREW, 8-32 x 3/8 inch THS phillips
71	381-073			2	BAR, retaining
72	131-283			1	CONNECTOR, crt anode
	- - - -			-	Includes:
	200-110			1	CAP, crt anode
	214-357			1	SPRING, crt anode connector
	432-046			1	BASE, crt anode connector
73	200-112			1	COVER, crt anode and plate assembly
	- - - -			-	Consisting Of:
	200-111			1	COVER, crt anode
	386-647			1	PLATE, crt anode

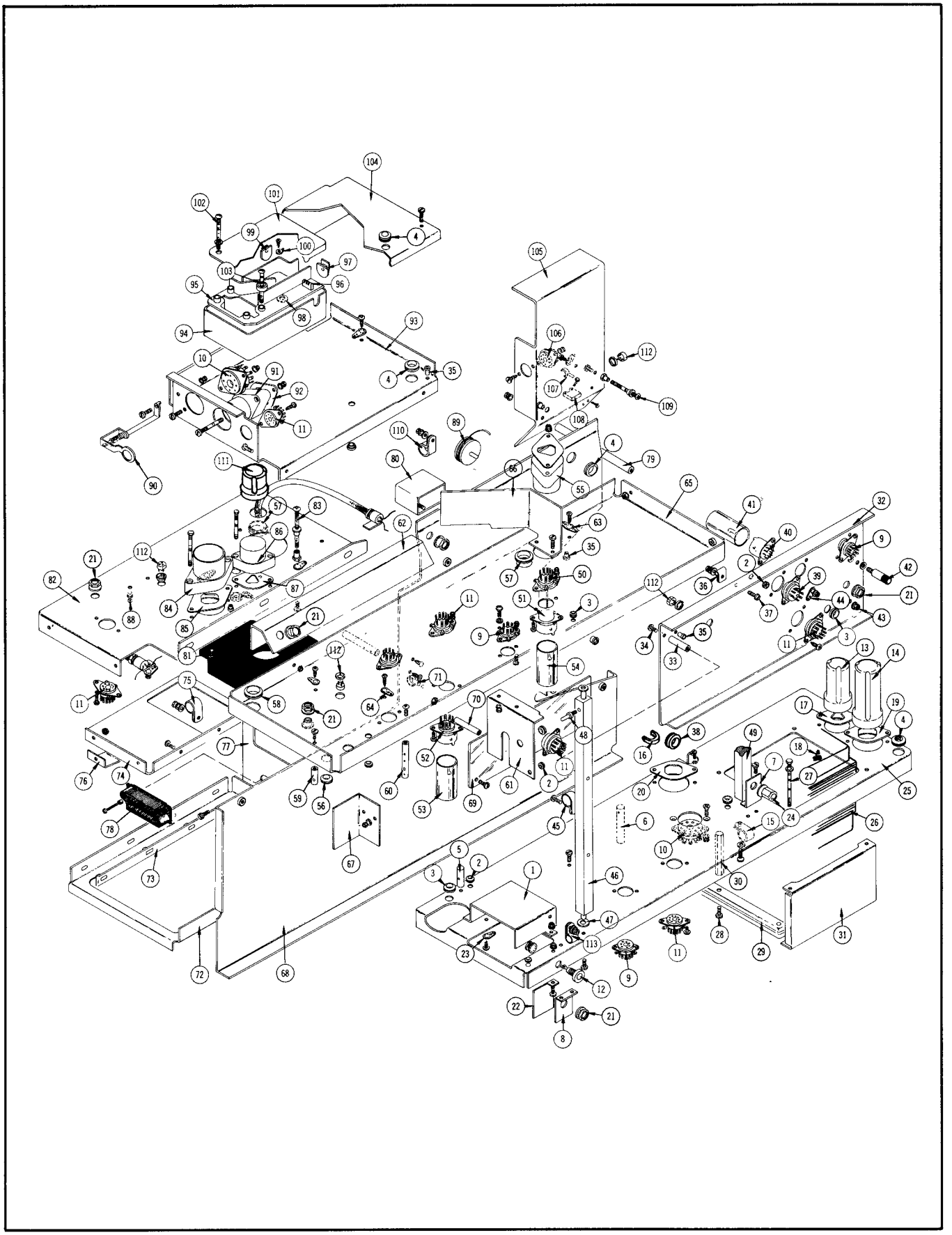
FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
74	337-620			1	SHIELD, crt
	- - - -			-	Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x 1/4 inch BHS
75	- - - -			-	Trace Rotator Coil Mounting Hardware:
	210-457			3	NUT, keps, 6-32 x 5/16 inch
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
76	122-109			1	ANGLE, rail, top left
	- - - -			-	Mounting Hardware: (not included)
	210-457			4	NUT, keps, 6-32 x 5/16 inch
77	211-559			4	SCREW, 6-32 x 3/8 inch FHS phillips
78	406-995			1	BRACKET, support
	- - - -			-	Mounting Hardware: (not included)
	210-458			2	NUT, keps, 8-32 x 11/32 inch BHS
	210-804			2	WASHER, 8S x 3/8 inch flat
	212-001			4	SCREW, 8-32 x 1/4 inch BHS
79	406-994			1	BRACKET, crt mounting
	- - - -			-	Mounting Hardware: (not included)
	210-458			1	NUT, keps, 8-32 x 11/32 inch
	210-804			1	WASHER, 8S x 3/8 inch flat
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
80	406-936			1	BRACKET, crt mounting
	- - - -			-	Mounting Hardware: (not included)
	210-458			3	NUT, keps, 8-32 x 11/32 inch
	210-804			2	WASHER, 8S x 3/8 inch flat
	212-004			5	SCREW, 8-32 x 5/16 inch BHS
81	252-547			FT	VINYL, extruded channel (8 1/8 inches)
82	354-215			1	RING, crt clamping assembly
	- - - -			-	Consisting Of:
	124-160			1	STRIP, liner, crt clamp
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	211-560			1	SCREW, 6-32 x 1 inch RHS
	354-211			1	RING, clamping
83	214-207			1	NUT, adjusting, securing
	- - - -			-	Mounting Hardware: (not included)
	210-949			4	WASHER, 9/64 ID x 1/2 inch OD
	211-576			2	SCREW, 6-32 x 7/8 inch socket head cap
84	136-191			1	SOCKET, crt
85	260-209			1	SWITCH, unwired—CRT CATHODE SELECTOR—toggle
	- - - -			-	Mounting Hardware: (not included)
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
	210-473			1	NUT, switch, 15/32-32 x 5/64 inch
	210-902			1	WASHER, .470 ID x 21/32 inch OD
86	122-019			1	ANGLE, frame, top right
	- - - -			-	Mounting Hardware: (not included)
	210-457			4	NUT, keps, 6-32 x 5/16 inch
	211-559			4	SCREW, 6-32 x 3/8 inch FHS phillips
87	369-007			1	BLADE, fan, 7 inch
88	147-026			1	MOTOR, fan
	- - - -			-	Mounting Hardware: (not included)
	210-458			4	NUT, keps, 8-32 x 11/32 inch
89	426-193			1	MOUNT, fan motor
	- - - -			-	Mounting Hardware: (not included)
	212-023			4	SCREW, 8-32 x 3/8 inch BHS
90	334-904			1	TAG, voltage rating
	- - - -			-	Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
91	407-027			1	BRACKET, shunt resistor
	- - - -			-	Mounting Hardware: (not included)
	211-537			2	SCREW, 6-32 x 3/8 inc THS phillips
92	- - - -			-	Mounting Hardware For Each Resistor:
	210-008			1	LOCKWASHER, internal, #8
	210-462			1	NUT, hex, 8-32 x 1/2 inch
	210-809			1	WASHER, centering
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
	212-037			1	SCREW, 8-32 x 1 3/4 inch Fil HS
93	- - - -			-	Resistor Mounting Hardware:
	210-478			1	NUT, hex, 5/16 x 21/32 inch
	210-805			1	WASHER, 10S x 7/16 inch flat
	210-886			1	WASHER, centering, 3/8 x 1/8 inch
	211-544			1	SCREW, 6-32 x 3/4 inch THS phillips
94	348-056			2	GROMMET, plastic, 3/8 inch
95	387-758			1	PLATE, sub-panel, rear
	- - - -			-	Includes:
	354-056			1	RING, ornamental
96	387-945			1	PLATE, rear overlay
	- - - -			-	Mounting Hardware: (not included)
	213-104			4	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
97	352-002			1	HOLDER, fuse assembly
	- - - -			-	Consisting Of:
	200-582			1	CAP, fuse
	210-873			1	WASHER, rubber, 1/2 ID x 11/16 inch
	352-010			1	HOLDER, fuse
	NO NUMBER			1	NUT, fuse holder
98	131-150			1	CONNECTOR, chassis mounted motor base
	- - - -			-	Consisting Of:
	129-041			1	POST, ground, 4-40 thread one end
	200-185			1	COVER, 3 wire motor base
	205-014			1	SHELL, mounting
	210-003			2	LOCKWASHER, external, #4
	210-551			2	NUT, hex, 4-40 x 1/4 inch
	211-015			1	SCREW, 4-40 x 1/2 inch RHS
	214-078			2	PIN, connecting
	377-041			1	INSERT, black urea
99	387-853			1	PLATE, binding post mounting
100	129-064			1	POST, binding
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
101	129-064			1	POST, binding
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	358-181			1	BUSHING, nylon, charcoal
102	346-027			1	STRAP, ground
103	175-592			1	WIRE, crt lead, 0.960 foot, striped green, with connector
	175-595			1	WIRE, crt lead, 0.960 foot, striped red, with connector
	175-641			1	WIRE, crt lead, 0.833 foot, striped brown, with connector
	175-642			1	WIRE, crt lead, 0.833 foot, striped blue, with connector
104	378-762			1	SCREEN, filter
	- - - -			-	Mounting Hardware: (not included)
	213-104			4	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
105	378-023			1	FILTER, air foam
106	380-018			1	HOUSING, air filter
	- - - -			-	Mounting Hardware: (not included)
	210-402			2	NUT, cap, hex, 8-32 x 5/16 inch
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	212-031			2	SCREW, 8-32 x 1 1/4 inch RHS

CHASSIS



CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-291			1	SHIELD, calibrator switch
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
2	348-055			23	GROMMET, plastic, 1/4 inch
3	348-056			15	GROMMET, plastic, 3/8 inch
4	348-063			6	GROMMET, plastic, 1/2 inch
5	385-135			1	ROD, delrin, 5/16 x 15/16 inch
	- - - -			-	Mounting Hardware: (not included)
	213-041			1	SCREW, 6-32 x 3/8 inch THS phillips
6	385-138			1	ROD, delrin, 5/16 x 1 9/16 inches
	- - - -			-	Mounting Hardware: (not included)
	213-041			1	SCREW, 6-32 x 3/8 inch THS phillips
7	406-108			1	BRACKET, pot, —150 adj.
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
8	406-022			1	BRACKET, pot
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
9	136-008			11	SOCKET, STM7G
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, 5-32 x 3/16 inch PHS phillips
10	136-011			3	SOCKET, STM8G
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK phillips
11	136-015			31	SOCKET, STM9G
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, 5-32 x 3/16 inch PHS phillips
12	136-037			1	SOCKET, tip jack
	- - - -			-	Mounting Hardware: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
13	200-256			1	COVER, capacitor, polyethylene, 2 1/32 x 1 inch diameter
14	200-258			3	COVER, capacitor, polyethylene, 3 1/2 x 1.365 inch diameter
15	343-004			5	CLAMP, cable 5/16 inch
	- - - -			-	Mounting Hardware: (not included)
	210-804			1	WASHER, 8S x 3/8 inch flat
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
16	252-547			1	EXTRUSION, rubber, 2 inches
17	386-252			1	PLATE, fiber, small
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
18	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
19	386-254			3	PLATE, fiber, large
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-543			2	SCREW, 6-32 x 5/16 inch RHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
20	386-255			3	PLATE, metal, large
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
21	- - - -			-	Mounting Hardware For Pot:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
22	337-290			1	SHIELD, calibrator switch
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	211-507			1	SCREW, 6-32 x 5/16 inch
23	210-202			5	LUG, solder, SE #6
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
24	- - - -			-	Mounting Hardware For Pot
	210-444			1	NUT, hex, 3/8-32 x 5/8 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
25	441-238			1	CHASSIS, power
	- - - -			-	Mounting Hardware: (not included)
	210-458			5	NUT, keps, 8-32 x 11/32 inch
	212-040			5	SCREW, 8-32 x 3/8 inch FHS
26	- - - -			-	Transformer Mounting Hardware:
	210-010			4	LOCKWASHER, internal, #10
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	210-564			4	NUT, hex, 10-32 x 3/8 inch
	210-812			4	WASHER, fiber, #10
	212-033			4	SCREW, 8-32 x 3/4 inch BHS
	212-509			2	SCREW, 10-32 x 5/8 inch BHS
27	212-524			4	SCREW, 10-32 x 3 1/4 inches HHS
28	212-534			2	SCREW, 10-32 x 1 inch BHS
29	381-221			2	BAR, transformer support
30	384-612			2	ROD, hex, transformer standoff
31	406-928			1	BRACKET, transformer
32	441-560			1	CHASSIS, delay sweep
	- - - -			-	Mounting Hardware: (not included)
33	166-143			2	TUBE, spacer, 3/8 x 13/16 inch
34	211-529			2	SCREW, 6-32 x 1 1/4 inches BHS
35	348-031			5	GROMMET, 1/4 inch plastic
36	343-001			3	CLAMP, cable, 1/8 inch plastic
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	210-803			1	WASHER, 6L x 3/8 inch flat
37	211-510			1	SCREW, 6-32 x 3/8 inch BHS
38	348-051			1	GROMMET, rubber, 1 1/8 inches
39	136-044			3	SOCKET, 7 pin
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, 5-32 x 3/16 inch PHS phillips

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
40	136-010			1	SOCKET, 7 pin
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-201			1	LUG, solder, SE #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
41	337-006			1	SHIELD, tube, 1 3/8 inches high
42	214-008			1	BOLT, captive
	210-812			1	WASHER, fiber, #10
	354-048			1	RING, securing
43	- - - -			-	Mounting Hardware For Minature Pot:
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
	210-940			1	WASHER, 1/4 ID x 3/8 inch OD
44	210-202			2	LUG, solder, SE #6
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, 5-32 x 3/16 inch PHS phillips
45	343-004			1	CLAMP, cable, 5/16 inch
	- - - -			-	Mounting Hardware: (not included)
	210-803			1	WASHER, 6L x 3/8 inch
	211-511			1	SCREW, 6-32 x 1/2 inch BHS
46	381-063			1	BAR, swivel support
	- - - -			-	Mounting Hardware: (not included)
47	210-821			2	WASHER, 1/4 x 1/2 x .046 inch
48	105-014			2	STOP, hex, 1/4 x 3/4 inch
49	381-064			1	BAR, swivel support
	- - - -			-	Mounting Hardware: (not included)
	212-008			2	SCREW, 8-32 x 1/2 inch BHS
50	136-015			12	SOCKET, STM9G
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
51	337-004			2	SHIELD, socket
52	136-022			1	SOCKET, STM9S
	- - - -			-	Mounting Hardware: (not included)
	213-044			2	SCREW, 5-32 x 3/16 inch PHS phillips
53	337-009			1	SHIELD, tube, 2 13/32 inches high
54	337-008			2	SHIELD, tube, 1 15/16 inches high
55	- - - -			-	Mounting Hardware For Capacitor:
	432-047			1	BASE, small capacitor mounting
	386-253			1	PLATE, metal, small
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
56	348-003			1	GROMMET, rubber, 5/16 inch
57	348-050			2	GROMMET, plastic, 3/4 inch
58	348-064			1	GROMMET, plastic, 5/8 inch
59	385-033			1	ROD, nylon, 5/16 x 5/8 inch
	- - - -			-	Mounting Hardware: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
60	385-129			2	ROD, nylon, $5/16 \times 1\ 5/8$ inches
	- - - -			-	Mounting Hardware For Each: (not included)
	213-041			1	SCREW, 6-32 x 3/8 inch THS phillips
61	406-451			1	BRACKET, horizontal display switch
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	210-803			2	WASHER, 6L x 3/8 inch
	211-510			2	SCREW, 6-32 x 3/8 inch BHS
62	406-454			1	BRACKET, pot
	- - - -			-	Mounting Hardware: (not included)
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
63	210-204			1	LUG, solder, DE #6
64	210-201			7	LUG, solder, SE #4
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, 5-32 x 3/16 inch PHS phillips
65	441-559			1	CHASSIS, sweep
	- - - -			-	Mounting Hardware: (not included)
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	212-040			4	SCREW, 8-32 x 3/8 inch FHS
66	337-664			1	SHIELD, amplifier
	- - - -			-	Mounting Hardware: (not included)
	210-457			2	NUT, keps, 6-32 x 5/16 inch
	210-507			2	SCREW, 6-32 x 5/16 inch BHS
67	337-660			1	SHIELD, switch
	- - - -			-	Mounting Hardware: (not included)
	210-406			2	NUT, hex, 4-40 x 3/16 inch
68	387-946			1	PLATE, rectifier mounting
	- - - -			-	Mounting Hardware: (not included)
	210-458			7	NUT, keps, 8-32 x 11/32 inch
	212-023			9	SCREW, 8-32 x 3/8 inch BHS
69	337-656			1	SHIELD, plastic, high voltage
	- - - -			-	Mounting Hardware: (not included)
70	166-099			3	SPACER, 1/4 x 1 23/32 inches
	211-507			6	SCREW, 6-32 x 5/16 inch BHS
71	343-089			3	CLAMP, cable, snap-in
72	387-755			1	PLATE, plug-in housing, bottom
	- - - -			-	Mounting Hardware: (not included)
	210-205			1	LUG, solder, SE #8
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	212-040			2	SCREW, 8-32 x 3/8 inch FHS 100°
73	351-058			4	GUIDE, shoe
74	387-754			1	PLATE, plug-in housing, top
	- - - -			-	Mounting Hardware: (not included)
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	210-804			1	WASHER, 8S x 3/8 inch flat
	212-004			5	SCREW, 8-32 x 5/16 BHS
75	343-004			1	CLAMP, cable, 5/16 inch
76	344-097			2	CLIP, grounding
77	387-753			1	PLATE, plug-in housing, back
	- - - -			-	Mounting Hardware: (not included)
	212-004			3	SCREW, 8-32 x 5/16 inch BHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
78	131-018			1	CONNECTOR, 16 pin, female
	- - - -			-	Mounting Hardware: (not included)
	166-107			2	TUBE, spacer, 1/4 OD x 7/32 inch
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-016			2	SCREW, 4-40 x 5/8 inch RHS
79	384-628			1	ROD, spacing
	- - - -			-	Mounting Hardware: (not included)
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
80	202-102			1	CAN, relay cover
	- - - -			-	Mounting Hardware: (not included)
	210-457			2	NUT, keps, 6-32 x 5/16 inch
81	119-034			1	DELAY LINE, assembly
	- - - -			-	Includes:
	380-049			1	HOUSING, delay line
	200-482			1	COVER, delay line housing
	131-271			2	CONNECTOR, right hand
	211-591			4	SCREW, 6-32 x 7/8 inch HHS
	210-006			4	LOCKWASHER, internal, #6
	210-407			4	NUT, hex, 6-32 x 1/4 inch
	- - - -			-	Mounting Hardware: (not included)
	210-006			1	LOCKWASHER, internal, #6
	210-202			2	LUG, solder, SE #6
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
82	441-562			1	CHASSIS, lower vertical amplifier
	- - - -			-	Mounting Hardware: (not included)
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	212-004			5	SCREW, 8-32 x 5/16 inch BHS
83	- - - -			-	Resistor Mounting Hardware:
	210-202			1	LUG, solder, SE #6
	210-478			1	NUT, hex, 5/16 x 21/32 inch
	210-601			1	EYELET, brass tapered barrel
	211-553			1	SCREW, 6-32 x 1 1/2 inches THS phillips
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
84	- - - -			-	Capacitor Mounting Hardware:
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-588			2	SCREW, 6-32 x 3/4 inch HHS
85	386-255			1	PLATE, metal, large capacitor
	432-048			1	BASE, large capacitor mounting
86	- - - -			-	Capacitor Mounting Hardware:
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-588			2	SCREW, 6-32 x 3/4 inch HHS
87	386-252			1	PLATE, fiber, small capacitor
	432-047			1	BASE, small capacitor mounting
88	131-181			2	CONNECTOR, terminal standoff
	- - - -			-	Mounting Hardware For Each: (not included)
	358-136			1	BUSHING, teflon
89	214-210			1	SPOOL, solder, assembly

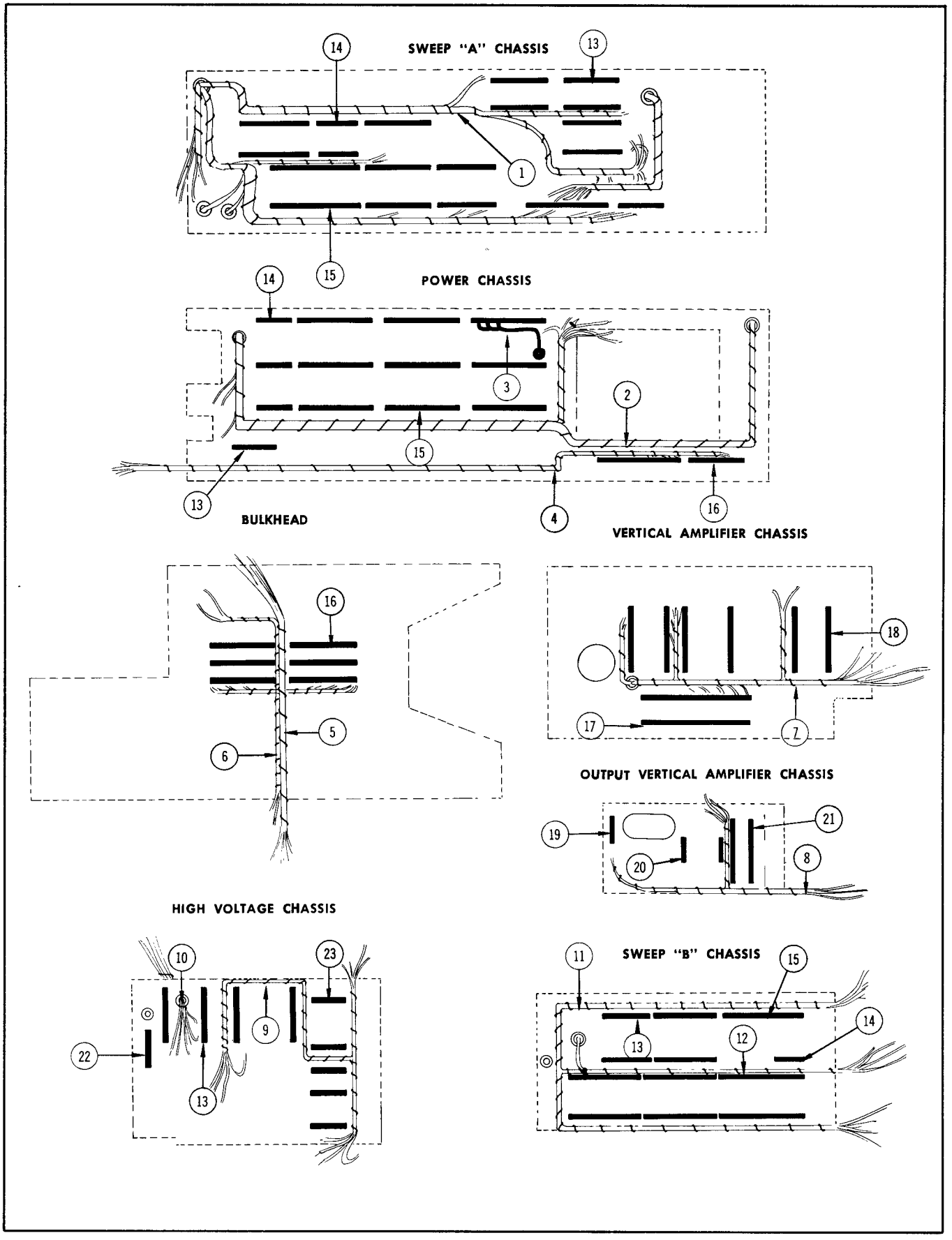
CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
90	343-095			1	CLAMP, tube
	- - - -			-	Mounting Hardware: (not included)
	210-004			1	LOCKWASHER, internal, #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	211-008			1	SCREW, 4-40 x 1/4 inch BHS
91	- - - -			-	Capacitor Mounting Hardware:
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
	432-047			1	BASE, small capacitor mounting
92	386-253			1	PLATE, metal, small capacitor
93	441-475			1	CHASSIS, high voltage
	- - - -			-	Mounting Hardware: (not included)
	210-458			1	NUT, keps, 8-32 x 11/32 inch
	212-004			3	SCREW, 8-32 x 5/16 inch BHS
	212-040			2	SCREW, 8-32 x 3/8 inch FHS phillips
94	380-048			1	HOUSING, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
95	392-147			1	BOARD, high voltage assembly
	- - - -			-	Includes:
96	124-162			1	STRIP, ceramic, 7/16 inch x 4 notches
	- - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon
	124-164			2	STRIP, ceramic, 4 notches
	124-163			4	STRIP, ceramic, 2 notches
	- - - -			-	Mounting Hardware For Board: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
97	166-357			1	SLEEVE, high voltage anode lead
98	210-966			2	WASHER, insulating, rubber, 7/16 ID x 7/8 inch OD
99	166-319			2	SLEEVE, high voltage
100	210-261			2	LUG, solder, high voltage
	- - - -			-	Mounting Hardware For Each: (not included)
	211-587			1	SCREW, 6-32 x 7/32 inch HHS
101	200-475			1	COVER, high voltage
	- - - -			-	Mounting Hardware: (not included)
	210-801			2	WASHER, 5S x 9/32 inch
102	211-521			2	SCREW, 6-32 x 1 1/2 inches RHS
103	- - - -			-	High Voltage Transformer Mounting Hardware:
	210-801			2	WASHER, 5S x 9/32 inch
	211-553			2	SCREW, 6-32 x 1 1/2 inches THS phillips
	358-228			2	BUSHING, insulator
104	337-566			1	SHIELD, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-504			4	SCREW, 6-32 x 1/4 inch BHS
	211-541			1	SCREW, 6-32 x 1/4 inch FHS phillips
105	441-563			1	CHASSIS, upper vertical amplifier
	- - - -			-	Mounting Hardware: (not included)
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	212-023			2	SCREW, 8-32 x 5/16 inch BHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
106	136-072			2	SOCKET, 9 pin, UHF
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, thread forming , 5-32 x 3/16 inch PHS phillips
107	426-121			1	MOUNT, toroid
108	406-635			1	BRACKET, pot, delrin
	- - - -			-	Mounting Hardware: (not included)
	213-035			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
109	- - - -			-	Resistor Mounting Hardware:
	210-478			1	NUT, hex, 5/16 x 21/32 inch
	210-601			1	EYELET, brass, tapered barrel
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
	211-553			1	SCREW, 6-32 x 1 1/2 inches THS phillips
110	343-004			4	CLAMP, 5/16 inch plastic
	- - - -			-	Mounting Hardware For Each: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	210-803			1	WASHER, 6L x 3/8 inch flat
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
111	200-257			1	COVER, capacitor
112	136-181			13	SOCKET, 3 pin, transistor
	- - - -			-	Mounting Hardware For Each: (not included)
	354-234			1	RING, mounting
113	343-003			1	CLAMP, cable, 1/4 inch plastic
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	210-803			1	WASHER, 6L x 3/8 inch
	211-507			1	SCREW, 6-32 x 5/16 inch BHS

CABLE HARNESS & CERAMIC STRIP DETAIL



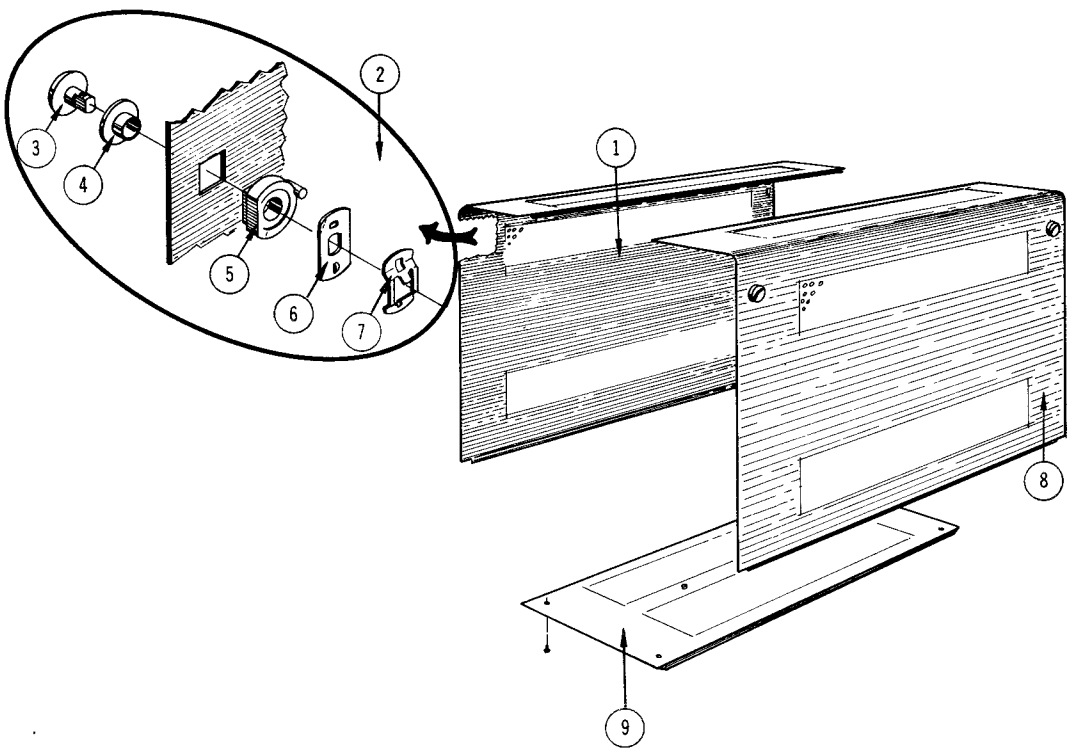
CABLE HARNESS & CERAMIC STRIP DETAIL

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-896	100	1199	1	CABLE, harness, sweep
	179-925	1200		1	CABLE, harness, sweep
2	179-893			1	CABLE, harness, power #1
3	179-324			1	CABLE, harness, power #2
4	179-306			1	CABLE, harness, power 110 Volt
5	179-894			1	CABLE, harness, rectifier
6	179-895			1	CABLE, harness, rectifier 110 Volt
7	179-901			1	CABLE, harnees, vertical amplifier
8	179-900			1	CABLE, harness, output vertical amplifier
9	179-899			1	CABLE, harness, Focus and Intensity
10	179-904			1	CABLE, harness, high voltage
11	179-897			1	CABLE, harness, delay sweep #1
12	179-898			1	CABLE, harness, delay sweep #2
13	124-089			17	STRIP, ceramic 3/4 inch x 7 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
14	124-088			7	STRIP, ceramic 3/4 inch x 4 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
15	124-091			25	STRIP, ceramic 3/4 inch x 11 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
16	124-090			7	STRIP, ceramic 3/4 inch x 9 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
17	124-145			2	STRIP, ceramic 7/16 inch x 20 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
18	124-147			6	STRIP, ceramic 7/16 inch x 13 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
19	124-087			1	STRIP, ceramic 3/4 inch x 3 notches
	- - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - -			-	Mounting Hardware: (not included)
	361-009			1	SPACER, nylon
20	124-149			2	STRIP, ceramic 7/16 inch x 7 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon

CABLE HARNESS & CERAMIC STRIP DETAIL *(Cont'd)*

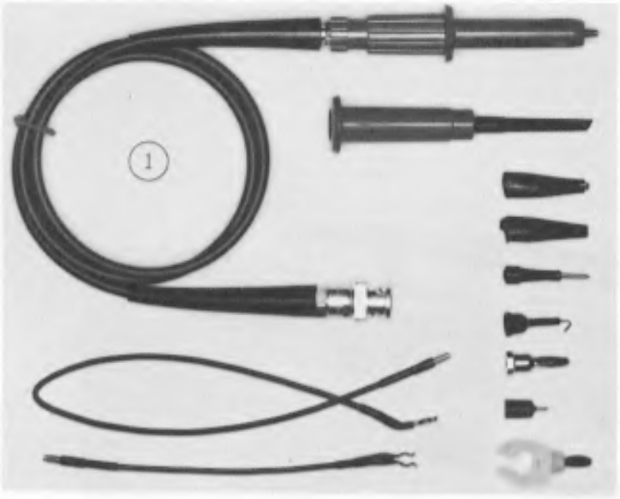
REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
21	124-146			2	STRIP, ceramic $^{7}/_{16}$ inch x 16 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon
22	124-120			1	STRIP, ceramic 4 notches
	- - - -			-	Includes
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware: (not included)
	361-009			2	SPACER, nylon
23	124-093			5	STRIP, ceramic $^{7}/_{16}$ inch x 5 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon

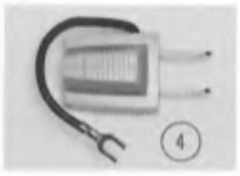
CABINET



REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
1	387-761			1	PLATE, cabinet side, left
	- - - -			-	Includes:
	134-028			1	PLUG, steel
2	214-361			2	LATCH, quarter turn, assembly
	- - - -			-	Each Consisting Of:
3	214-400			1	PIN, securing, index
4	358-218			1	BUSHING, latch bearing
5	387-871			1	PLATE, latch index
6	387-804			1	PLATE, latch locking
7	214-359			1	SPRING, latch
8	387-762			1	PLATE, cabinet side, right
	- - - -			-	Includes:
	214-361			2	LATCH, quarter turn, assembly
9	387-756			1	PLATE, cabinet, bottom
	- - - -			-	Includes:
	214-361			4	LATCH, quarter turn, assembly

ACCESSORIES





REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
1	010-127			2	PROBE, package, P6006, BNC, 42 inch, 10X
	- - - -			-	Each Includes:
	010-128			1	PROBE, only, P6006
2	012-031			1	CORD, patch—banana plug
3	012-076			1	CABLE, 50 Ω, BNC both ends
4	103-013			1	ADAPTER, power cord
5	103-015			1	ADAPTER, probe, BNC to UHF
6	103-033			2	ADAPTER, BNC to binding post
7	161-010			1	CORD, power
8	387-918			1	PLATE, protector

ELECTRICAL PARTS

Bulbs

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description		S/N Range
B129	150-030	Neon, NE-2V	READY	
B160W	150-030	Neon, NE-2V	UNCALIBRATED	
B167	150-027	Neon, NE-23		
B171	150-027	Neon, NE-23		
B267	150-027	Neon, NE-23		
B271	150-027	Neon, NE-23		
B347	150-030	Neon, NE-2V		
B386	150-027	Neon, NE-23		
B397	150-030	Neon, NE-2V		
B398	150-030	Neon, NE-2V		
B434A	150-030	Neon, NE-2V	Delay Time Multiplier Indicator Lights	
B434B	150-030	Neon, NE-2V		
B538	150-030	Neon, NE-2V		
B539	150-030	Neon, NE-2V		
B601	150-031	Incandescent #44	Graticule Light	
B602	150-031	Incandescent #44	Graticule Light	
B603	150-001	Incandescent #47	Pilot Light	

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3V — 50V = —10%, +250%
51V — 350V = —10%, +100%
351V — 450V = —10%, +50%

C1	281-534	3.3 pf	Cer	500 v	±0.25 pf	
C6	283-006	0.02 μf	Cer	600 v		
C9	281-529	1.5 pf	Cer	500 v	±0.25 pf	X194-up
C10	285-543	0.0022 μf	PTM	400 v		
C11	281-523	100 pf	Cer	350 v		
C15	283-000	0.001 μf	Cer	500 v		
C20	283-000	0.001 μf	Cer	500 v		
C24	283-004	0.02 μf	Cer	150 v		
C32	283-004	0.02 μf	Cer	150 v		
C36	283-057	0.1 μf	Cer	200 v		
C48	283-006	0.02 μf	Cer	600 v		
C49	290-158	50 μf	EMT	25 v	—15%, +75%	100-2119
C49	290-0287-00	47 pf	EMT	25 v		2120-up
C51	281-541	6.8 pf	Cer	500 v	10%	
C56	283-002	0.01 μf	Cer	500 v		
C60	285-501	0.001 μf	PTM	600 v		
C61	281-501	4.7 pf	Cer	500 v	±1 pf	X194-up
C65	283-000	0.001 μf	Cer	500 v		

Capacitors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
C70	283-000	0.001 μf	Cer	500 v		
C74	283-004	0.02 μf	Cer	150 v		
C76	283-057	0.1 μf	Cer	200 v		
C81	281-523	100 pf	Cer	350 v		
C87	281-513	27 pf	Cer	500 v		
C90	290-114	47 μf	EMC	6 v		
C95	283-023	0.1 μf	Cer	10 v		
C102	281-511	22 pf	Cer	500 v	10%	
C103	283-000	0.001 μf	Cer	500 v		
C105	283-000	0.001 μf	Cer	500 v		
C109	283-001	0.005 μf	Cer	500 v		
C116	283-000	0.001 μf	Cer	500 v		
C123	281-504	10 pf	Cer	500 v	10%	
C129	283-001	0.005 μf	Cer	500 v		
C131	281-513	27 pf	Cer	500 v		
C134	281-503	8 pf	Cer	500 v	±0.5 pf	
C138	283-001	0.005 μf	Cer	500 v		
C141	281-503	8 pf	Cer	500 v	±0.5 pf	
C150	281-528	82 pf	Cer	500 v	10%	
C151	283-001	0.005 μf	Cer	500 v		
C157	281-506	12 pf	Cer	500 v	10%	
C160A	281-007	3-12 pf	Cer	Var		
C160B	283-534	82 pf	Mica	500 v	5%	
C160C	281-010	4.5-25 pf	Cer	Var		
C160D	283-534	82 pf	Mica	500 v	5%	
C160E	281-010	4.5-25 pf	Cer	Var		
C160F	*291-008	0.001 μf			±½%	
C160G	*291-007	0.01 μf		Timing Series		
C160H		0.1 μf			±½%	
C160J		1 μf				
C160K	281-543	270 pf	Cer	500 v	10%	
C165	281-525	470 pf	Cer	500 v		
C167	283-000	0.001 μf	Cer	500 v		
C180A	283-536	220 pf	Mica	500 v	10%	
C180B	285-543	0.0022 μf	PTM	400 v		
C180C	285-515	0.022 μf	PTM	400 v		
C180D	285-526	0.1 μf	PTM	400 v		
C180E	285-526	0.1 μf	PTM	400 v		
C181	281-515	27 pf	Cer	500 v	±1.35 pf	
C187	283-001	0.005 μf	Cer	500 v		
C190	281-509	15 pf	Cer	500 v	10%	
C193	283-001	0.005 μf	Cer	500 v		
C196	283-000	0.001 μf	Cer	500 v		
C201	283-001	0.005 μf	Cer	500 v		
C203	283-001	0.005 μf	Cer	500 v		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
C214	283-002	0.01 μf	Cer		500 v	
C215	283-000	0.001 μf	Cer		500 v	
C231	281-513	27 pf	Cer		500 v	
C234	281-518	47 pf	Cer		500 v	
C241	281-534	3.3 pf	Cer		500 v	±0.25 pf
C250	281-516	39 pf	Cer		500 v	10%
C260A	281-007	3-12 pf	Cer	Var		
C260B	283-533	39 pf	Mica		500 v	5%
C260C	281-012	7-45 pf	Cer	Var		
C260D	*291-026	480 pf		Timing Series		
C260E		0.005 μf				
C260F		0.05 μf				
C260G		0.5 μf				
C267	283-000	0.001 μf	Cer		500 v	
C280A	281-510	22 pf	Cer		500 v	
C280B	281-525	470 pf	Cer		500 v	
C280C	285-506	0.0047 μf	PTM		400 v	
C280D	285-519	0.047 μf	PTM		400 v	
C280E	285-519	0.047 μf	PTM		400 v	
C295	281-509	15 pf	Cer		500 v	10%
C301C	281-012	7-45 pf	Cer	Var		
C301E	281-546	330 pf	Cer		500 v	10%
C301H	281-506	12 pf	Cer		500 v	10%
C320	283-001	0.005 μf	Cer		500 v	
C330	281-010	4.5-25 pf	Cer	Var		
C336	283-001	0.005 μf	Cer		500 v	
C340	281-501	4.7 pf	Cer		500 v	±1 pf
C347	283-000	0.001 μf	Cer		500 v	
C348	281-007	3-12 pf	Cer	Var		
C355	281-526	1.5 pf	Cer		500 v	±0.5 pf
C356	283-001	0.005 μf	Cer		500 v	
C364	281-538	1 pf	Cer		500 v	
C375	281-023	9-180 pf	Mica	Var		
C380	290-000	6.25 μf	EMT		300 v	
C384	281-538	1 pf	Cer		500 v	
C390	281-501	4.7 pf	Cer		500 v	±1 pf
C393	285-519	0.047 μf	PTM		400 v	
C396	283-001	0.005 μf	Cer		500 v	
C421	283-002	0.01 μf	Cer		500 v	
C426	283-001	0.005 μf	Cer		500 v	
C444	281-511	22 pf	Cer		500 v	10%
C454	281-518	47 pf	Cer		500 v	
C457	283-001	0.005 μf	Cer		500 v	
C471	Use 290-0185-00	2 x 40 μf	EMC		250 v	
C472	283-003	0.01 μf	Cer		150 v	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C475	285-526	0.1 μf	PTM		400 v		
C476A†	Use 290-0062-00	40 μf	EMC		475 v		
C476B†	Use 290-0062-00	20 μf	EMC		475 v		
C476C†	Use 290-0062-00	10 μf	EMC		475 v		
C477	285-526	0.1 μf	PTM		400 v		
C489	281-593	3.9 pf	Cer		500 v	10%	
C493	Use 283-002	0.01 μf	Cer		500 v		
C506	285-526	0.1 μf	PTM		400 v		
C513	283-088	0.0011 μf	Cer		500 v	5%	
C520	281-022	8-50 pf	Cer	Var			
C523	283-088	0.0011 μf	Cer		500 v	5%	
C533	283-002	0.01 μf	Cer		500 v		
C535	Use 283-003	0.01 μf	Cer		150 v		
C536	283-002	0.01 μf	Cer		500 v		
C543	283-002	0.01 μf	Cer		500 v		
C546	285-517	0.022 μf	PTM		600 v		
C551	281-601	7.5 pf	Cer		500 v		100-1079
C551	281-075	5-25 pf	Cer	Var			1080-up
C556	283-103	180 pf	Cer		500 v	5%	
C557	283-077	330 pf	Cer		500 v	5%	
C566	283-103	180 pf	Cer		500 v	5%	
C567	283-084	270 pf	Cer		1000 v	5%	
C568	281-022	8-50 pf	Cer	Var			
C570	283-000	0.001 μf	Cer		500 v		
C572	283-006	0.02 μf	Cer		600 v		
C574	281-602	68 pf	Cer		500 v	5%	
C578	281-536	0.001 μf	Cer		500 v	10%	
C579	281-543	270 pf	Cer		500 v	10%	
C580	281-513	27 pf	Cer		500 v		
C581	281-022	8-50 pf	Cer	Var			
C582	283-088	0.0011 μf	Cer		500 v	5%	
C590	283-006	0.02 μf	Cer		600 v		
C592	283-088	0.0011 μf	Cer		500 v	5%	
C597	283-000	0.001 μf	Cer		500 v		
C601	283-057	0.1 μf	Cer		200 v		
C610	285-510	0.01 μf	PTM		400 v		
C617	285-510	0.01 μf	PTM		400 v		
C628	285-510	0.1 μf	PTM		400 v		
C640	Use 290-0016-00	125 μf	EMC		350 v		
C648	283-002	0.01 μf	Cer		500 v		
C649	Use 290-0012-00	2 x 40 μf	EMC		250 v		
C650	285-510	0.01 μf	PTM		400 v		
C670	Use 290-0019-00	150 μf	EMC		250 v		
C671	Use 290-0019-00	150 μf	EMC		250 v		
C679A,B,C	Use 290-0005-00	3 x 10 μf	EMC		450 v		

†C476A, C476B, C476C furnished as a unit.

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
C680	285-510	0.01 μf	PTM	400 v		
C688	285-510	0.01 μf	PTM	400 v		
C700	Use 290-0017-00	125 μf	EMC	450 v		
C710	285-511	0.01 μf	PTM	600 v		
C730	Use 290-0016-00	125 μf	EMC	350 v		
C740	285-510	0.01 μf	PTM	400 v		
C760A,B	Use 290-0013-00	2 x 40 μf	EMC	450 v		
C780	283-001	0.005 μf	Cer	500 v		
C783	283-002	0.01 μf	Cer	500 v		
C785	283-002	0.01 μf	Cer	500 v		
C802	Use 290-0190-00	40 μf	EMC	400 v		
C803	283-000	0.001 μf	Cer	500 v		
C806	285-506	0.0047 μf	PTM	400 v		
C808	285-502	0.001 μf	PTM	1000 v		
C820	283-082	0.01 μf	Cer	4000 v		
C821	283-082	0.01 μf	Cer	4000 v		
C822	281-525	470 pf	Cer	500 v		
C823	283-101	0.0047 μf	Cer	6000 v		
C824	285-555	0.1 μf	PTM	100 v		
C829	283-082	0.01 μf	Cer	4000 v		
C830	283-082	0.01 μf	Cer	4000 v		
C833	281-556	500 pf	Cer	10000 v		
C834	281-556	500 pf	Cer	10000 v		
C836	283-096	500 pf	Cer	20000 v		
C841	283-006	0.02 μf	Cer	600 v		
C842	283-082	0.01 μf	Cer	4000 v		
C852	283-082	0.01 μf	Cer	4000 v		
C854	283-082	0.01 μf	Cer	4000 v		
C858	283-082	0.01 μf	Cer	4000 v		
C863	283-002	0.01 μf	Cer	500 v		
C871	Use 283-077	330 pf	Cer	500 v	5%	
C874	Use 283-077	330 pf	Cer	500 v	5%	
C885	281-513	27 pf	Cer	500 v		
C897	283-000	0.001 μf	Cer	500 v		

Diodes

D29	Use *152-185	Silicon Replaceable by 1N3605			
D30	Use *152-185	Silicon Replaceable by 1N3605			
D32	Use *152-185	Silicon Replaceable by 1N3605			
D43	152-064	Zener ¼M10Z10	¼ w 10 v	10%	
D46	152-141	Silicon 1N3605			
D47	152-141	Silicon 1N3605			
D48	*152-0185-00	Silicon Replaceable by 1N3605			X2120-up
D49	152-064	Zener ¼M10Z10	¼ w 10 v	10%	100-193
D49	152-126	Zener 1N3024A	1 w 15 v	10%	194-up
D78	Use *152-185	Silicon Replaceable by 1N3605			
D79	Use *152-185	Silicon Replaceable by 1N3605			
D81	Use *152-185	Silicon Replaceable by 1N3605			

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
D82	Use *152-185	Silicon Replaceable by 1N3605	
D90	*152-0185-00	Silicon Replaceable by 1N3605	X2120-up
D122	152-008	Germanium	
D131	152-008	Germanium	
D133	*152-061	Silicon Tek Spec	
D231	152-008	Germanium	
D233	*152-061	Silicon Tek Spec	
D642A,B,C,D,	152-066	Silicon 1N3194	
D672A,B,C,D	152-066	Silicon 1N3194	
D679	152-066	Silicon 1N3194	
D702A,B	152-066	Silicon 1N3194	
D732A,B	152-066	Silicon 1N3194	
D762A,B,C,D	152-066	Silicon 1N3194	

Fuses

F601	159-011	6.25 Amp 3AG Slo-Blo, 115 v, 50-60 and 400 cps	
	159-005	3 Amp 3AG Slo-Blo, 230 v, 50-60 and 400 cps	

Relays

K600	148-021	Relay Delay	
K601	148-016	45 v DC	

Inductors

LR45	*108-293	27 μh (wound on a 680 Ω resistor)	
L75	*108-245	3.9 μh	
LR84	*108-294	300 μh (wound on a 2.7 k resistor)	
LR149	*108-164	1.2 mh (wound on a 3.6 k resistor)	
L249	*108-165	4.7 mh	
L424	*108-015	255 μh	
LR529	*108-292	12 μh (wound on a 100 Ω resistor)	
L528†	*308-318	1.5 k 2 w WW 1% (8 μh)	
L533	276-507	Core Ferrite	
L545	*108-262	0.6 μh	
L546	*108-262	0.6 μh	
L551	*108-260	0.1 μh	
L553	*119-034	Delay Line Assembly	
L554	*114-091	2.7-5.4 μh Var Core 276-506	
L560	*114-130	1.45-2.9 μh Var Core 276-506	
L561	*108-181	0.2 μh	
L588	*114-079	1.8-3.7 μh Var Core 276-506	
L589	*114-164	6-11 μh Var Core 276-506	
L598	*114-079	1.8-3.7 μh Var Core 276-506	
L599	*114-164	6-11 μh Var Core 276-506	
L778	Use *108-323	Beam Rotator	

† Coil, resistor combination.

Transistors

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q34	*151-108	Replaceable by 2N2501	
Q35	*151-108	Replaceable by 2N2501	
Q45	*151-108	Replaceable by 2N2501	
Q85	*151-126	Replaceable by 2N2484	
Q95	*151-126	Replaceable by 2N2484	
Q513	*151-121	Selected from TA1938	
Q514	*151-127	Selected from 2N2369	
Q523	*151-121	Selected from TA1938	
Q524	*151-127	Selected from 2N2369	
Q534	*151-096	Selected from 2N1893	
Q543	*151-121	Selected from TA1938	
Q584	*151-127	Selected from 2N2369	
Q594	*151-127	Selected from 2N2369	

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	301-684	680 k	½ w		5%
R2	301-394	390 k	½ w		5%
R3	311-023	50 k		Var	INT TRIG DC LEVEL
R4	302-104	100 k	½ w		
R6	302-106	10 meg	½ w		
R9	302-225	2.2 meg	½ w		X194-up
R12	302-105	1 meg	½ w		
R13	302-104	100 k	½ w		
R15	302-474	470 k	½ w		
R17†	311-096	100 k		Var	TRIGGERING LEVEL
R18	302-223	22 k	½ w		
R19	302-474	470 k	½ w		
R20	302-563	56 k	½ w		
R22	302-470	47 Ω	½ w		
R23	302-470	47 Ω	½ w		
R24	302-222	2.2 k	½ w		
R26	Use 303-123	12 k	1 w		5%
R27	306-223	22 k	2 w		
R29	301-623	62 k	½ w		5%
R31	301-182	1.8 k	½ w		5%
R32	302-152	1.5 k	½ w		
R33	302-184	180 k	½ w		100-193
R33	302-120	120 k	½ w		194-up
R34	305-123	12 k	2 w		5%
R35	303-223	22 k	1 w		5%
R36	302-100	10 Ω	½ w		

† Furnished as a unit with R110 and SW110.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R37	301-103	10 k	½ w		5%	
R38	Use 303-183	18 k	1 w		5%	
R39	311-026	100 k		Var	TRIG LEVEL CENTERING	
R43	305-113	11 k	2 w		5%	100-2119
R43	308-0364-00	9-65 k	3 w	WW	1%	2120-up
R44	302-680	68 Ω	½ w			
R46	305-103	10 k	2 w		5%	100-2119
R46	308-0301-00	10 k	3 w	WW	1%	2120-up
R47	311-308	50 Ω		Var	TRIG SENS	
R48	305-103	10 k	2 w		5%	
R49	308-252	390 Ω	3 w	WW	5%	
R51	301-684	680 k	½ w		5%	
R52	301-394	390 k	½ w		5%	
R54	302-104	100 k	½ w			
R53	311-125	50 k	0.2 w	Var	INT TRIG DC LEVEL	
R56	302-106	10 meg	½ w			
R61	302-225	2.2 meg	½ w			X194-up
R92	Use 303-203	20 k	1 w			
R65	302-474	470 k	½ w			
R67†	311-096	100 k		Var	TRIGGERING LEVEL	
R68	302-223	22 k	½ w			
R69	302-474	470 k	½ w			
R70	302-563	56 k	½ w			
R72	302-470	47 Ω	½ w			
R73	302-470	47 Ω	½ w			
R74	302-332	3.3 k	½ w			
R75	301-242	2.4 k	½ w		5%	
R76	302-100	10 Ω	½ w			
R77	303-393	39 k	1 w		5%	
R78	301-753	75 k	½ w		5%	
R79	303-393	39 k	1 w		5%	
R81	Use 301-153	15 k	½ w		5%	
R82	311-026	100 k		Var	TRIG LEVEL CENTERING	
R85	301-331	330 Ω	½ w		5%	
R87	301-432	4.3 k	½ w		5%	
R88	303-123	12 k	1 w		5%	
R90	301-432	4.3 k	½ w		5%	
R92	Use 303-203	20 k	1 w		5%	
R93	302-561	560 Ω	½ w			
R95	302-152	1.5 k	½ w			
R97	303-223	22 k	1 w		5%	
R101	302-102	1 k	½ w			
R102	302-223	22 k	½ w			
R103	302-226	22 meg	½ w			
R105	302-394	390 k	½ w			
R106	302-105	1 meg	½ w			
R107	302-470	47 Ω	½ w			
R109	302-224	220 k	½ w			

† Furnished as a unit with R210 and SW210.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R110†	311-096	100 k		Var		STABILITY
R111	311-219	200 k	0.2 w	Var		PRESET ADJUST
R114	301-914	910 k	½ w			5%
R115	301-104	100 k	½ w			5%
R116	301-184	180 k	½ w			5%
R121	302-470	47 Ω	½ w			
R122	304-683	68 k	1 w			
R123	302-274	270 k	½ w			
R124	302-474	470 k	½ w			
R125	311-023	50 k		Var		LOCKOUT LEVEL
R126	302-104	100 k	½ w			
R127	302-470	47 Ω	½ w			
R128	302-123	12 k	½ w			
R129	302-103	10 k	½ w			
R130	306-223	22 k	2 w			
R131	308-077	1 k	3 w		WW	
R132	302-470	47 Ω	½ w			
R133	302-104	100 k	½ w			
R134	*310-555	6 k/3 k	3 w		WW	
R137	302-470	47Ω	½ w			
R138	302-470	47 Ω	½ w			
R141	324-339	33.2 k	1 w		Prec	1%
R143	324-335	30.1 k	1 w		Prec	1%
R144	308-294	8 k	5 w		WW	5%
R146	302-470	47 Ω	½ w			
R147	302-102	1 k	½ w			
R148	302-473	47 k	½ w			
R150	302-271	270 Ω	½ w			
R151	301-683	68 k	½ w			5%
R152	301-105	1 meg	½ w			5%
R153	302-103	10 k	½ w			
R155	302-185	1.8 meg	½ w			
R156	302-105	1 meg	½ w			
R157	302-474	470 k	½ w			
R158	302-102	1 k	½ w			
R159	306-332	3.3 k	2 w			
R160A	309-045	100 k	½ w		Prec	1%
R160B	309-051	200 k	½ w		Prec	1%
R160C	309-003	500 k	½ w		Prec	1%
R160D	309-014	1 meg	½ w		Prec	1%
R160E	309-023	2 meg	½ w		Prec	1%
R160F	309-087	5 meg	½ w		Prec	1%
R160G	310-107	10 meg	1 w		Prec	1%
R160H	310-107	10 meg	1 w		Prec	1%
R160J	310-505	30 meg	2 w		Prec	1%

† Furnished as a unit with R17 and SW110.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R160T	304-563	56 k	1 w			
R160V	302-105	1 meg	½ w			
R160W	302-104	100 k	½ w			
R160X	302-103	10 k	½ w			
R160Y†	311-108	20 k		Var		VARIABLE
R160Z	311-066	500 Ω	0.2 w	Var		
R164	306-223	22 k	2 w			
R165	306-223	22 k	2 w			
R166	306-223	22 k	2 w			
R167	302-155	1.5 meg	½ w			
R168	302-473	47 k	½ w			
R171	302-470	47 Ω	½ w			
R172	302-470	47 Ω	½ w			
R173	302-471	470 Ω	½ w			
R174	308-294	8 k	5 w		WW	5%
R176	311-008	2 k		Var		SWP LENGTH
R178	308-051	4 k	5 w		WW	5%
R180A	302-474	470 k	½ w			
R180B	302-475	4.7 meg	½ w			
R181	302-475	4.7 meg	½ w			
R183	302-470	47 Ω	½ w			
R186	302-470	47 Ω	½ w			
R187	302-470	47 Ω	½ w			
R189	306-563	56 k	2 w			
R190	302-473	47 k	½ w			
R191	301-114	110 k	½ w			5%
R192	302-470	47 Ω	½ w			
R193	302-470	47 Ω	½ w			
R194	304-472	4.7 k	1 w			
R196	302-104	100 k	½ w			
R199	304-104	100 k	1 w			
R201	302-470	47 Ω	½ w			
R203	302-470	47 Ω	½ w			
R210††	311-096	100 k		Var		STABILITY
R211	311-110	100 k		Var		PRESET ADJUST
R214	301-914	910 k	½ w			5%
R215	301-114	110 k	½ w			5%
R216	301-154	150 k	½ w			5%
R221	302-101	100 Ω	½ w			
R230	304-223	22 k	1 w			

† Concentric with SW160 and SW160Y.

Furnished as a unit with SW160Y.

††Furnished as a unit with R67 and SW210.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R231	301-472	4.7 k	½ w		5%	
R232	302-101	100 Ω	½ w			
R233	302-104	100 k	½ w			
R234	301-682	6.8 k	½ w		5%	
R235	301-682	6.8 k	½ w		5%	
R236	301-622	6.2 k	½ w		5%	
R237	301-274	270 k	½ w		5%	
R241	324-339	33.2 k	1 w	Prec	1%	
R243	324-335	30.1 k	1 w	Prec	1%	
R244	308-108	15 k	5 w	WW	5%	
R246	302-101	100 Ω	½ w			
R247	302-222	2.2 k	½ w			
R248	302-473	47 k	½ w			
R249	302-822	8.2 k	½ w			
R250	302-272	2.7 k	½ w			
R260A	*312-567	404 k	½ w	Prec	¼%	
R260B	*312-568	606 k	½ w	Prec	¼%	
R260C	*312-571	1.01 meg	½ w	Prec	¼%	
R260D	*312-575	4.04 meg	½ w	Prec	¼%	
R260E	*312-576	6.06 meg	½ w	Prec	¼%	
R260F	*312-577	10.1 meg	½ w	Prec	¼%	
R264	306-224	220 k	2 w			
R267	302-155	1.5 meg	½ w			
R268	302-104	100 k	½ w			
R271	302-101	100 Ω	½ w			
R272	301-822	8.2 k	½ w		5%	
R273	311-326	10 k		Var		MIN SWEEP LENGTH
R274	305-153	15 k	2 w		5%	
R276	311-016	10 k		Var		LENGTH
R277	Use 311-110	100 k		Var		MAX SWEEP LENGTH
R278	301-393	39 k	½ w		5%	
R279	303-123	12 k	1 w		5%	
R280	302-125	1.2 meg	½ w			
R281	302-475	4.7 meg	½ w			
R282	302-102	1 k	½ w			
R283	302-102	1 k	½ w			
R291	302-101	100 Ω	½ w			
R293	306-823	82 k	2 w			
R295	302-393	39 k	½ w			
R296	302-104	100 k	½ w			
R297	302-101	100 Ω	½ w			
R299	302-103	10 k	½ w			
R300	302-470	47 Ω	½ w			
R301C	323-611	900 k	½ w	Prec	1%	
R301E	323-610	111 k	½ w	Prec	1%	
R303	302-105	1 meg	½ w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R311	302-102	1 k	½ w			
R313	306-333	33 k	2 w			
R314	311-112	15 k		Var		VARIABLE 10-1
R315	306-333	33 k	2 w			
R317	311-026	100 k		Var		EXT HORIZ DC BAL
R319	302-224	220 k	½ w			
R320	302-332	3.3 k	½ w			
R321	302-101	100 Ω	½ w			
R324	306-273	27 k	2 w			
R330	309-017	1.5 meg	½ w		Prec	1%
R332	309-086	3.5 meg	½ w		Prec	1%
R333†	311-149	100 k		Var		HORIZONTAL POSITION
R336	309-268	12.1 meg	½ w		Prec	1%
R338†	311-149	200 k		Var		VERNIER
R340	302-222	2.2 k	½ w			
R341	302-101	100 Ω	½ w			
R345	304-104	100 k	1 w			
R347	302-104	100 k	½ w			
R348	311-125	50 k	0.2 w	Var		SWP CAL
R349	323-408	174 k	½ w		Prec	1%
R351	302-101	100 Ω	½ w			
R353	304-104	100 k	1 w			
R355	324-443	402 k	1 w		Prec	1%
R356	324-443	402 k	1 w		Prec	1%
R357	304-223	22 k	1 w			
R358	311-018	20 k		Var		NORM/MAG REGIS
R361	302-470	47 Ω	½ w			
R364	*310-506	25 k/6 k	5 w		WW	1%
R366	302-470	47 Ω	½ w			
R373	305-912	9.1 k	2 w			5%
R375	311-065	7 k		Var		MAG GAIN
R376	305-912	9.1 k	2 w			5%
R377	305-242	2.4 k	2 w			5%
R380	302-101	100 Ω	½ w			
R381	302-470	47 Ω	½ w			
R384	*310-507	30 k/6 k	5 w		WW	1%
R386	302-101	100 Ω	½ w			
R387	306-393	39 k	2 w			
R388	306-393	39 k	2 w			
R390	302-222	2.2 k	½ w			
R391	302-470	47 Ω	½ w			
R393	302-391	390 Ω	½ w			
R396	302-474	470 k	½ w			
R397	302-125	1.2 meg	½ w			
R398	302-125	1.2 meg	½ w			
R399	302-474	470 k	½ w			
R410	302-105	1 meg	½ w			

† R333 and R338 furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R411	302-101	100 Ω	½ w			
R415	302-473	47 k	½ w			
R416	302-123	12 k	½ w			
R421	302-101	100 Ω	½ w			
R424	302-103	10 k	½ w			
R425	302-104	100 k	½ w			
R426	302-473	47 k	½ w			
R427	302-101	100 Ω	½ w			
R428	302-103	10 k	½ w			
R431	308-054	10 k	5 w		WW	5%
R432	311-015	10 k		Var		DELAY STOP ADJ
R433	311-022	30 k		Var		DELAY TIME MULTIPLIER 1-10
R434	302-104	100 k	½ w			
R436	311-141	2 k		Var		DELAY START ADJUST
R437	308-108	15 k	5 w		WW	5%
R441	302-101	100 Ω	½ w			
R443	302-272	2.7 k	½ w			
R444	323-385	100 k	½ w		Prec	1%
R446	323-404	158 k	½ w		Prec	1%
R447	306-393	39 k	2 w			
R451	302-101	100 Ω	½ w			
R453	302-332	3.3 k	½ w			
R454	302-103	10 k	½ w			
R455	302-274	270 k	½ w			
R456	302-101	100 Ω	½ w			
R457	302-470	47 Ω	½ w			
R458	302-102	1 k	½ w			
R471	304-101	100 Ω	1 w			
R473	302-101	100 Ω	½ w			
R475	302-470	47 Ω	½ w			
R476	302-470	47 Ω	½ w			
R477	302-470	47 Ω	½ w			
R479	302-101	100 Ω	½ w			
R491	316-470	47 Ω	¼ w			
R493	316-470	47 Ω	¼ w			
R494	303-562	5.6 k	1 w			5%
R495	Use 311-475	5 k	4 w	Var	WW	DC BAL
R496	303-562	5.6 k	1 w			5%
R498	316-470	47 Ω	¼ w			
R499	301-622	6.2 k	½ w			5%
R500	301-622	6.2 k	½ w			5%
R501	315-154	150 k	¼ w			5%
R502	311-117	5 k		Var		DC SHIFT
R504	316-470	47 Ω	¼ w			
R506	302-101	100 Ω	½ w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R507	Use 301-910	91 Ω	½ w		5%	
R508	305-122	1.2 k	2 w		5%	
R509	323-181	750 Ω	½ w	Prec	1%	
R510	323-239	3.01 k	½ w	Prec	1%	
R511	322-093	90.9 Ω	¼ w	Prec	1%	
R513	315-121	120 Ω	¼ w		5%	
R515	Use 315-270	27 Ω	¼ w		5%	
R516	Use 315-270	27 Ω	¼ w		5%	
R517	308-305	1.3 k	10 w	WW	2%	
R519	Use 315-560	56 Ω	¼ w		5%	
R520	311-246	500 Ω	Var		GAIN	
R523	315-121	120 Ω	¼ w		5%	
R525	316-470	47 Ω	¼ w			
R526	322-093	90.9 Ω	¼ w	Prec	1%	
R527	323-239	3.01 k	½ w	Prec	1%	
R530	301-620	62 Ω	½ w		5%	
R532	308-306	3.26 k	3 w	WW	2%	
R533	308-307	5 k	3 w	WW	2%	
R535	302-184	180 k	½ w			
R536	302-123	12 k	½ w			
R537	302-685	6.8 meg	½ w			
R538	302-224	220 k	½ w			
R539	302-104	100 k	½ w			
R541	302-681	680 Ω	½ w			
R543	302-101	100 Ω	½ w			
R544	315-753	75 k	¼ w		5%	
R545	302-820	82 Ω	½ w			
R546	302-471	470 Ω	½ w			
R547	308-273	6.5 k	5 w	WW	2%	
R548	302-105	1 meg	½ w			
R549	302-102	1 k	½ w			
R552	302-222	2.2 k	½ w			
R554	323-166	523 Ω	½ w	Prec	1%	
R556	323-137	261 Ω	½ w	Prec	1%	
R557	323-074	57.6 Ω	½ w	Prec	1%	
R560	321-025	17.8 Ω	⅛ w	Prec	1%	
R561	323-126	200 Ω	½ w	Prec	1%	
R563	315-562	5.6 k	¼ w		5%	
R566	323-137	261 Ω	½ w	Prec	1%	
R567	323-074	57.6 Ω	½ w	Prec	1%	
R569	321-437	348 k	⅛ w	Prec	1%	
R570	321-313	17.8 k	⅛ w	Prec	1%	
R571	308-289	820 Ω	10 w	WW	5%	
R572	302-820	82 Ω	½ w			
R574	321-013	13.3 Ω	⅛ w	Prec	1%	
R576	321-013	13.3 Ω	⅛ w	Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R578	315-752	7.5 k	1/4 w			5%
R579	315-152	1.5 k	1/4 w			5%
R580	311-129	150 Ω	0.1 w	Var		DAMPING
R582	315-910	91 Ω	1/4 w			5%
R584	315-470	47 Ω	1/4 w			5%
R585	315-104	100 k	1/4 w			5%
R587	315-101	100 Ω	1/4 w			5%
R589	*310-613	1.1 k	4 w		Prec	2%
R590	302-820	82 Ω	1/2 w			
R592	315-910	91 Ω	1/4 w			5%
R594	315-470	47 Ω	1/4 w			5%
R595	315-104	100 k	1/4 w			5%
R596	303-562	5.6 k	1 w			5%
R597	315-101	100 Ω	1/4 w			5%
R599	*310-613	1.1 k	4 w		Prec	2%
R601	308-142	30 Ω	3 w		WW	5%
R602	311-055	50 Ω		Var	WW	SCALE ILLUM
R604	308-052	6 k	5 w		WW	5%
R608	302-333	33 k	1/2 w			
R610	302-104	100 k	1/2 w			
R615	323-369	68.1 k	1/2 w		Prec	1%
R616	311-015	10 k		Var		—150 ADJ
R617	323-356	49.9 k	1/2 w		Prec	1%
R618	302-104	100 k	1/2 w			
R621	302-102	1 k	1/2 w			
R623	302-474	470 k	1/2 w			
R625	302-104	100 k	1/2 w			
R628	302-275	2.7 meg	1/2 w			
R629	302-275	2.7 meg	1/2 w			
R633	302-105	1 meg	1/2 w			
R635	304-153	15 k	1 w			
R636	304-153	15 k	1 w			
R637	302-154	150 k	1/2 w			
R638	302-273	27 k	1/2 w			
R639	302-683	68 k	1/2 w			
R640	304-100	10 Ω	1 w			
R641	304-100	10 Ω	1 w			
R643	302-102	1 k	1/2 w			
R644	302-102	1 k	1/2 w			
R647	308-037	1 k	25 w		WW	5%
R648	302-100	10 Ω	1/2 w			
R650	323-440	374 k	1/2 w		Prec	1%
R651	323-675	543 k	1/2 w		Prec	1%
R663	302-155	1.5 meg	1/2 w			
R667	302-684	680 k	1/2 w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R668	302-473	47 k	½ w			
R669	302-393	39 k	½ w			
R670	306-100	10 Ω	2 w			
R675	308-147	750 Ω	25 w	WW	5%	
R676	308-037	1 k	25 w	WW	5%	
R677	308-155	800 Ω	25 w	WW	5%	
R680	323-440	374 k	½ w	Prec	1%	
R681	323-674	247 k	½ w	Prec	1%	
R682	302-124	120 k	½ w			
R683	302-102	1 k	½ w			
R685	304-823	82 k	1 w			
R686	302-184	180 k	½ w			
R688	302-155	1.5 meg	½ w			
R689	302-225	2.2 meg	½ w			
R690	302-102	1 k	½ w			
R693	302-155	1.5 meg	½ w			
R697	302-105	1 meg	½ w			
R698	302-274	270 k	½ w			
R699	302-563	56 k	½ w			
R700	306-100	10 Ω	2 w			
R710	324-458	576 k	1 w	Prec	1%	
R711	323-422	243 k	½ w	Prec	1%	
R712	302-154	150 k	½ w			
R723	302-155	1.5 meg	½ w			
R727	302-105	1 meg	½ w			
R728	302-564	560 k	½ w			
R729	302-473	47 k	½ w			
R730	304-100	10 Ω	1 w			
R731	304-100	10 Ω	1 w			
R732	306-823	82 k	2 w			
R736	308-040	1.5 k	25 w	WW	5%	
R740	323-418	221 k	½ w	Prec	1%	
R741	324-467	715 k	1 w	Prec	1%	
R753	302-105	1 meg	½ w			
R757	302-154	150 k	½ w			
R758	302-124	120 k	½ w			
R759	302-273	27 k	½ w			
R760	302-100	10 Ω	½ w			
R767	Use 308-066	4.5 k	5 w	WW	5%	
R778†	311-472	2 x 10 Ω	Var		TRACE ROTATION	
R780	302-154	150 k	½ w			
R785	302-104	100 k	½ w			
R802	306-271	270 Ω	2 w			
R803	306-563	56 k	2 w			
R806	302-104	100 k	½ w			

† Furnished as a unit with R864.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R807	301-432	4.3 k	½ w			5%	
R814	302-474	470 k	½ w				
R820	302-333	33 k	½ w				
R821	301-225	2.2 meg	½ w			5%	
R822	302-333	33 k	½ w				
R823	302-102	1 k	½ w				
R824	305-755	7.5 meg	2 w			5%	
R825	305-755	7.5 meg	2 w			5%	
R826	311-041	1 meg		Var		INTENSITY	
R827	302-333	33 k	½ w				
R830	302-335	3.3 meg	½ w				
R836	316-105	1 meg	¼ w				
R840	311-034	500 k		Var		HIGH VOLTAGE	
R841	303-205	2 meg	1 w			5%	
R842	303-225	2.2 meg	1 w			5%	
R843	303-225	2.2 meg	1 w			5%	
R845	303-335	3.3 meg	1 w			5%	
R846	311-121	5 meg		Var		FOCUS	
R847	301-364	360 k	½ w			5%	
R853	302-103	10 k	½ w				
R857	302-273	27 k	½ w				
R858	302-105	1 meg	½ w				
R859	302-471	470 Ω	½ w				
R861	311-026	100 k		Var		GEOMETRY	
R862	301-823	82 k	½ w			5%	100-169
R862	323-391	115 k	½ w		Prec	1%	170-up
R863	301-124	120 k	½ w			5%	100-169
R863	323-394	124 k	½ w		Prec	1%	170-up
R864†	311-472	100 k		Var		ASTIGMATISM	
R865	301-433	43 k	½ w			5%	
R870	Use 301-154	150 k	½ w			5%	
R871	Use 301-245	2.4 meg	½ w			5%	
R872	302-102	1 k	½ w				
R874	Use 301-395	3.9 meg	½ w			5%	
R875	Use 301-683	68 k	½ w			5%	
R876	302-102	1 k	½ w				
R878	304-333	33 k	1 w				
R879	311-016	10 k		Var		CAL ADJ	
R880	302-104	100 k	½ w				
R883	302-101	100 Ω	½ w				
R885	323-673	9.5 k	½ w		Prec	1%	
R886	323-672	6.375 k	½ w		Prec	1%	
R887	323-224	2.1 k	½ w		Prec	1%	
R888	323-664	1.025 k	½ w		Prec	1%	
R889	323-671	610 Ω	½ w		Prec	1%	

† Furnished as a unit with R778.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R890	323-126	200 Ω	½ w	Prec	1%	
R891	323-097	100 Ω	½ w	Prec	1%	
R892	323-606	60 Ω	½ w	Prec	1%	
R893	323-605	40 Ω	½ w	Prec	1%	
R896	323-385	100 k	½ w	Prec	1%	
R897	323-097	100 Ω	½ w	Prec	1%	
R898	323-097	100 Ω	½ w	Prec	1%	
R899	*308-090	0.25 Ω	1 w	WW		

Switches

	Unwired	Wired			
SW10A, SW10B	260-619	*262-657	Rotary	TRIGGER SLOPE, TRIGGERING MODE	TIME BASE A
SW60A, SW60B	260-261	*262-658	Rotary	TRIGGER SLOPE, TRIGGERING MODE	TIME BASE B
SW103	260-017		Push	RESET	
SW110†	311-096			PRESET (Time Base A)	
SW160††	260-230	*262-245	Rotary	TIME/CM A	
SW160Y†††	311-108				
SW210††††	311-096			PRESET (Time Base B)	
SW260	260-260	*262-208	Rotary	TIME/CM B	
SW301	260-502	*262-655	Rotary	HORIZONTAL DISPLAY (Front)	
SW347A, SW347B	260-503	*262-656	Rotary	HORIZONTAL DISPLAY (Rear), 5 X MAGNIFIER	
SW601	260-199		Toggle	POWER ON	
SW848	260-209		Toggle	CRT CATHODE SELECTOR	
SW870	260-253	*262-654	Rotary	AMPLITUDE CALIBRATOR	
TK601	260-618		Thermal	Cutout 140° F ±5° F	

Transformers

T500	276-541	Core, Ferrite
T555	*120-132	Toroid, 3T Bifilar
T601	*120-344	L.V. Power
T801	*120-308	H.V. Power

† Furnished as a unit with R17 and R110.

†† Concentric with SW160Y and R160Y.

††† Furnished as a unit with R160Y.

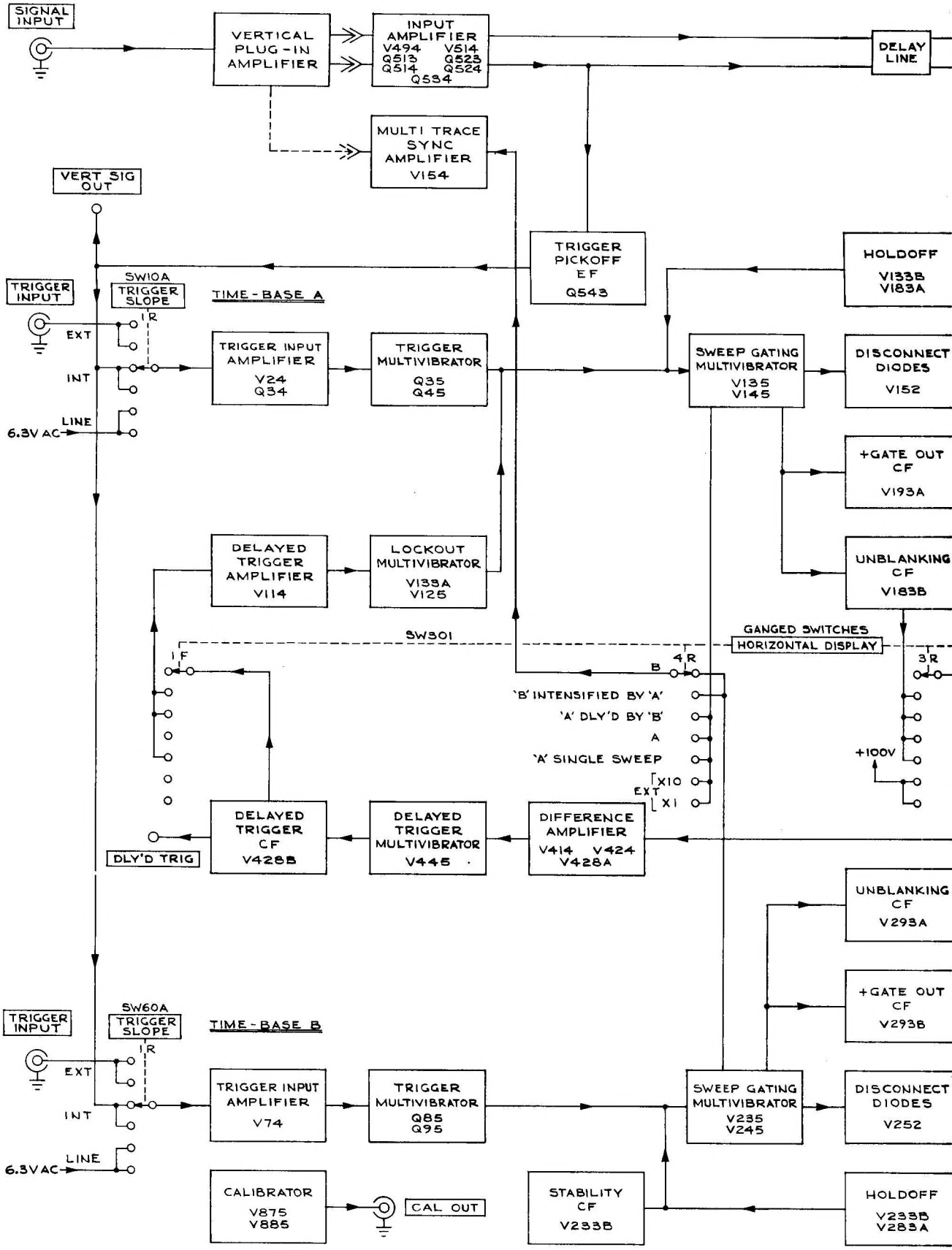
†††† Furnished as a unit with R67 and R210.

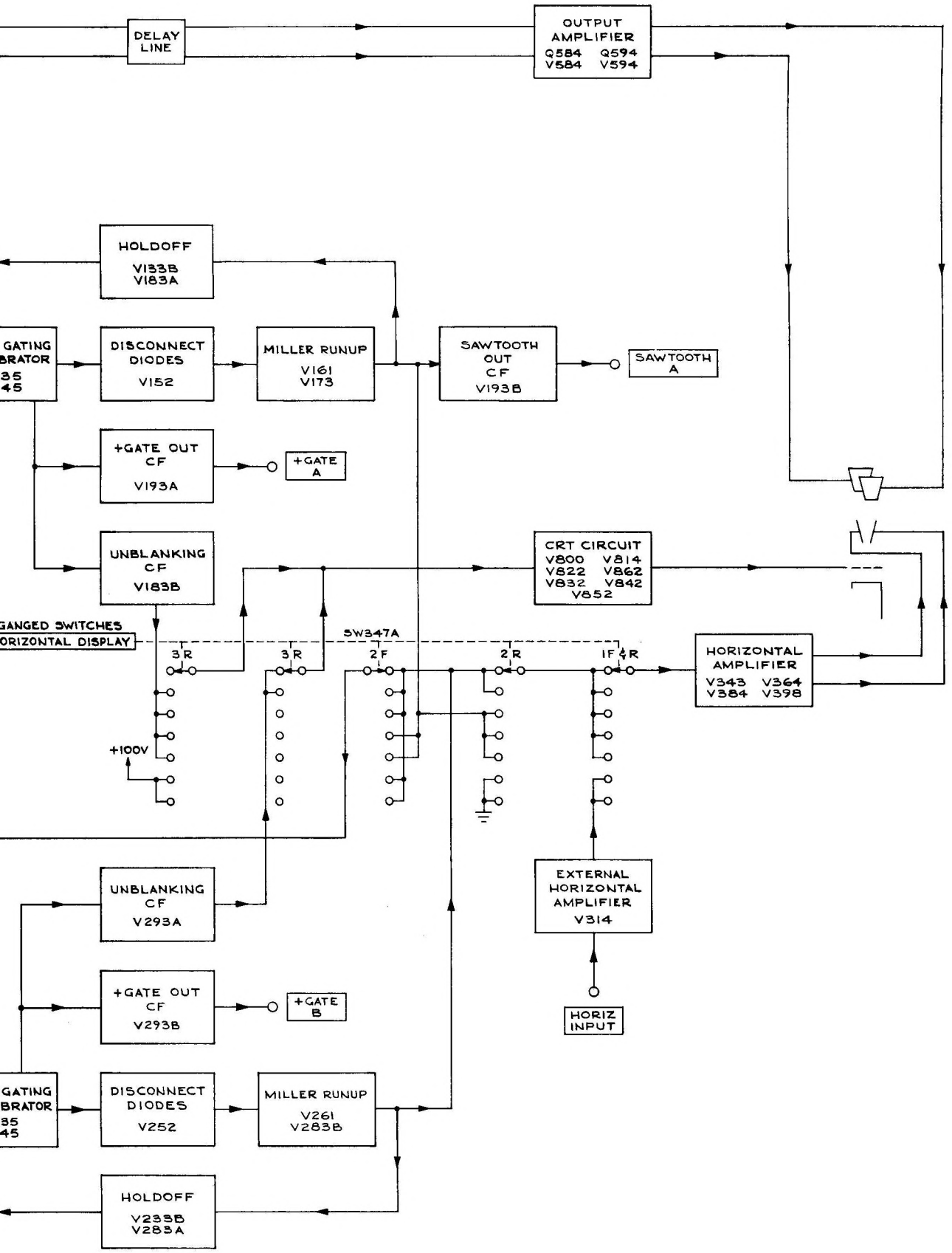
Electron Tubes

Ckt. No.	Tektronix Part No.		Description	S/N Range
V24	154-187	6DJ8		
V74	154-187	6DJ8		
V114	154-022	6AU6		
V125	154-022	6AU6		
V133	154-187	6DJ8		
V135	154-187	6DJ8		
V145	154-047	12BY7		
V152	154-016	6AL5		
V154	154-187	6DJ8		
V161	154-031	6CL6		
V173	154-187	6DJ8		
V183	154-187	6DJ8		
V193	154-187	6DJ8		
V233	154-187	6DJ8		
V235	154-187	6DJ8		
V245	154-022	6AU6		
V252	*157-075	12AL5	Checked	
V261	154-040	12AU6		
V283	154-187	6DJ8		
V293	154-187	6DJ8		
V314	154-187	6DJ8		
V343	154-187	6DJ8		
V364	154-187	6DJ8		
V384	154-187	6DJ8		
V398	154-031	6CL6		
V414	154-022	6AU6		
V424	154-022	6AU6		
V428	154-187	6DJ8		
V445	154-187	6DJ8		
V494	154-187	6DJ8		
V514	154-340	7119		
V584	154-420	7788		
V594	154-420	7788		
V609	154-052	5651		
V624	154-043	12AX7		
V627	154-044	12B4		
V634	154-022	6AU6		
V637	154-044	12B4		
V647	154-044	12B4		
V664	154-022	6AU6		
V677	154-056	6080		
V684	154-043	12AX7		
V694	154-022	6AU6		
V724	154-022	6AU6		
V737	154-056	6080		
V754	154-022	6AU6		

Electron Tubes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
V767	154-044	12B4	
V800	154-021	6AU5	
V814	154-041	12AU7	
V822	154-051	5642	
V832	154-051	5642	
V842	154-051	5642	
V852	154-051	5642	
V859	*154-429	T5470-31-2 Crt Standard Phosphor	
V862	154-051	5642	
V875	154-022	6AU6	
V885	154-041	12AU7	


SIGNAL INPUT
VERTICAL PLUG-IN AMPLIFIER
INPUT AMPLIFIER V494 V514 Q513 Q523 Q514 Q524 Q534
DELAY LINE
MULTI TRACE SYNC AMPLIFIER V154
VERT SIG OUT
TRIGGER PICKOFF EF Q543
HOLDOFF V133B V183A
SW10A
TRIGGER INPUT
TRIGGER SLOPE
TIME-BASE A
1R
EXT
INT
LINE
6.3V AC
TRIGGER INPUT AMPLIFIER V24 Q34
TRIGGER MULTIVIBRATOR Q35 Q45
SWEEP GATING MULTIVIBRATOR V135 V145
DISCONNECT DIODES V152
+GATE OUT CF V193A
UNBLANKING CF V183B
DELAYED TRIGGER AMPLIFIER V114
LOCKOUT MULTIVIBRATOR V133A V125
SW301
GANGED SWITCHES
HORIZONTAL DISPLAY
1F
4R
3R
B
'B' INTENSIFIED BY 'A'
'A' DLY'D BY 'B'
A
'A' SINGLE SWEEP
EXT
X10
X1
+100V
DLY'D TRIG
DELAYED TRIGGER CF V428B
DELAYED TRIGGER MULTIVIBRATOR V445
DIFFERENCE AMPLIFIER V414 V424 V428A
UNBLANKING CF V293A
+GATE OUT CF V293B
SW60A
TRIGGER INPUT
TRIGGER SLOPE
TIME-BASE B
1R
EXT
INT
LINE
6.3V AC
TRIGGER INPUT AMPLIFIER V74
TRIGGER MULTIVIBRATOR Q85 Q95
SWEEP GATING MULTIVIBRATOR V235 V245
DISCONNECT DIODES V252
CALIBRATOR V875 V885
CAL OUT
STABILITY CF V233B
HOLDOFF V233B V283A



MRH
464

A

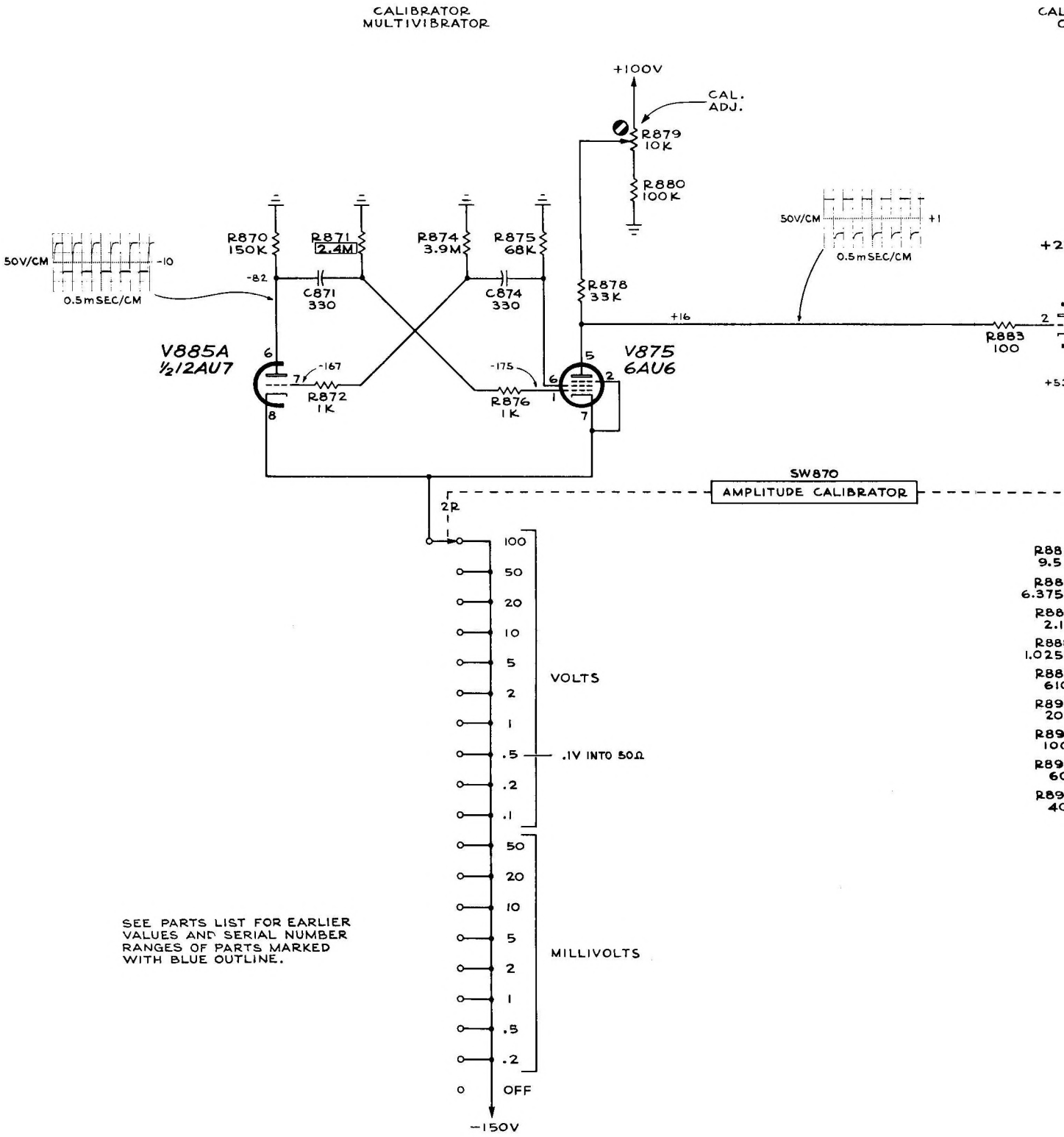
BLOCK DIAGRAM

CALIBRATOR

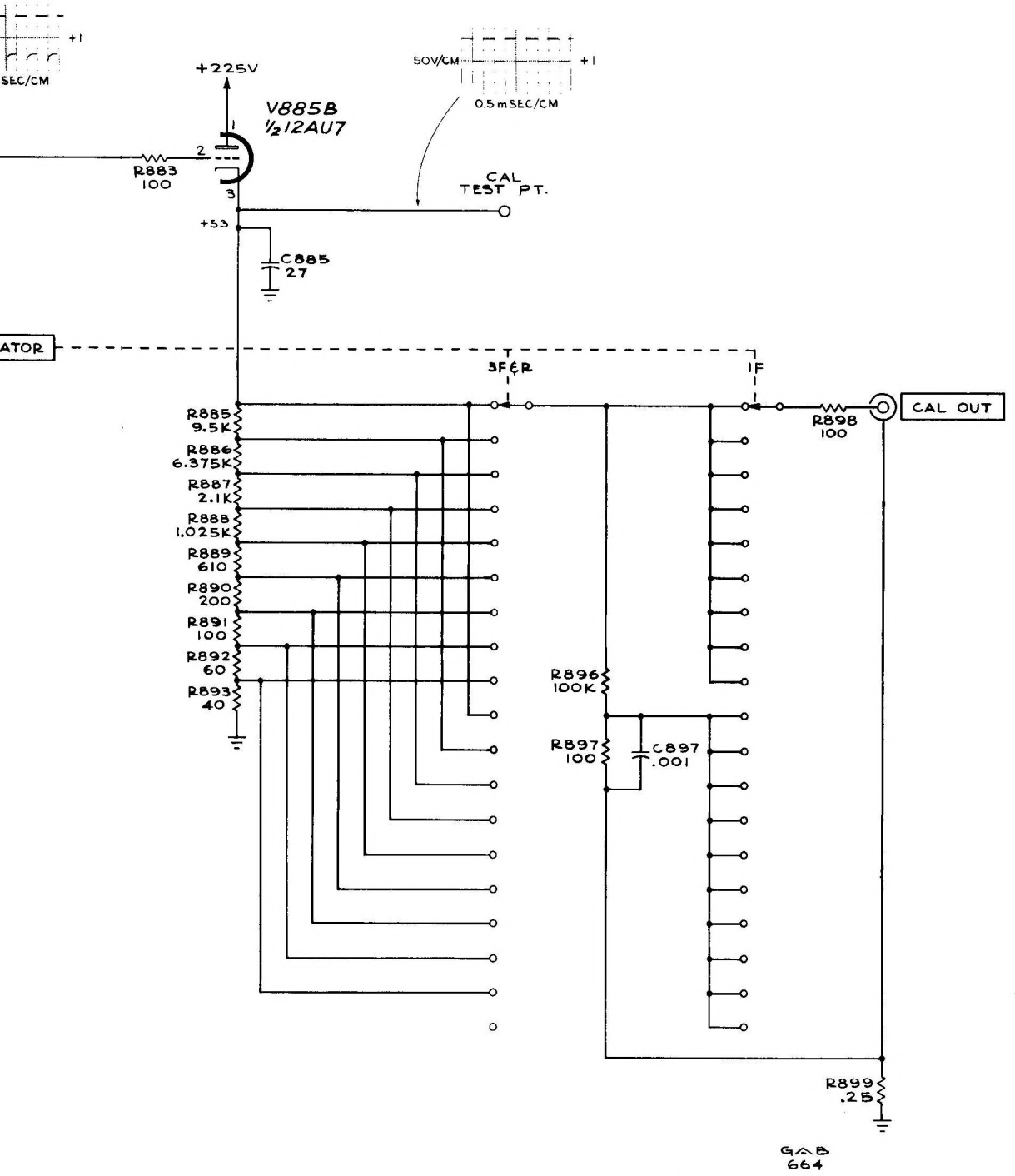
WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

AMPLITUDE CALIBRATOR . . . . . 100 VOLTS

Also see IMPORTANT note on Time Base A Trigger Diagram


CALIBRATOR
MULTIVIBRATOR
+100V
CAL.
ADJ.
R879
10K
R880
100K
R870
150K
R871
2.4M
R874
3.9M
R875
68K
R878
33K
C871
330
C874
330
50V/CM
0.5mSEC/CM
-10
-82
50V/CM
0.5mSEC/CM
+1
+16
R883
100
V885A
½12AU7
V875
6AU6
-167
-175
R872
1K
R876
1K
SW870
AMPLITUDE CALIBRATOR
2R
100
50
20
10
5
2
1
.5
.2
.1
VOLTS
.1V INTO 50Ω
50
20
10
5
2
1
.5
.2
0
OFF
MILLIVOLTS
-150V
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

CAL. OUT
CF



G&B
664

CALIBRATOR 13

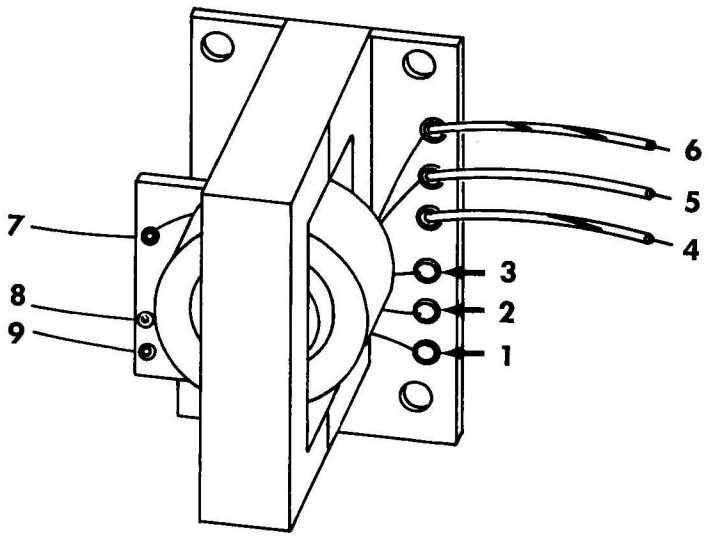
B

CRT CIRCUIT

VOLTAGE READINGS were obtained under the following conditions:
INTENSITY . . . . . Counterclockwise

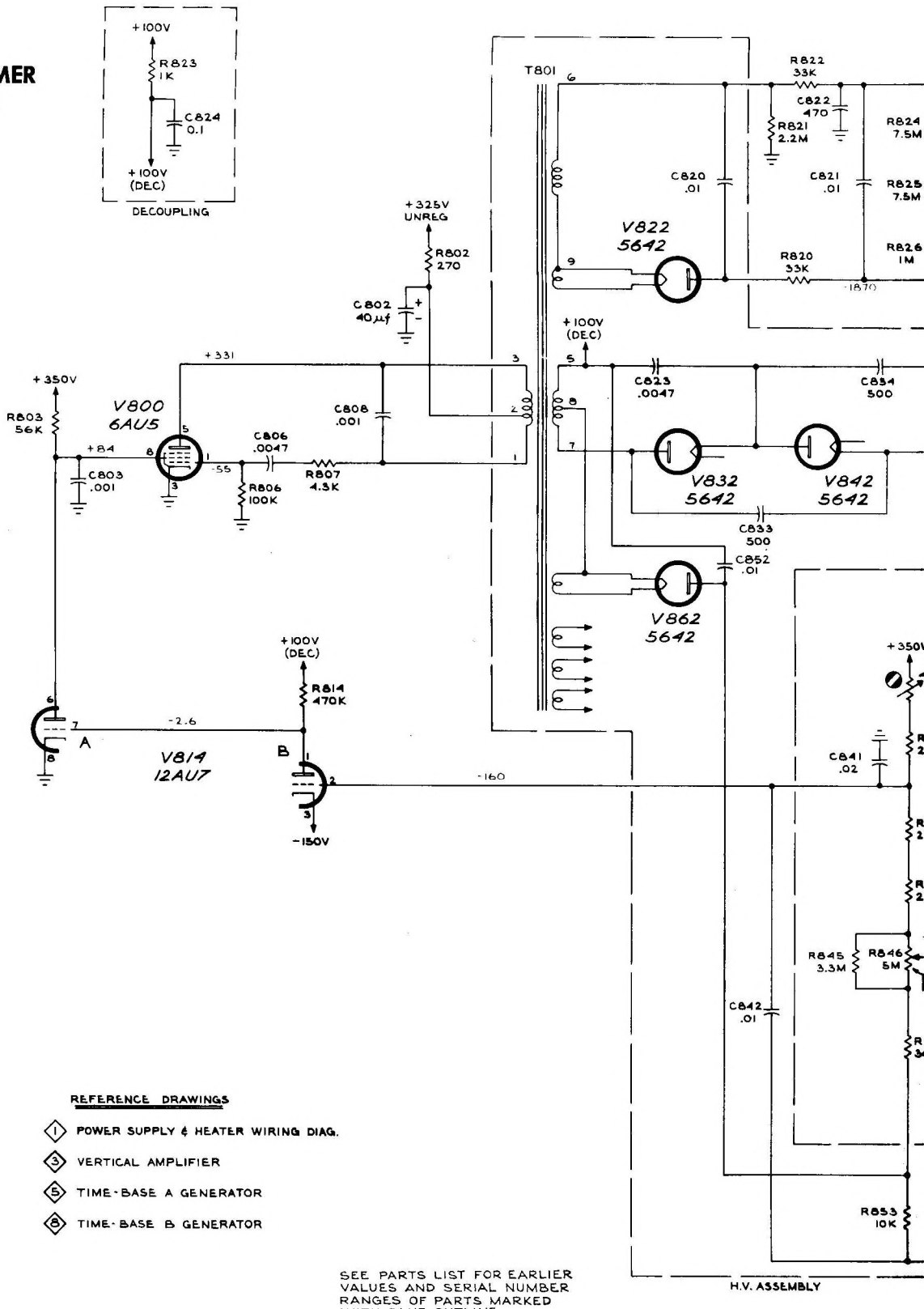
Voltage readings marked with asterisk (*) were obtained with the control set for normal operation

Also see IMPORTANT note on Time Base A Trigger Diagram.



T801 TRANSFORMER DETAILS

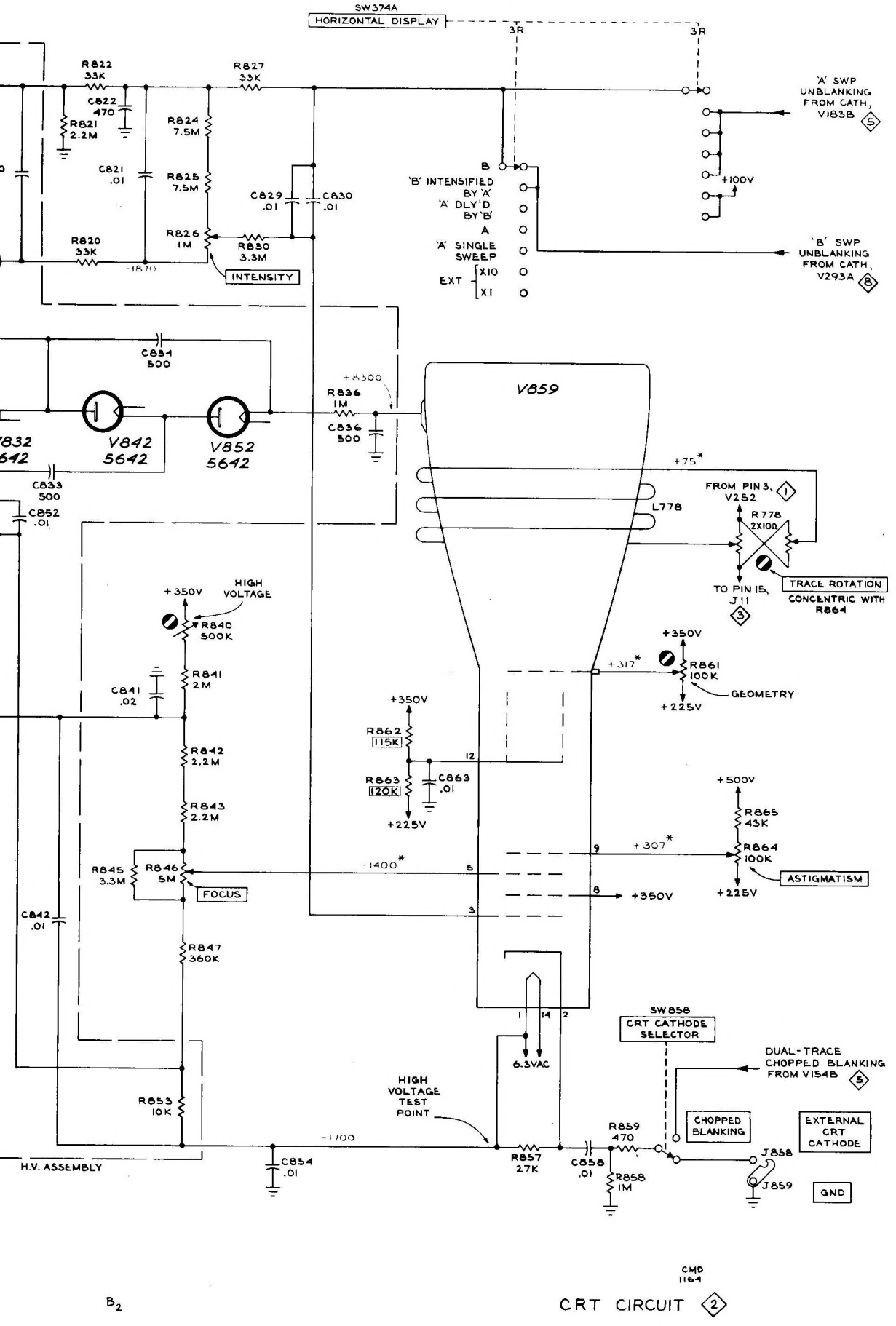
T801 TRANSFORMER DETAILS



REFERENCE DRAWINGS

- (1) POWER SUPPLY & HEATER WIRING DIAG.
- (3) VERTICAL AMPLIFIER
- (5) TIME-BASE A GENERATOR
- (8) TIME-BASE B GENERATOR

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



CMD 1164

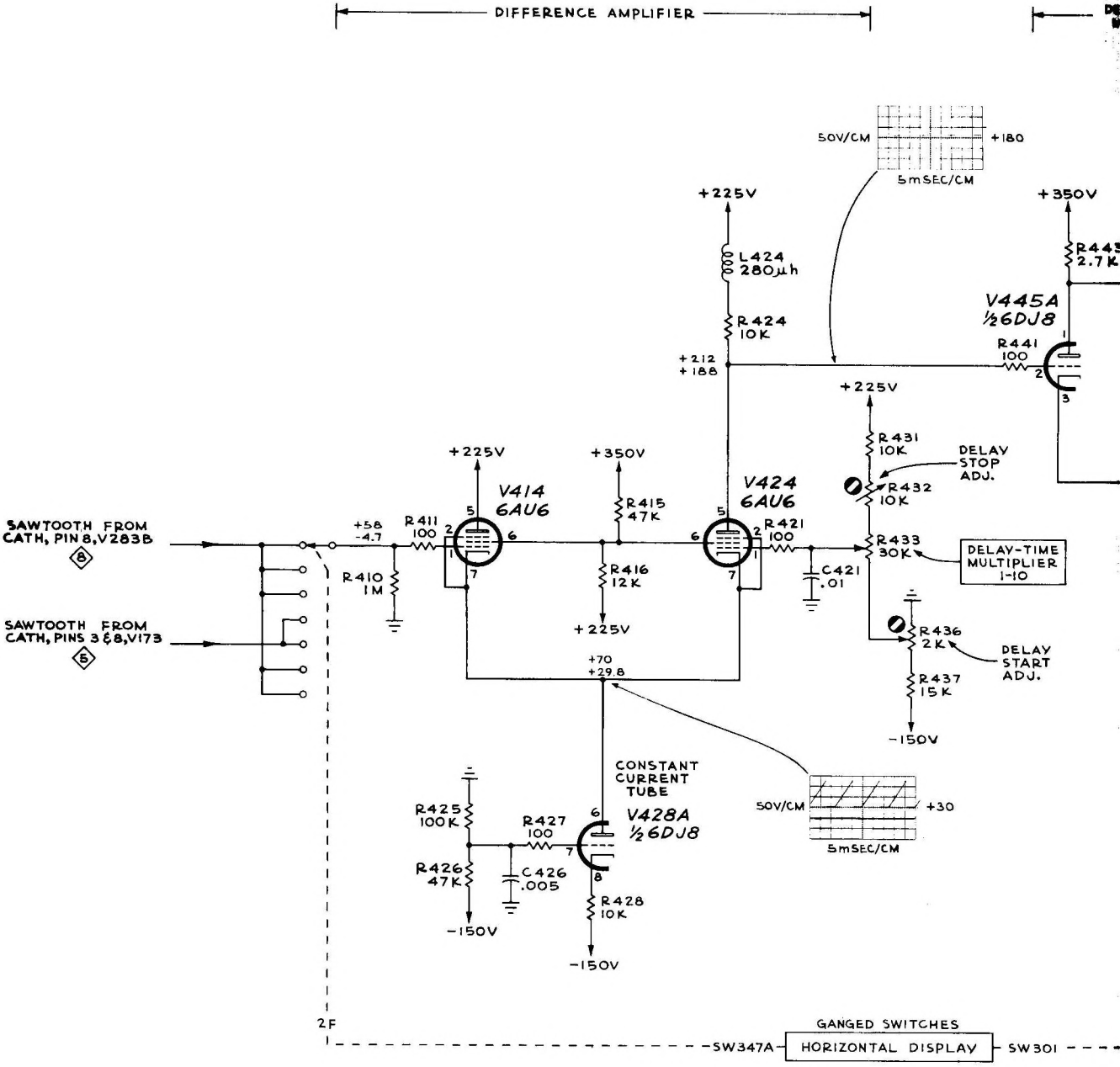
CRT CIRCUIT 2

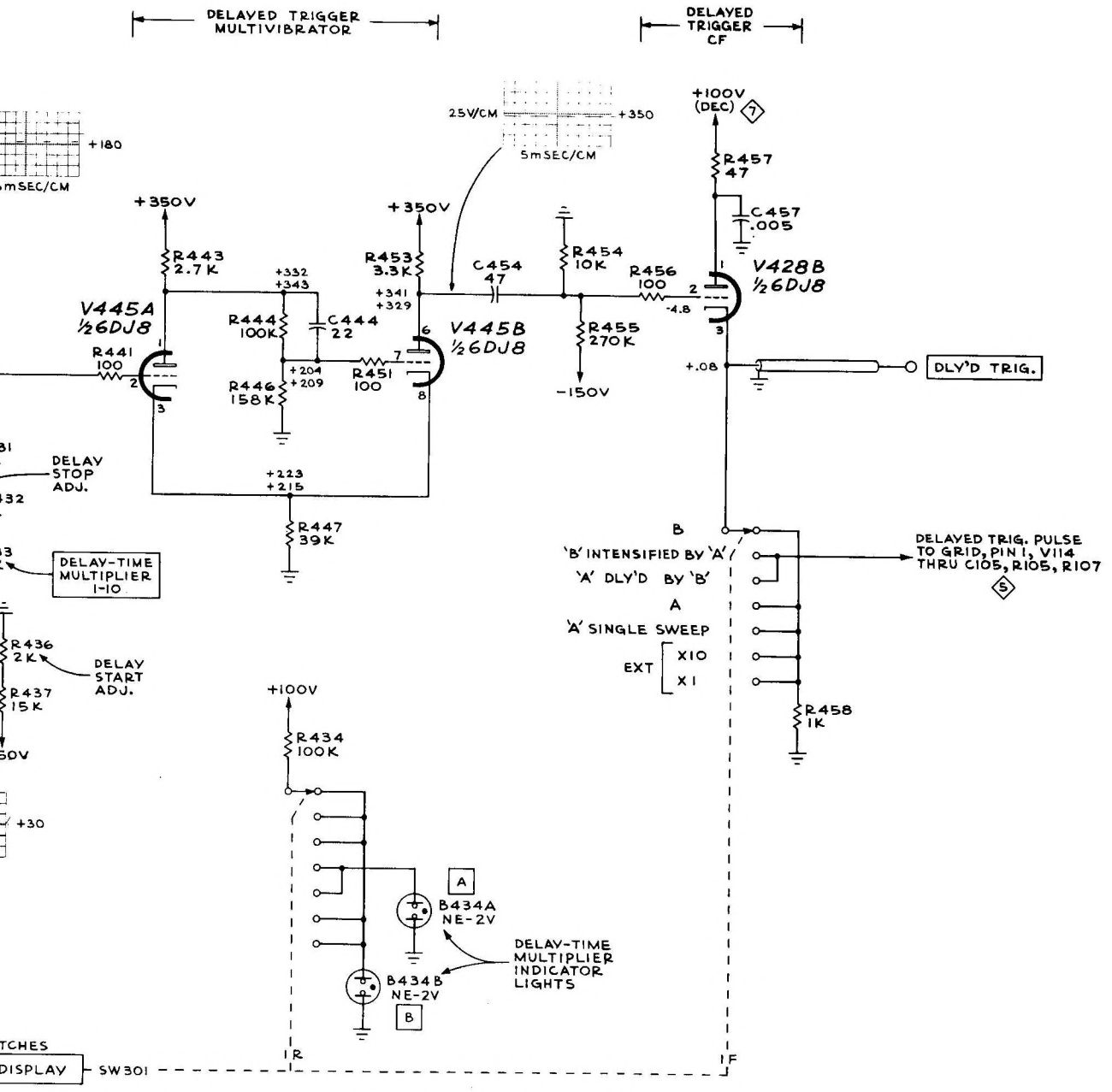
DELAY PICKOFF

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

HORIZONTAL DISPLAY	A
DELAY-TIME MULTIPLIER 1-10	2.0
STABILITY (Time Base A)	
For Waveforms	PRESET
For Upper Voltage Readings	Clockwise
For Lower Voltage Readings	Counterclockwise, but not switched to PRESET

Also see IMPORTANT note on Time Base A Trigger Diagram


DIFFERENCE AMPLIFIER
50V/CM
+180
5mSEC/CM
+225V
+350V
L424
280μh
R424
10K
V445A
½6DJ8
R441
100
+212
+188
+225V
R431
10K
DELAY
STOP
ADJ.
R432
10K
+225V
+350V
V414
6AU6
V424
6AU6
SAWTOOTH FROM
CATH, PIN 8, V283B
8
SAWTOOTH FROM
CATH, PINS 3 & 8, V173
5
+58
-4.7
R411
100
R410
1M
R415
47K
R416
12K
R421
100
C421
.01
R433
30K
DELAY-TIME
MULTIPLIER
1-10
R436
2K
DELAY
START
ADJ.
R437
15K
-150V
+225V
+70
+29.8
CONSTANT
CURRENT
TUBE
V428A
½6DJ8
R425
100K
R427
100
R426
47K
C426
.005
R428
10K
-150V
-150V
50V/CM
+30
5mSEC/CM
2F
GANGED SWITCHES
SW347A
HORIZONTAL DISPLAY
SW301



REFERENCE DRAWINGS

- 5 TIME-BASE A GENERATOR
- 7 TIME-BASE B TRIGGER
- 8 TIME-BASE B GENERATOR

GAB 764

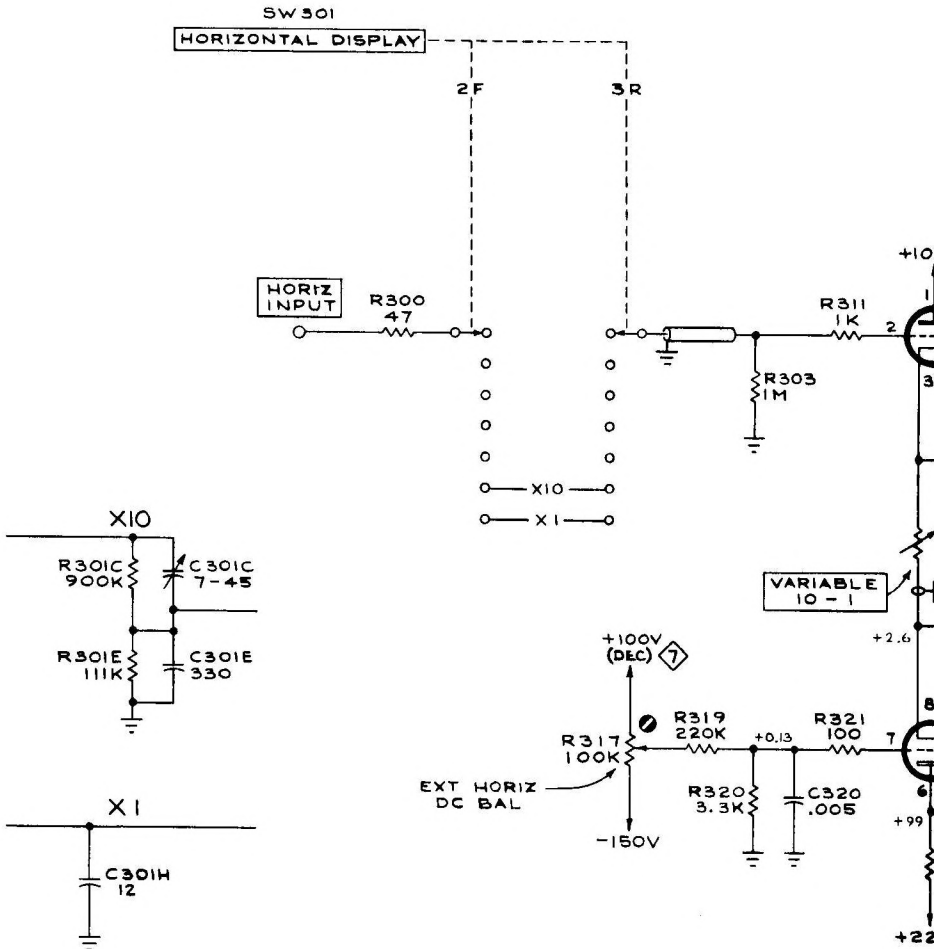
DELAY PICKOFF 10

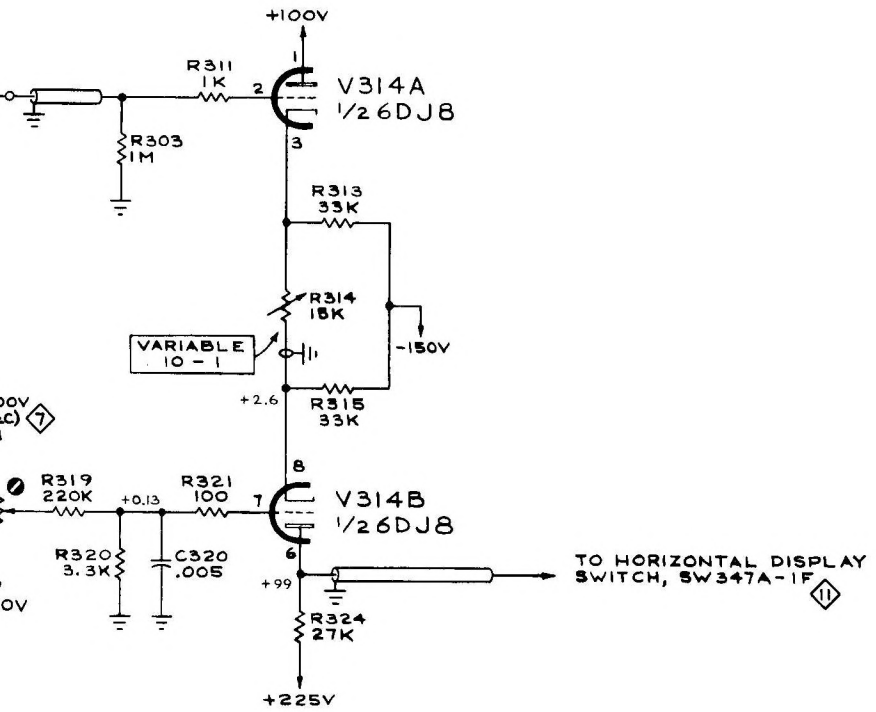
EXTERNAL HORIZONTAL AMPLIFIER

VOLTAGE READINGS were obtained under the following conditions:

External Horizontal Input Signal .... None
HORIZONTAL DISPLAY ..... EXT X10
VARIABLE 10-1 ..... Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram


SW 301
HORIZONTAL DISPLAY
2F
3R
HORIZ INPUT
R300 47
R311 1K
R303 1M
X10
X1
VARIABLE 10 - 1
+100V (DEC)
R319 220K
R317 100K
R321 100
EXT HORIZ DC BAL
R320 3.3K
C320 .005
-150V
+2.6
+99
+22
X10
R301C 900K
C301C 7-45
R301E 111K
C301E 330
X1
C301H 12



REFERENCE DRAWINGS

7 TIME-BASE B TRIGGER

11 HORIZONTAL AMPLIFIER

MRH
464

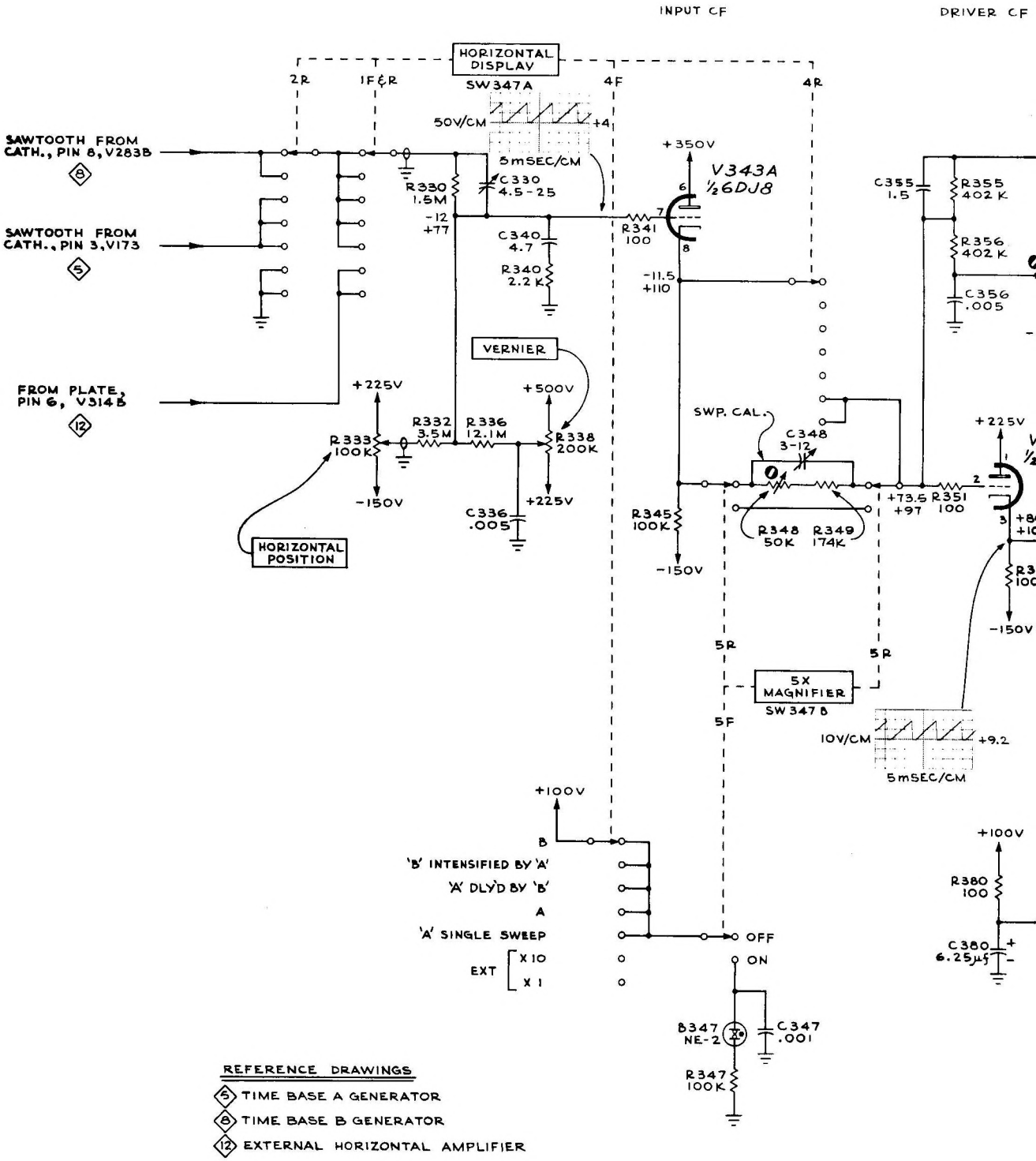
EXTERNAL HORIZONTAL AMPLIFIER 12

HORIZONTAL AMPLIFIER

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

HORIZONTAL DISPLAY	A
STABILITY (Time Base A)	
For Waveforms	Clockwise
For Voltage Readings	PRESET
HORIZONTAL POSITION	
For Upper Voltage Readings	Counterclockwise
For Lower Voltage Readings	Clockwise

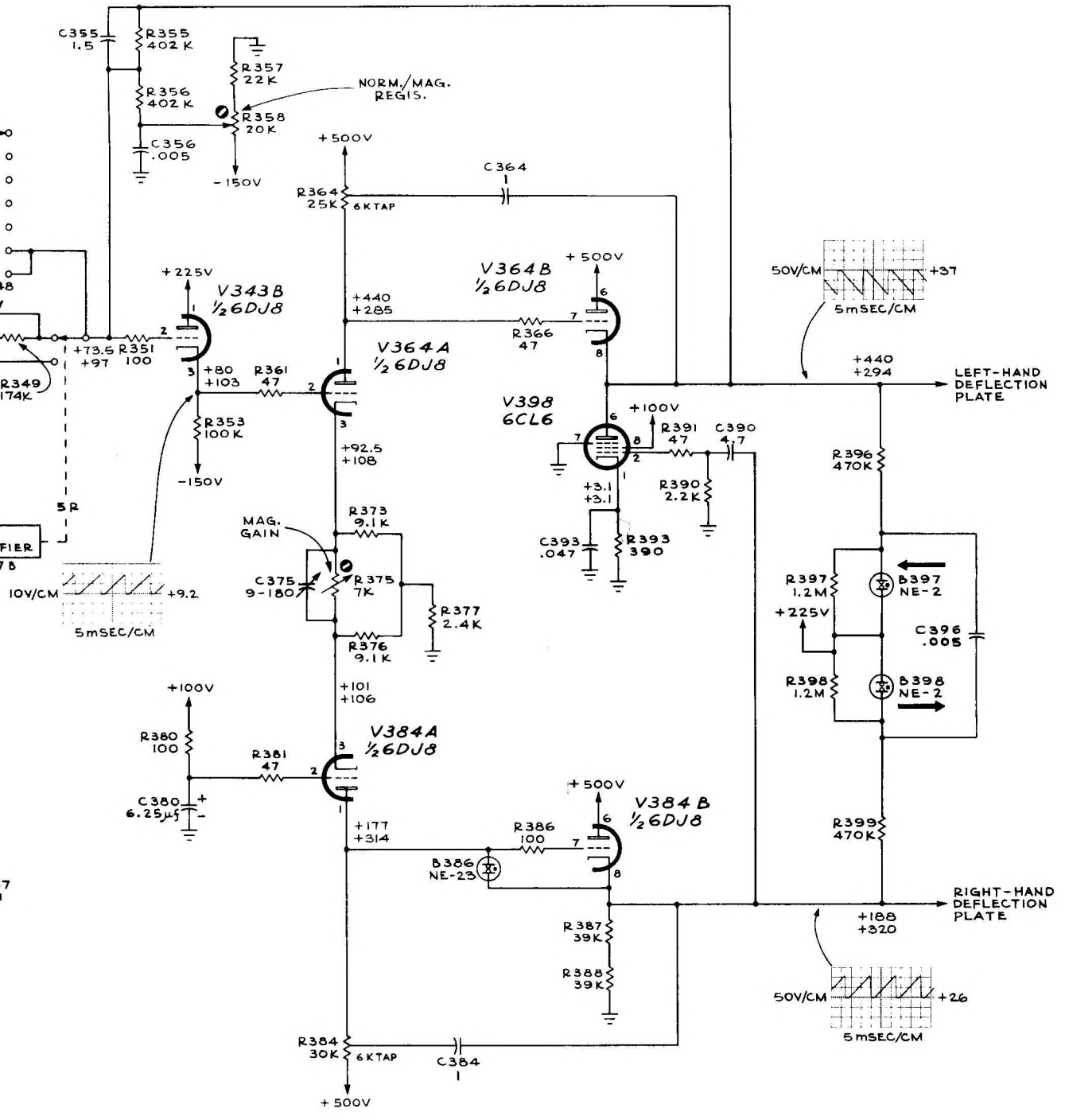
Also see IMPORTANT note on Time Base A Trigger Diagram


INPUT CF
DRIVER CF
HORIZONTAL DISPLAY
SW347A
2R
1F&R
4F
4R
5R
5F
SAWTOOTH FROM CATH., PIN 8, V283B
8
SAWTOOTH FROM CATH., PIN 3, V173
5
FROM PLATE, PIN 6, V314B
12
50V/CM
+4
5mSEC/CM
R330 1.5M
C330 4.5-25
-12
+77
C340 4.7
R340 2.2K
+350V
V343A ½6DJ8
R341 100
-11.5
+110
C355 1.5
R355 402K
R356 402K
C356 .005
VERNIER
+225V
+500V
R333 100K
R332 3.5M
R336 12.1M
R338 200K
-150V
C336 .005
+225V
HORIZONTAL POSITION
SWP. CAL.
C348 3-12
R345 100K
R348 50K
R349 174K
+73.5
+97
R351 100
+225V
-150V
5X MAGNIFIER
SW347B
10V/CM
+9.2
5mSEC/CM
+100V
B
'B' INTENSIFIED BY 'A'
'A' DLY'D BY 'B'
A
'A' SINGLE SWEEP
EXT
X10
X1
OFF
ON
B347 NE-2
C347 .001
R347 100K
+100V
R380 100
C380 6.25μs
REFERENCE DRAWINGS
5 TIME BASE A GENERATOR
8 TIME BASE B GENERATOR
12 EXTERNAL HORIZONTAL AMPLIFIER

DRIVER CF

OUTPUT AMPLIFIER

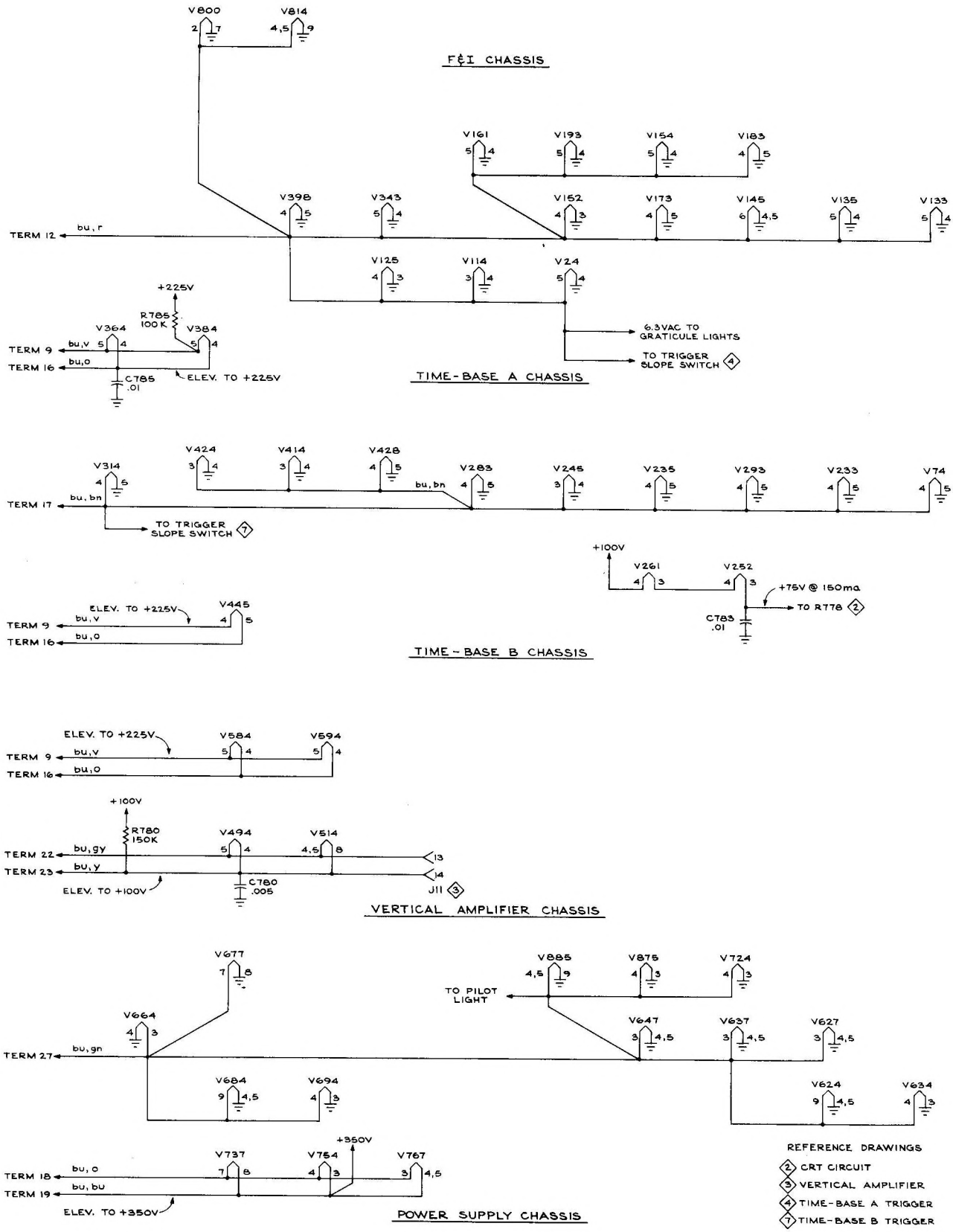
OUTPUT CFs & HF CAPACITANCE DRIVER



G.A.B. 464

A

HORIZONTAL AMPLIFIER ⟨11⟩

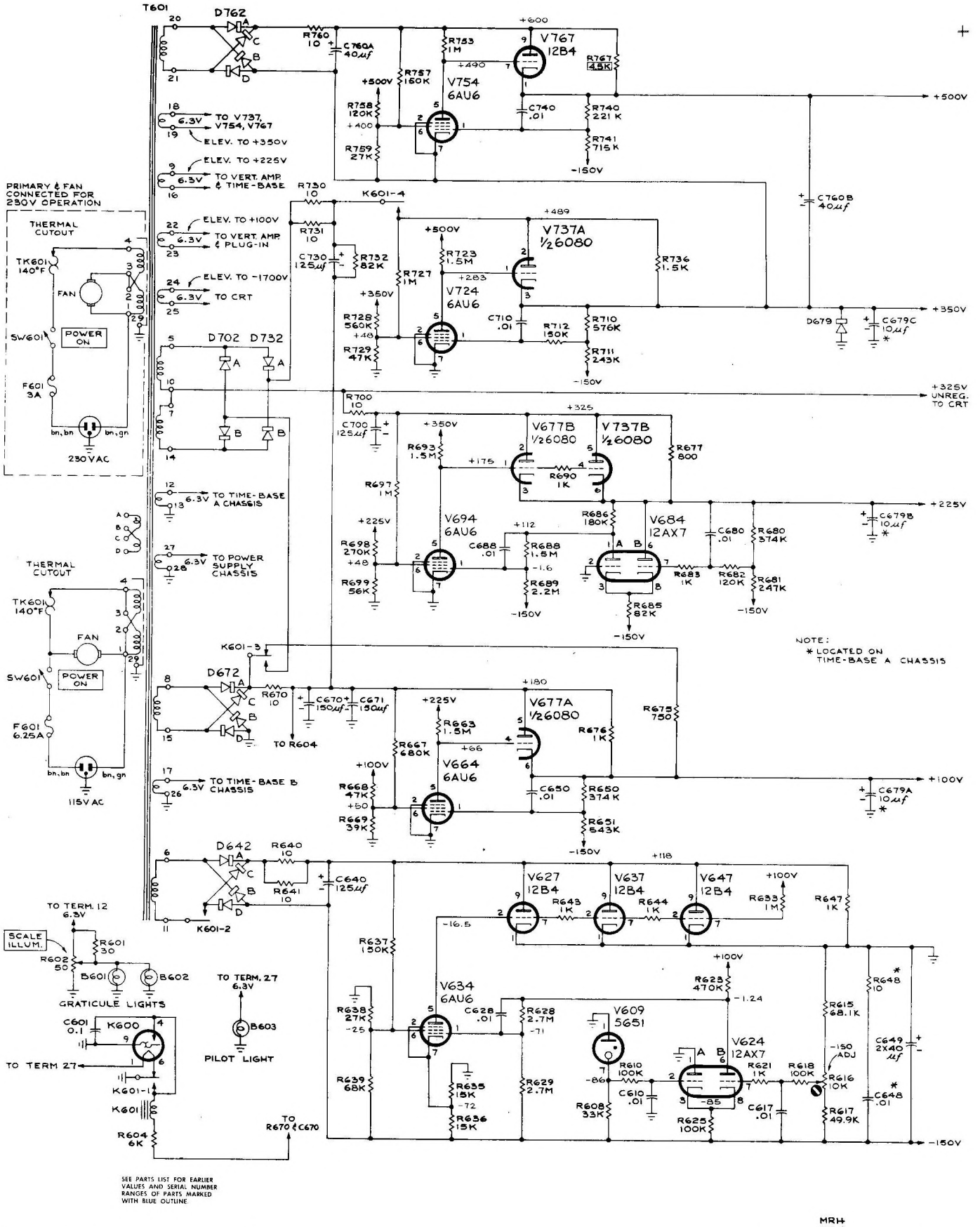


TYPE 545B OSCILLOSCOPE

DON

HEATER WIRING DIAGRAM

B



MRH
964

POWER SUPPLY ◇1

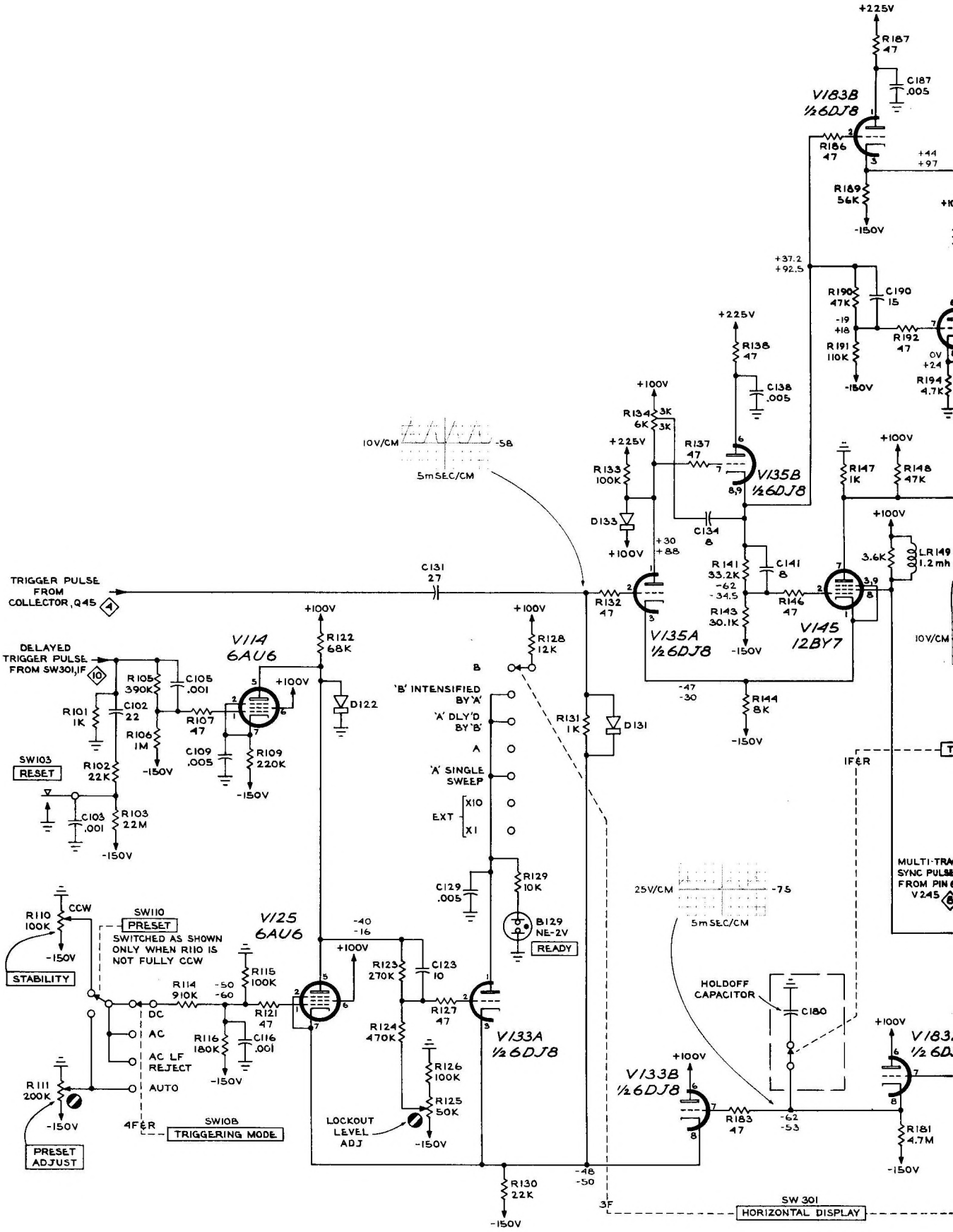
TIME BASE A GENERATOR

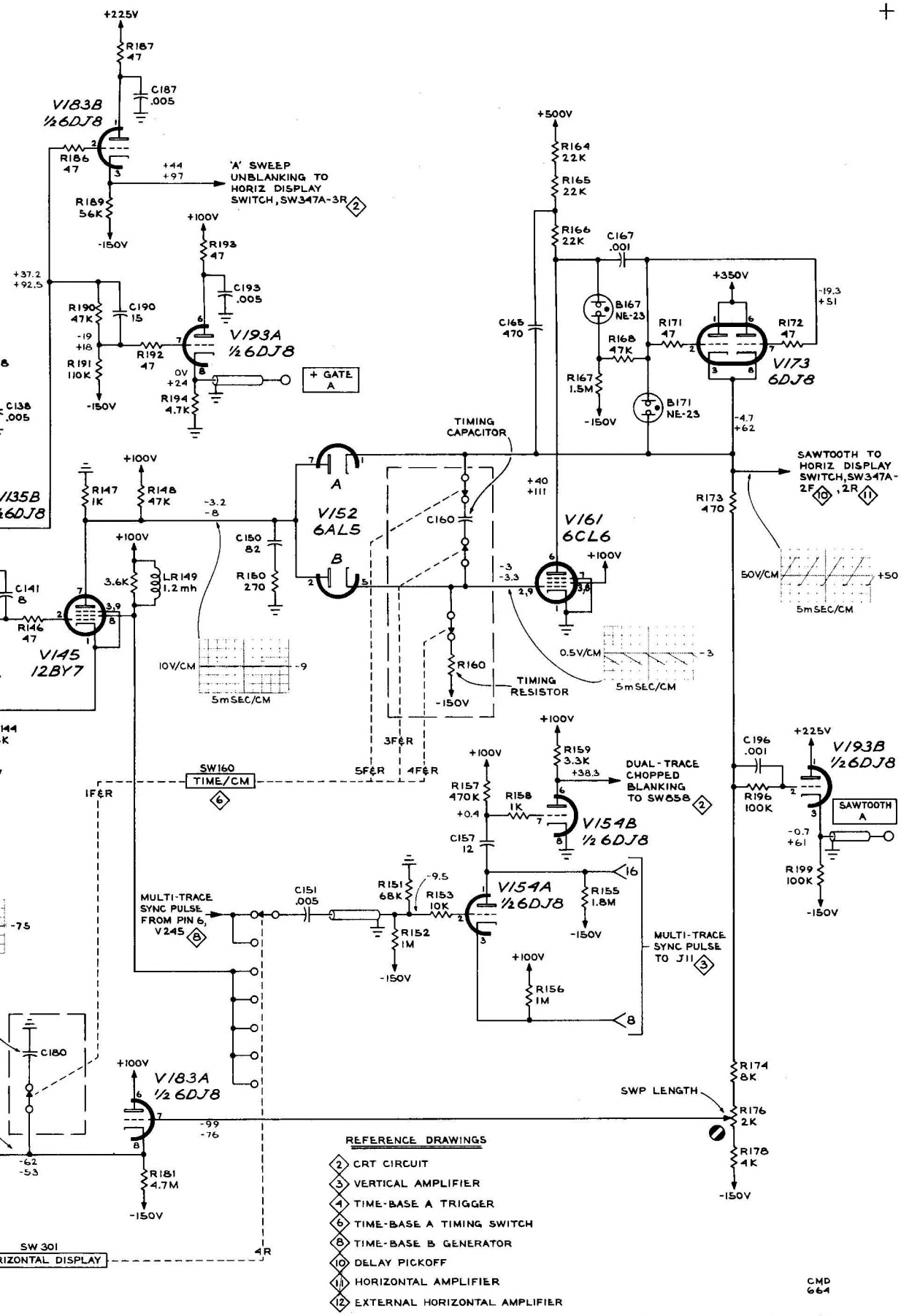
WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

STABILITY

For Waveforms	Clockwise
For Upper Voltage Readings	Counterclockwise, but not switched to PRESET
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram


+225V
R187 47
C187 .005
V183B ½6DJ8
R186 47
R189 56K
-150V
+37.2 +92.5
R190 47K
C190 15
R192 47
R191 110K
R194 4.7K
+225V
R138 47
C138 .005
+100V
R134 3K 6K 3K
R133 100K
D133
+225V
R137 47
V135B ½6DJ8
C134 8
+30 +88
+100V
R147 1K
R148 47K
LR149 1.2mh
3.6K
R141 33.2K -62 -34.5
C141 8
R143 30.1K
R146 47
V145 12BY7
R144 8K
-47 -30
10V/CM
-58
5mSEC/CM
TRIGGER PULSE FROM COLLECTOR, Q45 4
C131 27
R132 47
V135A ½6DJ8
DELAYED TRIGGER PULSE FROM SW301, 1F 10
V114 6AU6
R105 390K
C105 .001
R101 1K
C102 22
R107 47
R106 1M
C109 .005
R109 220K
R102 22K
SW103 RESET
C103 .001
R103 22M
-150V
R122 68K
D122
R128 12K
D131
R131 1K
B
'B' INTENSIFIED BY 'A'
'A' DLY'D BY 'B'
A
'A' SINGLE SWEEP
EXT X10 X1
R129 10K
C129 .005
B129 NE-2V
READY
IF&R
MULTI-TRA SYNC PULSE FROM PIN V245 6
25V/CM
-75
5mSEC/CM
HOLDOFF CAPACITOR
C180
R110 100K CCW
SW110 PRESET
SWITCHED AS SHOWN ONLY WHEN R110 IS NOT FULLY CCW
STABILITY
V125 6AU6
-40 -16
R115 100K
R114 910K -50 -60
R121 47
DC
AC
AC LF REJECT
AUTO
R116 180K
C116 .001
R111 200K
PRESET ADJUST
4F&R
SW10B TRIGGERING MODE
R123 270K
C123 10
R127 47
R124 470K
V133A ½6DJ8
R126 100K
R125 50K
LOCKOUT LEVEL ADJ
V133B ½6DJ8
R183 47
-62 -53
R181 4.7M
R130 22K
-48 -50
3F
SW 301 HORIZONTAL DISPLAY

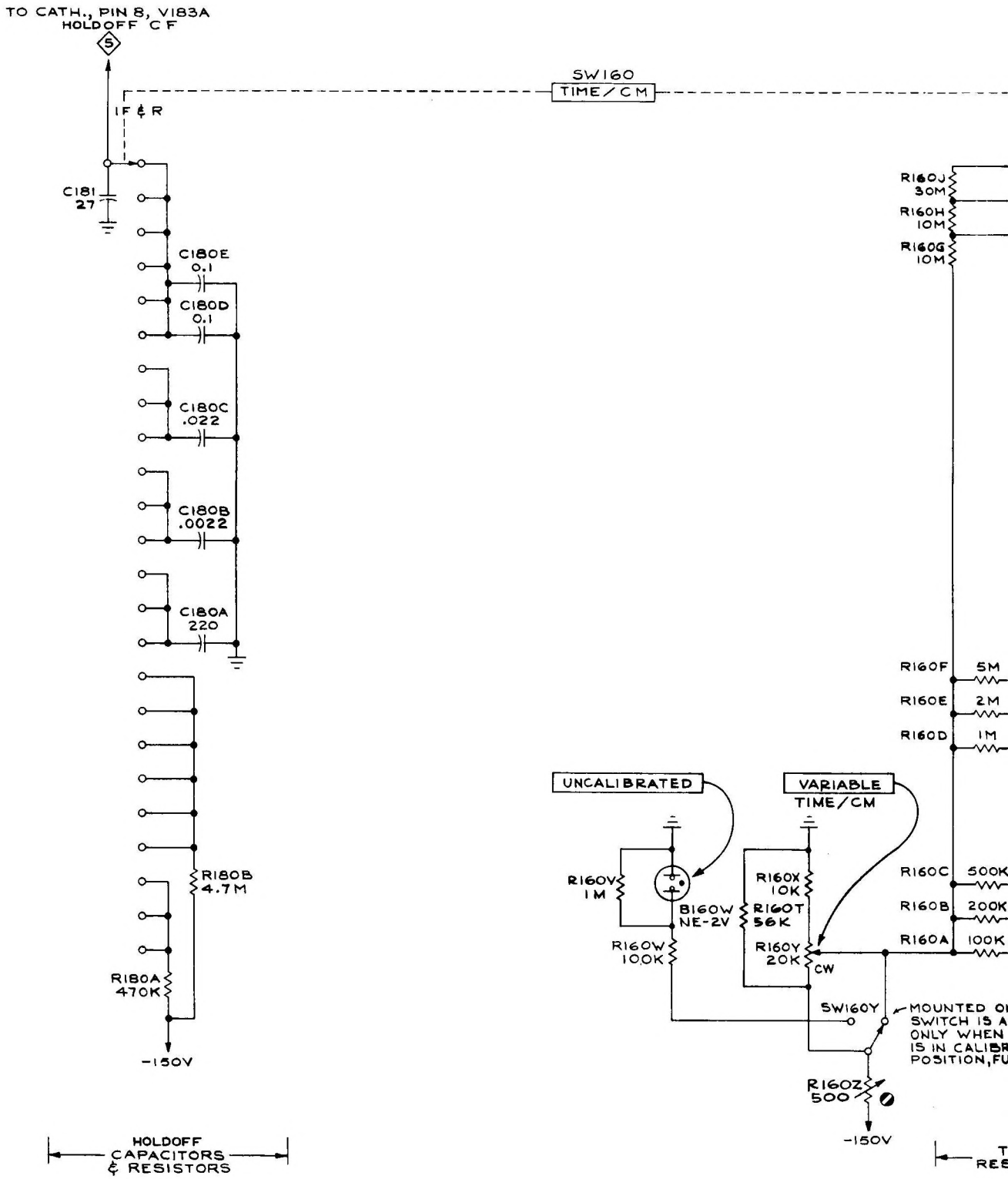


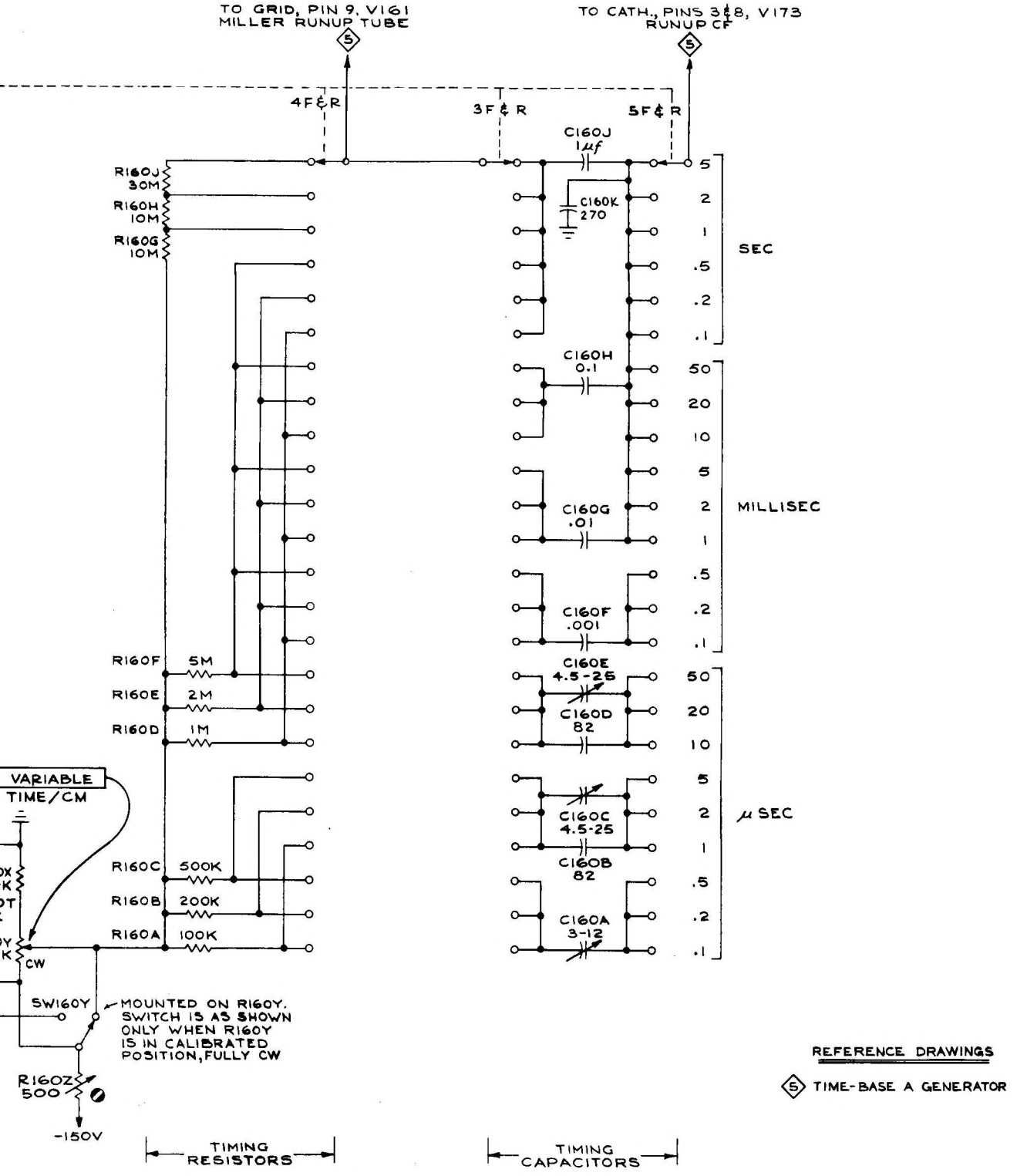
REFERENCE DRAWINGS

- 2 CRT CIRCUIT
- 3 VERTICAL AMPLIFIER
- 4 TIME-BASE A TRIGGER
- 6 TIME-BASE A TIMING SWITCH
- 8 TIME-BASE B GENERATOR
- 10 DELAY PICKOFF
- 11 HORIZONTAL AMPLIFIER
- 12 EXTERNAL HORIZONTAL AMPLIFIER

CMD 664

TIME-BASE A GENERATOR 5


TO CATH., PIN 8, V183A
HOLDOFF C F
5
IF & R
SW160
TIME/CM
C181
27
C180E
0.1
C180D
0.1
C180C
.022
C180B
.0022
C180A
220
R180B
4.7M
R180A
470K
-150V
HOLDOFF
CAPACITORS
& RESISTORS
R160J
30M
R160H
10M
R160G
10M
R160F
5M
R160E
2M
R160D
1M
UNCALIBRATED
VARIABLE
TIME/CM
R160V
1M
B160W
NE-2V
R160W
100K
R160X
10K
R160T
56K
R160Y
20K
CW
R160C
500K
R160B
200K
R160A
100K
SW160Y
MOUNTED O
SWITCH IS A
ONLY WHEN
IS IN CALIBR
POSITION, FU
R160Z
500
-150V
T
REE



REFERENCE DRAWINGS

5 TIME-BASE A GENERATOR

MRH
464

A

TIME-BASE A TIMING SWITCH 6

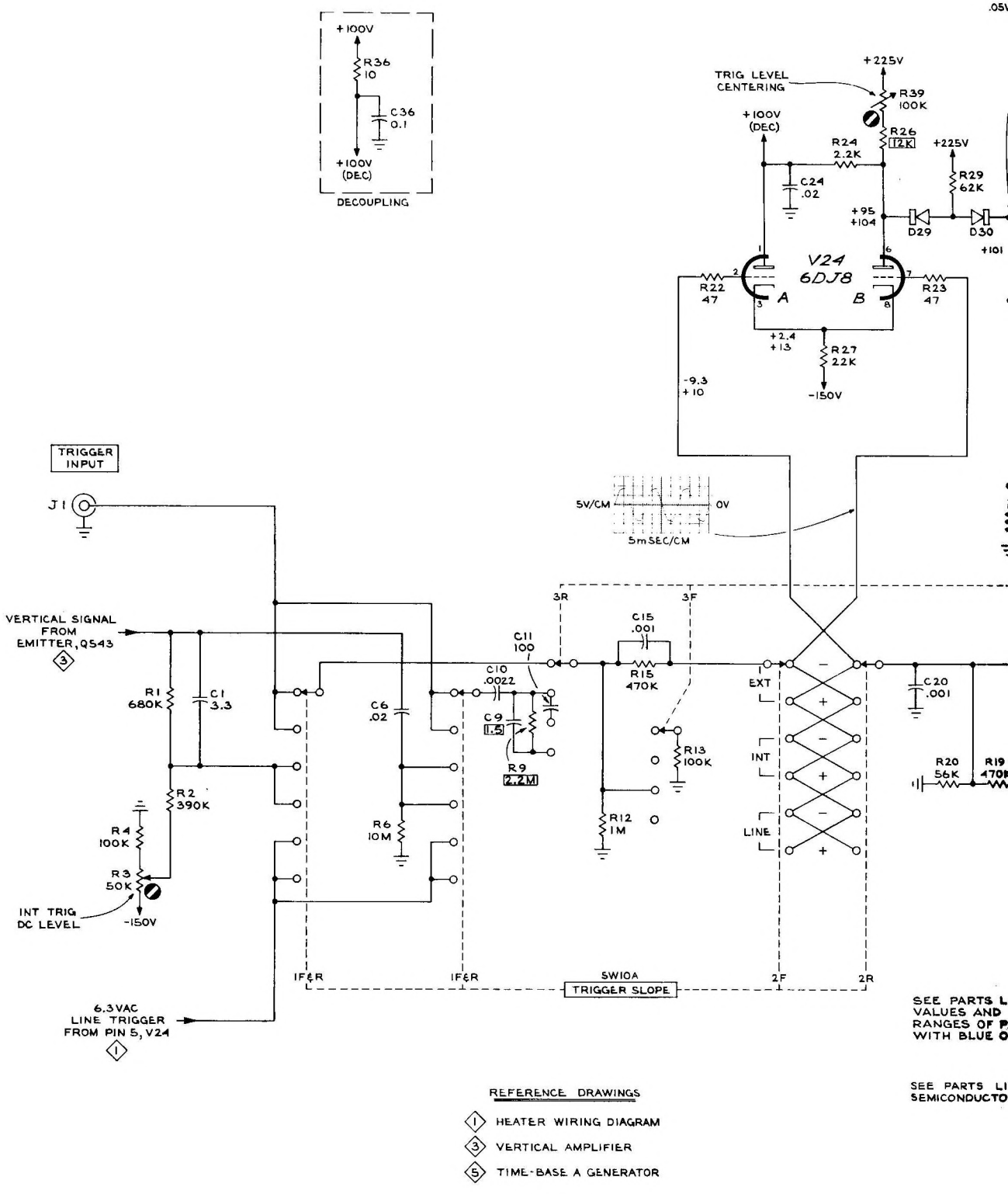
TIME BASE A TRIGGER

IMPORTANT
Waveforms closely approximate those found in this instrument, provided controls are set as indicated below and on each diagram.
Voltage readings were taken with a 20,000 ohms/volt voltmeter.
Before starting to check this instrument the following controls should be set, and not disturbed unless otherwise noted on the diagram being used. Return controls to the positions listed below before moving to the next diagram.

	AMPLITUDE CALIBRATOR	OFF
	HORIZONTAL DISPLAY	A
	5X MAGNIFIER	OFF
	VARIABLE (A TIME/CM)	Clockwise
	LENGTH	Clockwise
Both Time Bases	TIME/CM	1mSEC
	TRIGGERING MODE	DC
	TRIGGER SLOPE	+EXT
	TRIGGERING LEVEL	Clockwise
	STABILITY	PRESET

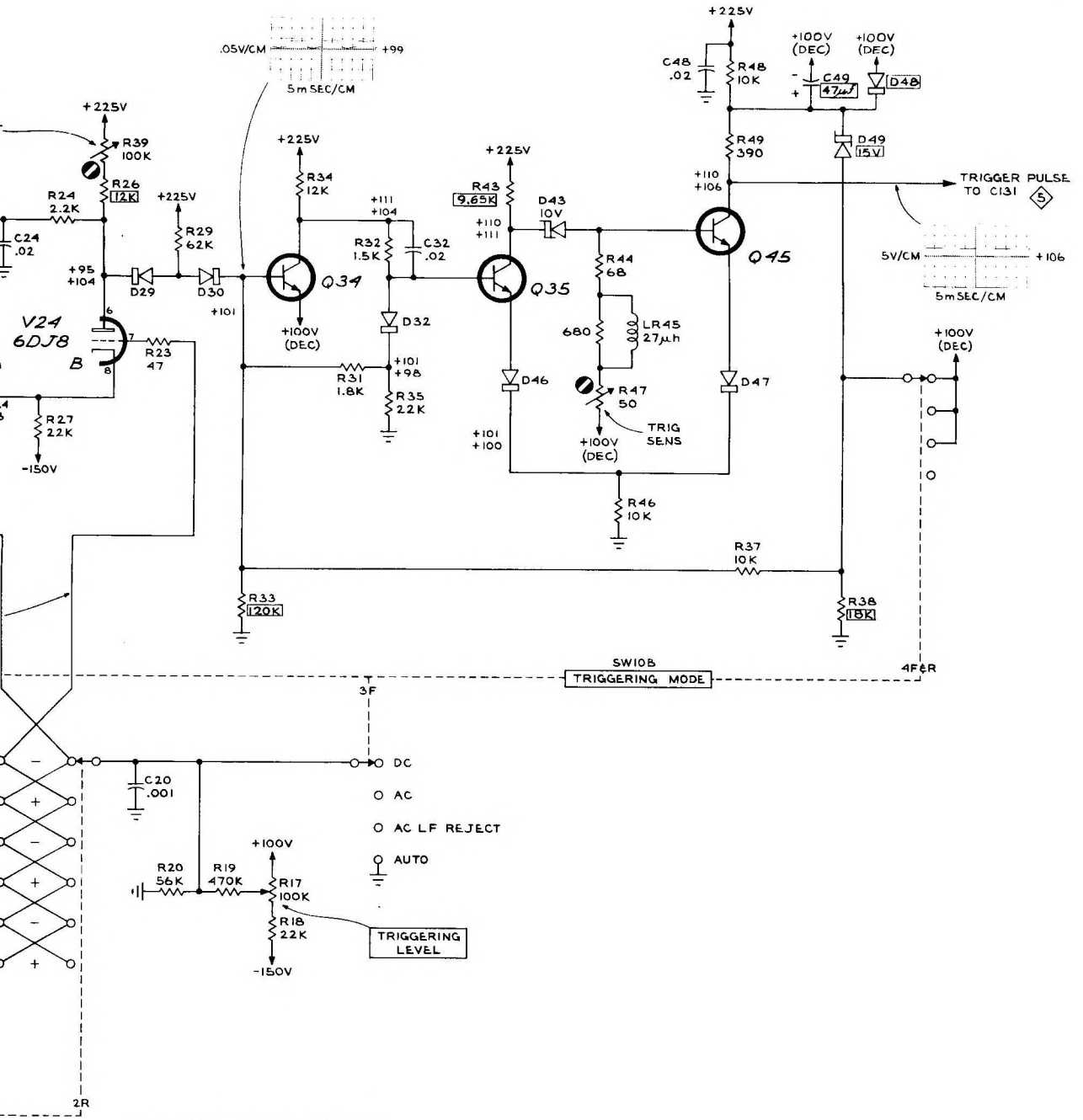
WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

TRIGGER SLOPE	—LINE
TRIGGERING LEVEL	
For Waveforms	Centered
For Upper Voltage Reading	Counterclockwise
For Lower Voltage Reading	Clockwise



REFERENCE DRAWINGS

1. HEATER WIRING DIAGRAM
3. VERTICAL AMPLIFIER
5. TIME-BASE A GENERATOR



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

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

CMD 565

E

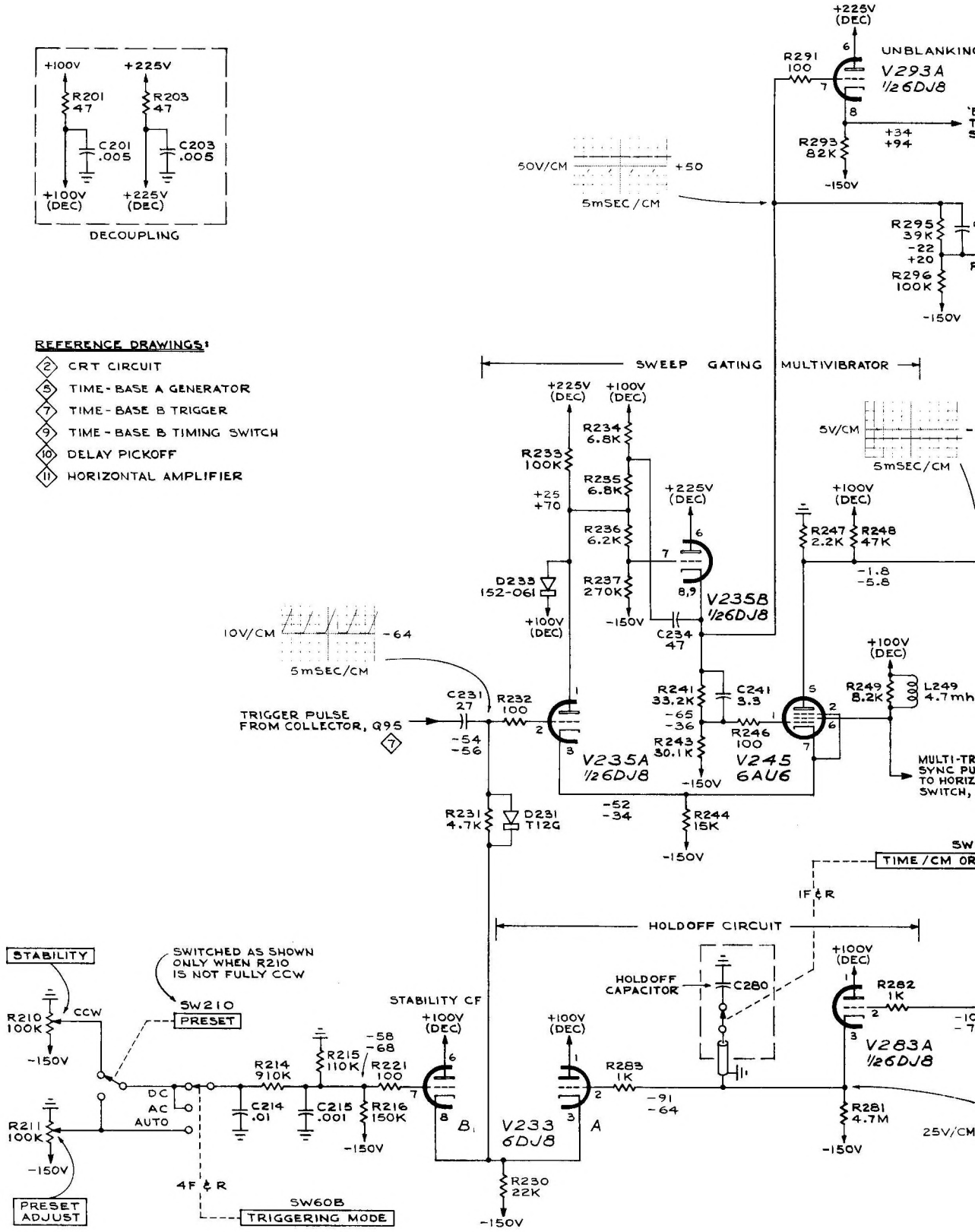
TIME-BASE A TRIGGER ◇4

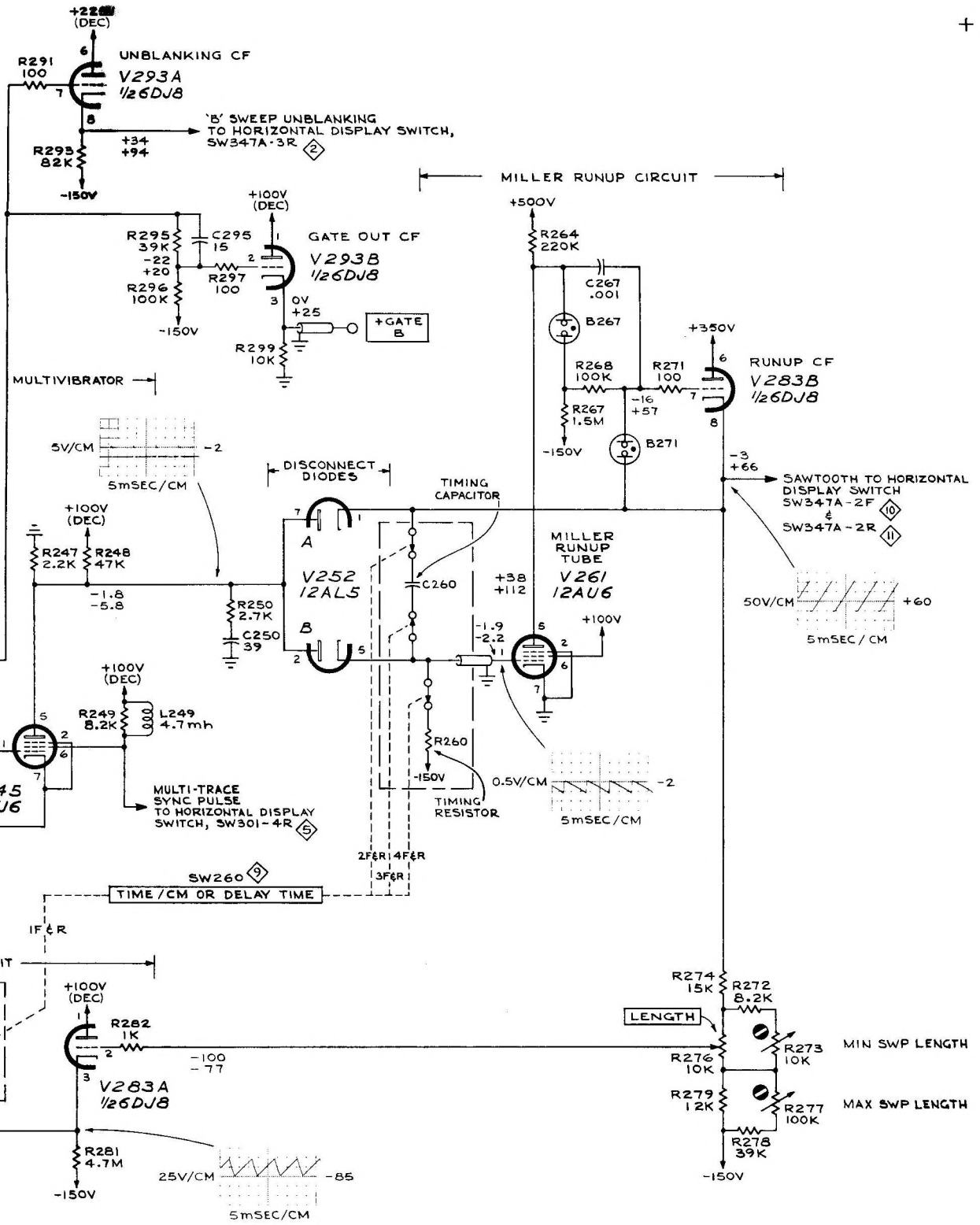
TIME BASE B GENERATOR

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

LENGTH	Clockwise
STABILITY	
For Waveforms	Clockwise
For Upper Voltage Readings	Counterclockwise, but not switched to PRESET
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram

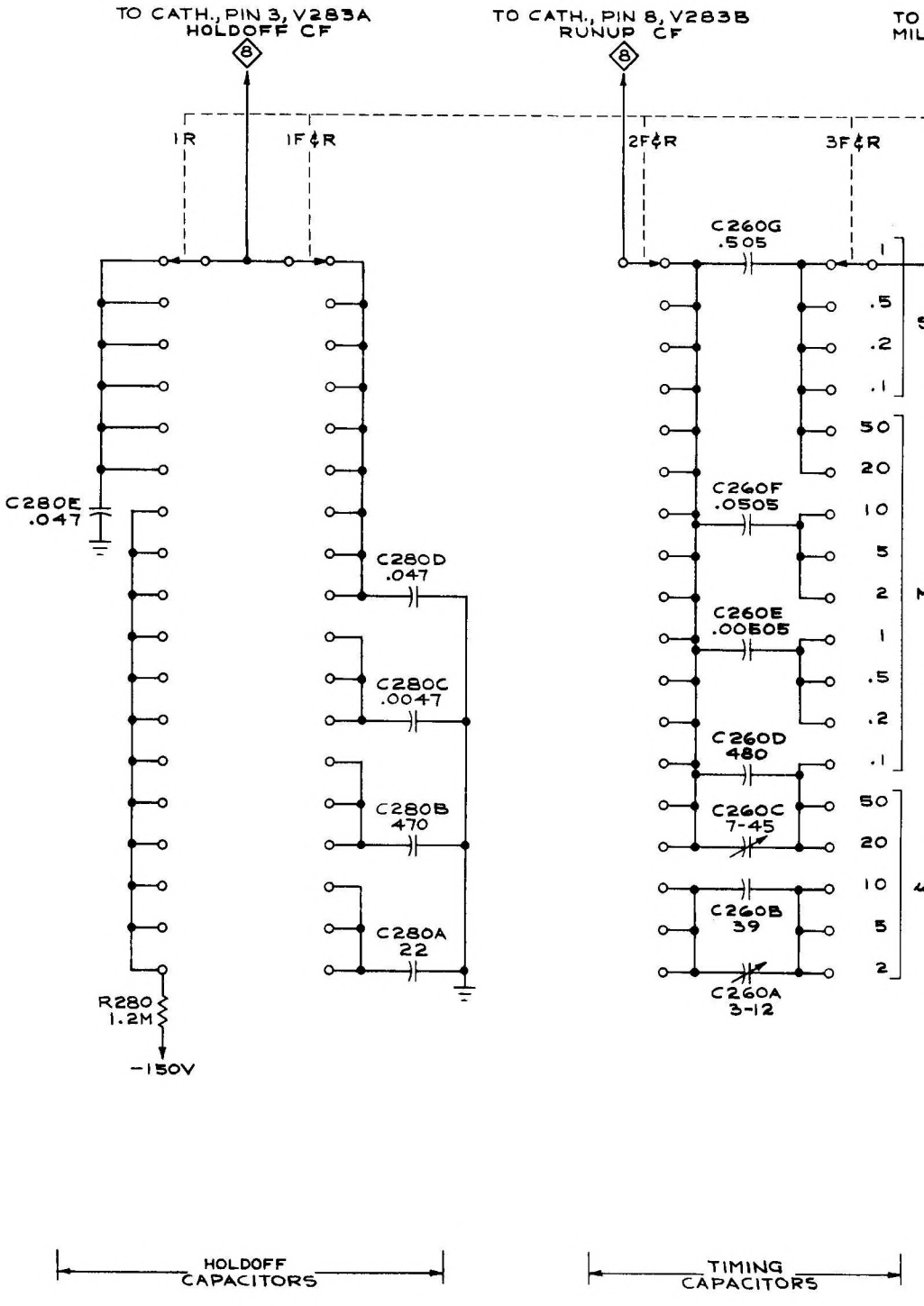

+100V
+225V
R201 47
R203 47
C201 .005
C203 .005
+100V (DEC)
+225V (DEC)
DECOUPLING
REFERENCE DRAWINGS:
2 CRT CIRCUIT
5 TIME-BASE A GENERATOR
7 TIME-BASE B TRIGGER
9 TIME-BASE B TIMING SWITCH
10 DELAY PICKOFF
11 HORIZONTAL AMPLIFIER
+225V (DEC)
R291 100
V293A 1/2 6DJ8
UNBLANKING
R293 82K
+34
+94
-150V
50V/CM
+50
5mSEC/CM
R295 39K
-22
+20
R296 100K
-150V
SWEEP GATING MULTIVIBRATOR
+225V (DEC)
+100V (DEC)
R234 6.8K
R233 100K
R235 6.8K
+25
+70
R236 6.2K
R237 270K
D233 152-061
+100V (DEC)
-150V
C234 47
V235B 1/2 6DJ8
5V/CM
5mSEC/CM
R247 2.2K
R248 47K
-1.8
-5.8
10V/CM
-64
5mSEC/CM
TRIGGER PULSE FROM COLLECTOR, Q95
7
C231 27
R232 100
-54
-56
V235A 1/2 6DJ8
R241 33.2K
-65
-36
C241 3.3
R243 30.1K
R246 100
V245 6AU6
R249 8.2K
L249 4.7mh
MULTI-TR
SYNC PU
TO HORIZ
SWITCH,
R231 4.7K
D231 T12G
-52
-34
R244 15K
-150V
SW
TIME/CM OR
IF & R
HOLDOFF CIRCUIT
HOLDOFF CAPACITOR
C280
+100V (DEC)
R282 1K
V283A 1/2 6DJ8
R283 1K
-91
-64
R281 4.7M
-150V
25V/CM
STABILITY
SWITCHED AS SHOWN ONLY WHEN R210 IS NOT FULLY CCW
SW210
PRESET
R210 100K
CCW
-150V
R214 910K
R215 110K
R221 100
-58
-68
C214 .01
C215 .001
R216 150K
-150V
STABILITY CF
+100V (DEC)
V233 6DJ8
B1
A
DC
AC
AUTO
R211 100K
-150V
PRESET ADJUST
4F & R
SW60B
TRIGGERING MODE
R230 22K
-150V

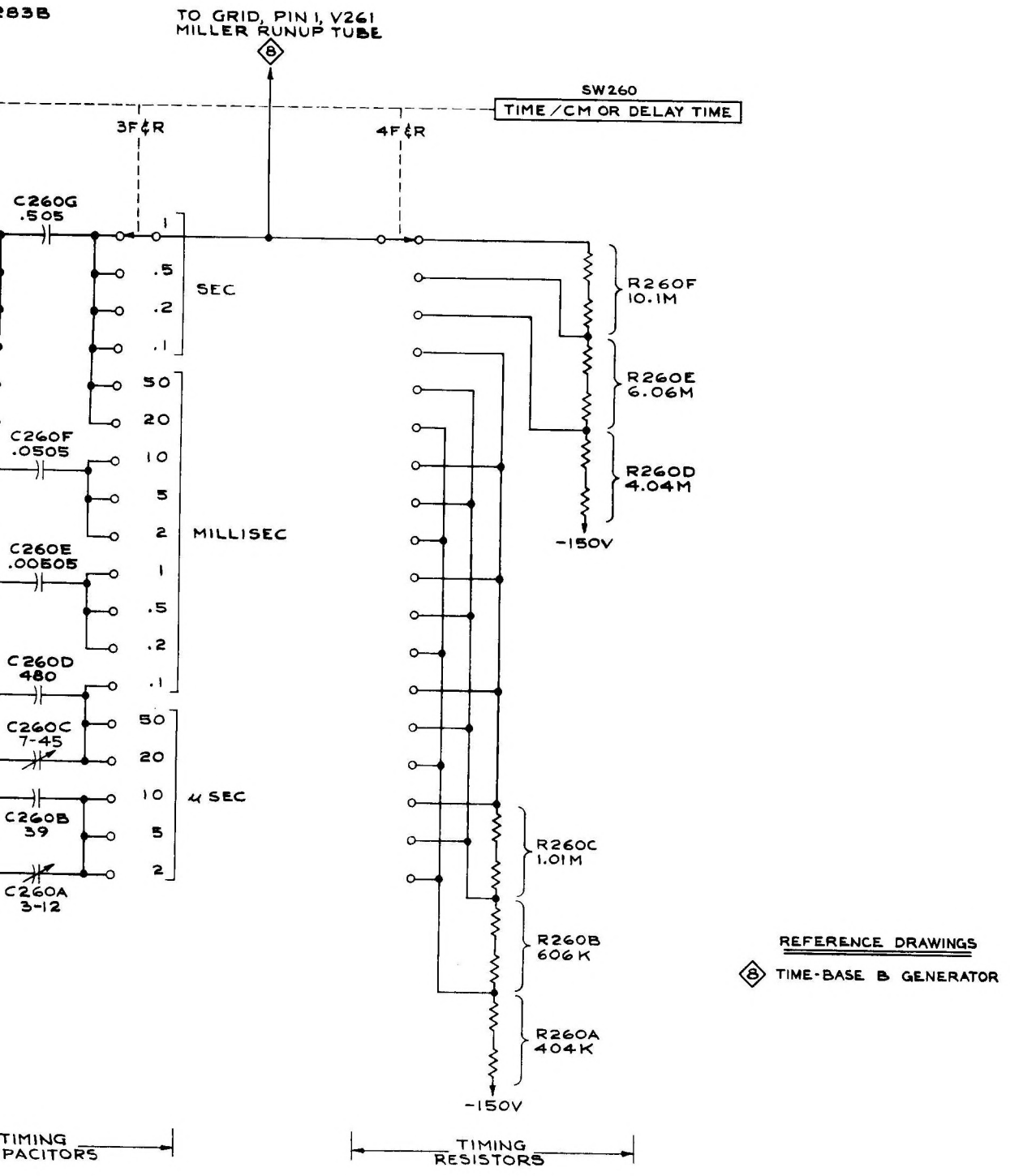


MRH
1264

A2

TIME-BASE B GENERATOR ⑧


TO CATH., PIN 3, V283A
HOLDOFF CF
TO CATH., PIN 8, V283B
RUNUP CF
TO
MIL
8
8
1R
1F↕R
2F↕R
3F↕R
C260G
.505
1
.5
.2
.1
50
20
C260F
.0505
10
5
2
C260E
.00505
1
.5
.2
C260D
480
.1
50
C260C
7-45
20
10
C260B
39
5
2
C260A
3-12
C280E
.047
C280D
.047
C280C
.0047
C280B
470
C280A
22
R280
1.2M
-150V
HOLDOFF
CAPACITORS
TIMING
CAPACITORS



REFERENCE DRAWINGS

8 TIME-BASE B GENERATOR

MRH
464

A

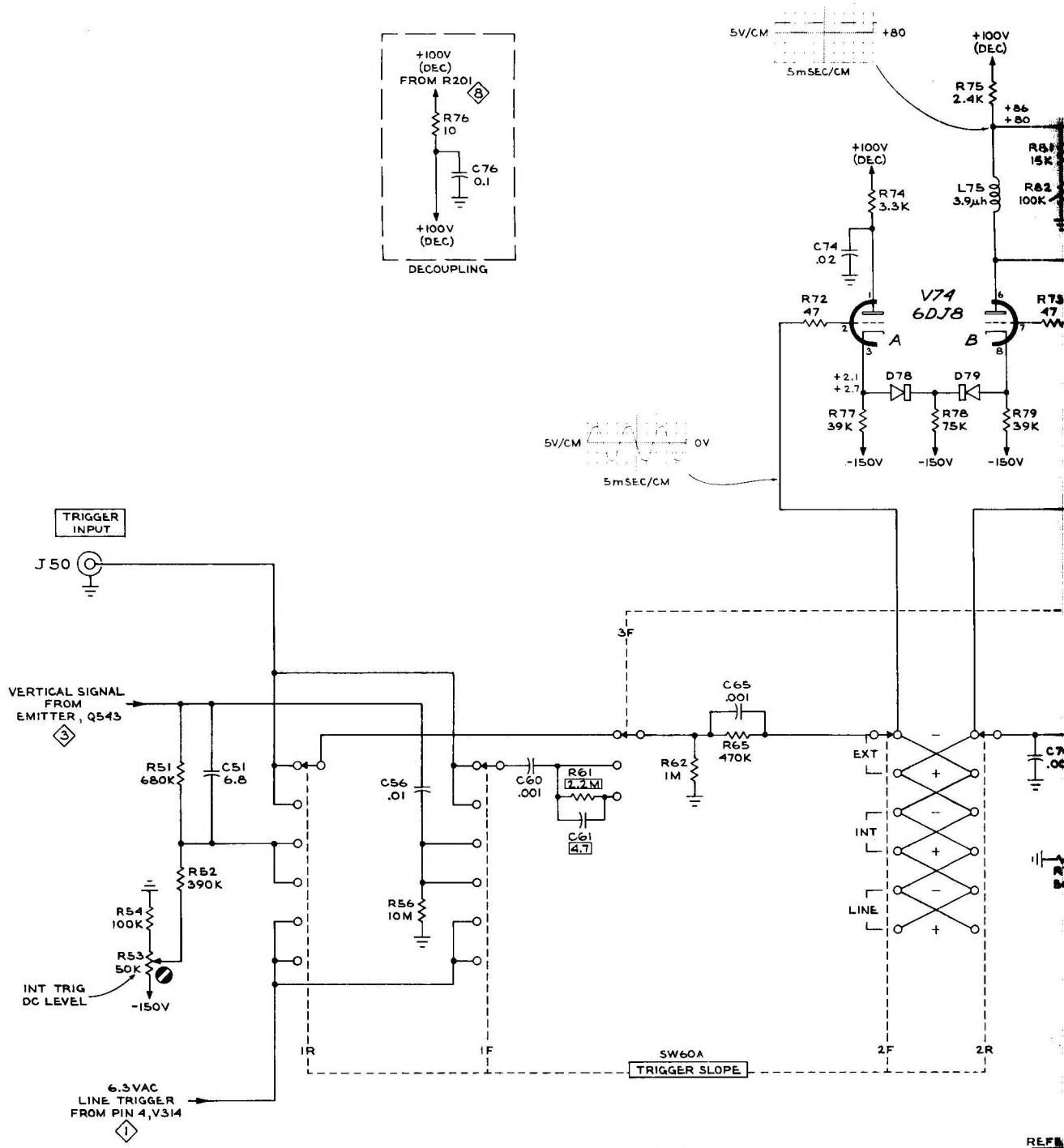
TIME-BASE B TIMING SWITCH 9

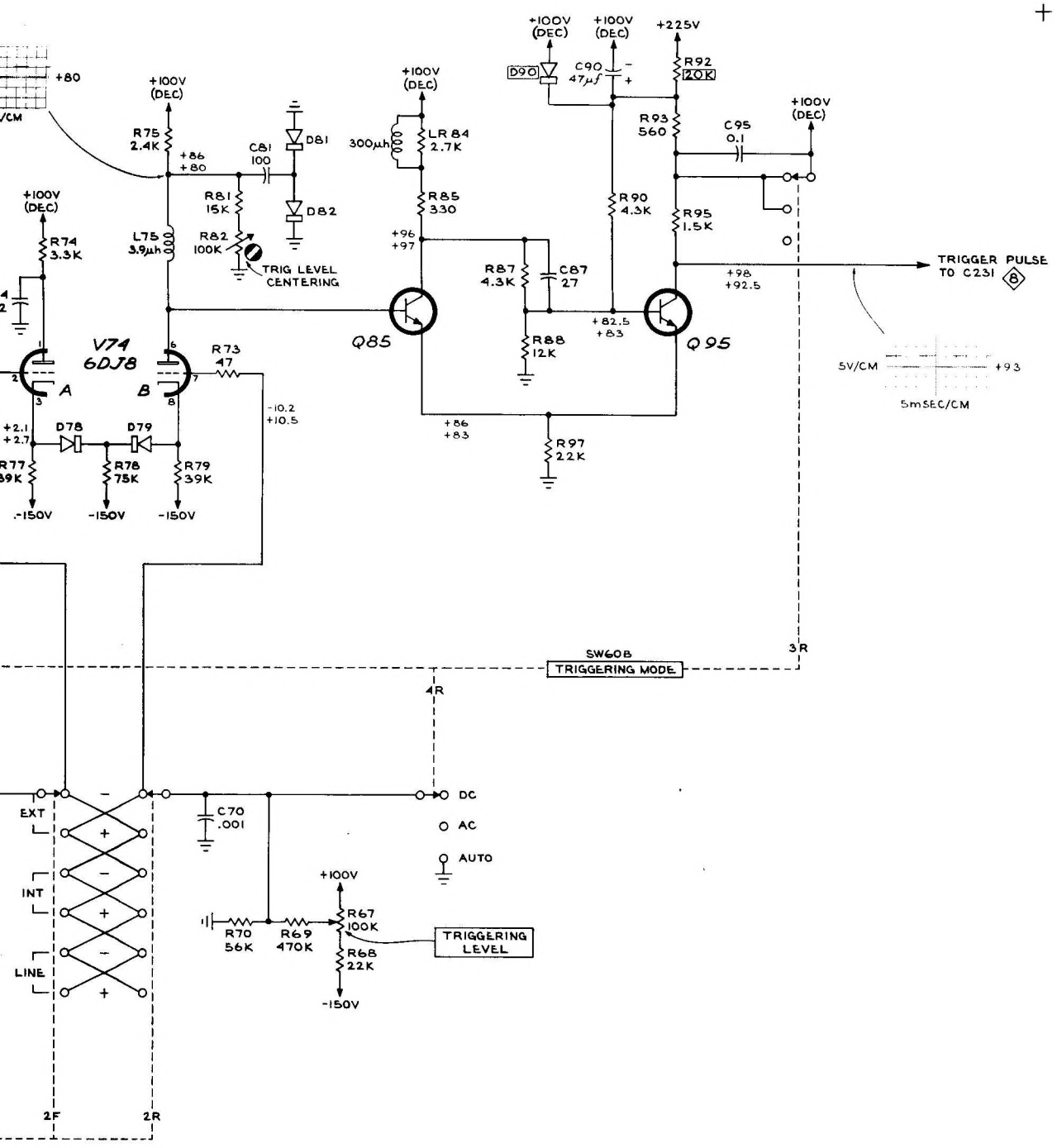
TIME BASE B TRIGGER

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

TRIGGER SLOPE	—LINE
TRIGGERING LEVEL	
For Waveforms	Centered
For Upper Voltage Readings	Counterclockwise
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram


+100V (DEC) FROM R201
8
R76 10
C76 0.1
+100V (DEC)
DECOUPLING
5V/CM
+80
5mSEC/CM
+100V (DEC)
R75 2.4K
+86 +80
+100V (DEC)
R74 3.3K
L75 3.9µh
R82 100K
C74 .02
V74 6DJ8
R72 47
A
B
+2.1 +2.7
D78
D79
R77 39K
R78 75K
R79 39K
-150V
-150V
-150V
5V/CM
0V
5mSEC/CM
TRIGGER INPUT
J50
3F
VERTICAL SIGNAL FROM EMITTER, Q543
3
R51 680K
C51 6.8
C56 .01
C60 .001
R61 2.2M
C61 4.7
C65 .001
R65 470K
R62 1M
EXT
INT
LINE
R52 390K
R54 100K
R53 50K
R56 10M
INT TRIG DC LEVEL
-150V
6.3VAC LINE TRIGGER FROM PIN 4, V314
1
1R
1F
SW60A
TRIGGER SLOPE
2F
2R
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
SEE PARTS LIST FOR SEMICONDUCTOR TYPES



REFERENCE DRAWINGS

- (1) HEATER WIRING DIAGRAM
- (3) VERTICAL AMPLIFIER
- (8) TIME-BASE B GENERATOR

CMD 565

D

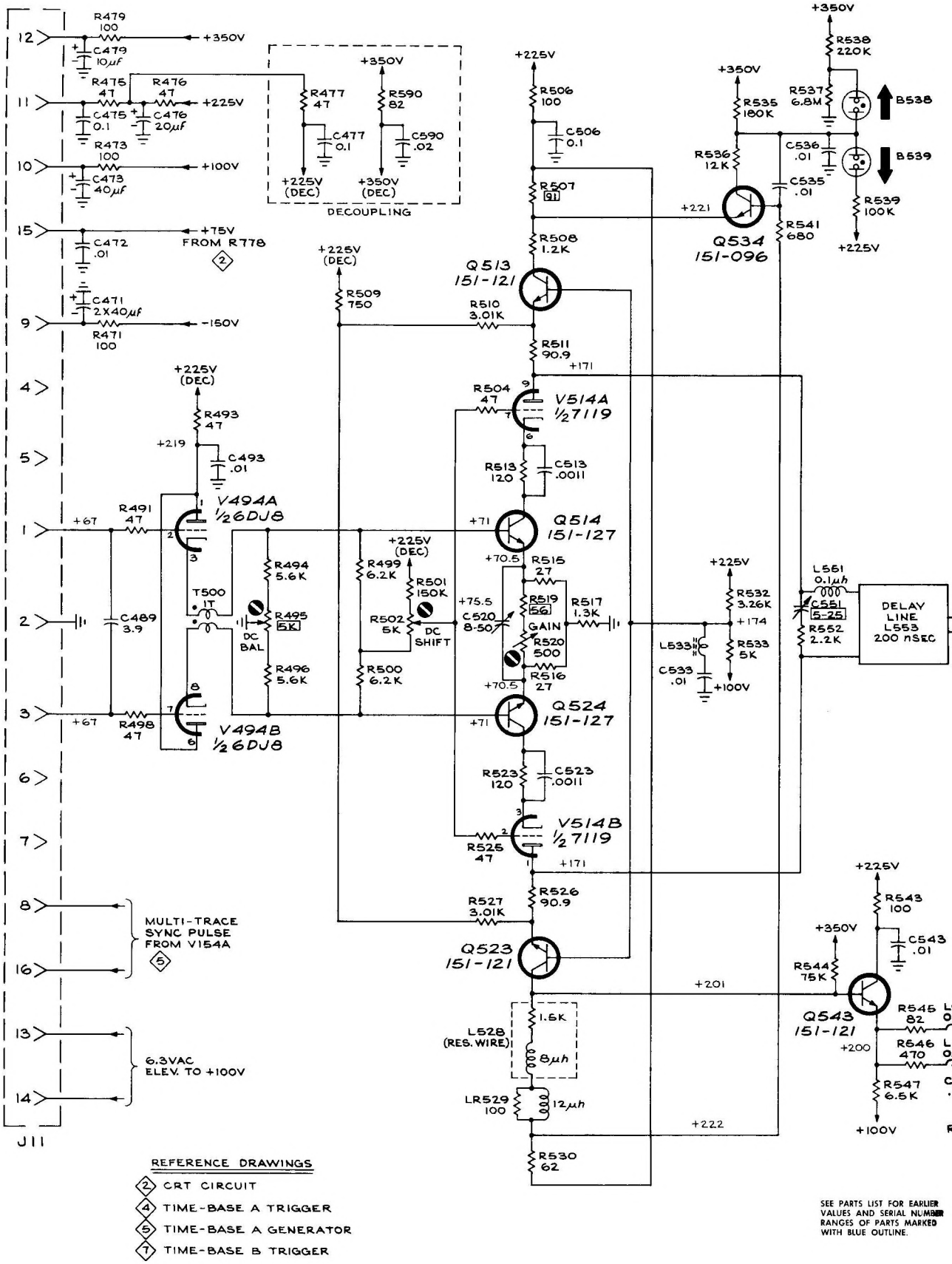
TIME-BASE B TRIGGER (7)

VERTICAL AMPLIFIER

VOLTAGE READINGS were obtained under the following conditions:
Input Signal ..... None
Test Function (TU-7) ..... *Common Mode

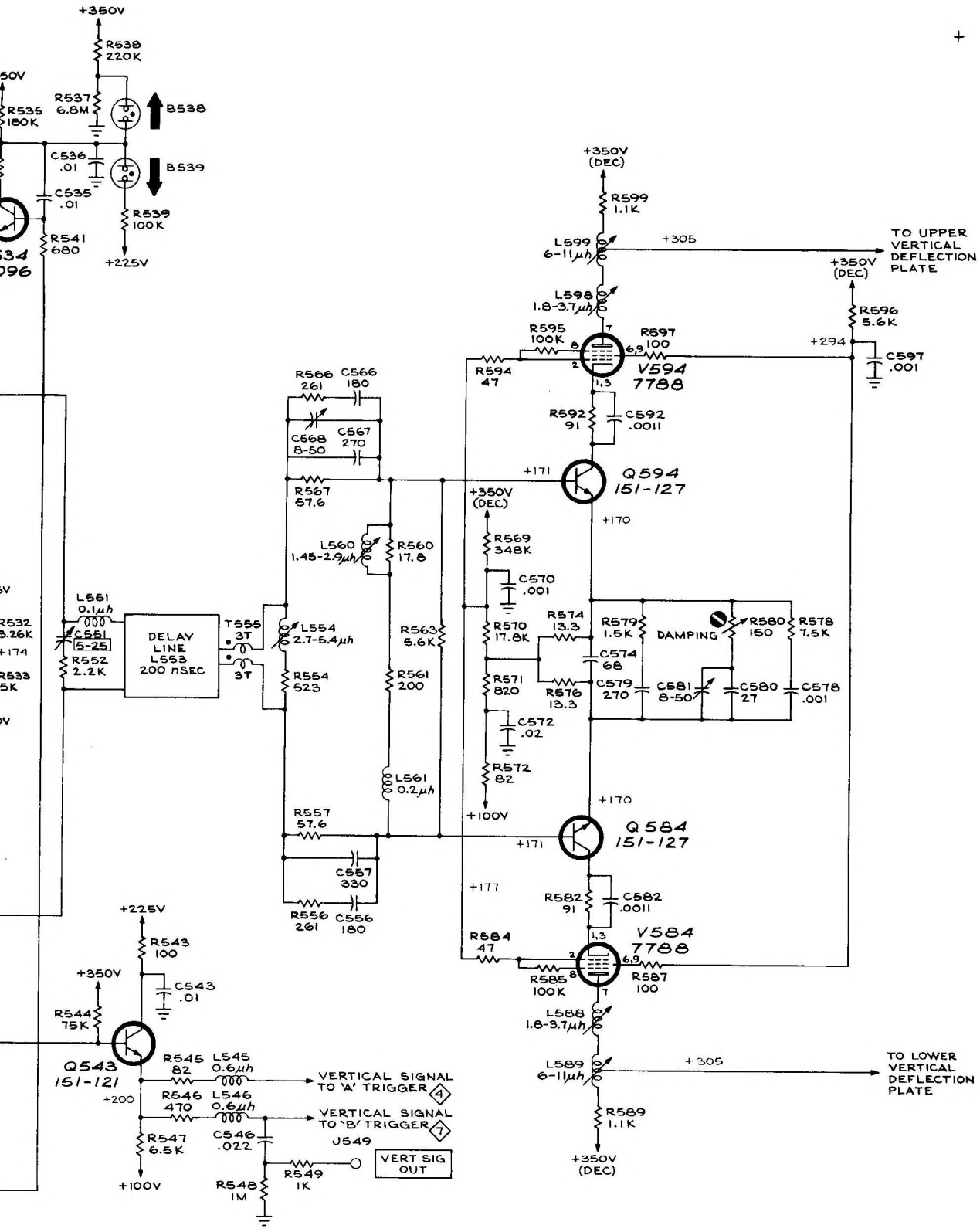
*If a letter-series or '1'-series plug-in unit is used, adjust the plug-in unit Vertical Position Control to obtain zero volts reading between pins 1 and 3 of the Interconnecting Plug.

Also see IMPORTANT note on Time Base A Trigger Diagram.



TYPE 545B OSCILLOSCOPE

D



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

VERTICAL AMPLIFIER 3

DON 1264

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 531A --- TENT. S/N 26080
TYPE RM31A -- TENT. S/N 2610
TYPE 535A --- TENT. S/N 33160
TYPE RM35A -- TENT. S/N 3750
TYPE 541A --- EFFECTIVE S/N 23260
TYPE RM41A -- EFFECTIVE S/N 1561

TYPE 545B ---- EFFECTIVE S/N 2180
TYPE RM545B -- EFFECTIVE S/N 410
TYPE 551 ----- EFFECTIVE S/N 6110
TYPE 581A ---- EFFECTIVE S/N 5400
TYPE 585A ---- EFFECTIVE S/N 10320
TYPE RM585A -- EFFECTIVE S/N 1170

PARTS LIST CORRECTION

CHANGE TO:

V152	*157-0104-02	6AL5	Checked

TYPE 543B -- TENT. S/N 590

TYPE RM543B -- TENT. S/N 140

TYPE 545B -- TENT. S/N 2290

TYPE RM545B -- TENT. S/N 140

PARTS LIST CORRECTION

CHANGE TO:

R580	311-0539-00	150 Ω	.25 w	Var	20 MV GAIN

TYPE 543B -- TENT. S/N 544
TYPE RM543B -- TENT. S/N 140
TYPE 544 -- TENT. S/N 320
TYPE RM544 -- TENT. S/N 120
TYPE 545B -- TENT. S/N 2200
TYPE RM545B -- TENT. S/N 410
TYPE 546 -- TENT. S/N 450
TYPE RM546 -- TENT. S/N 151
TYPE 547 -- TENT. S/N 2110
TYPE RM547 -- TENT. S/N 250

PARTS LIST CORRECTION

CHANGE TO:

V859	*154-0478-00	CRT	T5470-31-2	Standard Phosphor