INSTRUCTION MANUAL

Serial Number 994

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543B

OSCILLOSCOPE

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

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Specifications and price change privileges reserved.

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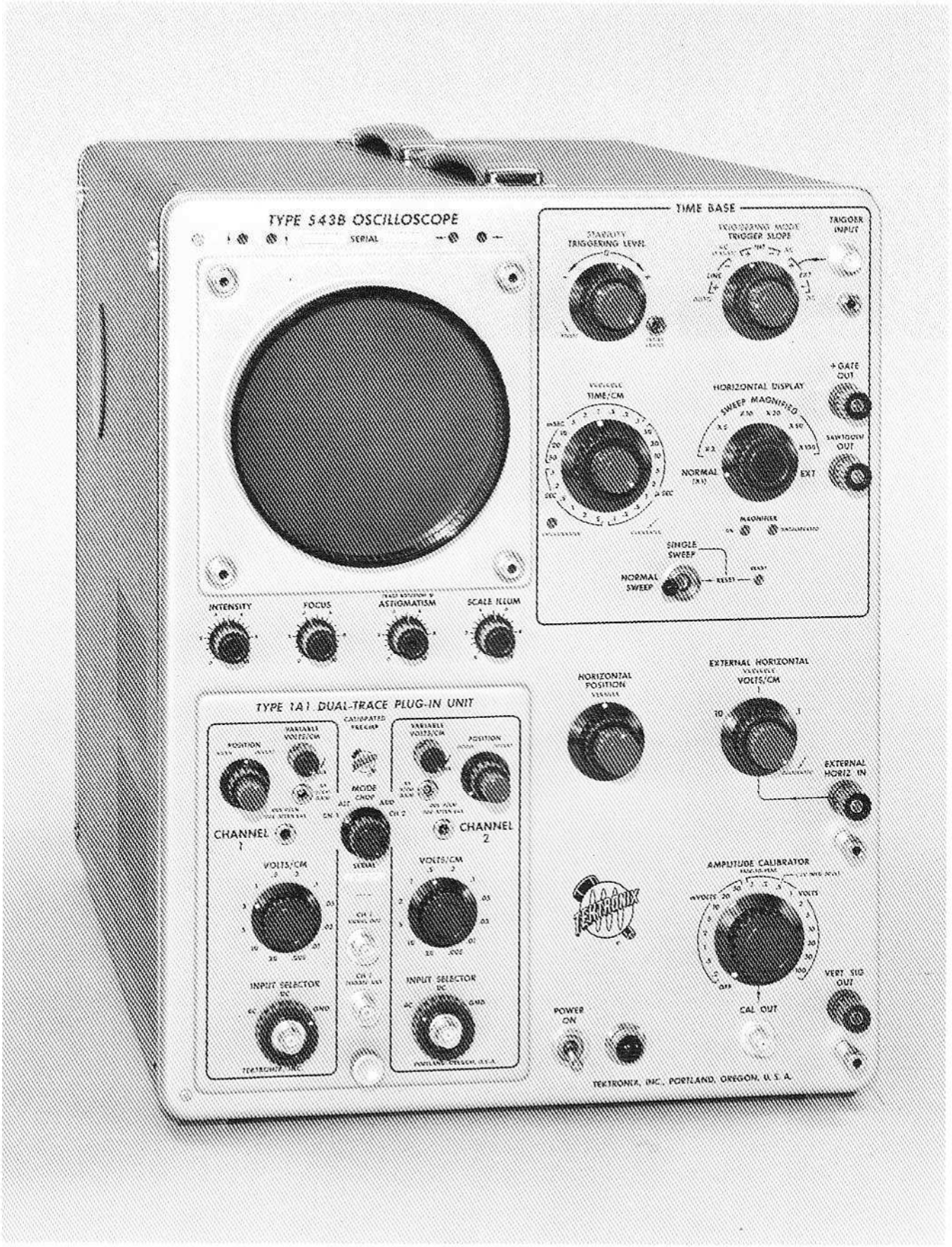
A list of abbreviations and symbols used in this manual will be found on page 6-1. Change information, if any, is located at the rear of the manual.



The Type 543B Oscilloscope

SECTION 1

CHARACTERISTICS

Introduction

The Type 543B Oscilloscope is a versatile laboratory instrument designed for use with all Tektronix lettered- or 1-series plug-in units.

VERTICAL DEFLECTION SYSTEM

Refer to Table 1-1 for the characteristics.

SWEEP GENERATOR

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 of the indicated rate.

Sweep Magnification — Any sweep rate can be increased 2, 5, 10, 20, 50 or 100 times by expanding the center portion of the display horizontally. Sweep-rate accuracy is within ±5% in the magnified positions until the sweep rate exceeds 0.02 μsec/cm.

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 to 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.

TABLE 1-1

Plug-In Characteristics for the Type 543B 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 v/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	50Ω 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

*Multiple-trace plug-in units.

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

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

External (dc): Minimum amplitude is 0.2 volt 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 (automatic): 0.5 v at 150 cps. Will trigger from 50 cps to 10 mc with increased signal.

HORIZONTAL DEFLECTION SYSTEM

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

Deflection Factor	A calibrated deflection of 0.1, 1 or 10 volts/cm with the VARIABLE 10-1 control set fully clockwise. The VARIABLE 10-1 control provides at least a 10:1 attenuation of the input signal when it is turned fully counterclockwise.
Frequency Response	Dc to 500 kc at maximum gain (30% down).
Input Characteristics	1 megohm paralleled by approximately 43 pf.

AMPLITUDE CALIBRATOR

Output Voltage	0.2 mvolts 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 special output from the .1 V INTO 50 Ω connector is accurate to within ±3% of the indicated value.

FRONT-PANEL OUTPUT SIGNALS

SAWTOOTH OUT	Approximately a 130-volt, peak-to-peak sawtooth voltage having the same duration as the sweep. Minimum allowable load resistance is 100 k.
+GATE OUT	Approximately a 20-volt peak-to-peak square-wave pulse having the same duration as the 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	6 × 10 cm with vertical and horizontal 1-cm divisions 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 center line.

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.*
Power Consumption	535 watts maximum.

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

MECHANICAL

Construction	Front panel is anodized. Chassis is aluminum alloy.
Net Weight	81 pounds.

ACCESSORIES INCLUDED

	Tektronix Part No.
2 Instruction Manuals	070-437
2 P6006 Probes with BNC connectors	010-127
2 Adapters, BNC to Binding Post	103-033
1 Test Lead	012-031
1 Crt Protector Plate	387-918
1 50-ohm Cable, BNC to BNC, 18 inches long	012-076
1 3-wire Power Cord	161-010
1 3- to 2-wire Adapter	103-013
1 Adapter, BNC to UHF	103-015
12 10-24 x 5/16 THS Screws	212-533
12 10-32 x 5/16 THS Screws	212-535

SECTION 2

OPERATING INSTRUCTIONS

FUNCTION OF CONTROLS AND CONNECTORS

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 smiple 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, proproviding 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. With 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 — 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.

HORIZONTAL DISPLAY — NORMAL (×1) and SWEEP MAGNIFIED positions expand the display horizontally by the amount indicated. Sweep-rate accuracy is ±5% in the magnified positions.

EXT position allows an external signal to drive the horizontal deflection system. The horizontal deflection factor is set by the EXTERNAL HORIZONTAL VOLTS/CM switch and variable.

MAGNIFIER Lamps — The MAGNIFIER ON lamp lights whenever the HORIZONTAL DISPLAY switch is in any of the SWEEP MAGNIFIED positions. The MAGNIFIER UNCALIBRATED lamp is connected to light whenver the sweep rate exceeds the maximum calibrated rate of 0.02 μsec/cm. This lamp will not light as long as the setting of the TIME/CM switch, divided by the magnification factor is not faster than 0.02 μsec.

EXTERNAL HORIZONTAL VOLTS/CM VARIABLE — Selects the horizontal deflection factor when the HORIZONTAL DISPLAY switch is set to EXT. The VARIABLE control must be fully clockwise when using the calibrated horizontal deflection factors.

SINGLE SWEEP — Permits single sweep operation at all settings of the HORIZONTAL DISPLAY switch except EXT.

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

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	Connector for applying an external trigger signal to the time base when TRIGGER SLOPE switch is set to the EXT position.
+GATE OUT	Supplies approximately a 20-volt square-wave pulse when the time base is operating. Pulse duration is approximately 10.5× the setting of the TIME/CM switch.
SAWTOOTH OUT	Supplies the sawtooth voltage of the time base. Peak amplitude is about +130 volts.
EXTERNAL HORIZ INPUT	Jack for applying external horizontal signal when the HORIZONTAL DISPLAY switch is set to EXT.
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 position) when using multi-channel plug-in units in 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. Always have the ground strap connected except when applying Z-axis modulating signals.

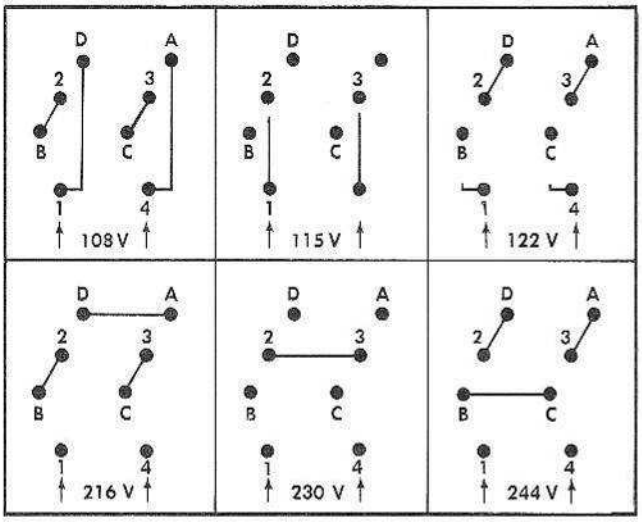


Fig. 2-1. Transformer connections for 108 to 244 volt, 50 to 60 cps and 400 cps operation.

NORMAL SWEEP

Power Connections

Unless otherwise indicated, the Type 543B 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 shows alternative connections for other input voltages to the power transformer. When the transformer is changed from a 108, 115, or 122 volts to 216, 230, or 244 volts connection, the fan wiring must be changed. Fig. 2-2 shows the fan connections for each voltage range.

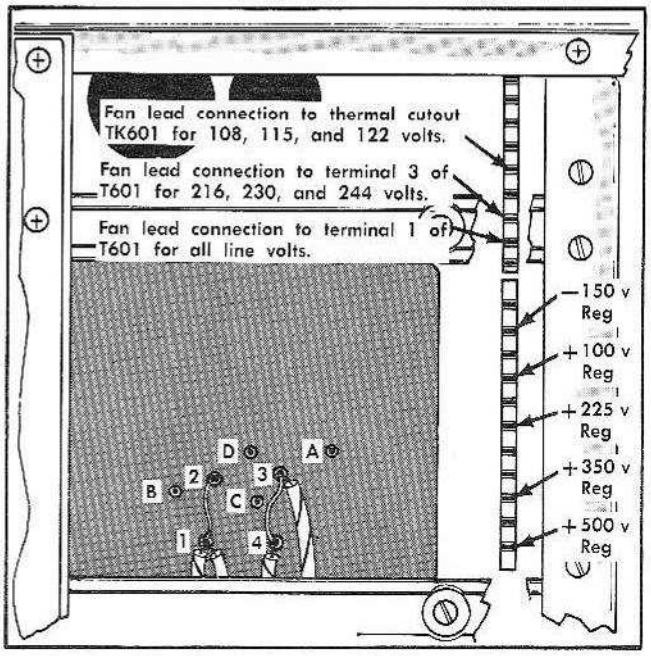


Fig. 2-2. Fan connections for 100-124 volts and 220-248 volts. See the label on the side of T601 for the placement of jumper leads.

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 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 frequency.

To trigger the time base from an external signal, set the TRIGGER SLOPE switch to an EXT position and connect the

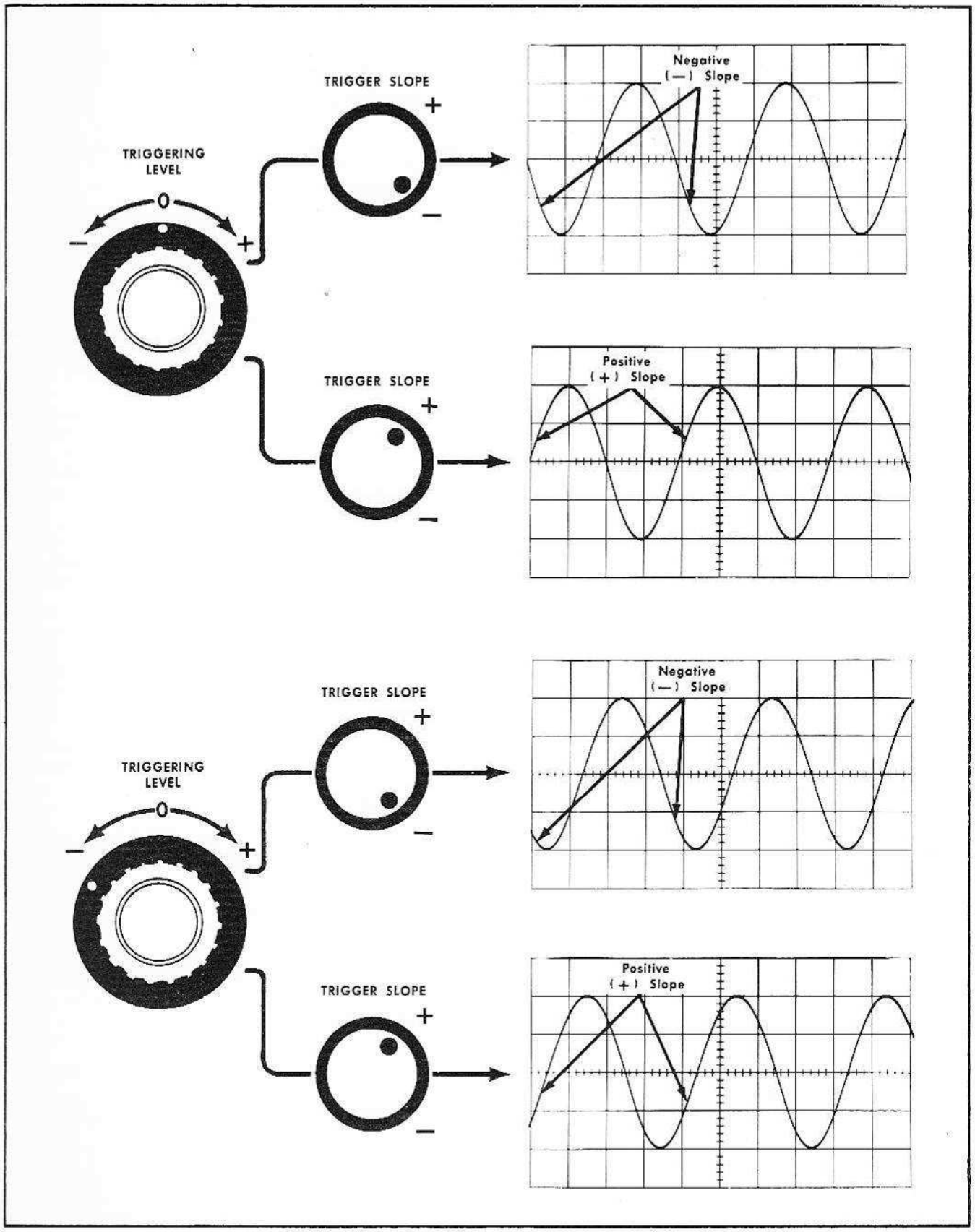


Fig. 2-3. Effects of the TRIGGERING LEVEL and SLOPE controls.

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 amplification 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 AC, 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 multitrace 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 multitrace 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 + (plus) direction causes the trigger circuit to respond at some higher positive amplitude on the triggering signal. Moving the TRIGGERING LEVEL control in the — (minus) 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 HORIZONTAL DISPLAY switches control sweep rate.

The TIME/CM and HORIZONTAL DISPLAY switches allow 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.

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

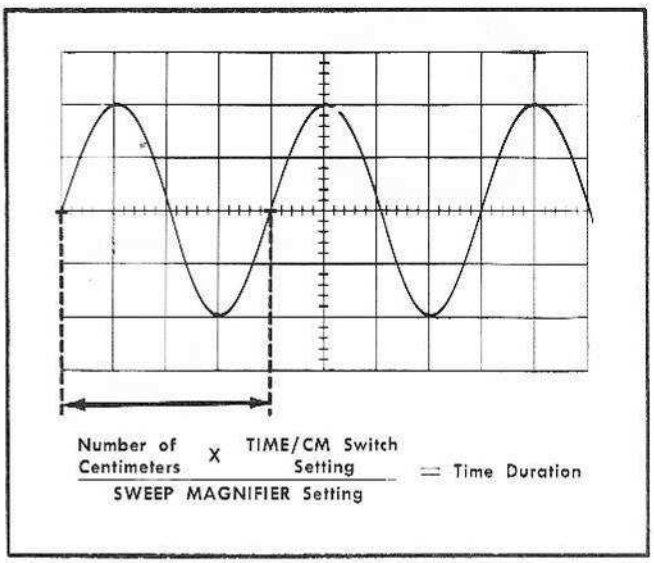


Fig. 2-4. Time measurement from the graticule.

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 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. Then, press the SINGLE SWEEP switch to RESET and release. When this is completed, the next trigger pulse will actuate the sweep and the Type 543B will display the event on a single trace. The READY lamp, near the SINGLE SWEEP 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 SINGLE SWEEP switch to RESET and release. In single-sweep operation, make sure the TRIGGER MODE switch is not set to AUTO.

NONTRIGGERED SWEEP

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 543B, 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 follows:

TRIGGER SLOPE	+EXT
TRIGGERING MODE	AC
STABILITY	Fully clockwise
TIME/CM	1 mSEC

Connect a lead from the SAWTOOTH OUT connector to the vertical input. The display should consist of a sloping line.

The oscilloscope display is the sawtooth pulse that is available during each sweep. 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 triggered in the normal manner.

The +GATE OUT connector output signal of the Type 543B can be used as a variable repetition-rate pulse generator. To use the Type 543B in this manner, proceed as follows:

Set the controls and switches as follows:

TRIGGER SLOPE	+EXT
TRIGGERING MODE	AC
STABILITY	Fully clockwise
TIME/CM	As desired

Monitor the signal available at the +GATE OUT connector on another oscilloscope and establish the desired pulse repetition rate by setting the TIME/CM and VARIABLE controls.

Light Filter

The light filter provided with the Type 543B 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 EXTERNAL HORIZ IN connector. Set the HORIZONTAL DISPLAY switch to EXT and the EXTERNAL HORIZONTAL VOLTS/CM control to 0.1, 1 or 10. The signal is dc coupled to the deflection amplifier.

The time-base generator still controls the unblanking of the crt display when the HORIZONTAL DISPLAY switch is set to EXT. To unblank the crt at a normal setting of the INTENSITY control, it will be necessary to have the SINGLE SWEEP switch set to NORMAL SWEEP and the time-base triggering controls set for a free-running sweep. If it is undesirable to have the time-base generator running, then the INTENSITY control will have to be turned up until the beam is visible.

DUAL-TRACE CHOPPED BLANKING

A dual-trace plug-in unit provides two separate traces on the crt and thus permits two functions to be displayed simultaneously. Detailed instructions for operating the dual-trace plug-in unit in conjunction with the Type 543B Oscilloscope are contained in the plug-in unit instruction manual.

When the dual-trace 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 on the rear of the instrument in the CHOPPED BLANKING position.

INTENSITY MODULATION

The Type 543B 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 EXTERNAL 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 approximately 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 contains the theory of operation of the various circuits in the Type 543B. A simplified block diagram analysis is given first to explain the operation of each circuit in general terms, 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 543B. 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 circuit of the time base. The trigger is picked off at the output of the vertical input amplifier.

Time-Base Generator

The time-base generator provides accurate ramp voltages for the horizontal deflection system, unblanking for the crt, and a + gate to the front-panel connector. The time-base generator may be triggered by signals derived from either internal or external sources.

Horizontal Amplifier

The input to the horizontal amplifier is selected from the output of the time-base 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 input 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 0.1 to about 100 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 543B 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 543B 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.

DETAILED CIRCUIT DESCRIPTION

The following description is a detailed discussion of the operation of each circuit in the Type 543B. 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 543B (see Power Supply schematic diagram) actually consists of five in-

terrelated 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 543B 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 cps and 400 cps.

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 temperatures return 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-volts 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 543B 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 flow 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 due to increased line voltage or some other cause, 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, and this holds both cathodes more or less 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 has decreased instead of increased, then the error voltage applied to the grids of the series regulators would have been positive-going. The positive-going error voltage on the grids of the series regulators would lower the resistance of the series regulator tubes, 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 ripple from the output of the bridge rectifier, and the series regulator circuit functions also to reduce this output ripple voltage. Any ripple between the —150-volt output point and ground reaches the grid (pin 7) of V624B via capacitor C617. This input ripple voltage is amplified by V624 acting as a cathode-coupled amplifier. The ripple output voltage at the plate (pin 6) of V624B has the same polarity as the ripple voltage at the —150-volt output. C628 couples this ripple output voltage to the grid of V634. The ripple voltage is further amplified by V634 and applied to the grids of the series regulator tubes with a polarity that opposes the original ripple voltage. Ripple in the positive side of the —150-volt supply is coupled into a degenerative feedback loop through R637 to 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 string of filaments at all times. When the Type 543B is first turned on, relay K601 contacts are open and all the regulated supplies are inoperative. During this time, the series-string 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-string filaments have reached operating temperature. When K601 is activated by K600, relay contacts K601-3 shift the series-string 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 the error amplifier, and V677A is the series regulator tube. The error-feedback circuit is through R650 and R651, the junction of which 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 is connected to the output of the regulated —150-volt supply to obtain reference voltage. With normal line voltages and loads, the voltage at the junction of R650 and R651 is about —1.7 volts with reference to ground; this is the operating bias of V664.

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 end of R650 permits the voltage at the junction of R650 and R651 to go more negative than the normal —1.7-volt level at that point. The increase in negative bias on the grid of V664 reduces the flow of plate current through 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 that V677A offers to the flow of current is decreased and the output voltage rises, compensating for the drop in output voltage which initiated regulating action. Of course, the regulator circuit can never completely compensate for a change in output voltage, for there must be an error input for the circuit to operate, but 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 is applied to the screen of V664, amplified and inverted in phase by V664, then applied to the grid of V677A. By the time the amplified and inverted ripple gets to the grid of V677A, it is of proper amplitude and phase to cancel out the ripple appearing at the plate of V677A.

Unregulated +325-Volt Supply. The unregulated +325-volt supply voltage source differs somewhat from the voltage source for the —150- and +100-volt supplies. A center-tapped secondary on T601 (pins 5, 7, 10, and 14) and silicon diodes D702 and D732 form a center-tapped bridge rectifier circuit with the negative side connected to the positive unregulated side of the voltage source for the +100-volt supply. The unregulated +325-volt output is taken from the transformer center-tap (pins 7 and 10) connection.

The unregulated output of the voltage source for the +100-volt supply is approximately +180 volts. The unregulated output of the center-tapped bridge circuit is approximately +290 volts; this added to the unregulated +180 volts provides the +470 volts. However, for the unregulated +350-volt output, the connection is made at the center tap (+145 volts) of the bridge (the midpoint of the +290 volts). Adding the +180 and +145 volts provides the desired 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 found 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 longtailed 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 in phase, 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 supply 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. The use of a 50-kc input to the high-voltage transformer permits the size of the transformer and filter components to be kept small. A modified Hartely 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 Harley 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 approximately 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 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. Larger 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 unblanking 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 via R836 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 543B 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 543B is used with a multichannel 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 543B 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. Input cathode followers V494A and V494B are the two halves of a 6DJ8 twin triode. The cathodes of the

cathode followers 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, not only provides trigger signals to the time base, but supplies the VERT SIG OUT jack with a vertical signal.

Beam-Position Indicators. The beam-position indicators B538 and B539 driven by Q534 and 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 across either neon is insufficient to light it. 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 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 beam has been moved.

Time Base

The Time Base consists of the sweep trigger and the sweep generator circuits. The 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 sweep generator. The sweep generator circuit is basically a Miller runup circuit. The sweep generator provides ramp voltages for the horizontal deflection system and the SAWTOOTH OUT connector, unblanking pulses, and + gate pulses.

Trigger Generator. The input to the sweep trigger circuit is selected by TRIGGER SLOPE switch SW10A from the trigger-pickoff circuit in the vertical amplifier, the power transformer for line triggering, or from the front-panel TRIGGER INPUT connector. TRIGGER 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 sweep trigger circuit is selected by adjusting TRIGGERING LEVEL control R17. After this triggering signal has been selected by the preceding controls 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 establishees the voltage present at the plate under no-signal conditions.

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

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

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.

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 the 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 Q45 base; hence the emitter voltage starts to rise.

As the Q35 base goes down and its emitter goes up, it stops conducting. As Q45 conducts, its voltage drops, creating a negative step at the output. This transistion 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 configuration 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 multivibrator 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 that transistor 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 stage V135B. V135B, used as a cathode follower between the two halves of the multivibrator, isolates the positive-going plate of V135A from the capacitance of the loads requiring a positive-going pulse. This results in a faster rise of the positive-going pulse at the plate of V135A.

The cathode of V135B is longtailed 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 D150 of the disconnect diodes. 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 instantaneously, this voltage is coupled to the grid of the Miller tube in a direction to correct for the attempt of the Miller-tube grid to go negative.

Current to charge the timing capacitor is supplied through 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 generator have had time to reach their quiescent state. The point at which the holdoff circuit will allow the sweep gating multivibrator to return to its quiescent state is determined by the adjustment of R176 (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 C180, thus determining when the sweep ends.

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

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 V135B 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 of the beam to be seen.

The end of the unblanking pulse coincides with the end of the time base, and the crt is blanked during the retrace portion of the sweep and during quiescent period 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 OUT 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 OUT front-panel connector.

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

In the first stable state 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.

Placing the SINGLE SWEEP switch to the RESET position grounds C122. This causes a sharp drop in the plate voltage of V125. The drop in the plate is fed through the divider between the plate of V125 and the grid of V133A and forces the lockout multivibrator into its other stable state with V125 conducting and V133A cut off. With V133A cut off, its plate voltage rises and ignites the READY light. With V125 conducting, the STABILITY control regains control over the grid level of V135A.

Depending on the adjustment of the STABILITY control, a sweep can now be produced in one of two ways. If the STABILITY control is turned 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 of V133B up, V125 cuts off and V133A conducts. As the cathodes continue to rise (following the rise in the sawtooth sweep voltage) V133A cuts off again. Both tubes are then held cut off for the remainder of the sweep and the READY light stays on. When the grid of V135A rises to the point at which the sweep gating multivibrator reverts, the sweep is terminated.

As hold-off capacitor C180 discharges, the cathodes of the lockout multivibrator start to fall. The grid level of V133A is such that this tube comes out of cutoff first, thus V133A conducts and V125 remains in cutoff. As V133A

conducts, its plate drops and extinguishes the READY light. A new sweep cannot be initiated until the SINGLE SWEEP switch is again pressed to the RESET position.

Dual-Trace Sync Pulse and Chopped Blanking Circuitry. Synchronizing pulses for dual-trace plug-in preamplifiers are supplied by V154B. When multivibrator V145 cuts off, a sharply differentiated positive pulse is developed at its screen. This pulse, coupled to the grid of V154B, produces a negative trigger at the plate of V154B. 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 V154A. The resultant positive pulse at the plate of V154A 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.

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

Input Amplifier

The positive-going sweep sawtooth voltage produced by the time-base generator circuit is coupled through a frequency-compensated voltage divider to the grid of input cathode follower V343. The attenuation of the divider can be altered slightly by the adjustment of R342 ×1 CAL. The small time-constant network C339-R339 inproves the start of the waveform at the faster sweep rates. The two positioning controls, HORIZONTAL POSITION R340 and VERNIER R346, affect the beam positioning by altering the dc level at the grid of V343. The voltage and resistance values in the positioning circuits are such that the VERNIER can move the spot about 1 cm while the HORIZONTAL POSITION control can move the spot about 10 cm when the HORIZONTAL DISPLAY switch is in the NORMAL (×1) position. Because of their low impedance, an adjustment of the positioning controls does not materially alter the attenuation of the divider network.

Input amplifier V354-V364 is a cathode-coupled phase inverter; the positive-going sawtooth at the grid of V364 is converted to a push-pull sawtooth at the plate circuits of V354 and V364.

The impedance network connected between the two cathode circuits plays an important role in determining the amount of negative feedback applied to the input amplifier. Two of the components in this network, R361 and C361, have their value selected by the HORIZONTAL DISPLAY switch. The negative feedback which comes from the output cathode follower stage is applied through a frequency-compensated divider consisting of R387-C387 on one side and R388-C388 on the other, and the impedance connected between the cathodes of the input amplifier. The smaller the impedance connected between the two cathodes the greater the drop across the series components and the less the amount of feedback applied to the input amplifier. Details of the R361-C361 network are shown in the switch layout on the Horizontal Amplifier diagram. In the ×100 SWEEP MAGNIFIER position of the HORIZONTAL DISPLAY switch, R361 and C361 are replaced with very small impedance. This decreases the negative feedback and increases the gain of the stage 100 times over that of the NORMAL (×1) position of the switch. ×100 CAL R375 is adjusted so that the stage gain in the ×100 SWEEP MAGNIFIED position of the HORIZONTAL DISPLAY switch is 100 times that of the NORMAL (×1) position. The ×1 CAL control R342 is adjusted to attenuate the input signal so that the Horizontal Amplifier has the desired amount of deflection in the NORMAL (×1) position of the HORIZONTAL DISPLAY switch.

To adjust for the dc shift in V354 which is caused by thermal changes in the tube, a dc shift network consisting of C364, R364 and R365 is connected between the cathode of V374B and the input grid of V354. The dc shift network provides positive feedback to V354; the amount of positive feedback is controlled by adjusting DC SHIFT R365. When the DC SHIFT control has been properly set, the start of the trace will remain constant.

SWP/MAG REGIS R359 is adjusted to preserve the dc balance of the amplifier as the degeneration networks in the cathode circuit of the input amplifier are changed. This will insure that the portion of the trace in the exact center of the crt, when the HORIZONTAL DISPLAY switch is in the NORMAL (×1) position, will be expanded symmetrically about the center when the switch is moved to any of the SWEEP MAGNIFIED positions.

Two MAGNIFIER neon glow lamps are located on the front panel immediately below the HORIZONTAL DISPLAY switch; circuitry for the lamps is shown in the switch-detail on the Horizontal Amplifier schematic. The MAGNIFIER ON lamp lights whenever the HORIZONTAL DISPLAY switch is in any of the SWEEP MAGNIFIED positions. The MAGNIFIER UNCALIBRATED lamp is connected to light whenever the sweep rate exceeds the maximum calibrated rate of 0.02 μsec/cm. This lamp will not light as long as the setting of the TIME/CM switch, divided by the magnification factor, is not faster than 0.02 μsec.

Output Amplifier

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

cathode follower stage to charge and discharge the stray capacitance in the plate circuit of the output amplifier.

The positive feedback network of C368, R360, R367, R368, R369 and R370 gives the output amplifier its extremely high gain. This network is connected between the cathode of V374B-V384B and the input grid of V374A-V384A. C368 is adjustable so that the feedback network will provide the same impedance at each plate of the driver stage.

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

Because the plate current of a pentode is fairly constant over a large range of plate voltage, the cathode current of V374B will remain nearly constant even though its cathode falls about 100 volts during the trace portion of the negative sweep waveform.

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

Beam-Position Indicators. The beam-position indicators B380 and B390 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 insufficient 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. The setting of the EXTERNAL HORIZONTAL VOLTS/CM switch determines whether the signal is directly coupled to the grid circuit of V324A, or whether one or two frequency-compensated attenuators is connected to the signal path. For all positions of this switch the input impedance is 1 megohm shunted by approximately 43 pf.

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

The gain of the Horizontal Amplifier, when connected to the External Horizontal Amplifier, is calibrated by means of EXT HORIZ AMP CAL control R361M, shown on the switch layout section of the Horizontal Amplifier diagram. R361M is adjusted so the horizontal deflection will agree with the setting of the EXTERNAL HORIZONTAL VOLTS/CM switch when the VARIABLE control is turned fully clockwise to the CALIBRATED position.

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, connects 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

MAINTENANCE

PREVENTIVE MAINTENANCE

Panel Removal

The side and bottom panels of the Type 543B are held in place with coin-slotted fasteners. To remove the panels, turn each fastener a quarter turn counterclockwise.

When replacing the panels, position 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 RM543B see Rackmounting Instructions.

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 of this manual.

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 543B 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 overheating before the heat-damaged parts are replaced; otherwise, the damage may be repeated.

Cleaning

The Type 543B should be cleaned 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 electricity. 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 Number 006-580) or "Handi-Koter" (available locally through most air conditioner suppliers). Let the filter dry thoroughly before reinstalling.

Exterior. Loose dust accumulated on the outside of the Type 543B 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. Some chemicals to avoid are benzene, toluene, xylene, acetone or similar solvents.

Interior. Although air entering the Type 543B is filtered, some dust may penetrate into the interior of the instrument. This dust should be removed occasionally due to its conductivity under high humidity conditions. The best way to clean the interior of the equipment 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 brush or a damp 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 or 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 543B. Additional silver-bearing solder can usually be purchased locally; however, it may be purchased through your Tektronix Field Engineer or representative—specify part number 251-514.

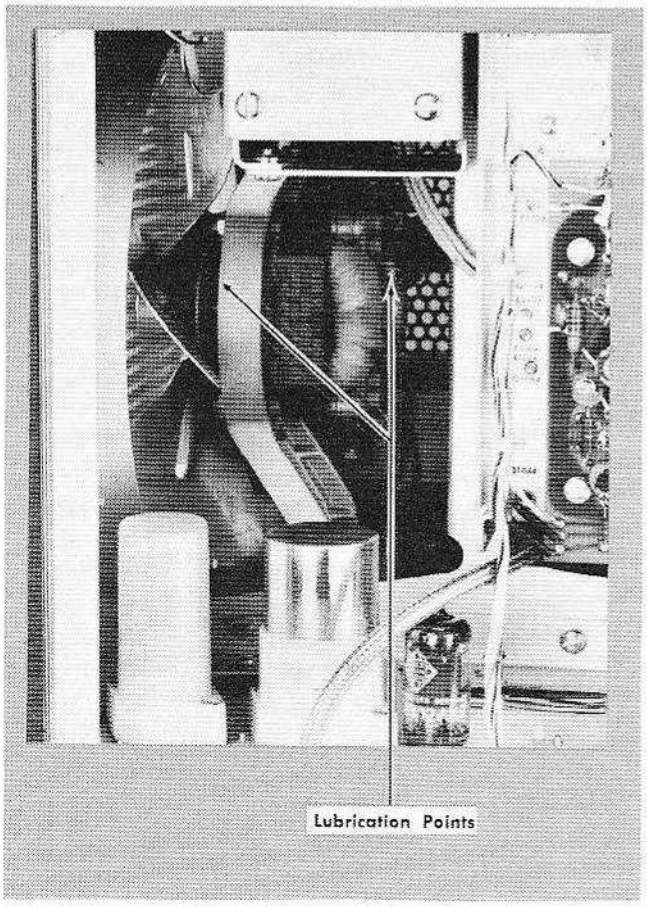


Fig. 4-1. Fan motor lubrication points.

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.

When soldering to metal terminals (e.g., pins on a tube socket or terminals on a switch) a slightly different technique should be used. Prepare the iron as described previously and apply the iron to the junction to be soldered. Use only enough heat to allow the solder to flow freely along the wire so that a solid solder joint is formed. Excessive solder and/or heat may cause the solder to run into the tube socket or onto the switch contacts and ruin the part; whereas, inadequate heat will result in a poor electrical connection.

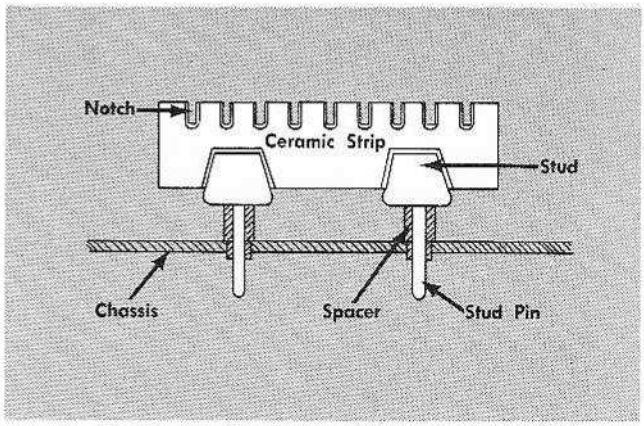


Fig. 4-2. Ceramic strip assembly.

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.

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. Attempt to 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.

WARNING

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 representative. 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 representative. 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 543B 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 circuit. 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 of switch assemblies are normally not replaced. Replacement switches may be ordered from Tektronix either wired or unwired; see the parts list for the part numbers.

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.

1. Remove crt bezel nuts, bezel and plastic light filter or crt protector plate (see Fig. 4-2).
2. Remove plastic eyebrow and retaining spring from the top of the crt (see Fig. 4-3).
3. Remove crt anode lead, disconnect all leads from the neck of the crt except the crt trace-rotation coil leads.

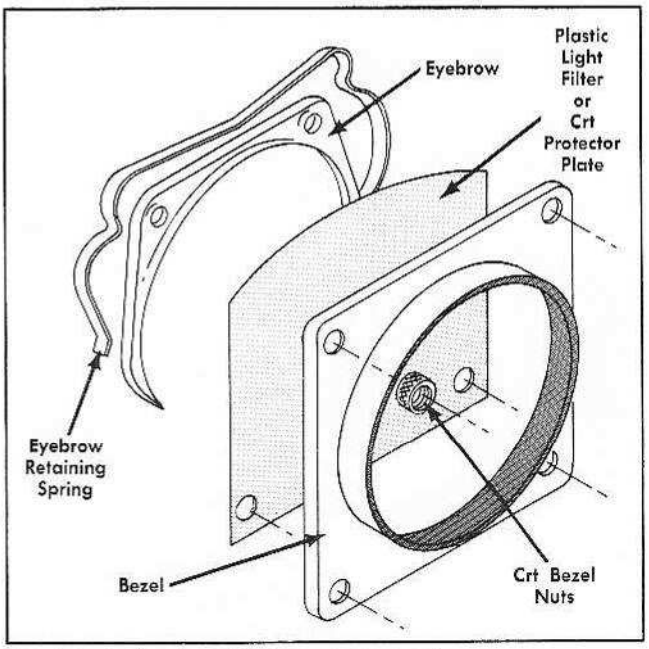


Fig. 4-3. Crt bezel and eyebrow arrangement.

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 towards the front of the instrument 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 power 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 front surfaces of the light pipe and eyebrow are flush.
12. Tighten the base clamp.

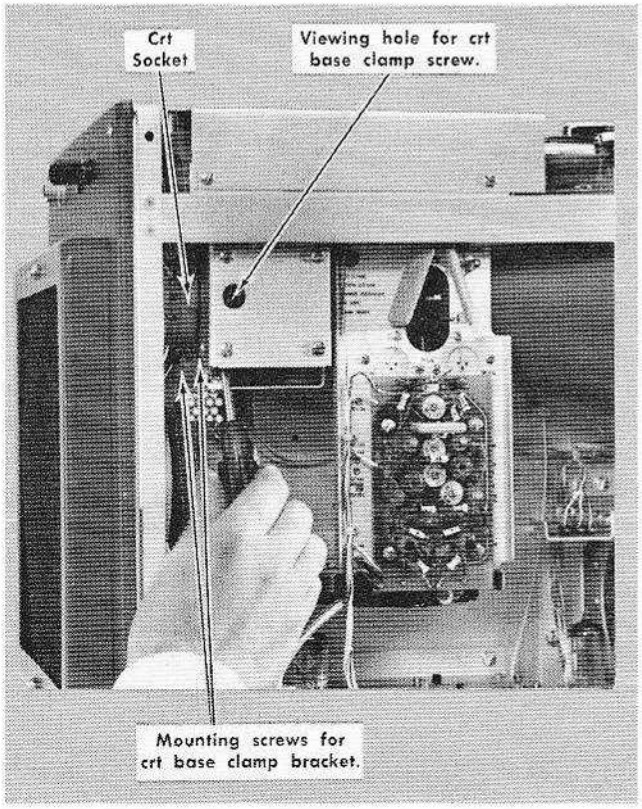


Fig. 4-4. Loosening the crt base clamp.

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 at the back of this manual. In addition, a block diagram provides an overall picture of instrument operation. The circuit reference designation for each electronic component in the instrument is shown on the circuit diagrams along with important voltages and waveforms. Component description and tolerance is given in Section 6 of this manual.

The following list shows the circuit reference designations associated with each circuit in this instrument.

Circuit Numbers—

1 — 99.....Time-Base Trigger
100 — 199.....Time-Base Generator
300 — 399.....Horizontal Amplifier
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 543B 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 543B is not color-coded in any particular manner; the color used is to facilitate point-to-point circuit tracing within the instrument.

Resistor Color-Code

Some stable metal-film resistors are used in this instrument. These resistors can be identfied 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.

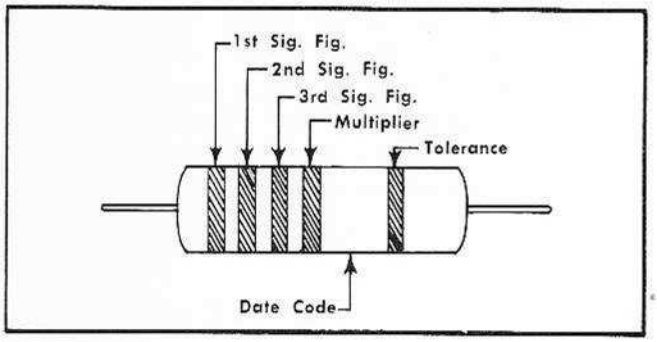


Fig. 4-5. Standard EIA color code for metal-film resistors.

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

TROUBLESHOOTING

General Information

This portion of the Instruction Manual includes information to facilitate more efficient troubleshooting of the Type 543B if a trouble develops. During troubleshooting, information contained in this section of the manual should be correlated with information obtained from other portions of the manual.

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 are included to help isolate the trouble to the circuit involved. The circuit troubleshooting information should be used to locate the defective component.

Circuit Isolation

The Type 543B can be divided into 7 major circuits. These circuits are:

1. Time-Base Trigger.
2. Time-Base Generator.
3. Horizontal Amplifier.
4. Vertical Amplifier.
5. Power Supply.
6. Crt Circuit.
7. Calibrator.

Although the Type 543B 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. 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 543B or the vertical plug-in unit. The best 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 if 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 anaysis 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 543B 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

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 adjustments on the affected circuit.
3. Check the voltage in the circuit. Typical operating voltages are given on the schematic diagram.
4. Check waveforms in the circuit with another oscilloscope. Typical waveforms are given on the schematic diagram.
5. Check the components in the circuit (i.e., check for faulty capacitors, off-tolerance resistors, etc.).

SECTION 5

CALIBRATION

Introduction

The Type 543B Oscilloscope is a stable instrument which will provide many hours of trouble-free operation. However, to ensure 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 neceessary, you may perform individual steps, provided 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 543B Oscilloscope.

1. A Dc voltmeter having a sensitivity of at least 5000 Ω/volt 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 plug-connectors on each end. Tektronix Part No. 012-057.
8. Adapter, single binding post fitted with a BNC plug. Tektronix Part No. 103-033.
9. Coaxial connector adapter with BNC-jack and UHF-plug 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. Fits one BNC jack and accepts two BNC plugs. 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 1½" long shank and ⅛" 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 repositioning, if necessary, the TRIGGERING LEVEL control knob.

PRELIMINARY PROCEDURE

Remove the cover(s) from the instrument to be calibrated.

Set the front-panel controls as follows:

Crt Controls

INTENSITY	0
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	5

Time Base

TRIGGERING LEVEL	Fully clockwise
STABILITY	Fully clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC
HORIZONTAL DISPLAY	NORMAL (×1)
SINGLE SWEEP	NORMAL SWEEP

Other Controls

HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
EXTERNAL HORIZONTAL VOLTS/CM	10
VARIABLE (EXTERNAL HORIZONTAL VOLTS/CM)	CALIBRATED
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.

Nominal Resistances of Power Supplies

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

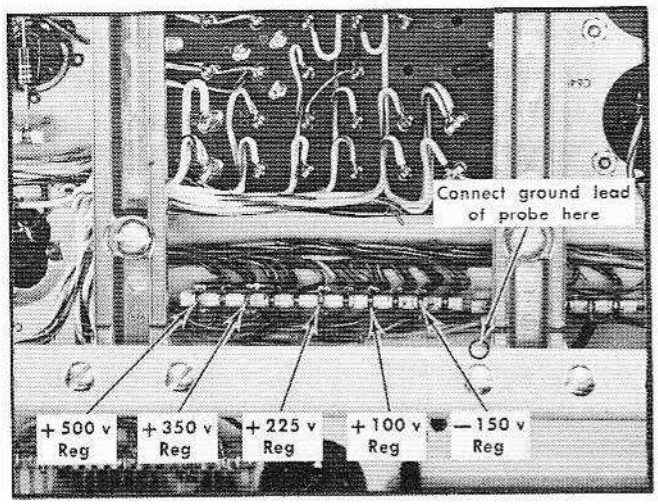


Fig. 5-1. Low-voltage power supply test point locations.

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

Vertical Position	Centered
Test Function	Low Load
Other Controls	As is

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 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 delay relay. The relay armature should pull in with a "click" sound after 15 to 60 seconds 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-volt and the other regulated supplies must be within 3% of their rated values. Set the −150 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 one times 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

CAL ADJ R879 should be set to provide exactly +100 volts at the CAL TEST PT when the AMPLITUDE CALIBRATOR switch is in the OFF position. Under these conditions, the CAL OUT voltages should be within 3% of the front-panel readings.

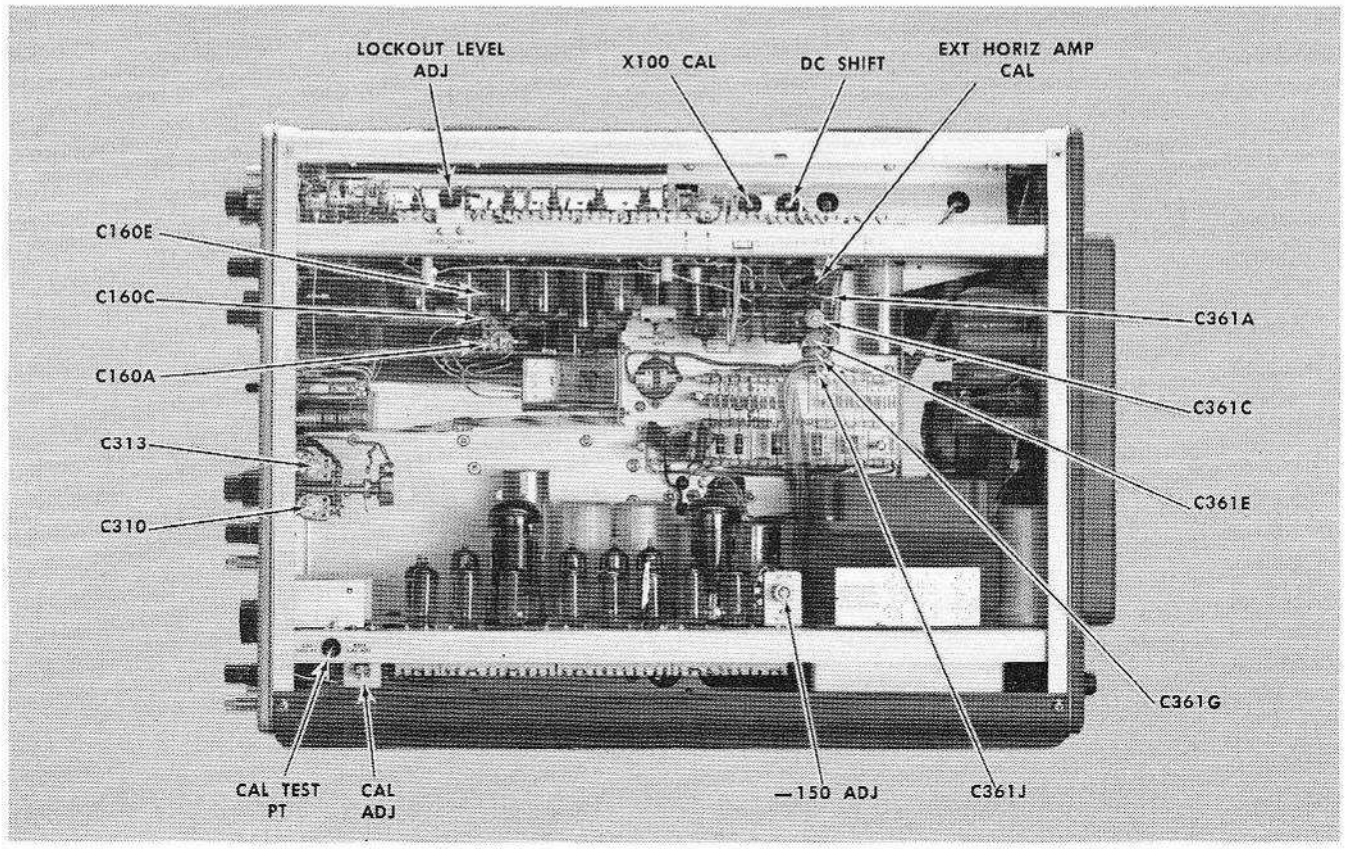


Fig. 5-2. Location of internal adjustments and test points for time base, power supply, and amplitude calibrator.

To make this adjustment, connect the voltmeter between the CAL TEST PT jack and ground (see Fig. 5-2), and adjust CAL ADJ R879 for a reading of exactly +100 volts. To assure suitable symmetry of the calibrator waveform, the reading at this point should not be less than 45 nor more than 55 volts 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 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 NORMAL (×1) 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

The geometry of the crt display is adjusted by means of the GEOM control. To achieve optimum linearity, vertical lines are displayed on the crt and the GEOM 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 triggering controls, and adjust the GEOM control (see Fig. 5-3) for straight vertical lines running parallel to the left and right edges of the graticule (see Fig. 5-4).

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 DC BAL R495 until the trace is superimposed on the center graticule line.

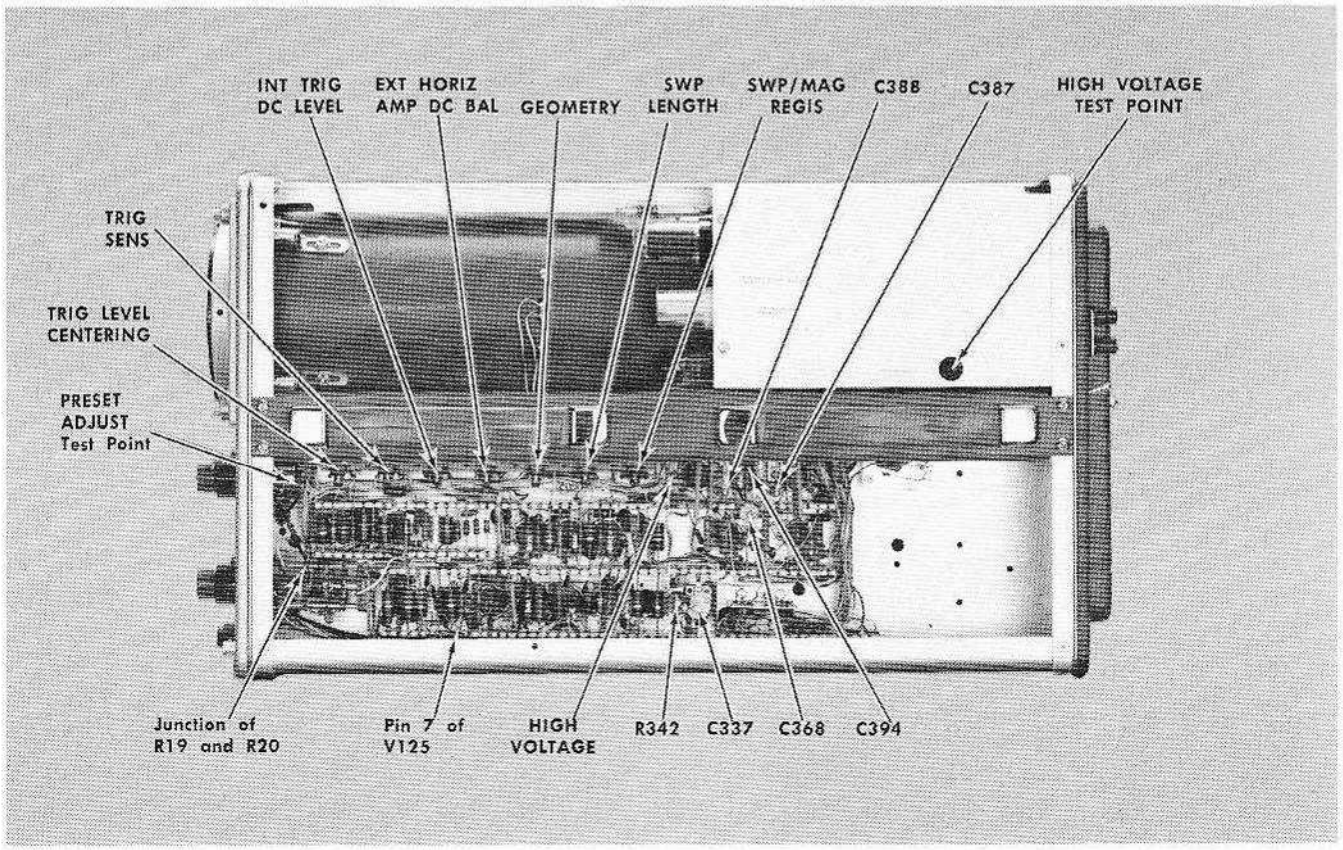


Fig. 5-3. Location of internal adjustments and test points for time base and crt circuit.

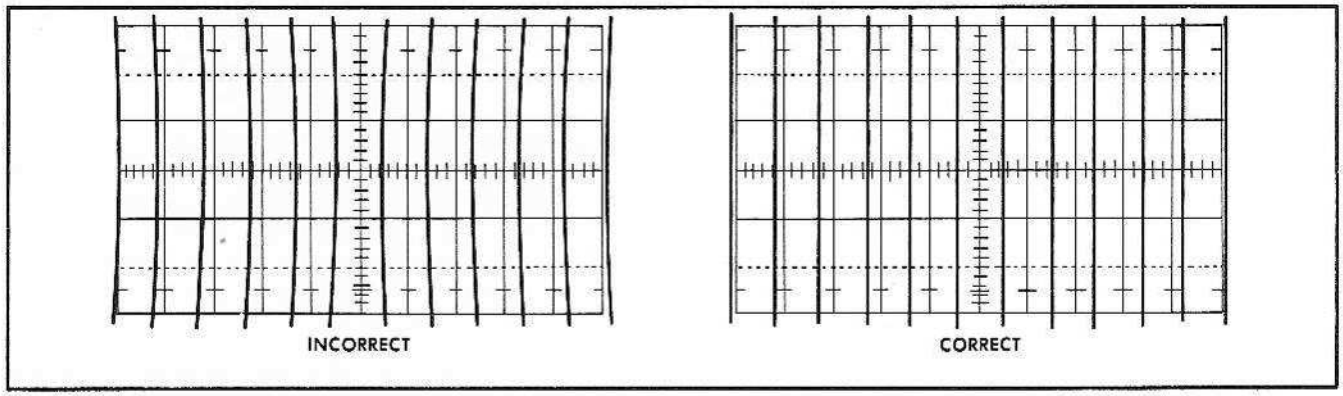


Fig. 5-4. Adjustment of GEOMETRY control.

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 TU-7. Adjust GAIN R520 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%.

Set 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-centimeter area of the crt.

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 drive 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. Connect a jumper from the CAL OUT to the Ext Input connector of the TU-7. Center the display with the Vertical Position control and check each sweep rate of the 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 Type TU-7 Test Function switch to Chopped and the TIME/CM control to 5 μSEC. Adjust the triggering controls for a stable display. Switch the CRT CATHODE SELECTOR to 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

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AUTO
TRIGGER SLOPE	+EXT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC
HORIZONTAL DISPLAY	NORMAL (×1)
SINGLE SWEEP	NORMAL SWEEP
Other Controls	
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
EXTERNAL HORIZONTAL VOLTS/CM	10
VARIABLE (EXTERNAL HORIZONTAL VOLTS/CM)	CALIBRATED
AMPLITUDE CALIBRATOR	100 VOLTS

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Vertical Position	Centered
Test Function	Gain Set
Other Controls	As is

TRIGGERING ADJUSTMENTS

8. 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 test oscilloscope sweep rate for 10 msec/cm, the vertical controls 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. 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 screen, then two or three degrees further counterclockwise.

Turn the TRIG LEVEL CENTERING control counterclockwise until the display reappears on the crt. 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. 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. 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. Preset Adjust

Place the TRIGGERING MODE switch at AUTO and the TRIGGERING SLOPE switch to +LINE. Connect the dc voltmeter between the PRESET ADJUST potentiometer wiper arm (see Fig. 5-3) and ground and turn 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.

Front-panel controls should be set as shown in Table 5-2 before proceeding with step 13.

TABLE 5-2

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base	
TRIGGERING LEVEL	0
STABILITY	Clockwise
VARIABLE (TIME/CM)	CALIBRATED
TRIGGERING MODE	AC
HORIZONTAL DISPLAY	NORMAL (X1)
TRIGGER SLOPE	+ INT
TIME/CM	1 mSec
SINGLE SWEEP	NORMAL SWEEP
Other Controls	
HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
EXTERNAL HORIZONTAL VOLTS/CM	10
VARIABLE (EXTERNAL HORIZONTAL VOLTS/CM)	CALIBRATED
AMPLITUDE CALIBRATOR	OFF
TU-7	
Vertical Position	Centered
Test Function	Low Load
Variable	Adjust for desired amplitude
Other Controls	As is

13. Normal (×1) Calibration

Apply 1 msec markers from the Type 180A to the vertical input and adjust triggering controls for a stable display. Now adjust ×1 CAL R342 (see Fig. 5-3) for 1 time-marker/cm display.

NOTE

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

14. ×100 Sweep Magnified Calibration

Turn the HORIZONTAL DISPLAY switch to the ×100 SWEEP MAGNIFIED position. Remove the 1-msec markers and apply 10-μsec markers to the vertical input connector and adjust ×100 CAL R375 (see Fig. 5-2) for 1 marker/cm.

Repeat steps 13 and 14 as there is interaction between these adjustments.

15. Adjust Horizontal Dc Shift Compensation

Remove any signal from the vertical input connector of the TU-7; leave the TIME/CM control at 1 mSEC and set the HORIZONTAL DISPLAY switch to ×100. Turn the STABILITY control clockwise until the sweep free runs, and adjust the HORIZONTAL POSITION control so that the start of the trace coincides with one of the vertical graticule lines. Slowly turn the sweep generator off and on with the STABILITY control and observe the start of the trace for drift. Adjust DC SHIFT R365 for minimum drift in the start of the trace.

16. Adjust Sweep Length

Set the HORIZONTAL DISPLAY switch to NORMAL (×1) and apply 1 millisecond markers to the vertical input connector. Obtain a stable display with the triggering controls. Position the start of the display to the left edge of the graticule and adjust the SWP LENGTH R176 (see Fig. 5-3) for a sweep length of 10.5 CM.

17. Sweep Magnifier Registration

With 1 msec time markers applied to the vertical input connector, turn the STABILITY control fully counterclockwise but not to PRESET, and increase the intensity so that a vertical trace is visible at the left side of the graticule; then use the HORIZONTAL POSITION control to position the vertical trace to the horizontal center of the graticule. Set the HORIZONTAL DISPLAY switch to the ×100 SWEEP

MAGNIFIED position and reposition the vertical trace to the exact horizontal center of the graticule. (The HORIZONTAL POSITION controls will appear extermely sensitive to touch in the ×100 position.) Now turn the HORIZONTAL DISPLAY switch back to the NORMAL (×1) position and adjust SWP MAG REGIS R359 so that the trace falls exactly under the center graticule line. Repeat this adjustment several times to obtain exact coincidence of the trace for both positions of the HORIZONTAL DISPLAY switch. Recheck step 13 before continuing to step 18.

Set the HORIZONTAL DISPLAY switch to NORMAL (×1), the triggering controls for a stable display and the INTENSITY control for normal brilliancy. Position the start of the display to the left side of the graticule. Observe the marker that appears near the center of the graticule and position the display so that the center marker is aligned with the center graticule line. Then turn the HORIZONTAL DISPLAY switch to the ×100 SWEEP MAGNIFIED position and position the marker near the center graticule line so that the leading edge is exactly aligned with the center graticule line. Turn the HORIZONTAL DISPLAY switch through all SWEEP MAGNIFIED positions back to NORMAL (×1) and observe the leading edge of the marker; it should remain stationary, aligned with the center line of the graticule.

18. Check Sweep Rates —1 msec to 5 sec

With the HORIZONTAL DISPLAY switch set to NORMAL (×1) and the triggering control set for a stable display, check time base sweep rates according to the following table:

TIME/CM Switch Setting	Time Markers	Markers Displayed
.1 mSEC	100 μsec	1/cm
.2 mSEC	100 μsec	2/cm
.5 mSEC	500 μsec	1/cm
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

19. Check Variable Time/Cm Control and Uncalibrated Neon.

The VARIABLE control provides for a complete range of control between the calibrated TIME/CM steps. To check the operation of this control, set TIME/CM to 1 mSEC CALIBRATED. Connect 5 msec markers to the vertical input connector and trigger the oscilloscope for a stable display consisting of 1 marker/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.

Set the front-panel controls as shown in Table 5-3 before proceeding with step 20.

TABLE 5-3

Crt Controls

INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is

Time Base

TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.1 mSEC
HORIZONTAL DISPLAY	NORMAL (×1)
SINGLE SWEEP	NORMAL SWEEP

Other Controls

HORIZONTAL POSITION	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
EXTERNAL HORIZONTAL VOLTS/CM	10
VARIABLE (EXTERNAL HORIZONTAL VOLTS/ CM)	CALIBRATED
AMPLITUDE CALIBRATOR	OFF

TU-7

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

20. Adjust Time Base Sweep Rates 50 μsec/cm to 0.02 μsec/cm.

Apply 10 μsec markers from the Type 180A to the vertical input connector, and adjust the triggering controls for a stable display. Turn the HORIZONTAL DISPLAY switch to ×5 SWEEP MAGNIFIED 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 C337 (see Fig. 5-3) until the first marker of both the .1 mSEC and 50 μSEC positions occur at the same point.

Turn the HORIZONTAL DISPLAY switch to NORMAL (×1), Time Base A TIME/CM to 10 μSEC and proceed with the following adjustments:

TIME/CM Switch Setting	HORIZONTAL DISPLAY (SWEEP MAGNIFIER) Switch Setting	Time Markers	Adjustments	Observe
10 μSEC	NORMAL (×1)	10 μsec	C160E for best 10, 20 and 50 μsec timing.	1 marker/cm
5 μSEC	NORMAL (×1)	5 μsec	C160C for best 1, 2 and 5 μsec timing.	1 marker/cm
2 μSEC	×100	50 mc	*C387, C388, C394	1 cycle/cm
5 μSEC	×100	10 mc	*C368	1 cycle/2 cm
.5 μSEC	NORMAL (×1)	10 mc	C160A for best 0.5 and 0.2 μsec timing.	5 cycles/cm
.1 μSEC	NORMAL (×1)	10 mc	C361A	1 cycle/cm
.1 μSEC	×2	50 mc	**C361C	5 cycles/2 cm
.1 μSEC	×5	50 mc	†C361E	1 cycle/cm
.2 μSEC	×10	50 mc	†C361G	1 cycle/cm
.5 μSEC	×20	50 mc	†C361J	5 cycles/4 cm

*The adjustment of C368 and C387, C388, C394 interact and must be repeated several times to obtain final adjustments.

**Adjustment is made disregarding the first centimeter of sweep.

†Disregard the first 3 cm of sweep when making these adjustments.

21. Set Lockout Level Adjust

Set the HORIZONTAL DISPLAY switch at NORMAL (×1) the STABILITY control fully counterclockwise but not to PRESET, and the A TIME/CM switch at .1 mSEC. Connect a voltmeter to the cathode, pin 7, of V125 and adjust the STABILITY control to a point just before the sweep free runs; observe the voltmeter reading at this setting. Set the SINGLE SWEEP switch to SINGLE SWEEP (center position) and trigger the sweep by turning the STABILITY control fully clockwise; the READY light should extinguish indicating the sweep is now locked out. Then adjust LOCKOUT LEVEL ADJ R125 for a voltmeter reading 11 volts below (less negative) the previous reading.

Return the SINGLE SWEEP switch to the NORMAL SWEEP position. Connect a test lead between the CAL OUT connector and the vertical input connector. Set the AMPLITUDE CALIBRATOR for a 2-volt output and adjust the triggering controls and the Variable control of the TU-7 to obtain a stable one-centimeter-high display. Remove the lead from the vertical input connector, depress the SINGLE SWEEP switch to RESET and let it return to SINGLE SWEEP (center position); the READY light should ignite indicating the sweep circuit is armed. Touch the test lead to the vertical input connector to produce one sweep; the READY light should extinguish upon completion of the sweep. Then turn the STABILITY control fully counterclockwise but not to PRESET; the READY light should not ignite and the sweep should not run. Return the SINGLE SWEEP switch to NORMAL SWEEP.

22. Adjust External Horizontal Amplifier Dc Balance

Connect a jumper from the SAWTOOTH OUT to the Ext Input connector, set the Type TU-7 Test Function switch to Gain Set, the HORIZONTAL DISPLAY to EXT and turn the STABILITY control fully clockwise. Use the HORIZONTAL POSITION control to position the vertical trace to the left vertical graticule line. Now, adjust the EXT HORIZ DC BAL (see Fig. 5-3) control for no horizontal shift of the trace while turning the horizontal VARIABLE front-panel control.

23. External Horizontal Amplifier Input Gain

With conditions as in step 22, connect a jumper from CAL OUT to EXTERNAL HORIZ IN, set AMPLITUDE CALIBRATOR to .5 VOLTS, EXTERNAL HORIZONTAL VOLTS/CM to .1 and turn VARIABLE control to CALIBRATED. Adjust EXT HORIZ AMP CAL R361M (see Fig. 5-2) until 5 cm of horizontal deflection are observed between the two vertical lines. Set the AMPLITUDE CALIBRATOR control to 5 VOLTS and the EXTERNAL HORIZONTAL VOLTS/CM to 1. Check for 5 cm of horizontal deflection between the vertical lines. Switch EXTERNAL HORIZONTAL VOLTS/CM to 10 and the AMPLITUDE CALIBRATOR to 50. Horizontal deflection should be 5 cm. (Attenuator accuracy ±3%.)

24. Adjust External Horizontal Attenuator Compensation

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

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

Ajust triggering controls for a stable square wave, displayed vertical. Adjust C310 (see Fig. 5-2) for an optimum square-wave presentation. Set AMPLITUDE CALIBRATOR control to 50 VOLTS, the EXTERNAL HORIZONTAL VOLTS/CM to 10 and adjust C313 for an optimum square-wave presentation.

Set the oscilloscope and plug-in controls as described in Table 5-4 before proceeding with step 25.

TABLE 5-4

Crt Controls	
INTENSITY	Usable level
FOCUS	As is
ASTIGMATISM	As is
SCALE ILLUM	As is
Time Base	
TRIGGERING LEVEL	0
STABILITY	Clockwise
TRIGGERING MODE	AC
TRIGGER SLOPE	+INT
VARIABLE (TIME/CM)	CALIBRATED
TIME/CM	.5 mSEC
HORIZONTAL DISPLAY	NORMAL (×1)
SINGLE SWEEP	NORMAL SWEEP
Other Controls	
HORIZONTAL DISPLAY	Midrange
VERNIER (HORIZONTAL POSITION)	Midrange
EXTERNAL HORIZONTAL VOLTS/CM	10
VARIABLE (EXTERNAL HORIZONTAL VOLTS/CM)	CALIBRATED
AMPLITUDE CALIBRATOR	OFF
TU-7	
Vertical Position	Centered
Test Function	+Pulse
Amplitude	Adjust for 6 cm of signal
Repetition Rate	Low
Other Controls	As is

25. Vertical Amplifier High-Frequency Adjustments

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

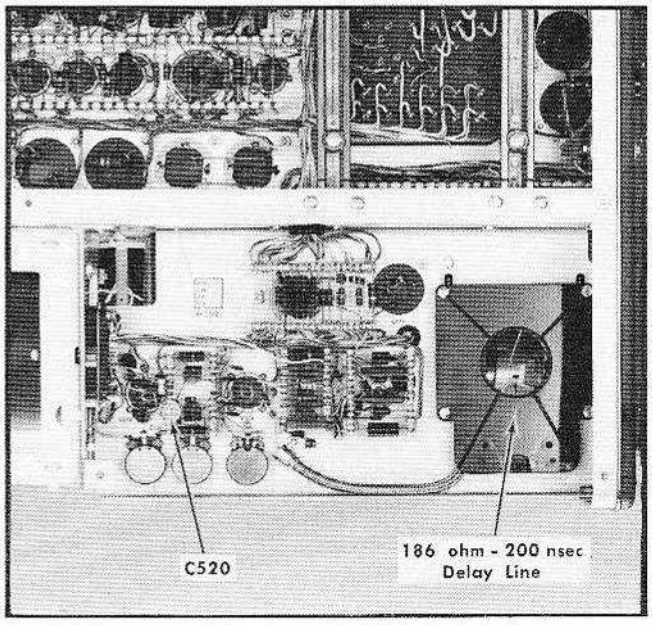


Fig. 5-5. Location of internal adjustments for the vertical input.

Set the Repetition Rate to High and the TIME/CM control to .1 μSEC. Adjust L588, L589, L598, L599, C520 and R580 for minimum rolloff or overshoot 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.

Set the TIME/CM control to 2 μSEC and adjust L560 for minimum tilt on the waveform.

Set the TIME/CM control to .2 μSEC and adjust L554 and C581 for minimum rolloff or overshoot on the front corner

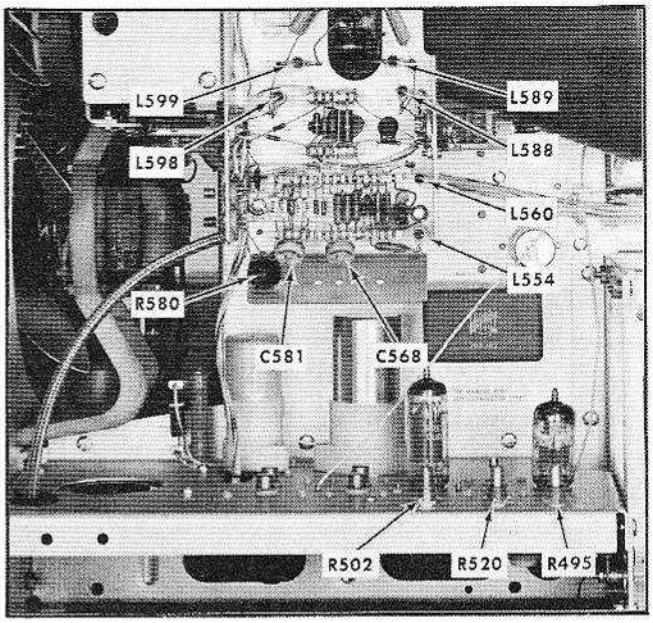


Fig. 5-6. Location of internal adjustments for the vertical output amplifier.

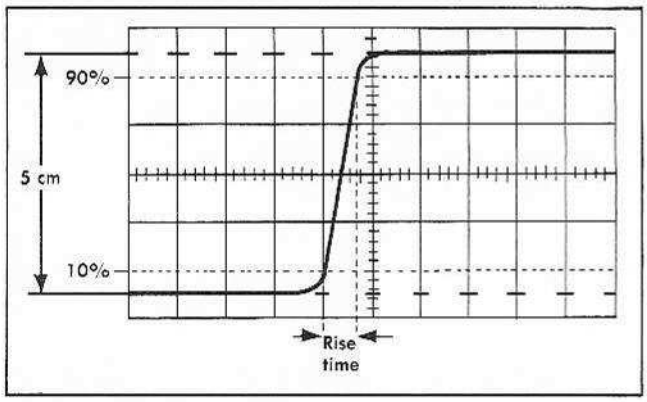


Fig. 5-7. Measuring risetime.

area. Again, be sure that the front corner does not begin to tilt up or down.

With the TIME/CM switch at .2 μSEC, adjust C568 for minimum ringing on the front corner area of the wavfeorm.

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

26. Checking Risetime

With all controls left as in step 25, set the HORIZONTAL DISPLAY switch to ×5 SWEEP MAGNIFIED. With the magnifier on and the TIME/CM control set to .1 μSEC each centimeter of horizontal deflection on the graticule represents 20 nsec.

Adjust the 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 2½ cm point above the center graticule line. The bottom of the display should now be on the long dash line 2½ 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 line, to a point near the center of the graticule where a 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 gives the risetime of the waveform. The risetime should be less than 10 nsec. 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, use the same technique as described previously. 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.

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.

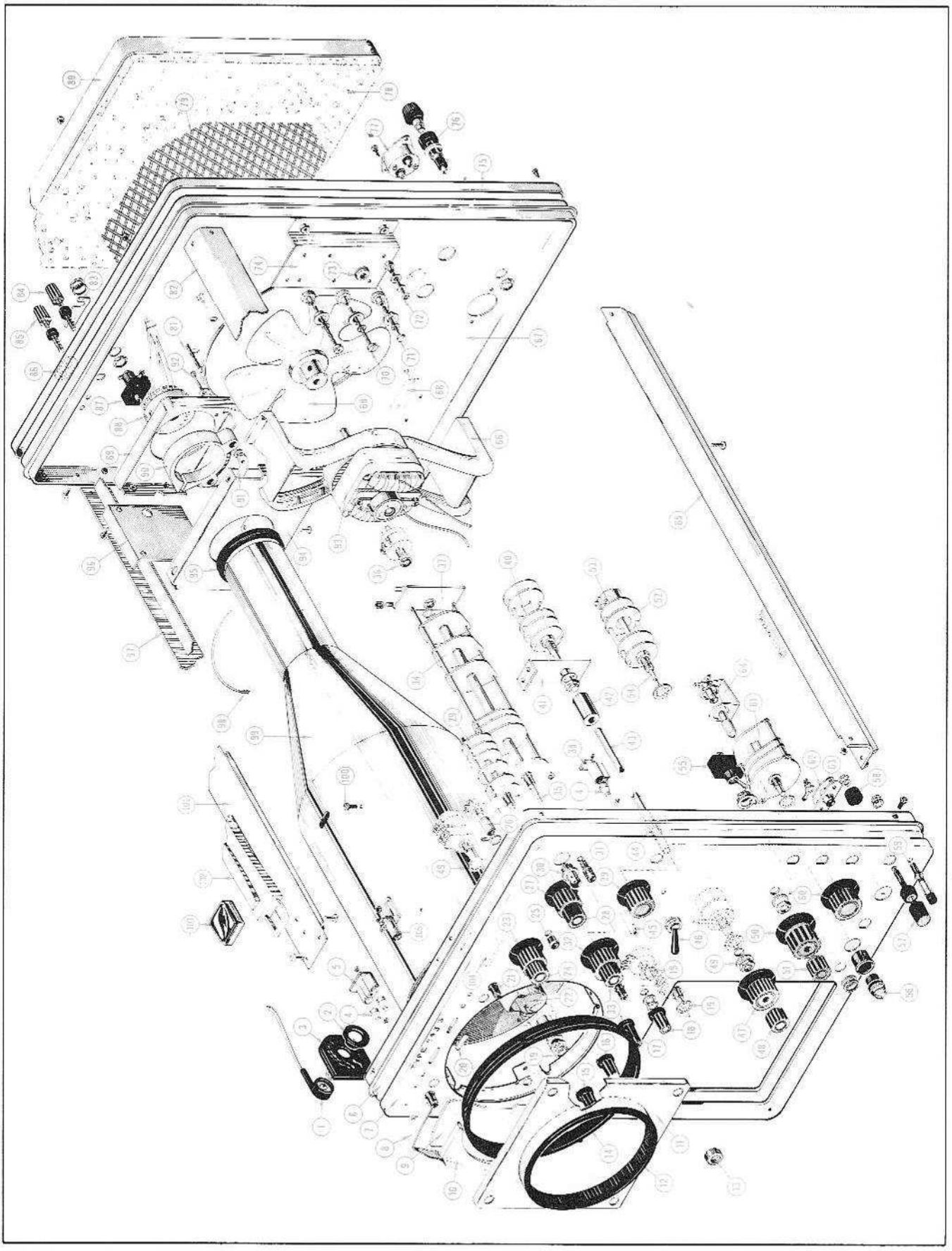
ABBREVIATIONS AND SYMBOLS

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 & REAR



FRONT & REAR

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	131-0283-00			1	CONNECTOR, anode assembly
	- - - - - -			-	Includes:
	200-0110-00			1	CAP, crt anode
	214-0357-00			1	SPRING, crt anode connector
	432-0046-00			1	BASE, crt anode and plate assembly
2	200-0112-00			1	COVER, crt anode and plate assembly
	- - - - - -			-	Consisting Of:
	200-0111-00			1	COVER, crt anode
3	386-0647-00			1	PLATE, crt anode
4	378-0541-00			8	FILTER, lens, neon light
5	352-0064-00			3	HOLDER, neon dual
	- - - - - -			-	Mounting Hardware For Each: (no included)
	211-0031-00			1	SCREW, 4-40 x 1 inch FHS
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
6	387-0950-00			1	PLATE, front sub-panel
	- - - - - -			-	Includes:
	354-0056-00			1	RING, ornamental
7	333-0836-00			1	PANEL, front
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
8	214-0433-00	100	546	1	SPRING, light reflector
	354-0262-00	547		1	RING, light plate reflector
9	- - - - - -			1	FILTER, LIGHT (see standard accessories)
10	387-0917-00	100	546	1	PLATE, light reflector
	386-0212-00	547		1	PLATE, light reflector
11	300-0382-00			1	COVER, graticule
	- - - - - -			-	Includes:
12	354-0116-00			1	RING, ornamental
	- - - - - -			-	Mounting Hardware: (not included)
13	210-0424-00			4	NUT, knurled, 3/8-24 x 9/16 inch
	210-0816-00			4	WASHER, rubber
14	354-0204-00			1	RING, shockmount
15	366-0220-00			1	KNOB, small charcoal—INTENSITY
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
16	366-0220-00			1	KNOB, small charcoal—FOCUS
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
17	366-0254-00			1	KNOB, small charcoal—ASTIGMATISM
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
18	366-0220-00			1	KNOB, small charcoal—SCALE ILLUM
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
19	- - - - - -			-	Mounting Hardware For Each Pot:
	210-0590-00			1	NUT, hex, 3/8-32 x 7/16 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
20	334-0679-00			1	TAG, metal serial number insert
	334-0829-00			1	TAG, metal blank mod. insert
21	355-0043-00			4	STUD, graticule, replacement
	- - - - - -			-	Each Includes:
	212-0507-00			1	SCREW, 10-32 x 3/8 inch BHS
	210-0010-00			1	LOCKWASHER, internal, #10
22	200-0269-00			2	COVER, pot

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
23	366-159			1	KNOB, large charcoal—TRIGGERING LEVEL
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
24	366-039			1	KNOB, small red—STABILITY
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
25	- - - -			-	Mounting Hardware For Pot:
	358-054			1	BUSHING, banana jack
	210-223			1	LUG, solder, 1/4 inch
26	210-471			1	NUT, hex, 1/4-32 x 5/16 x 19/32 inch long
	210-046			1	LOCKWASHER, internal, .400 OD x .261 inch ID
27	366-160			1	KNOB, large charcoal—TRIGGER SLOPE
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
28	366-038			1	KNOB, small red—TRIGGERING MODE
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
29	262-657			1	SWITCH, wired—TRIGGER
	- - - -			-	Includes:
	260-619			1	SWITCH, unwired—TRIGGER
	- - - -			-	Mounting Hardware: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
30	131-126			1	CONNECTOR, coaxial, chassis mounted, BNC
31	129-035			1	POST, ground, assembly
	- - - -			-	Consisting Of:
	355-507			1	STEM, adapter
	200-103			1	CAP
	210-455			1	NUT, hex, 1/4-28 x 3/8 inch
	210-046			1	LOCKWASHER, internal, .400 OD x .261 inch ID
32	366-144			1	KNOB, large charcoal—TIME/CM
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
33	366-038			1	KNOB, small red—VARIABLE
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
34	262-244			1	SWITCH, wired—TIME/CM
	- - - -			-	Includes:
	260-230			1	SWITCH, unwired—TIME/CM
35	384-162			1	ROD, extension
	376-014			1	COUPLING, pot
36	- - - -			-	Mounting Hardware For Pot:
	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
37	406-316			1	BRACKET, time/cm switch
	- - - -			-	Mounting Hardware: (not included)
	210-449			2	NUT, hex, 5-40 x 1/4 inch
	210-202			1	LUG, solder, SE #6
	210-203			1	LUG, solder, SE #6 long
	- - - -			-	Mounting Hardware For Switch: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	210-803			1	WASHER, 6L x 3/8 inch
	210-457			2	NUT, keps, 6-32 x 5/16 inch

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
38	352-067			2	HOLDER, single neon
	- - - -			-	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
39	366-117			1	KNOB, large charcoal — HORIZONTAL DISPLAY
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
40	262-664			1	SWITCH, wired — HORIZONTAL DISPLAY
	- - - -			-	Includes:
	260-210			1	SWITCH, unwired — HORIZONTAL DISPLAY
	- - - -			-	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
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
41	406-349			1	BRACKET, switch
	- - - -			-	Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
42	376-007			1	COUPLING, aluminum
	- - - -			-	Includes:
	213-005			2	SCREW, set, 8-32 x 1/8 inch HSS
43	384-165			1	ROD, extension
44	358-029			1	BUSHING, hex, 3/8-32 x 13/32 inch
	- - - -			-	Mounting Hardware: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
45	385-135			1	ROD, delrin, 15/16 inch
	- - - -			-	Mounting Hardware: (not included)
	213-068			1	SCREW, thread cutting, 6-32 x 5/16 inch FHS phillips
46	260-190			1	SWITCH, lever — SINGLE SWEEP
	- - - -			-	Mounting Hardware: (not included)
	210-473			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
	210-902			1	WASHER, .470 ID x 21/32 inch OD
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
47	366-159			1	KNOB, large charcoal — HORIZONTAL POSITION
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
48	366-039			1	KNOB, small red — VERNIER
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
49	- - - -			-	Mounting Hardware For Each Pot:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-207			1	LUG, solder, 3/8 inch
50	366-160			1	KNOB, large charcoal — EXTERNAL HORIZONTAL VOLTS/CM
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
51	366-038			1	KNOB, small red — VARIABLE
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
52	262-663			1	SWITCH, wired — EXTERNAL HORIZONTAL VOLTS/CM
	- - - -			-	Includes:
	260-207			1	SWITCH, unwired — EXTERNAL HORIZONTAL VOLTS/CM
53	- - - -			-	Mounting Hardware For Pot:
	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
54	384-100			1	ROD, extension
	376-014			1	COUPLING, pot
	- - - -			-	Mounting Hardware For Switch: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
55	260-199			1	SWITCH, toggle — POWER ON
	- - - -			-	Mounting Hardware: (not included)
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
	354-055			1	RING, locking, switch
	210-902			1	WASHER, .470 ID x 21/32 inch OD
	210-473			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
56	378-518			1	JEWEL, pilot light, red
57	129-063			4	POST, binding, charcoal
	- - - -			-	Mounting Hardware For Each: (not included)
58	358-169			1	BUSHING, binding post
	220-410			1	NUT, keps, 10-32 x 3/8 inch
59	129-051			2	POST, binding, assembly
	- - - -			-	Each Consisting Of:
	355-507			1	STEM, adapter
	200-182			1	CAP
	- - - -			-	Mounting Hardware For Each: (not included)
	210-455			1	NUT, hex, 1/4-28 x 3/8 inch
	210-223			1	LUG, solder, 1/4 inch
60	366-115			1	KNOB, large charcoal — AMPLITUDE CALIBRATOR
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
61	262-654			1	SWITCH, wired — AMPLITUDE CALIBRATOR
	- - - -			-	Includes:
	260-253			1	SWITCH, unwired — AMPLITUDE CALIBRATOR
	210-207			1	LUG, solder, 3/8 inch
	- - - -			-	Mounting Hardware: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
62	131-279			1	CONNECTOR, chassis mounted, female, BNC
	- - - -			-	Mounting Hardware: (not included)
	211-025			2	SCREW, 4-40 x 3/8 inch FHS
	210-812			2	WASHER, fiber, #10
	210-224			2	LUG, solder, #10 non-locking
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
63	406-244			1	BRACKET, nylon, coaxial insulator
64	136-025			1	SOCKET, light
65	122-108			2	ANGLE, rail, bottom
	- - - -			-	Mounting Hardware For Each: (not included)
	212-039			4	SCREW, 8-32 x 3/8 inch THS phillips
	210-458			4	NUT, keps, 8-32 x 11/32 inch

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
66	426-193			1	MOUNT, fan motor
	- - - -			-	Mounting Hardware: (not included)
	212-023			4	SCREW, 8-32 x 3/8 inch BHS
67	387-758			1	PLATE, rear sub-panel
	- - - -			-	Includes:
	354-056			1	RING, ornamental
68	334-904			1	TAG, voltage rating
	- - - -			-	Mounting Hardware: (not included)
	213-088			2	SCREW, thread forming, 4-40 x 1/4 inch PHS phillips
69	369-007			1	FAN, 7 inch
70	- - - -			-	Mounting Hardware For 20-Watt Resistor:
	212-037			1	SCREW, 8-32 x 1 3/4 inches Fil HS
	210-808			1	WASHER, resistor centering
	210-462			1	NUT, hex, resistor mounting
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
71	- - - -			-	Mounting Hardware For Each 25-Watt Resistor:
	212-037			1	SCREW, 8-32 x 1 3/4 inches Fil HS
	210-809			1	WASHER, resistor centering
	210-008			1	LOCKWASHER, internal, #8
	210-462			1	NUT, hex, resistor mounting
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
72	- - - -			-	Mounting Hardware For 8-Watt Resistor:
	211-544			1	SCREW, 6-32 x 3/4 inch THS phillips
	210-886			1	WASHER, centering, 3/8 OD x 1/8 inch thick
	210-805			1	WASHER, 10S x 7/16 inch
	210-478			1	NUT, hex, resistor mounting
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
73	348-056			2	GROMMET, delrin, .406 OD x .353 inch ID
74	407-027			1	BRACKET, shunt resistor
	- - - -			-	Mounting Hardware: (not included)
	211-537			2	SCREW, 6-32 x 3/8 inch THS phillips
75	387-945			1	PLATE, rear overlay
	- - - -			-	Mounting Hardware: (not included)
	213-104			4	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
76	352-002			1	HOLDER, fuse, assembly
	- - - -			-	Consisting Of:
	352-010			1	HOLDER, fuse
	200-582			1	CAP, fuse
	210-873			1	WASHER, rubber, 1/2 ID x 11/16 inch OD
	NO NUMBER			1	NUT, fuse holder
77	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
	- - - -			-	Mounting Hardware: (not included)
	213-104			2	SCREW, thread forming, 6-32 x 3/8 inch THS phillips

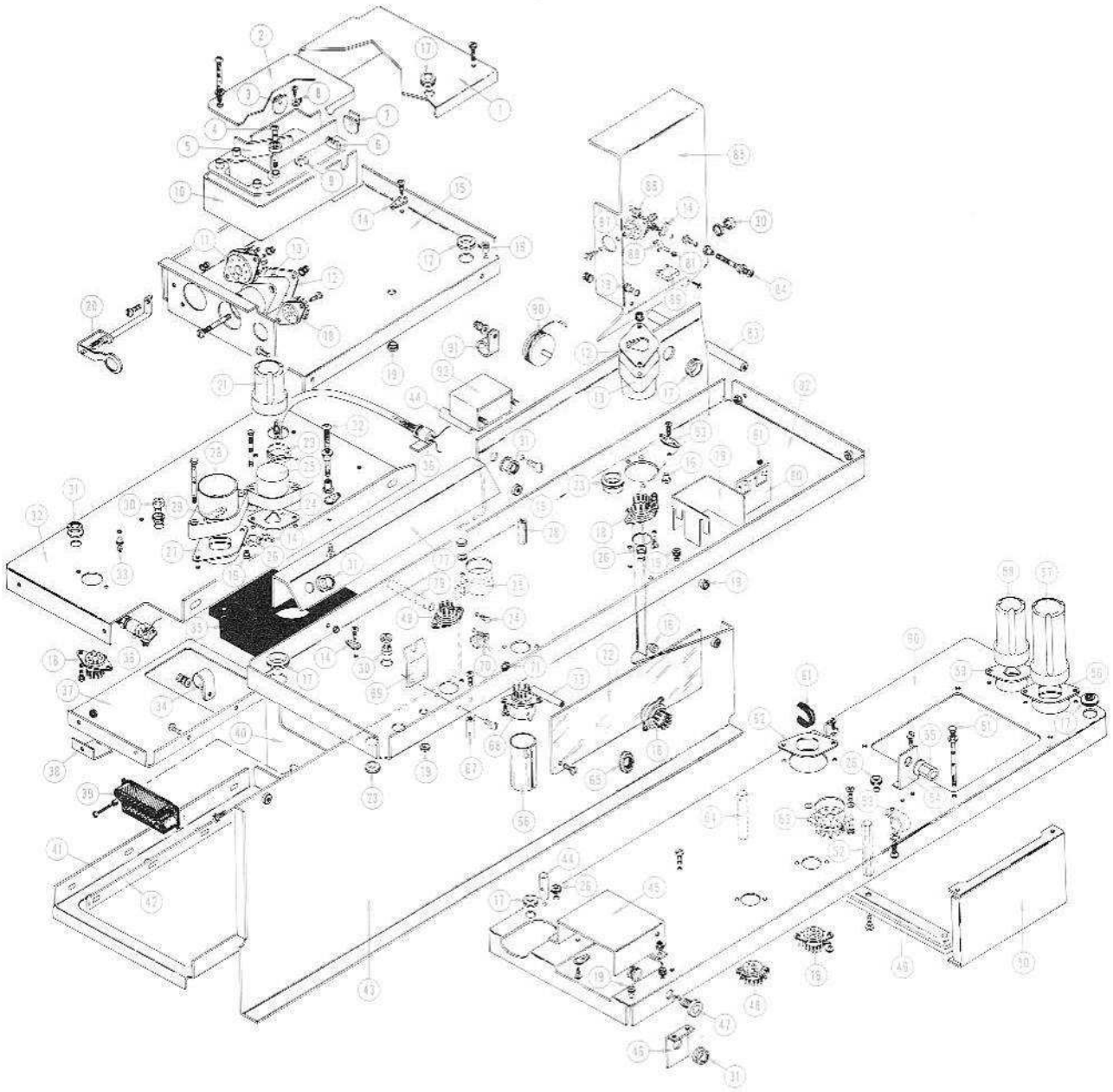
FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
78	378-023			1	FILTER, air, foam
79	378-762			1	SCREEN, filter
	- - - -			-	Mounting Hardware: (not included)
	213-104			4	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
80	380-018			1	HOUSING, air filter
	- - - -			-	Mounting Hardware: (not included)
81	212-031			2	SCREW, 8-32 x 1 1/4 inches RHS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	210-402			2	NUT, cap, hex, 8-32 x 5/16 inch
82	122-019			1	ANGLE, frame, top right
	- - - -			-	Mounting Hardware: (not included)
	211-559			4	SCREW, 6-32 x 3/8 inch FHS phillips
	210-457			4	NUT, keps, 6-32 x 5/16 inch
83	346-027			1	STRAP, ground
84	129-064			1	POST, binding
	- - - -			-	Mounting Hardware: (not included)
	358-181			1	BUSHING, charcoal, binding post
	210-457			1	NUT, keps, 6-32 x 5/16 inch
85	129-064			1	POST, binding
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
86	387-853			1	PLATE, binding post mounting
87	260-209			1	SWITCH, toggle — CRT CATHODE SELECTOR
	- - - -			-	Mounting Hardware: (not included)
	210-414			1	NUT, hex, 15/32-32 x 9/16 inch
	210-902			1	WASHER, .470 ID x 21/32 inch OD
	210-473			1	NUT, switch, 15/32-32 x 5/64 inch
88	136-191			1	SOCKET, crt, assembly
	- - - -			-	Includes:
	136-117			1	SOCKET, crt, raw
	131-178			8	CONNECTOR, cable end, crt
	387-393			1	PLATE, back, crt socket
	- - - -			-	Mounting Hardware: (not included)
	213-086			2	SCREW, thread cutting, 2-32 x 7/16 inch PHS
89	406-944			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
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
90	354-215			1	RING, crt, clamping, assembly
	- - - -			-	Consisting Of:
	354-211			1	RING, clamping
	211-560			1	SCREW, 6-32 x 1 inch RHS
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	124-160			1	STRIP, liner, crt clamp
91	214-207			1	NUT, adjusting, securing
	- - - -			-	Mounting Hardware: (not included)
92	211-576			2	SCREW, 6-32 x 7/8 inch socket head
	210-949			4	WASHER, 9/64 ID x 1/2 inch OD
93	147-026			1	MOTOR, fan
	- - - -			-	Mounting Hardware: (not included)
	210-458			4	NUT, keps, 8-32 x 11/32 inch

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
94	406-0936-00			1	BRACKET, crt
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			1	NUT, hex, 8-32 x 11/32 inch
	210-0804-00			1	WASHER, 8S x 3/8 inch
	212-0004-00			5	SCREW, 8-32 x 5/16 inch BHS
95	252-0547-00			FT	VINYL, extruded channel (8 1/2 inches)
96	406-0995-00			1	BRACKET, support
	- - - - - -			-	Mounting Hardware: (not included)
	212-0023-00			4	SCREW, 8-32 x 5/16 inch BHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	210-0804-00			2	WASHER, 8S x 3/8 inch
97	122-0109-00			1	ANGLE, rail, top left
	- - - - - -			-	Mounting Hardware: (not included)
	211-0559-00			4	SCREW, 6-32 x 3/8 inch FHS phillips
	210-0457-00			4	NUT, keps, 6-32 x 5/16 inch
98	175-0589-00			1	WIRE, crt lead, 1.380 feet, striped orange, with connector
	175-0592-00			1	WIRE, crt lead, .960 foot, striped green, with connector
	175-0595-00			1	WIRE, crt lead, .960 foot, striped red, with connector
	175-0641-00			1	WIRE, crt lead, .833 foot, striped brown with connector
	175-0642-00			1	WIRE, crt lead, .833 foot, striped blue, with connector
99	337-0620-00			1	SHIELD, crt
	- - - - - -			-	Mounting Hardware: (not included)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch BHS
100	- - - - - -			-	Mounting Hardware For Trace Rotator Coil:
	211-0589-00	100	349	3	SCREW, 6-32 x 5/16 inch BHB
	211-0596-00	350		3	SCREW, 6-32 x 3/8 inch PHB, phillips
	210-0811-00	X350		3	WASHER, fiber, #6
	210-0803-00	X350		3	WASHER, 6L x 3/8 inch
	210-0407-00	100	349	3	NUT, hex., 6-32 x 1/4 inch
	210-0457-00	350		3	NUT, keps, 6-32 x 5/16 inch
101	381-0217-00			1	BAR, top support, with handle
	- - - - - -			-	Includes:
102	367-0037-00			2	HANDLE
103	344-0098-00			4	CLIP, handle
	- - - - - -			-	Mounting Hardware: (not included)
	212-0566-00			1	SCREW, 10-32 x 5/16 inch RHS, phillips
	- - - - - -			-	Mounting Hardware For Bar: (not included)
104	381-0073-00			2	BAR, retaining
	212-0039-00			4	SCREW, 8-32 x 3/8 inch THS phillips
105	136-0001-00			2	SOCKET, graticule lamp
	- - - - - -			-	Mounting Hardware For Each: (not included)
	211-0534-00			1	SCREW, 6-32 x 5/16 inch PHS with lockwasher
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	166-0328-00			2	SLEEVE, insulating, graticule lamp

CHASSIS



CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
1	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
2	200-475			1	COVER, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-553			2	SCREW, 6-32 x 1 1/2 inches THS phillips
	210-801			2	WASHER, 5S x 9/32 inch
3	166-319			2	SLEEVE, high voltage
4	- - - -			-	Mounting Hardware For High Voltage Transformer:
	211-553			2	SCREW, 6-32 x 1 1/2 inches THS phillips
	210-801			2	WASHER, 5S x 9/32 inch
	358-228			2	BUSHING, insulator
5	392-147			1	BOARD, high voltage, assembly
	- - - -			-	Includes:
6	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, .063 inch
	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
7	166-357			1	SLEEVE, high voltage anode lead
8	210-261			2	LUG, solder, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-587			1	SCREW, 6-32 x 7/32 inch HHS
9	210-966			2	WASHER, insulating, rubber, 7/8 OD x 7/16 inch ID
10	380-048			1	HOUSING, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
11	136-011			1	SOCKET, STM8
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
12	386-253			2	PLATE, metal, small capacitor
13	432-047			2	BASE, small capacitor mounting
	- - - -			-	Mounting Hardware For Each: (not included)
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
14	210-201			10	LUG, solder, SE #4
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
15	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
16	348-031			5	GROMMET, plastic snap-in
17	348-063			8	GROMMET, delrin, 1/2 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
18	136-0015-00			22	SOCKET, STM9G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
19	348-0055-00			20	GROMMET, delrin, 1/4 inch
20	343-0095-00			1	CLAMP, tube
	- - - - - -			-	Mounting Hardware: (not included)
	211-0008-00			1	SCREW, 4-40 x 1/4 inch BHS
	210-0004-00			1	LOCKWASHER, internal, #4
	210-0406-00			1	NUT, hex, 4-40 x 3/16 inch
21	200-0257-00			1	COVER, capacitor
22	- - - - - -			-	Mounting Hardware For 10-Watt Resistor:
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches THS phillips
	210-0601-00			1	EYELET
	210-0478-00			1	NUT, hex, resistor mounting
	210-0202-00			1	LUG, solder, SE #6
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
23	348-0050-00			3	GROMMET, delrin, 3/4 inch
24	386-0252-00			1	PLATE, fiber, small capacitor
25	432-0047-00			1	BASE, small capacitor mounting
	- - - - - -			-	Mounting Hardware: (not included)
	211-0588-00			2	SCREW, 6-32 x 3/4 inch HHS
	210-0006-00			2	LOCKWASHER internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
26	348-0056-00			6	GROMMET delrin, 3/8 inch
27	386-0255-00			1	PLATE, metal, large capacitor
28	432-0048-00			1	BASE, large capacitor mounting
	- - - - - -			-	Mounting Hardware: (not included)
	211-0588-00			2	SCREW, 6-32 x 3/4 inch HHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
29	210-0204-00	100	639	1	LUG, solder, DE #6
	210-0201-00	640		1	LUG, solder, SE #4
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
30	136-0181-00			11	SOCKET, transistor, 3 pin
	- - - - - -			-	Mounting Hardware For Each:: (not included)
	354-0234-00			1	RING, insulator
31	- - - - - -			-	Mounting Hardware For Each Pot:
	210-0413-00			1	NUT, hex, 3/8 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
32	441-0562-00			1	CHASSIS, vertical amplifier
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			5	SCREW, 8-32 x 5/16 inch BHS
	212-0040-00			1	SCREW, 8-32 x 3/8 inch FHS phillips
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch
33	131-0181-00			2	CONNECTOR, terminal standoff
	- - - - - -			-	Mounting Hardware For Each: (not included)
	358-0136-00			1	BUSHING, teflon
34	343-0004-00			1	CLAMP, cable, 5/16 inch
	- - - - - -			-	Mounting Hardware: (not included)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
35	119-034			1	DELAY LINE, assembly
	- - - -			-	Includes:
	380-049			1	HOUSING, delay line
	200-482			1	COVER, delay line housing
	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
36	131-271			2	CONNECTOR, right hand
	- - - -			-	Mounting Hardware: (not included)
	210-006			5	LOCKWASHER, internal, #6
	210-202			1	LUG, solder, SE #6
	210-407			6	NUT, hex, 6-32 x 1/4 inch
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
37	387-754			1	PLATE, plug-in housing, top
	- - - -			-	Mounting Hardware: (not included)
	210-458			4	NUT, keps, 8-32 x 11/32 inch
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	212-023			2	SCREW, 8-32 x 3/8 inch BHS
	212-040			2	SCREW, 8-32 x 3/8 inch FHS phillips
38	344-097			2	CLIP, grounding
39	131-018			1	CONNECTOR, chassis mounted, 16 contact, female
	- - - -			-	Mounting Hardware: (not included)
	211-015			2	SCREW, 4-40 x 1/2 inch RHS
	166-107			2	TUBE, spacing, 7/32 inch
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
40	387-753			1	PLATE, plug-in housing, back
	- - - -			-	Mounting Hardware: (not included)
	212-004			3	SCREW, 8-32 x 5/16 inch BHS
	212-039			1	SCREW, 8-32 x 3/8 inch THS phillips
	210-458			1	NUT, keps, 8-32 x 11/32 inch
41	387-755			1	PLATE, plug-in housing, bottom
	- - - -			-	Mounting Hardware: (not included)
	212-023			2	SCREW, 8-32 x 3/8 inch BHS
	212-040			2	SCREW, 8-32 x 3/8 inch FHS phillips
	210-205			1	LUG, solder, SE #8
	210-458			4	NUT, keps, 8-32 x 11/32 inch
42	351-058			4	GUIDE, shoe
43	387-946			1	PLATE, vertical bulkhead
	- - - -			-	Mounting Hardware: (not included)
	212-004			3	SCREW, 8-32 x 5/16 inch BHS
	212-040			4	SCREW, 8-32 x 3/8 inch FHS phillips
	210-458			4	NUT, keps, 8-32 x 11/32 inch
44	385-135			2	ROD, delrin, 15/16 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	213-041			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
45	337-291			1	SHIELD, upper calibrator switch
	- - - -			-	Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
	210-202			1	LUG, solder, SE #6
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
46	406-0022-00			1	BRACKET, pot
	- - - - - -			-	Mounting Hardware: (not included)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
47	136-0037-00			1	SOCKET, tip jack
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
48	136-0008-00			11	SOCKET, STM7G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
49	381-0221-00			2	BAR, transformer support
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0033-00			2	SCREW, 8-32 x 3/4 inch BHS
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0509-00			1	SCREW, 10-32 x 5/8 inch BHS
	212-0534-00			1	SCREW, 10-32 x 1 inch BHS
50	406-0928-00			1	BRACKET, transformer
51	- - - - - -			-	Mounting Hardware For Transformer:
	212-0524-00			4	SCREW, 10-32 x 3 1/4 inches HHS
	210-0812-00			4	WASHER, fiber, #10
	210-0010-00			4	LOCKWASHER, internal, #10
	210-0564-00			2	NUT, hex, 10-32 x 3/8 inch
52	384-0612-00			2	ROD, transformer standoff
53	343-0006-00	100	238X	1	CLAMP, cable, 1/2 inch
	- - - - - -			-	Mounting Hardware: (not included)
	212-0008-00			1	SCREW, 8-32 x 1/2 inch BHS
	210-0863-00			1	WASHER, "D" type
	210-0458-00			1	NUT, hex, 8-32 x 11/32 inch
54	406-0108-00			1	BRACKET, —150 adj. pot
	- - - - - -			-	Mounting Hardware: (not included)
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
55	- - - - - -			-	Mounting Hardware For Pot:
	210-0444-00			1	NUT, hex, 3/8-32 x 1/2 x 5/8 inch long
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
56	386-0254-00			3	PLATE, fiber, large capacitor
	- - - - - -			-	Mounting Hardware For Each: (not included)
	211-0543-00			2	SCREW, 6-32 x 5/16 inch RHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
57	200-0258-00			3	COVER, capacitor
58	200-0256-00			1	COVER, small capacitor
59	386-0252-00			1	PLATE, fiber, small capacitor
	- - - - - -			-	Mounting Hardware: (not included)
	211-0534-00			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
60	441-238			1	CHASSIS, power
	- - - -			-	Mounting Hardware: (not included)
	212-023			6	SCREW, 8-32 x 3/8 inch BHS
	212-040			5	SCREW, 8-32 x 3/8 inch FHS phillips
	210-458			11	NUT, keps, 8-32 x 11/32 inch
61	358-166			1	BUSHING, plastic, black
62	386-255			3	PLATE, metal, large capacitor
	- - - -			-	Mounting Hardware For Each: (not included)
	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
63	136-011			2	SOCKET, STM8
	- - - -			-	Mounting Hardware For Each: (not included)
	211-538			2	SCREW, 6-32 x 5/16 inch FHS phillips
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
64	385-138			1	ROD, delrin, 1 9/16 inches
	- - - -			-	Mounting Hardware: (not included)
	213-041			1	SCREW, thread cutting, 6-32 x 3/8 inch THS phillips
65	348-051			1	GROMMET, rubber, 1 1/8 inches
66	337-007			2	SHIELD, tube
67	385-134			2	ROD, delrin
	- - - -			-	Mounting Hardware For Each: (not included)
	213-104			1	SCREW, thread forming, 6-32 x 3/8 inch THS phillips
68	136-010			2	SOCKET, 7 pin
	- - - -			-	Mounting Hardware For Each: (not included)
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
	210-004			1	LOCKWASHER, internal, #4
	210-201			1	LUG, solder, SE #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
69	386-768			1	PLATE, pot mounting
	- - - -			-	Mounting Hardware: (not included)
	211-007			2	SCREW, 4-40 x 3/16 inch BHS
70	343-089			4	CLAMP, cable, delrin, size "D"
71	- - - -			-	Mounting Hardware For Relay:
	211-503			2	SCREW, 6-32 x 3/16 inch BHS
72	337-656			1	SHIELD, rectifier
	- - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
73	166-099			3	TUBE, spacer
	- - - -			-	Mounting Hardware For Each: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
74	- - - -			-	Mounting Hardware For Thermal Cutout Switch:
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
75	343-036			1	CLAMP, stainless steel
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-504			1	SCREW, 6-32 x 1/4 inch BHS
	214-012			1	BOLT, spade, 6-32 x 3/8 inch
76	385-137			1	ROD, delrin, 2 1/4 inches
	- - - -			-	Mounting Hardware: (not included)
	213-041			1	SCREW, thread cutting, 6-32 x 3/8 inch PHS phillips

CHASSIS *(Cont'd)*

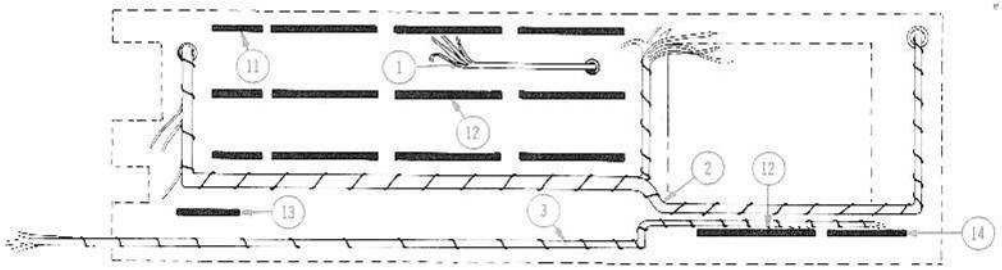
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
77	407-029			1	BRACKET, seven pot
	- - - -			-	Mounting Hardware: (not included)
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
78	384-542			2	ROD, capacitor mounting
	- - - -			-	Mounting Hardware For Each: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
79	337-215			1	SHIELD, horizontal amplifier
80	407-030			1	BRACKET, two pot
	- - - -			-	Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
	210-202			1	LUG, solder, SE #6
	210-457			2	NUT, keps, 6-32 x 5/16 inch
81	- - - -			-	Mounting Hardware For Each Miniature Pot:
	210-438			2	NUT, hex, 1-72 x 5/32 inch
82	441-561			1	CHASSIS, sweep
	- - - -			-	Mounting Hardware: (not included)
	212-040			4	SCREW, 8-32 x 3/8 inch FHS phillips
	210-458			2	NUT, keps, 8-32 x 11/32 inch
83	384-628			1	ROD, support
	- - - -			-	Mounting Hardware: (not included)
	212-004			1	SCREW, 8-32 x 5/16 inch BHS
84	- - - -			-	Mounting Hardware For 10-Watt Resistor:
	211-553			1	SCREW, 6-32 x 1 1/2 inches THS phillips
	210-601			1	EYELET
	210-478			1	NUT, hex, resistor mounting
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
85	441-563			1	CHASSIS, output vertical amplifier
	- - - -			-	Mounting Hardware: (not included)
	212-004			2	SCREW, 8-32 x 5/16 inch BHS
	212-023			1	SCREW, 8-32 x 3/8 inch BHS
	210-458			2	NUT, keps, 8-32 x 11/32 inch
86	- - - -			-	Mounting Hardware For Each Coil:
	213-035			1	SCREW, thread cutting, 4-40 x 1/4 inch PHS phillips
87	136-072			2	SOCKET, 9 pin UHF
	- - - -			-	Mounting Hardware For Each: (not included)
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
88	426-121			1	MOUNT, toroid
	- - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon, .063 inch
89	406-635			1	BRACKET, low capacity pot mounting
	- - - -			-	Mounting Hardware: (not included)
	213-035			2	SCREW, thread cutting, 4-40 x 1/4 inch PHS phillips
90	214-210			1	SPOOL, solder, assembly
	- - - -			-	Includes:
	214-209			1	SPOOL, solder
	- - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon, .063 inch

CHASSIS *(Cont'd)*

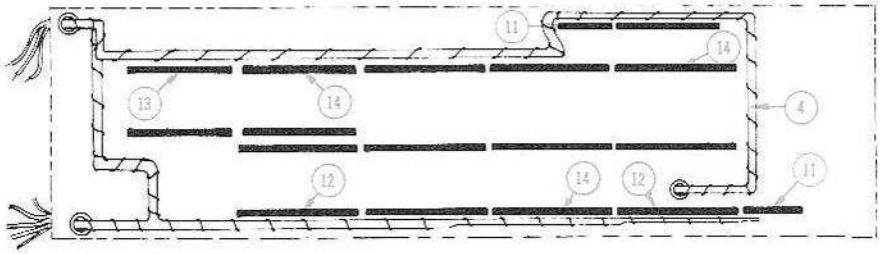
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
91	343-0004-00			1	CLAMP, cable, 5/16 inch
	- - - - - -			-	Mounting Hardware: (not included)
	211-0510-00			1	SCREW, 6-32 x 3/8 inch BHS
	210-0803-00			1	WASHER, 6L x 3/8 inch
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
92	202-0102-00			1	CAN, relay cover
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
93	210-0204-00			1	LUG, solder, DE6
	- - - - - -			-	Mounting Hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread forming, 5-32 x 3/46 inch PHS, phillips

CABLE HARNESS & CERAMIC STRIP DETAIL

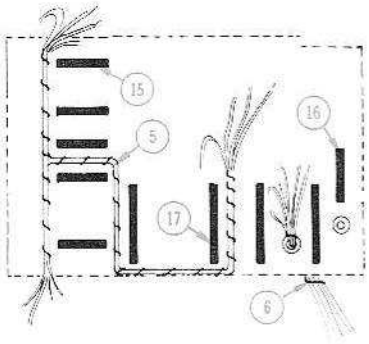
POWER CHASSIS



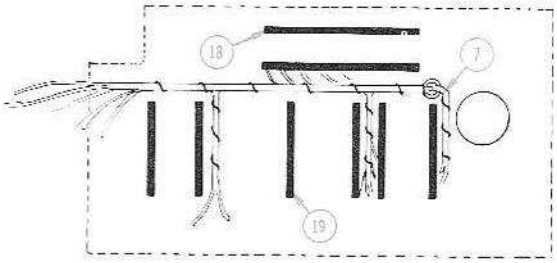
SWEEP "A" CHASSIS



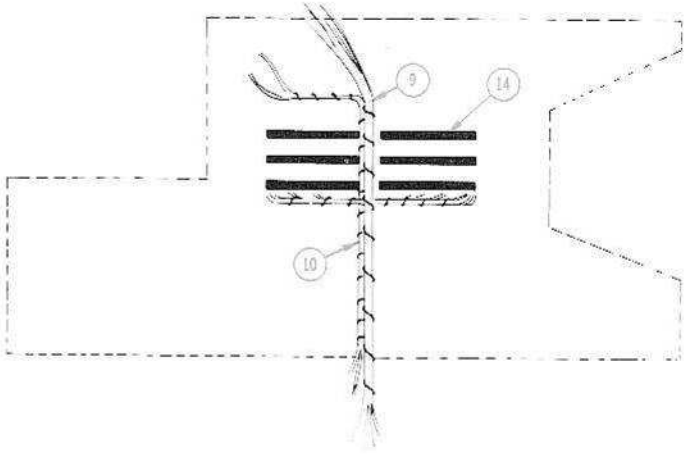
HIGH VOLTAGE CHASSIS



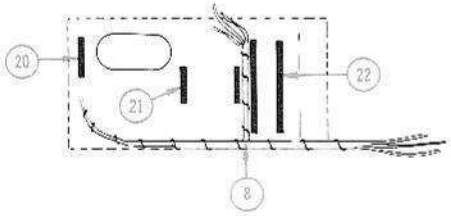
VERTICAL AMPLIFIER CHASSIS



BULKHEAD



OUTPUT VERTICAL AMPLIFIER CHASSIS



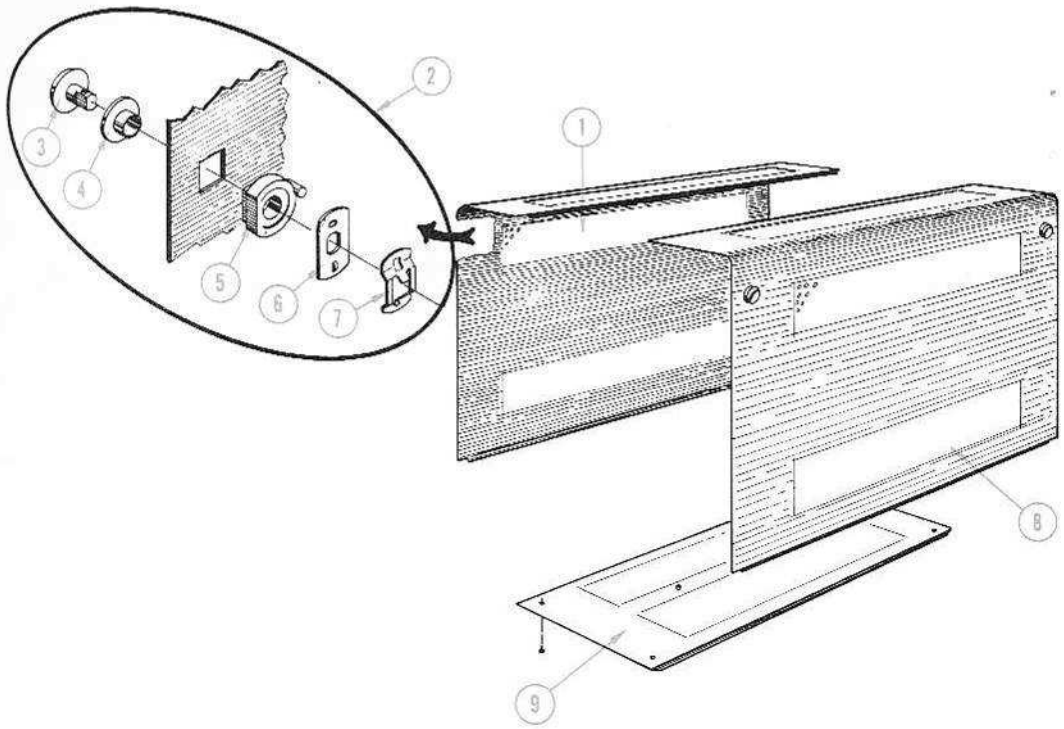
CABLE HARNES & CERAMIC STRIP DETAIL

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-0324-00			1	CABLE HARNESS, power #2
2	179-0906-00			1	CABLE HARNESS, power
3	179-0306-00			1	CABLE HARNESS, 110-volt power
4	179-0905-00	100	299	1	CABLE HARNESS, sweep
	179-0926-00	300		1	CABLE HARNESS, sweep
5	179-0904-00	100	419	1	CABLE HARNESS, high voltage
	179-0767-00	420		1	CABLE HARNESS, high voltage
6	179-0899-00			1	CABLE HARNESS, focus and intensity
7	179-0901-00			1	CABLE HARNESS, lower vertical amplifier
8	179-0900-00			1	CABLE HARNESS, upper vertical amplifier
9	179-0894-00			1	CABLE HARNESS, rectifier
10	179-0895-00			1	CABLE HARNESS, rectifier 110-volt
11	124-0088-00			5	STRIP, ceramic, 3/4 inch x 4 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch
12	124-0091-00			18	STRIP, ceramic, 3/4 inch x 11 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch
13	124-0089-00			3	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch
14	124-0090-00			13	STRIP, ceramic, 3/4 inch x 9 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch
15	124-0093-00			5	STRIP, ceramic, 7/16 inch x 5 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch
16	124-0120-00			1	STRIP, ceramic, 7/16 inch x 4 notches
	- - - - - -			-	Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .156 inch
17	124-0089-00			4	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0008-00			2	SPACER, nylon, .156 inch
18	124-0145-00			2	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon, .281 inch

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

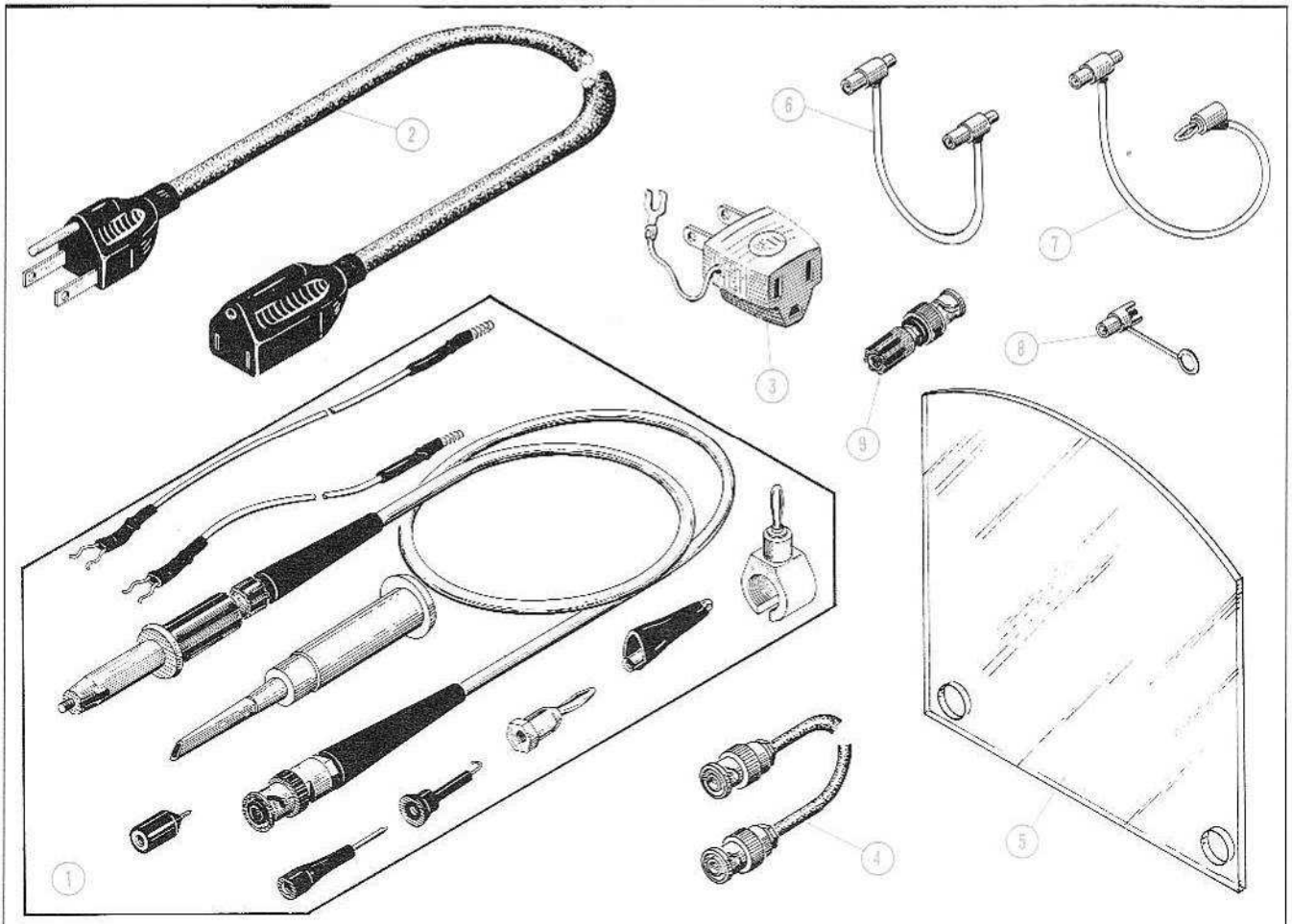
REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
19	124-147			6	STRIP, ceramic, 7/16 inch x 13 notches
	- - - -			-	Each Includes:
	355-046			2	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			2	SPACER, nylon, .281 inch
20	124-087			1	STRIP, ceramic, 3/4 inch x 3 notches
	- - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - -			-	Mounting Hardware For Each: (not included)
	361-009			1	SPACER, nylon, .281 inch
21	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, .281 inch
22	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, .281 inch

CABINET



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	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. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	010-0127-00			2	PROBE, package, P6006
2	161-0010-00			1	CORD, power
3	103-0013-00			1	ADAPTER, 3 to 2 wire
4	012-0076-00			1	CABLE, 50 Ω
5	387-0918-00			1	PLATE, protector
	378-0546-00	100	612	1	FILTER, light, smoke gray (installed)
	378-0567-00	613		1	FILTER, light, smoke gray (installed)
6	012-0031-00	100	381	1	CORD, patch
	012-0087-00	382		1	CORD, patch
7	012-0091-00	X382		1	CORD, patch
8	012-0092-00	X382		1	JACK, BNC — post
9	103-0033-00	100	381X	2	ADAPTER, BNC to binding post (not shown)
	103-0015-00	100	381X	2	ADAPTER, BNC to UHF (not shown)
- -	070-0429-00			2	MANUAL, instruction (not shown)

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			S/N Range
		Bulbs			
B129	150-030	Neon, NE-2V	READY		
B160W	150-030	Neon, NE-2V	UNCALIBRATED		
B167	150-027	Neon, NE-23			
B170	150-027	Neon, NE-23			
B361V	150-030	Neon, NE-2V	UNCALIBRATED		
B361Z	150-030	Neon, NE-2V	MAGNIFIER		
B380	150-030	Neon, NE-2V			
B390	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):

3 V — 50 V = −10%, +250%
51 V — 350 V = −10%, +100%
351 V — 450 V = −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	
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%	101-489
C49	290-0287-00	47 μf	EMT	25 v		490-up
C116	283-000	0.001 μf	Cer	500 v		
C117	283-000	0.001 μf	Cer	500 v		
C122	281-525	470 pf	Cer	500 v		
C124	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	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
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					
C160H		0.1 μf		Timing Series		±½%	
C160J		1 μf					
C160K	281-543	270 pf	Cer		500 v	10%	
C165	281-528	82 pf	Cer		500 v	10%	
C167	283-000	0.001 μf	Cer		500 v		
C174	281-513	27 pf	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		
C191	283-000	0.001 μf	Cer		500 v		
C195	281-509	15 pf	Cer		500 v	10%	
C198	283-001	0.005 μf	Cer		500 v		
C310	281-012	7-45 pf	Cer	Var			
C311	283-518	330 pf	Mica		500 v	10%	
C312	281-512	27 pf	Cer		500 v	10%	
C313	281-007	3-12 pf	Cer	Var			
C314	283-523	500 pf	Mica		500 v	5%	
C331	283-001	0.005 μf	Cer		500 v		
C337	281-005	1.5-7 pf	Cer	Var			100-679
C337	281-0007-00	3-12 pf	Cer	Var			680-up
C338	281-578	18 pf	Cer		500 v	5%	100-679
C338	281-0509-00	15 pf	Cer		500 V	10%	680-up
C339	281-517	39 pf	Cer		500 v	10%	
C361A	281-053	0.35-1.37 pf	Poly	Var			
C361C	281-036	3-12 pf	Cer	Var			
C361E	281-022	8-50 pf	Cer	Var			
C361G	281-022	8-50 pf	Cer	Var			
C361J	281-022	8-50 pf	Cer	Var			
C361K	281-523	100 pf	Cer		350 v		
C361N	281-519	47 pf	Cer		500 v	10%	
C361P	281-543	270 pf	Cer		500 v	10%	
C361S	281-524	150 pf	Cer		500 v		
C364	290-094	8 μf	EMC		450 v		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C365	283-003	0.01 μf	Cer		150 v		
C368	281-034	1.5-7 pf	Cer	Var			
C378	283-060	100 pf	Cer		200 v	5%	
C382	283-060	100 pf	Cer		200 v	5%	
C385	283-001	0.005 μf	Cer		500 v		
C387	281-027	0.7-3 pf	Tub.	Var			
C388	281-027	0.7-3 pf	Tub.	Var			
C391	283-004	0.02 μf	Cer		150 v		
C394	281-034	1.5-7 pf	Cer	Var			
C395	281-525	470 pf	Cer		500 v		
C471	Use 290-185	2 x 40 μf	EMC		250 v		
C472	283-003	0.01 μf	Cer		150 v		
C475	285-526	0.1 μf	PTM		400 v		
C476A		40 μf	EMC		475 v		
C476B	Use 290-062	20 μf	EMC		475 v		
C476C		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		100-239
C551	281-075	5-25 pf	Cer	Var			240-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		

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
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	0.01 μf	PTM	400 v		
C640	Use 290-016	125 μf	EMC	350 v		
C648	283-002	0.01 μf	Cer	500 v		
C649	Use 290-012	2 x 40 μf	EMC	250 v		
C650	285-510	0.01 μf	PTM	400 v		
C670	Use 290-019	150 μf	EMC	250 v		
C671	Use 290-019	150 μf	EMC	250 v		
C679A,B,C	Use 290-005	3 x 10 μf	EMC	450 v		
C680	285-510	0.01 μf	PTM	400 v		
C688	285-510	0.01 μf	PTM	400 v		
C700	Use 290-017	125 μf	EMC	450 v		
C710	285-511	0.01 μf	PTM	600 v		
C730	Use 290-016	125 μf	EMC	350 v		
C740	285-510	0.01 μf	PTM	400 v		
C760A,B	Use 290-013	2 x 40 μf	EMC	450 v		
C780	283-001	0.005 μf	Cer	500 v		
C783	283-0002-00	0.01 μf	Cer	500 v		
C785	283-0002-00	0.01 μf	Cer	500 v		
C802	Use 290-190	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	0.01 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	283-077	330 pf	Cer	500 v	5%	
C874	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

Ckt. No.	Tektronix Part No.	Description	S/N Range
D29	152-141	Silicon 1N3605	
D30	152-141	Silicon 1N3605	
D32	152-141	Silicon 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	X490-up
D49	152-126	Zener 1N3024A 1 w, 15 v, 10%	
D131	152-008	Germanium	
D135	*152-061	Silicon Tek Spec	
D150	Use *152-0224-00	Silicon UTR 166 (Unitrode)	
D152	*152-173	Silicon Selected from 1N3605	
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

Connector

J11	131-018	16 Contact, Female, chassis mounted

Relays

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

Inductors

LR45	*108-293	27 μh (wound on a 680 Ω resistor)			
LR149	*108-058	850 μh (wound on a 3.3 k resistor)			
L528†	*308-318	(8 μh) 1.5 k 2 w WW 1%			
LR529	*108-292	12 μh (wound on a 100 Ω resistor)			
L533	276-507	Core, Ferrite			
L545	*108-262	0.6 μh			100-679X
L546	*108-262	0.6 μh			
L551	*108-260	0.1 μh			
L553	*119-034	Delay Line Assy			
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	Use *151-0127-00	Selected from 2N2369	
Q35	Use *151-0127-00	Selected from 2N2369	
Q45	Use *151-0127-00	Selected from 2N2369	
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	½ w	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				
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				100-679
R27	306-0153-00	15 k	2 w				680-up
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	302-124	120 k	½ w				
R34	305-123	12 k	2 w			5%	
R35	303-223	22 k	1 w			5%	
R36	302-100	10 Ω	½ w				
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%	100-489
	308-364	9.65 k	3 w		WW	1%	490-up

†Furnished as a unit with R110 and SW110.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R44	302-680	68 Ω	½ w				
R46	305-103	10 k	2 w			5%	100-489
R46	308-0301-00	10 k	3 w		WW	1%	490-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%	
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%	
R117	302-102	1 k	½ w				
R118	302-475	4.7 meg	½ w				
R120	301-274	270 k	½ w			5%	
R121	302-101	100 Ω	½ w				
R122	302-223	22 k	½ w				
R123	301-474	470 k	½ w			5%	
R124	301-104	100 k	½ w			5%	
R125	311-078	50 k		Var		LOCKOUT LEVEL ADJ	
R127	302-101	100 Ω	½ w				
R128	302-123	12 k	½ w				
R129	302-273	27 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				
R134	*310-555	6 k/3 k	3 w		WW		
R135	302-104	100 k	½ w				
R137	302-470	47 Ω	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	301-471	470 Ω	½ w			5%	
R148	302-473	47 k	½ w				
R150	302-271	270 Ω	½ w				
R151	302-683	68 k	½ w				
R152	302-105	1 meg	½ w				
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				

†Furnished as a unit with R17 and SW110.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
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%	
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	WW VARIABLE	
R162	304-682	6.8 k	1 w			
R163	304-123	12 k	1 w			
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			
R170	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	302-101	100 Ω	½ w			
R186	302-101	100 Ω	½ w			
R187	302-470	47 Ω	½ w			
R189	306-683	68 k	2 w			
R191	302-104	100 k	½ w			
R193	304-104	100 k	1 w			
R195	302-473	47 k	½ w			
R196	301-114	110 k	½ w		5%	
R197	302-470	47 Ω	½ w			
R198	302-470	47 Ω	½ w			
R199	304-472	4.7 k	1 w			
R301	302-470	47 Ω	½ w			
R310	323-611	900 k	½ w		Prec 1%	
R311	323-610	111 k	½ w		Prec 1%	
R313	323-614	990 k	½ w		Prec 1%	
R314	322-605	10.1 k	¼ w		Prec 1%	
R320	323-481	1 meg	½ w		Prec 1%	
R321	302-102	1 k	½ w			

†Concentric with SW160 and SW160Y. Furnished as a unit with SW160Y.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R323	306-333	33 k	2 w			
R325	Use 311-571	15 k		Var		VARIABLE
R327	306-333	33 k	2 w			
R328	306-273	27 k	2 w			
R330	302-101	100 Ω	½ w			
R331	302-332	3.3 k	½ w			
R332	302-224	220 k	½ w			
R334	311-026	100 k		Var		EXT HORIZ AMP DC BAL
R337	309-017	1.5 meg	½ w		Prec	1%
R338	309-017	1.5 meg	½ w		Prec	1%
R339	302-331	330 Ω	½ w			
R340†	311-431	50 k		Var		HORIZONTAL POSITION
R342	311-082	2 meg		Var		X1 CAL
R343	309-149	1.2 meg	½ w		Prec	1%
R344	309-095	10 meg	½ w		Prec	1%
R346†	311-431	50 k		Var		VERNIER
R347	302-223	22 k	½ w			
R348	302-101	100 Ω	½ w			
R349	304-473	47 k	1 w			
R351	302-101	100 Ω	½ w			
R353	303-303	30 k	1 w			5%
R354	323-268	6.04 k	½ w		Prec	1%
R357	308-310	12 k	5 w		WW	1%
R358	308-310	12 k	5 w		WW	1%
R359	311-460	500 Ω		Var		SWP/MAG REGIS
R360	302-393	39 k	½ w			
R361A	302-682	6.8 k	½ w			
R361B	323-679	18.9 k	½ w		Prec	1%
R361C	302-472	4.7 k	½ w			
R361D	323-678	4.73 k	½ w		Prec	1%
R361E	302-182	1.8 k	½ w			
R361F	323-224	2.1 k	½ w		Prec	1%
R361G	302-821	820 Ω	½ w			
R361H	323-677	996 Ω	½ w		Prec	1%
R361J	302-471	470 Ω	½ w			
R361K	323-676	386 Ω	½ w		Prec	1%
R361L	302-270	27 Ω	½ w			
R361M	311-010	2.5 k		Var		EXT HORIZ AMP CAL
R361P	302-270	27 Ω	½ w			
R361R	323-124	191 Ω	½ w		Prec	1%
R361S	301-202	2 k	½ w			5%
R361V	302-104	100 k	½ w			
R361Z	302-104	100 k	½ w			
R363	302-334	330 k	½ w			
R364	302-334	330 k	½ w			

†R340 and R346 furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R365	311-483	500 Ω		Var	DC SHIFT	
R367	301-564	560 k	½ w		5%	
R368	301-563	56 k	½ w		5%	
R369	301-563	56 k	½ w		5%	
R370	301-564	560 k	½ w		5%	
R371	302-101	100 Ω	½ w			
R372	303-303	30 k	1 w		5%	
R373	323-268	6.04 k	½ w	Prec	1%	
R374	308-311	24 k	5 w	WW		
R375	311-482	150 Ω		Var	X100 CAL	
R376	302-101	100 Ω	½ w			
R377	302-101	100 Ω	½ w			
R378	*310-506	25 k/6 k	5 w	WW	1%	
R379	302-474	470 k	½ w			
R380	302-125	1.2 meg	½ w			
R381	302-101	100 Ω	½ w			
R382	*310-506	25 k/6 k	5 w	WW	1%	
R384	308-311	24 k	5 w	WW	1%	
R386	302-101	100 Ω	½ w			
R387	*310-614	41.5 k	½ w	Prec	½%	
R388	*310-614	41.5 k	½ w	Prec	½%	
R389	302-125	1.2 meg	½ w			
R390	302-474	470 k	½ w			
R391	302-103	10 k	½ w			
R394	302-101	100 Ω	½ w			
R395	302-222	2.2 k	½ w			
R397	302-104	100 k	½ w			
R398	302-154	150 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		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			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R506	302-101	100 Ω	½ w			
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	315-270	27 Ω	¼ w		5%	
R516	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			100-679
R545	302-0270-00	27 Ω	½ w			680-up
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	17.3 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	17.3 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%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R576	321-013	13.3 Ω	1/8 w		Prec 1%	
R578	315-752	7.5 k	1/4 w		5%	
R579	315-152	1.5 k	1/4 w		5%	
R580	Use 311-0539-00	150 Ω	0.25 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	308-312	1.1 k	25 w		WW	
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			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R667	302-684	680 k	½ w			
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	308-031	2 k	20 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	308-113	3 k	8 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			

†*Furnished as a unit with R864.*

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R803	306-563	56 k	2 w			
R806	302-104	100 k	½ w			
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	½ w			5%
R825	305-755	7.5 meg	½ 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	323-391	115 k	½ w		Prec	1%
R863	323-394	124 k	½ w		Prec	1%
R864†	311-472	100 k		Var		ASTIGMATISM
R865	301-433	43 k	½ w			5%
R870	301-154	150 k	½ w			5%
R871	301-245	2.4 meg	½ w			5%
R872	302-102	1 k	½ w			
R874	301-395	3.9 meg	½ w			5%
R875	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%

†Furnished as a unit with R778.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R888	323-664	1.025 k	½ w	Prec	1%	
R889	323-671	610 Ω	½ w	Prec	1%	
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 TRIGGER
SW110†	311-096			PRESET	
SW120	260-190		Lever	RESET	
SW160††	260-230	*262-244	Rotary	TIME/CM	
SW160Y†††	311-108				
SW310	260-207	*262-663	Rotary	EXTERNAL HORIZONTAL	
SW360	260-210	*262-664	Rotary	HORIZONTAL DISPLAY	
SW601	260-199		Toggle	POWER ON	
SW858	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

Electron Tubes

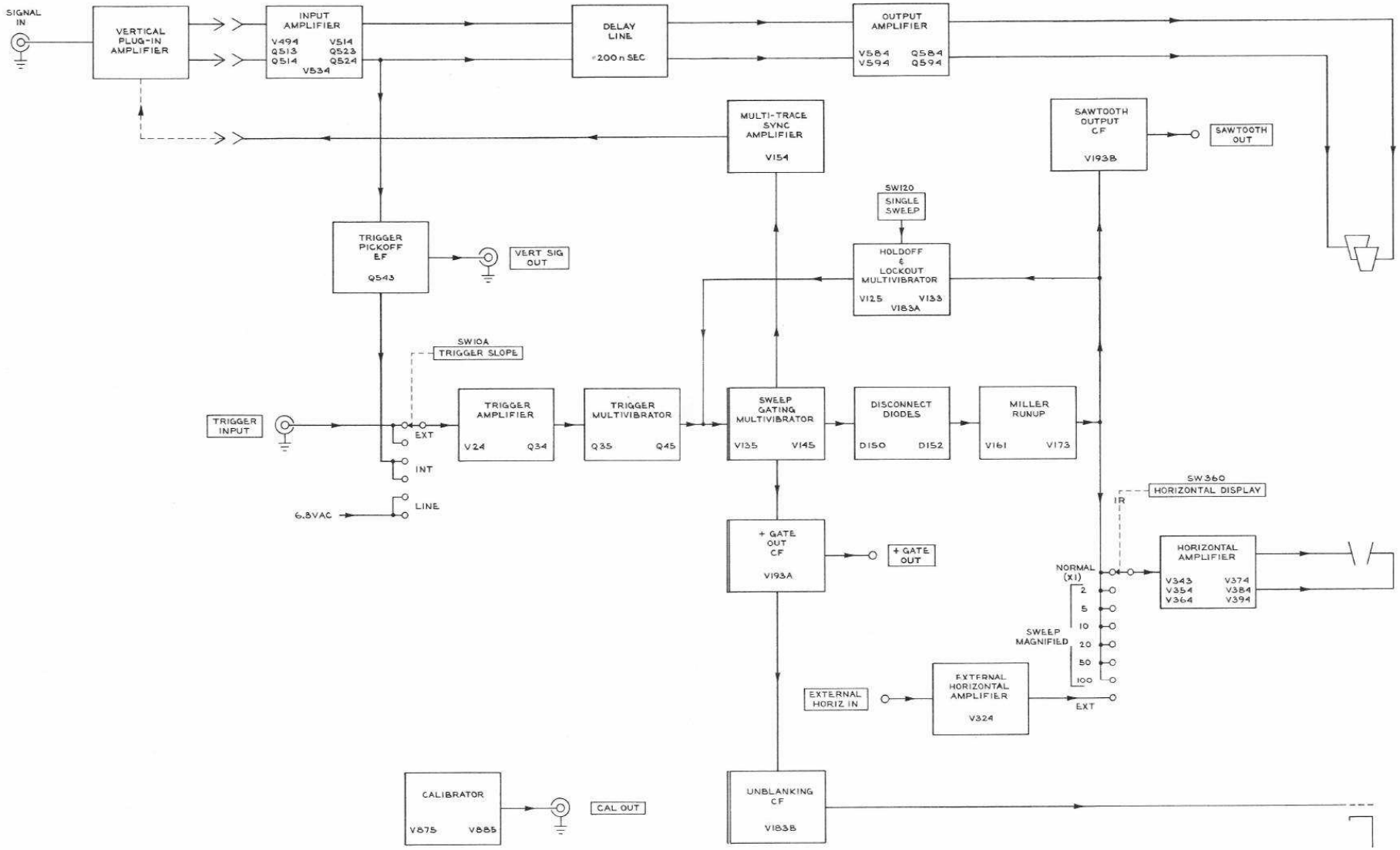
V24	154-187	6DJ8
V125	154-022	6AU6
V133	154-187	6DJ8
V135	154-187	6DJ8
V145	154-047	12BY7

†Furnished as a unit with R17 and R110.
††Concentric with SW160Y and R160Y.
†††Furnished as a unit with R160Y.

Electron Tubes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
V154	154-187	6DJ8	
V161	154-040	12AU6	
V173	154-187	6DJ8	
V183	154-187	6DJ8	
V193	154-187	6DJ8	
V324	154-187	6DJ8	
V343	154-040	12AU6	
V354	154-212	6EW6	
V364	154-212	6EW6	
V374	154-163	6BA8	
V384	154-163	6BA8	
V394	154-367	8136	
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	
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†	Use *154-0478-00	T5470-31-2 Crt Standard Phosphor	100-546
V859	*154-0478-00	T5470-31-2 Crt Standard Phosphor	547-up
V862	154-051	5642	
V875	154-022	6AU6	
V885	154-041	12AU7	

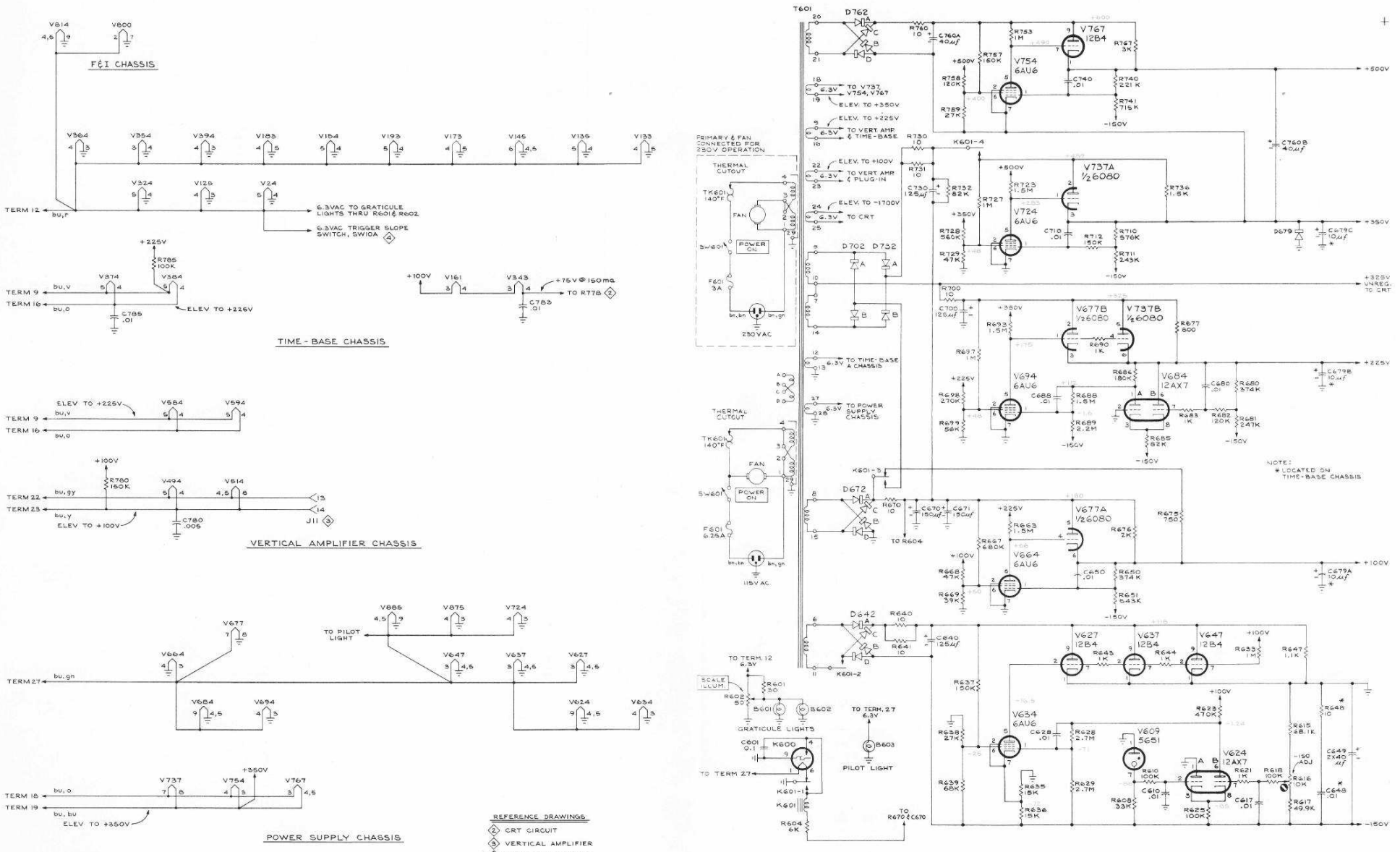
† S/N 100-546 add *050-0246-00 kit.



CMD 464

TYPE 543B OSCILLOSCOPE

BLOCK DIAGRAM



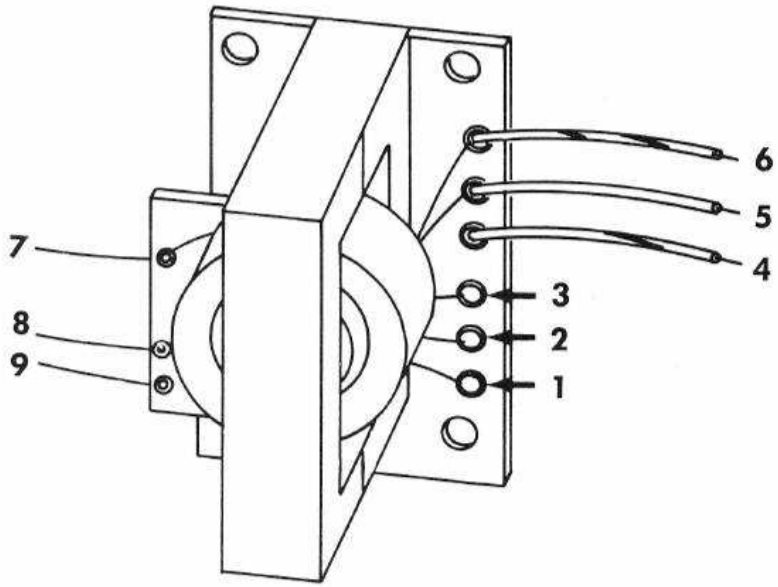
TYPE 543B OSCILLOSCOPE

DON

HEATER WIRING DIAGRAM — A1

MRH 365

POWER SUPPLY (1)



T801 TRANSFORMER DETAILS

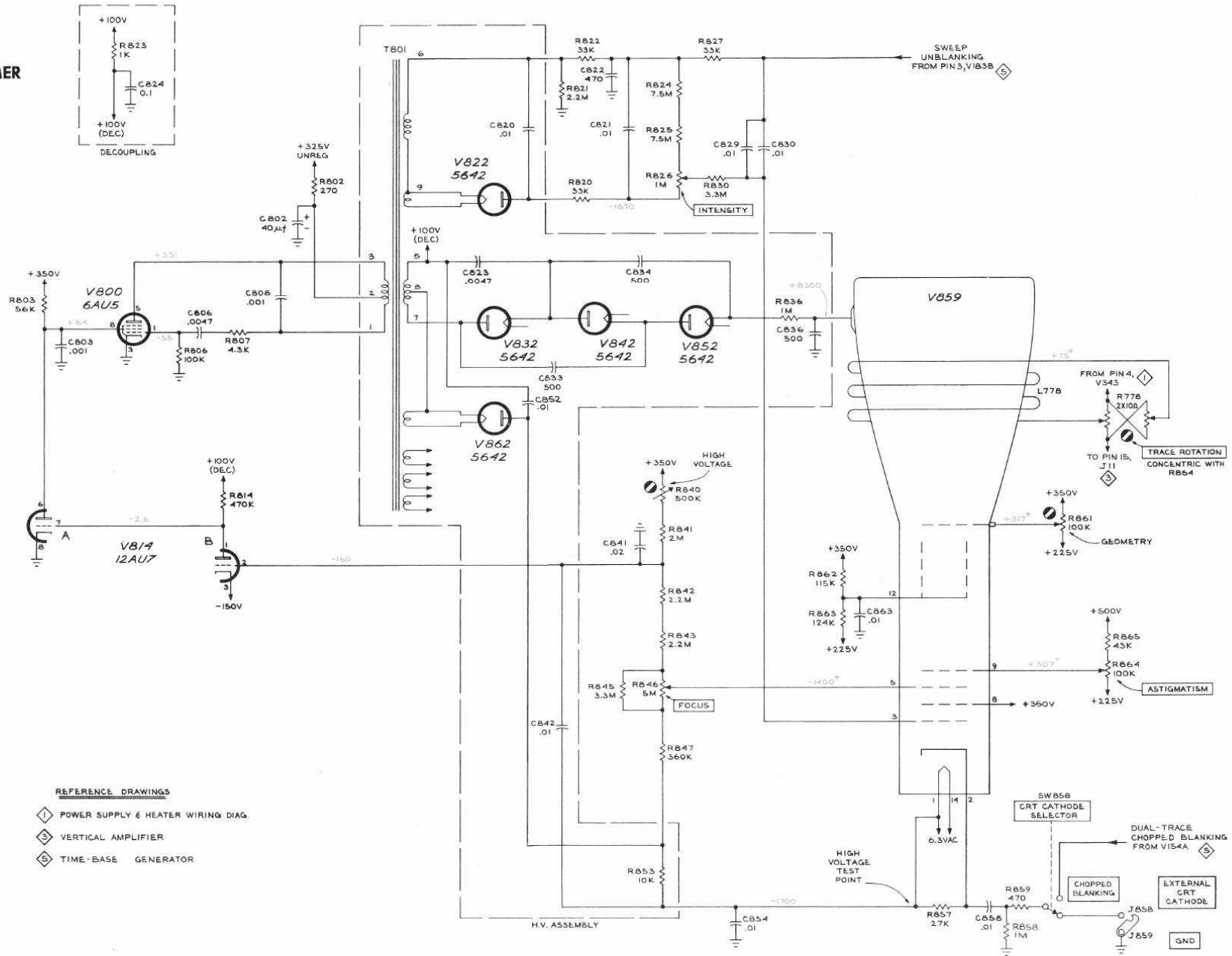
CRT CIRCUIT

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 Trigger Diagram

T801 TRANSFORMER DETAILS



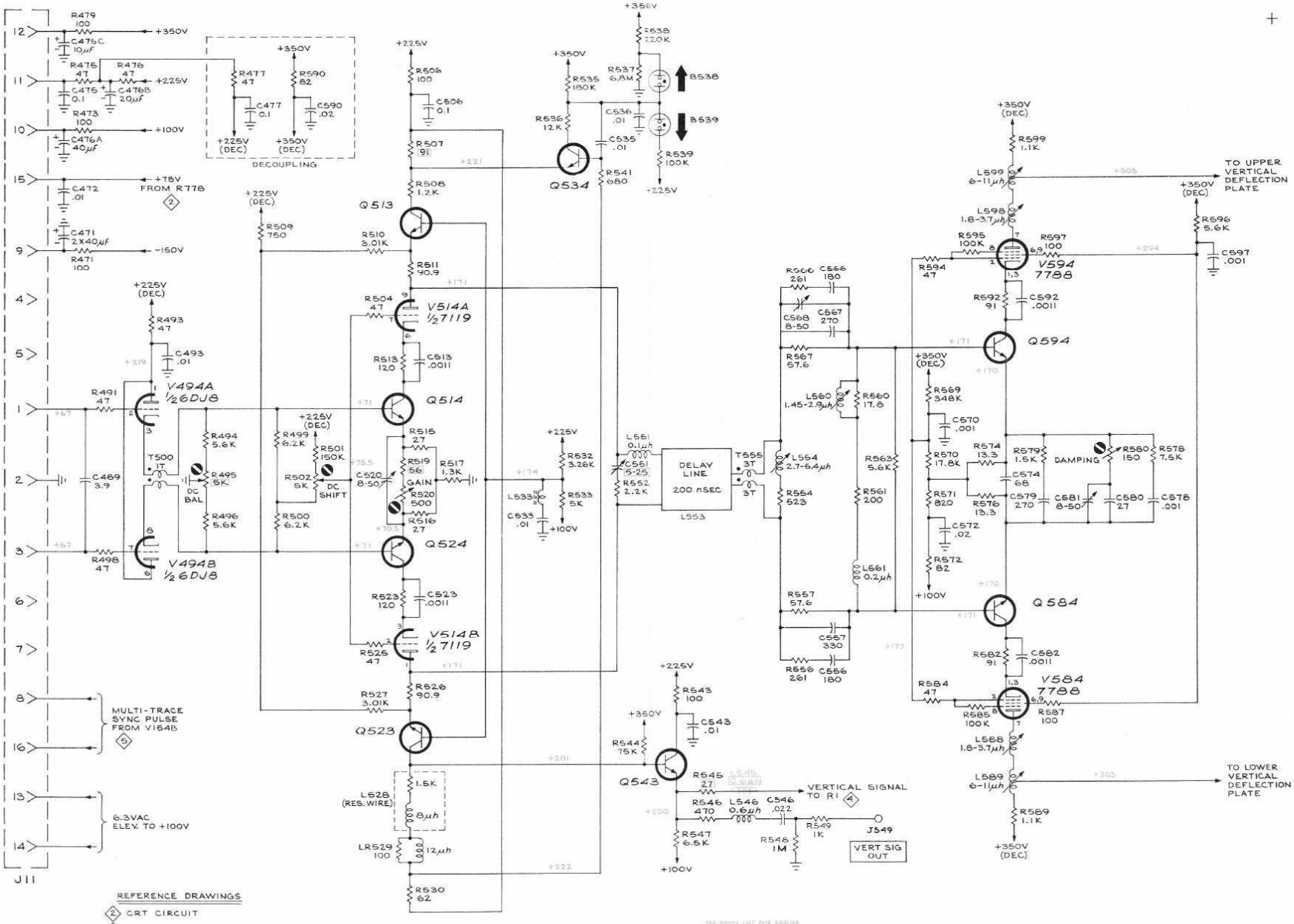
VERTICAL AMPLIFIER

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 Trigger Diagram



TYPE 543B OSCILLOSCOPE

VERTICAL AMPLIFIER 3

DON 965

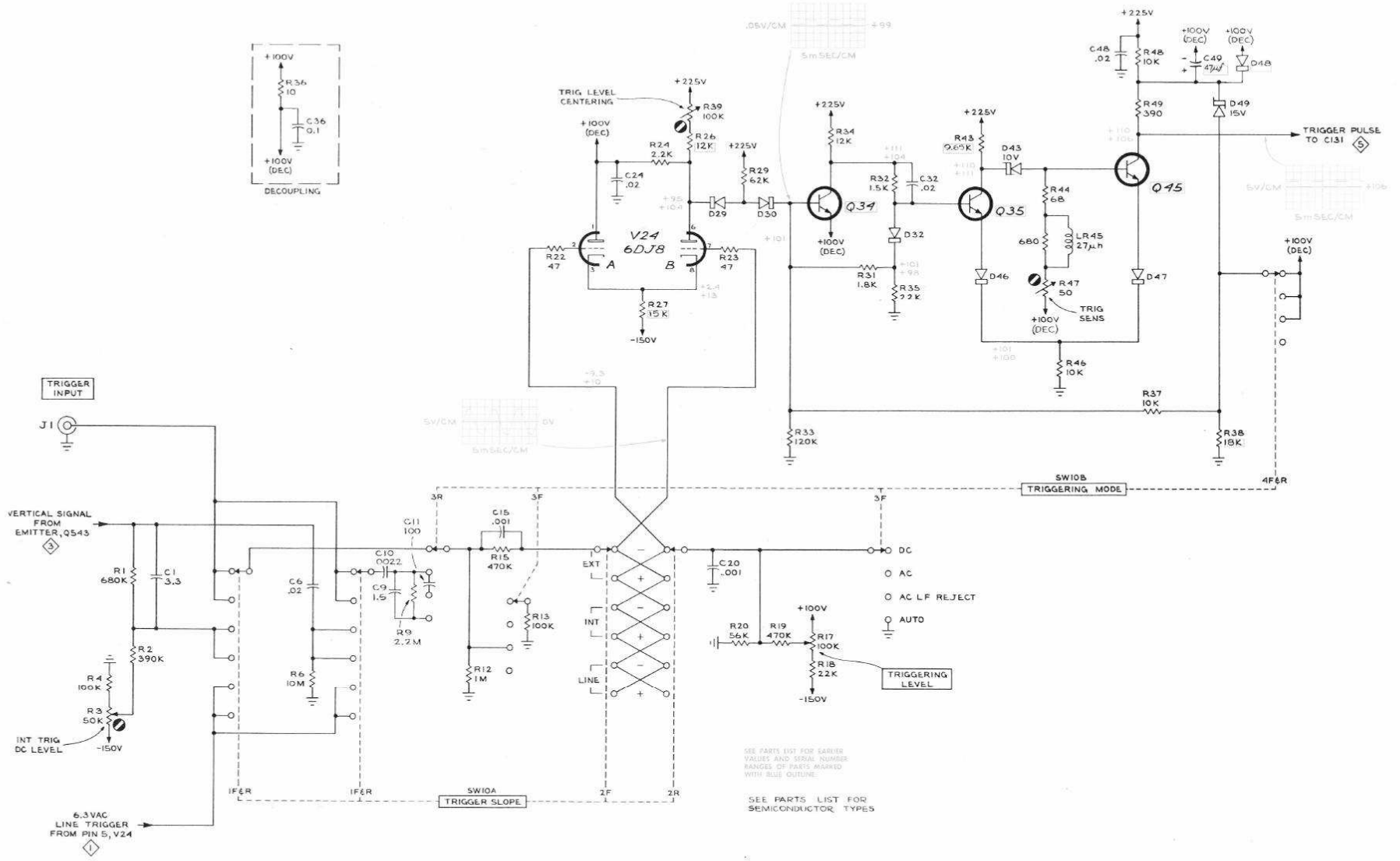
TIME BASE TRIGGER

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	NORMAL (X1)
SINGLE SWEEP	NORMAL SWEEP
VARIABLE	Clockwise
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

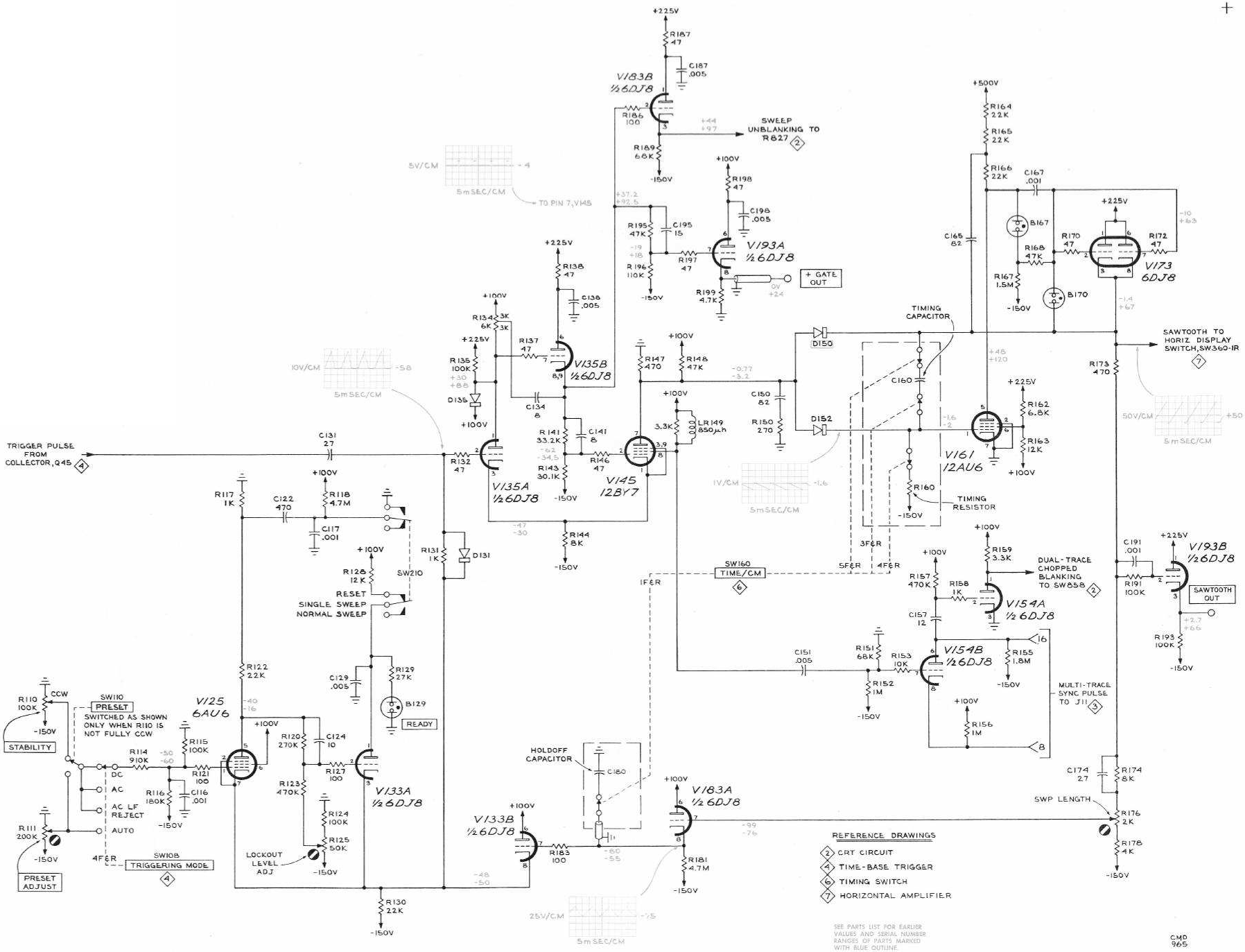

DECOUPLING
+100V
R36 10
C36 0.1
+100V (DEC)
TRIG LEVEL CENTERING
+225V
R39 100K
R26 12K
R24 2.2K
C24 .02
+100V (DEC)
R29 62K
D29
D30
V24 6DJ8
A
B
R22 47
R23 47
R27 15K
-150V
Q34
Q35
Q45
R34 12K
R32 1.5K
C32 .02
D32
R31 1.8K
R35 22K
R43 0.65K
D43 10V
R44 68
680
LR45 27μh
R47 50
TRIG SENS
D46
D47
R46 10K
R48 10K
C48 .02
C49 47μf
D48
D49 15V
R49 390
TRIGGER PULSE TO C131
R37 10K
R38 18K
R33 120K
SW10B
TRIGGERING MODE
4F&R
TRIGGER INPUT
J1
VERTICAL SIGNAL FROM EMITTER, Q543
R1 680K
C1 3.3
R2 390K
R4 100K
R3 50K
INT TRIG DC LEVEL
C6 .02
R6 10M
C10 .0022
C11 100
C9 1.5
R9 2.2M
C15 .001
R15 470K
R13 100K
R12 1M
EXT
INT
LINE
C20 .001
DC
AC
AC LF REJECT
AUTO
R20 56K
R19 470K
R17 100K
R18 22K
TRIGGERING LEVEL
6.3VAC LINE TRIGGER FROM PIN 5, V24
SW10A
TRIGGER SLOPE
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
5 TIME-BASE GENERATOR

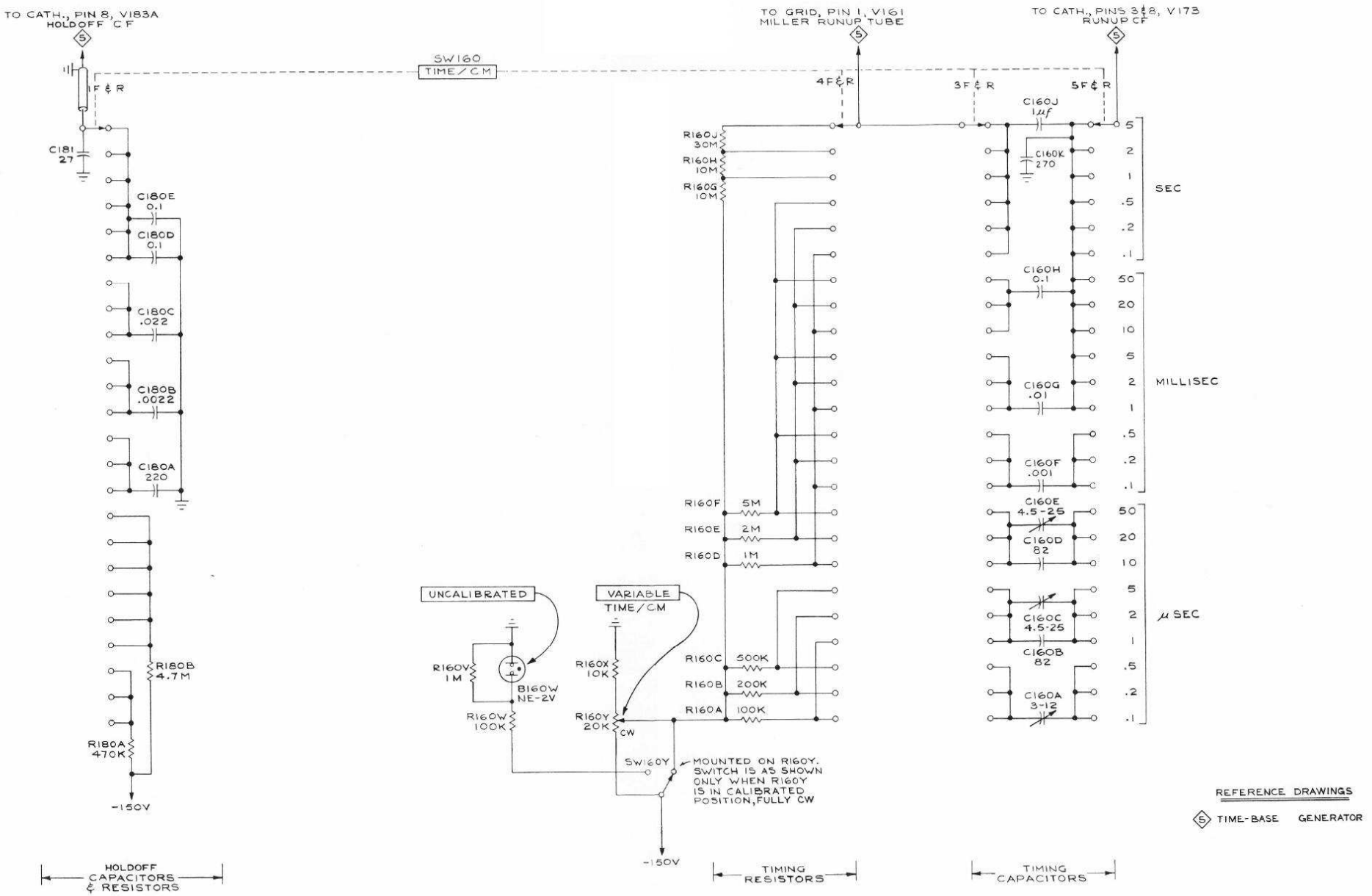
TIME BASE GENERATOR

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 Trigger Diagram


+225V
R187 47
C187 .005
V183B ½6DJ8
R186 100
SWEEP UNBLANKING TO R827
2
R189 68K
-150V
+100V
R198 47
C198 .005
V193A ½6DJ8
+ GATE OUT
R199 4.7K
R195 47K
C195 15
R197 47
R196 110K
+500V
R164 22K
R165 22K
R166 22K
C167 .001
B167
R168 47K
R167 1.5M
B170
C165 82
R170 47
R172 47
V173 6DJ8
TIMING CAPACITOR
SAWTOOTH TO HORIZ DISPLAY SWITCH, SW360-IR
7
R173 470
D150
D152
C160
V161 12AU6
R162 6.8K
R163 12K
R160
TIMING RESISTOR
R138 47
C138 .005
V135B ½6DJ8
R134 6K 3K
R135 100K
R137 47
D135
C134 8
R147 470
R148 47K
C150 82
R150 270
R141 33.2K
C141 8
R143 30.1K
R146 47
LR149 850µh
3.3K
V145 12BY7
R144 8K
V135A ½6DJ8
R132 47
C131 27
TRIGGER PULSE FROM COLLECTOR, Q45
4
R117 1K
C122 470
R118 4.7M
C117 .001
R131 1K
D131
R128 12K
SW210
RESET
SINGLE SWEEP
NORMAL SWEEP
SW160 TIME/CM
6
1FER
3FER
5FER
4FER
R159 3.3K
DUAL-TRACE CHOPPED BLANKING TO SW858
2
R157 470K
R158 1K
V154A ½6DJ8
C157 12
C151 .005
R151 68K
R153 10K
V154B ½6DJ8
R155 1.8M
R152 1M
R156 1M
MULTI-TRACE SYNC PULSE TO J11
3
C191 .001
R191 100K
V193B ½6DJ8
SAWTOOTH OUT
R193 100K
R122 2.2K
C129 .005
R129 27K
B129
READY
V125 6AU6
R120 270K
C124 10
R123 470K
R127 100
V133A ½6DJ8
R124 100K
R125 50K
LOCKOUT LEVEL ADJ
R130 2.2K
HOLDOFF CAPACITOR
C180
V133B ½6DJ8
R183 100
V183A ½6DJ8
R181 4.7M
C174 2.7
R174 8K
SWP LENGTH
R176 2K
R178 4K
SW110
PRESET
SWITCHED AS SHOWN ONLY WHEN R110 IS NOT FULLY CCW
R110 100K
CCW
STABILITY
R114 910K
R115 100K
R121 100
R116 180K
C116 .001
DC
AC
AC LF REJECT
AUTO
R111 200K
PRESET ADJUST
SW108
TRIGGERING MODE
4
5V/CM
5mSEC/CM
TO PIN 7, V145
10V/CM
1V/CM
50V/CM
25V/CM
REFERENCE DRAWINGS
2 CRT CIRCUIT
4 TIME-BASE TRIGGER
6 TIMING SWITCH
7 HORIZONTAL AMPLIFIER
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
CMD 965



MRH
464

TIMING SWITCH (6)

HORIZONTAL AMPLIFIER

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

HORIZONTAL DISPLAY

For Waveforms	NORMAL (X1)
For Voltage Readings	EXT

STABILITY

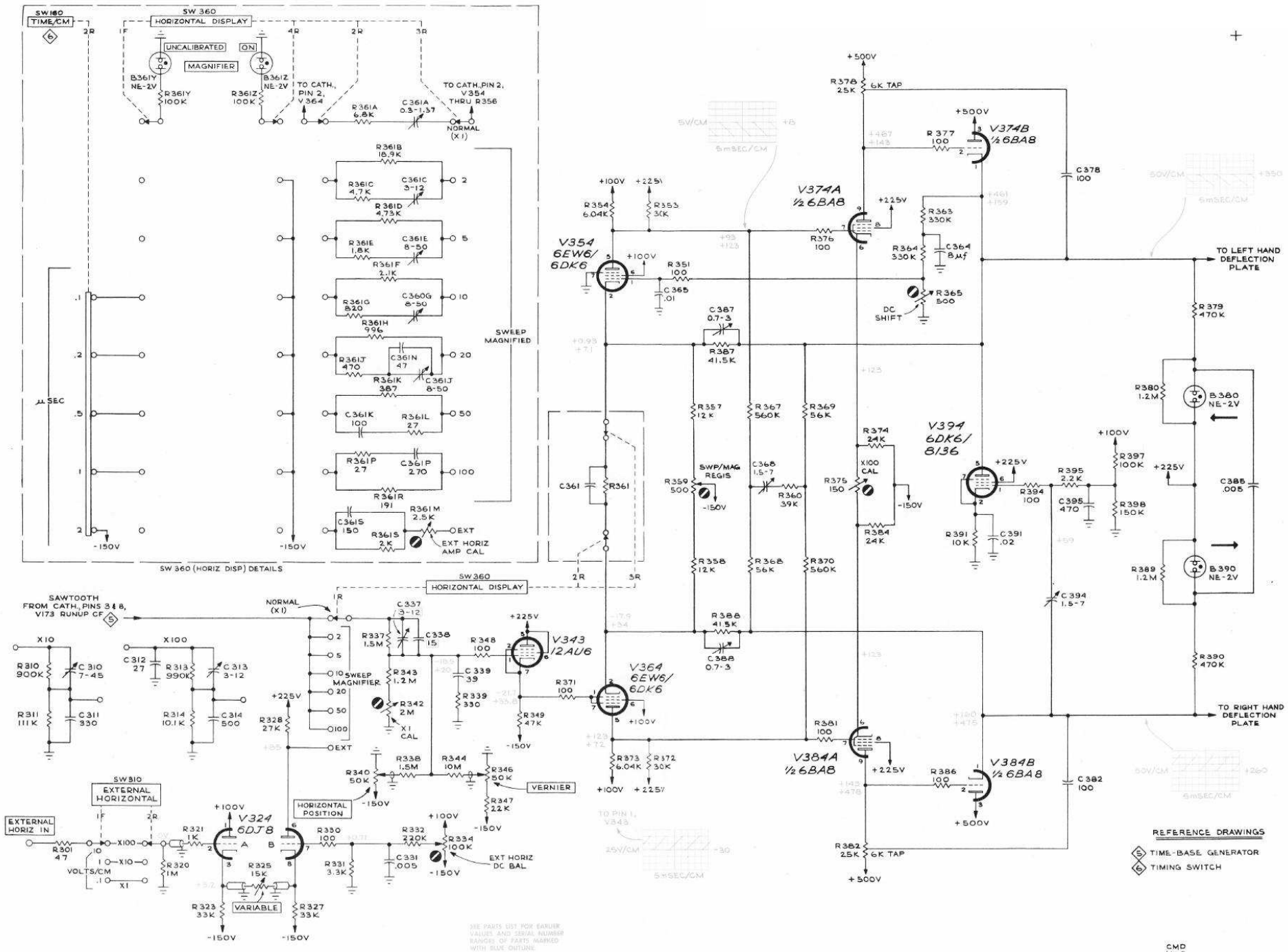
For Waveforms	Clockwise
For Voltage Readings	PRESET

HORIZONTAL POSITION

For Upper Voltage Readings	Counterclockwise
For Lower Voltage Readings	Clockwise

VARIABLE (External Horizontal) . . . . . Clockwise

Also see IMPORTANT note on Time Base Trigger Diagram

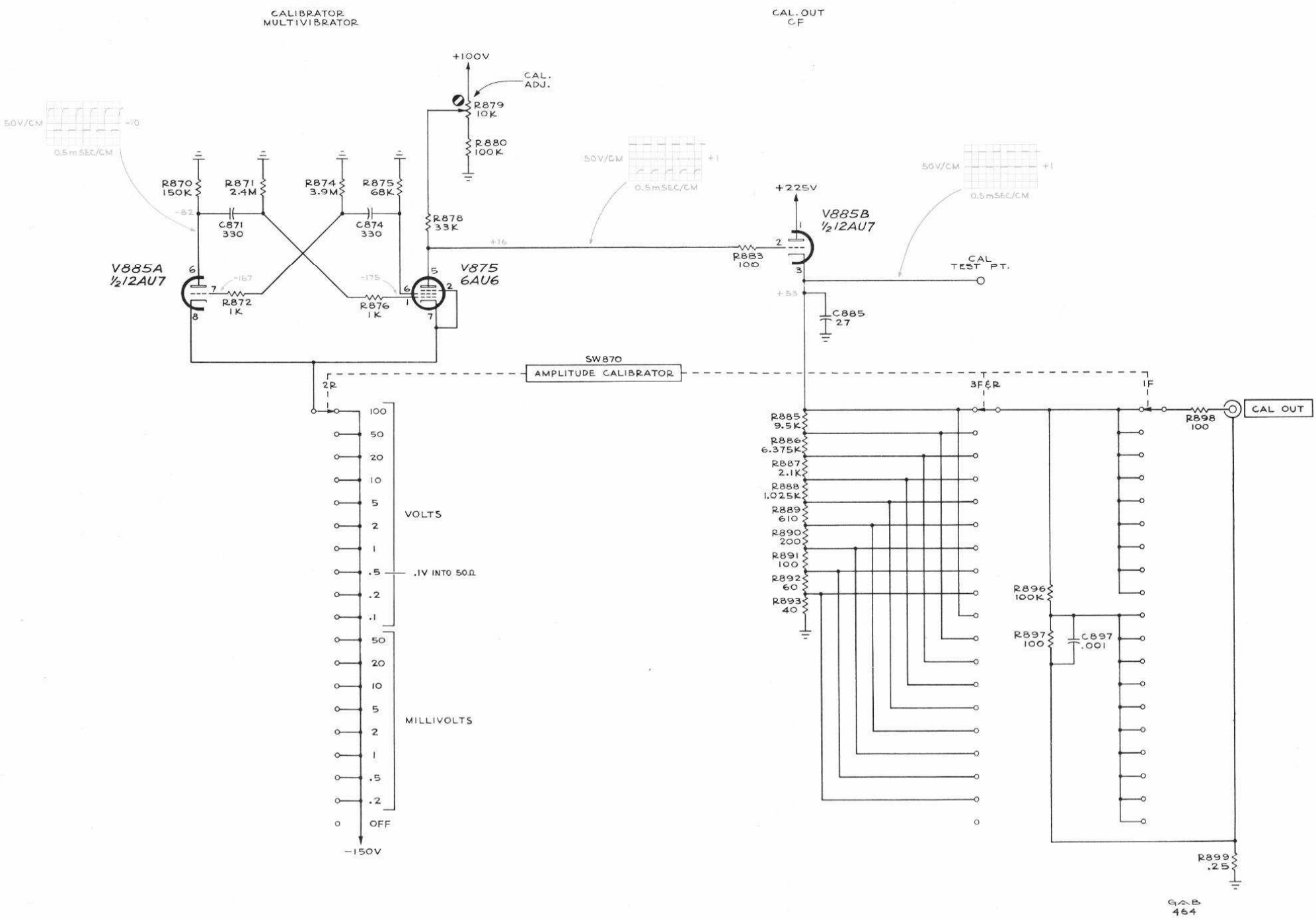

SW 360 (HORIZ DISP) DETAILS
SW360
HORIZONTAL DISPLAY
UNCALIBRATED
MAGNIFIER
ON
TO LEFT HAND DEFLECTION PLATE
TO RIGHT HAND DEFLECTION PLATE
SWEEP MAGNIFIED
SAWTOOTH FROM CATH., PINS 3 & 8, V173 RUNUP CF
SWEEP MAGNIFIER
EXTERNAL HORIZ IN
EXTERNAL HORIZONTAL
HORIZONTAL POSITION
VERNIER
EXT HORIZ DC BAL
EXT HORIZ AMP CAL
DC SHIFT
VARIABLE
SWP/MAG REGIS
X100 CAL
X1 CAL
V324 6DJ8
V354 6EW6/6DK6
V364 6EW6/6DK6
V374A ½6BA8
V374B ½6BA8
V384A ½6BA8
V384B ½6BA8
V394 6DK6/8136
V343 12AU6
REFERENCE DRAWINGS
TIME-BASE GENERATOR
TIMING SWITCH
TYPE 543B OSCILLOSCOPE
HORIZONTAL AMPLIFIER
CMD 1165

CALIBRATOR

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

AMPLITUDE CALIBRATOR . . . . . 100 VOLTS

Also see IMPORTANT note on Time Base Trigger Diagram



TYPE 543B OSCILLOSCOPE

A

CALIBRATOR ⑧