INSTRUCTION MANUAL

Serial Number ____________

TYPE 5T1 PLUG-IN

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Tektronix International A.G.
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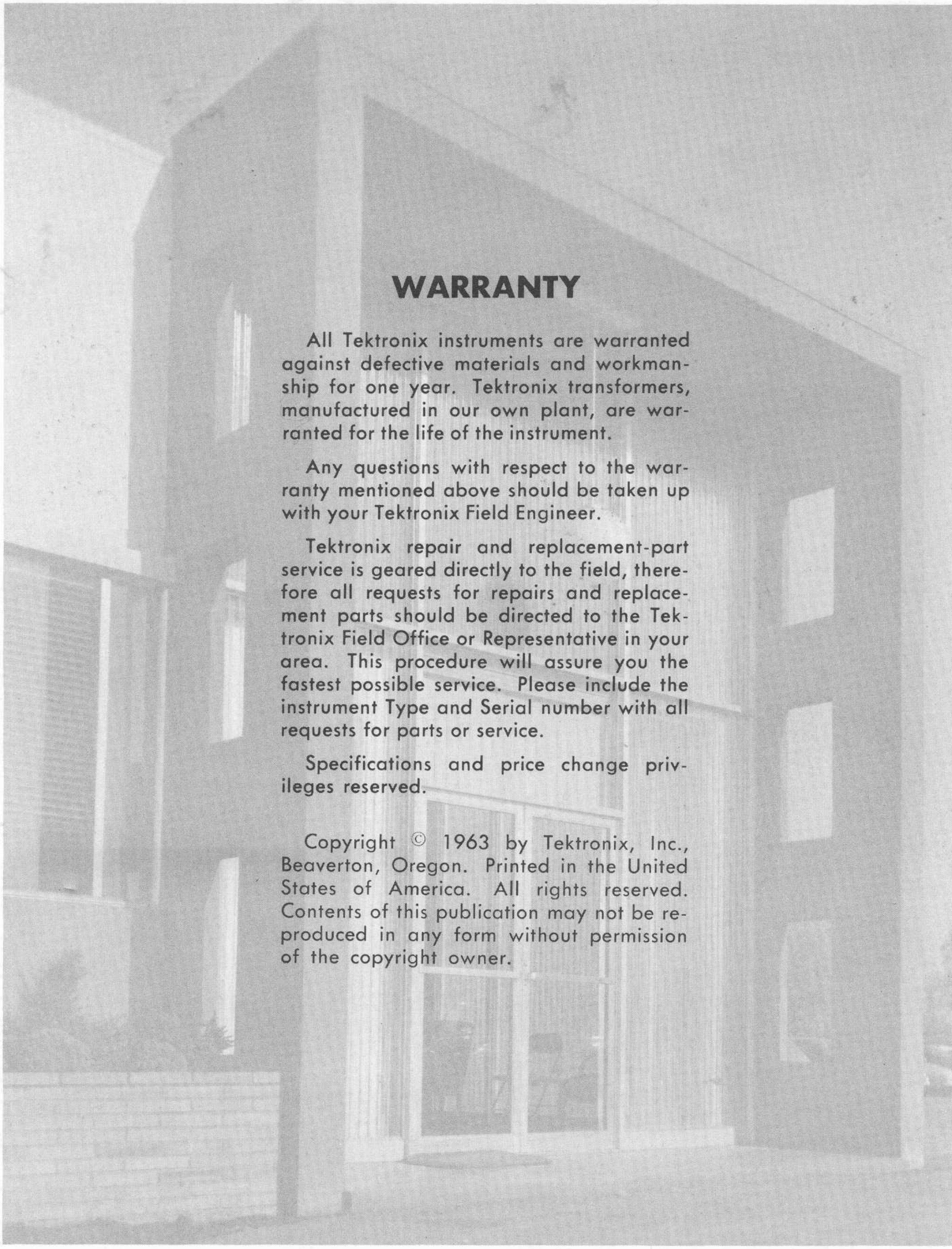

WARRANTY

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

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

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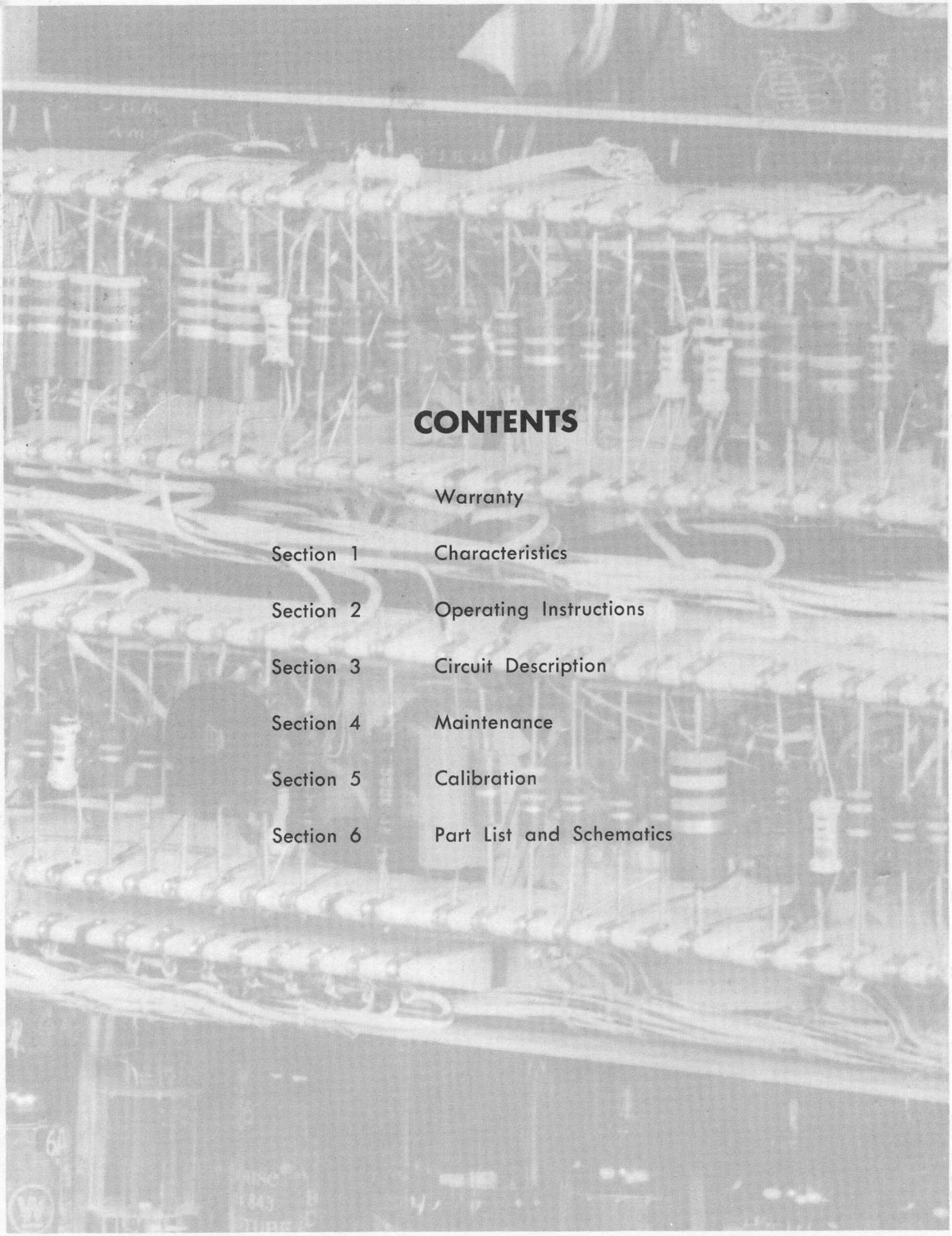

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CALIBRATED
TEKTRONIX, INC. PORTLAND, OREGON, U. S. A.

Type 5T1

SECTION 1
CHARACTERISTICS

GENERAL INFORMATION

The Tektronix Type 5T1 Timing Unit is a sampling-type timing plug-in unit for use with the Type 661 Oscilloscope. The Type 5T1 has sixteen calibrated equivalent sweep rates ranging from 1 nsec/cm to 100 μsec/cm and uncalibrated variable sweep rates between these steps and extending to about $\frac{1}{3}$ nsec/cm. This range of sweep rates enables the system to display risetimes as short as a fraction of a nanosecond (nsec). The triggering circuitry operates on either positive-going or negative-going signals and permits stable presentation of repetitive waveforms whether the repetition rates are recurrent or random.

If the vertical plug-in unit has a trigger-takeoff circuit, the Type 5T1 can trigger the sweep internally from the input signal. The sweep can also be triggered internally from the oscilloscope calibrator signal or externally from a trigger signal applied through a front-panel connector. The circuit, when triggered, automatically counts down to approximately 100 kc from signals of higher frequency.

A front-panel switch on the Type 5T1 provides selection of dot density from 5 to 100 samples/cm. A TIME DELAY control permits delaying the sweep trigger up to 100 nsec, to position the display horizontally on the screen. Either repetitive or single-display operation may be selected with the SWEEP MODE switch. Trigger lockout time may be varied with the RECOVERY TIME control, providing adjustment for jitter-free triggering.

OPERATING CHARACTERISTICS

Sweep Rate

Sixteen calibrated steps in equivalent time from 1 nsec/cm to 100 μsec/cm in a 1, 2, 5, 10 sequence; accuracy within 3%. An uncalibrated variable control provides a continuous range up to three times the calibrated sweep rate on each step, extending the rate to about $\frac{1}{3}$ nsec/cm on the 1 nSEC position.

Sweep Mode

Either repetitive or single-display. START position of SWEEP MODE switch begins single-display.

Trigger Source

Internal from signal, external, free run, or internal from calibrator. Sensitive to positive-going or negative-going polarity. A stable display is presented in free run when using the oscilloscope delayed pulse.

Trigger Sensitivity

5 mv external, for a 2 nsec pulse. Internal trigger sensitivity is determined by output of sampling unit trigger-takeoff circuit.

Triggering Threshold

Continuously variable over a $\pm$200 mv range.

Lockout Time (Recovery)

Variable from about 10 μsec to about 13 μsec on sweep rates of 0.1 μsec/cm and faster; longer on slower sweep rates.

Time Delay

Continuously variable trigger delay, from 0 to 100 nsec.

Samples/Cm

5, 10, 20, 50 and 100 with an unmagnified display; accuracy within 3%.

Time Jitter

Less than 30 picoseconds (psec) or .01% of fast ramp duration, whichever is greater, in 100 μsec/cm through 2 nsec/cm sweep rates.

External Trigger Kickout (S/N 494-up)

Less than 8 millivolts.

MECHANICAL

Construction

Aluminum-alloy chassis; photo-etched anodized front panel.

Dimensions

Height—7 inches; width—6 inches; depth—14 inches.

Weight

Approximately 6 pounds.

STANDARD ACCESSORIES

2 — 50-ohm 10X T Attenuators, with GR-874 connectors 017-044

2 — 50-ohm 10-nsec coax cables, with GR-874 connectors 017-501

2 — Instruction manuals 070-330

NOTES

SECTION 2

OPERATING INSTRUCTIONS

INTRODUCTION

The following operating instructions consist of a brief description of front panel controls and connectors, a discussion of triggering methods, and instructions on setting up the crt display. Because the Type 5T1 Timing Unit is part of a system, you should also read the operating instructions for the Type 661 Oscilloscope and the '4'-Series sampling unit used with it.

For triggered operation, the Type 5T1 requires a trigger signal that is time-related to the signal to be displayed. Trigger signals may be obtained externally from the input signal, through a test probe from the device under test, or from a pulse generator that is pulsing the device being tested. These external trigger signals are then applied to the front-panel EXTERNAL TRIGGER INPUT connector on the Type 5T1. Externally applied trigger signals must have an amplitude between 5 mv and 250 mv, either positive or negative polarity.

When using a sampling unit with internal trigger takeoff, the trigger signals may be obtained from the input signal if the signal amplitude is sufficient for the sampling unit to provide at least 5 mv of signal to the Type 5T1.

If the oscilloscope Delayed Pulse output is used to pulse a device under test, a stable display will result with the Type 5T1 set for free run operation.

FRONT-PANEL CONTROLS AND CONNECTORS

All controls and connectors required for the operation of the Type 5T1 are located on the front-panel of the unit.

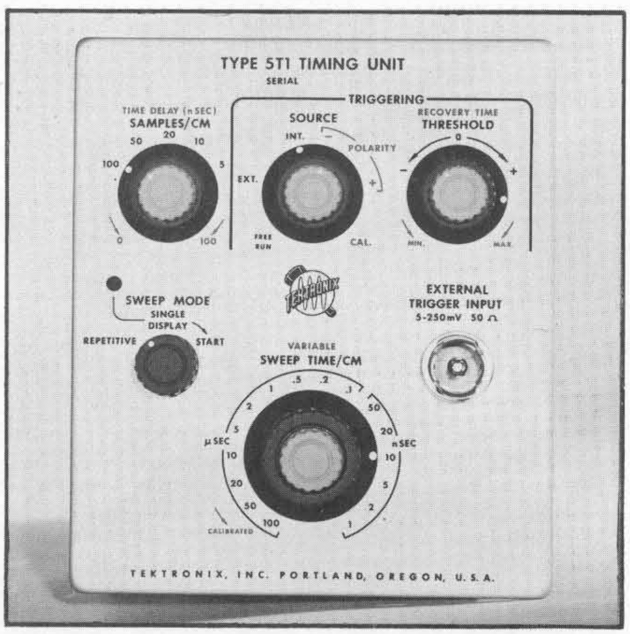


Fig. 2-1. Front-panel controls and connectors.

Table 2-1 gives a brief description of the function of each of these controls and connectors.

TABLE 2-1

Functions of Controls and Connectors

SAMPLES/CM Switch	Establishes the number of dots (samples) per horizontal centimeter of the crt display, with sweep unmagnified.
TIME DELAY (nSEC) Control	Permits equivalent-time positioning of the sweep start. Acts as a movable time-delay window for the display by delaying the sweep trigger nominally —5 nsec to +95 nsec with respect to the input signal.
TRIGGERING SOURCE Switch	Provides selection of triggering signal from either the sampling plug-in or the EXTERNAL TRIGGER INPUT connector. Also provides for operation of trigger circuit in free run mode. Functions are over-ridden by calibrator triggering when POLARITY switch is at CAL. position.
TRIGGERING POLARITY Switch	Permits selection of positive-going (+) or negative-going (—) slope for triggering from internal or external sources, or positive-going trigger pulses from the oscilloscope calibrator circuit. RECOVERY TIME control should be at MIN. for calibrator triggering.
TRIGGERING THRESHOLD Control	Determines the voltage level that triggering pulses must pass through in order to start the sweep.
RECOVERY TIME Control	Varies the length of time that the sweep is locked out after a sample has been taken, while the trigger circuit recovers. Allows the presentation of a stable display regardless of the triggering signal repetition rate.
SWEEP MODE Switch	Permits operation in either REPETITIVE or SINGLE DISPLAY mode. Spring-return START position starts the single-display presentation.
SWEEP TIME/CM Switch	Provides selection of equivalent time per horizontal centimeter of display, from 100 μsec/cm to 1 nsec/cm, when VARIABLE control is in CALIBRATED position.
VARIABLE Control	Permits up to three-times increase in sweep rate between steps of SWEEP TIME/CM switch; can extend the 1-nsec/cm range to about ⅓ nsec/cm.

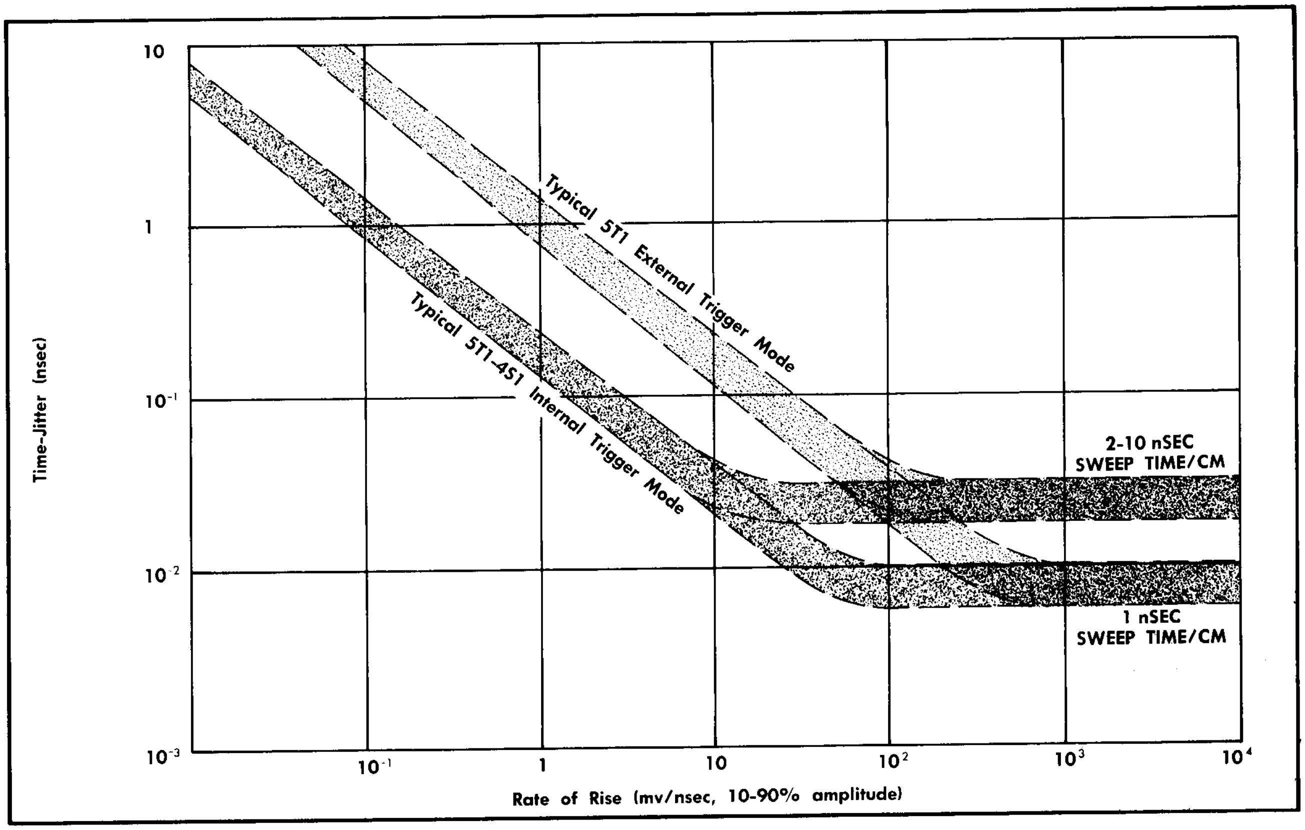


Fig. 2-2. Triggering jitter as a function of triggering signal rate of rise.

EXTERNAL TRIGGER INPUT Connector — Allows direct connection of the triggering signal to the Type 5T1. Nominal 50-ohm ac-coupled input is primarily for use with sampling units without trigger takeoff, and signals that have less amplitude than that required for internal triggering. Signals from 5 to 250 mv will permit proper operation of the timing unit. For proper triggering on slow-rise signals, 10-mv/μsec minimum rate of change is required. See Fig. 2-2.

Delayed Pulse Output

The Type 5T1 provides a triggering pulse to the Delayed Pulse generator in the oscilloscope. The —400-mv pulse appears at the Delayed Pulse Output connector on the oscilloscope front panel about 40 nsec after the trigger circuit in the Type 5T1 has operated. This allows the system to view the delayed pulse. The initial negative step has a risetime of less than .2 nsec. The pulse is available when the Type 5T1 is free running, and may be used to pulse a device under test.

INSTALLING THE TYPE 5T1 IN THE OSCILLOSCOPE

CAUTION

Always turn off the oscilloscope power before inserting or removing plug-in units.

With the oscilloscope power off, begin installation of the Type 5T1 by first pulling outward on the locking latch at the bottom of the upper plug-in compartment of the Type 661, until the latch is perpendicular to the front panel. Next insert the plug-in unit into the compartment and push it in as far as possible by hand. The Type 5T1 front panel will be against the oscilloscope front panel and the latch will be at about a 45° angle if the unit has been pushed far enough. Complete the operation by pressing the locking latch firmly against the front panel.

To remove the plug-in, first turn off the oscilloscope power switch, then pull the locking latch outward until it is perpendicular to the front panel. The unit may then be withdrawn the rest of the way by hand.

TRIGGERING CONSIDERATIONS

General

NOTE

For the Type 5T1 to operate properly, bias for the Delayed Pulse generator in the oscilloscope must be adjusted each time the unit is used in a different oscilloscope. This adjustment is made, as explained later in this section, with the Delayed Pulse Gen. Bias control in the Oscilloscope.

The Type 5T1 may be triggered either from trigger signals received internally or from an external trigger source. Internal trigger pulses may be derived from the oscilloscope calibrator, or from the input signal when a sampling unit with a trigger takeoff circuit is used. The Type 5T1 is operated in free run when the oscilloscope Delayed Pulse output is used to pulse the device under test.

Triggering pulses must be related in time to the signal to be displayed, and must have a repetition rate less than, or equal to, that of the input signal. They must also meet the amplitude and timing requirements given in the following paragraphs under Internal and External Sources.

Time jitter of the display is related to the rate of rise of the triggering signal. Fig. 2-2 shows the relationship between rate of rise and jitter for both internally—and externally—derived trigger signals. The rate of rise in mv/nsec is calculated by multiplying the frequency (in cycles/nsec) by the 10% to 90% rise (in mv).

The Type 5T1 can trigger internally or externally up to about 1 Gc. However, triggering stability can be increased by use of a Type 280 Trigger Countdown unit, with external triggering, from 50 Mc to 5 Gc.

INTERNAL SOURCES

Input Signal

In order to use the input signal to trigger the Type 5T1 internally, the amplitude of the signal sent from the trigger-takeoff of the sampling unit must be at least 5 millivolts. The amplitude required at the input therefore depends on the ratio that exists between the input signal and the derived trigger signal. For example, the Type 4S1 provides a trigger signal that is about 1/8 the amplitude of the input signal. Thus, the input amplitude must be at least 40 millivolts for internal triggering. Placing the TRIGGERING SOURCE switch at the INT. position connects the trigger signal from the sampling unit to the Trigger circuit of the Type 5T1. Signal delay following the trigger-takeoff circuit in the sampling unit allows time for the unit to begin operation before the signal arrives at the sampling gate.

Calibrator

With the POLARITY switch set to CAL. position, the Type 5T1 Trigger circuit receives internally-connected triggering signals from the oscilloscope Calibrator circuit. Regardless of the position of the TRIGGERING SOURCE switch, when the POLARITY switch is set to CAL., the Trigger circuit is controlled by signals from the Calibrator. This triggering source should be used for stable triggering when observing the Calibrator waveform, and is especially useful for low-amplitude Calibrator signals. The RECOVERY TIME control should be left at MIN. when using CAL. triggering.

Delayed Pulse

When the oscilloscope Delayed Pulse output is used for pulsing the device under test or for checking the system, the Trigger circuit in the Type 5T1 is normally operated in free run mode. The repetition rate of the delayed pulse is set by the Hold-Off circuit, and is variable over a 1-to-1.3 range with the RECOVERY TIME control. The delayed pulse may also be operated at a lower repetition rate if desired, by triggering the Type 5T1 externally at the desired repetition rate.

EXTERNAL SOURCES

When a sampling unit without signal delay (such as the Type 4S2) is used, an external trigger signal must be supplied to the Type 5T1 through the EXTERNAL TRIGGER INPUT connector. External triggering may also be used instead of internal triggering, if desired, with a sampling unit that has provision for internal triggering. Placing the SOURCE switch in the EXT. position connects the EXTERNAL TRIGGER INPUT connector to the trigger circuit through an ac-coupling circuit. For instruments with serial numbers above 493, the input signal also passes through an external trigger isolation circuit.

To view the signal that triggers the unit, the Type 5T1 must be triggered at least 35 nsec before the input signal reaches the sampling gate of the sampling unit. The TIME DELAY control in the Type 5T1 allows the sampling cycle to be delayed over a range of 100 nsec, moving the display "time window" and permitting flexibility in the test set-up. The time interval between triggering and sampling may be provided either by pre-triggering the Type 5T1 before pulsing the device under test, or by taking the triggering signal from the input signal, then delaying the input signal in its path to the sampling gate.

Pretriggering

When the circuit under test can be triggered by an input pulse, a pretrigger pulse may be sent from the pulse generator to start operation of the Type 5T1 about 40 nsec prior to pulsing the device under test. Typical circuits that can be checked with this method are blocking oscillator and avalanche transistor circuits.

A suitable instrument for pretriggering the Type 5T1 is the Type 111 Pretrigger Pulse Generator. The Type 111 supplies a trigger pulse to the Type 5T1 first, then after a precise time interval it pulses the circuit being tested. The signal delay and the trigger delay should be set so the time interval between the pretrigger signal to the Type 5T1 and the trigger pulse to the circuit under test is 35 to 50 nsec, minus the time delay between input and output of the device under test.

When using the pretriggering technique, keep in mind that any time-jitter between the pretrigger and the input signal will appear as time-jitter in the display.

Trigger Takeoff and Signal Delay

For circuits that cannot be tested by external pulsing, a trigger signal may be picked off and coaxial cables used to delay the signal from the device, to produce the trigger-to-sample delay needed to view the leading edge of the input waveform. If the sampling unit has an internal delay line in the signal path, external delay cables are unnecessary. Remember, however, that if any time-delay is added in the path of the trigger signal, an equal amount must be added to the input signal path to allow viewing of the leading edge of the waveform. In general, it is advisable to keep the signal delay at a minimum, because of the attenuation of high-frequency information by coaxial cables. If signal delay in excess of 60 nsec is required, the use of a Type 113 Delay Cable is recommended. The Type 113 has a risetime of less than .1 nsec. Connecting cables for the triggering signal may be RG-8A/U or RG-58A/U.

A trigger probe can be used to trigger the Type 5T1 if a signal that is time-related to the input signal can be taken from the device under test. P6034 and P6035 Probes can be used as trigger probes. The P6034 provides 10X attenuation, with input resistance of 500 ohms and about 0.8 pf capacitance. The P6035 provides 100X attenuation, with 5000 ohms input resistance and about 0.7 pf capacitance.

When the input signal must be used for providing the triggering signal, some means of dividing the signal or taking off a portion of it for triggering without introducing severe distortion must be found. The following paragraphs list a few devices that may be used for this purpose.

The Type 110 Pulse Generator and Trigger Takeoff System provides a transformer-type trigger takeoff in a 50-ohm system. 98% of the signal passes through the system, and a trigger signal equal to 20% of the signal voltage is provided for triggering the Type 5T1. The Type 110 has a dynamic range versatility that will allow most signals from 50-ohm sources to be used for triggering the Type 5T1. The pulse generator section of the Type 110 may be used to pulse a circuit under test (see the Type 110 instruction manual).

Another suitable transformer-type trigger takeoff is the CT-1 Nanosecond Current Transformer. No specific impedance is required of the input circuit for use with the CT-1. The output is 5 mv/ma. Voltage output (E_{out}) from the CT-1, in relation to the ac signal amplitude (E_{sig}) and the characteristic impedance of the signal circuit (Z_o) is approximately:

$$E_{out} = \frac{5\ E_{sig}}{Z_o}$$

Output impedance of the CT-1 is 50 ohms, suitable for direct connection to the Type 5T1 EXTERNAL TRIGGER INPUT connector. Be sure the amplitude into the Type 5T1 is within the 5 mv to 250 mv range.

The VP-1 Voltage Pickoff unit may also be used as a trigger signal source, with either a P6034 or a P6035 Probe. The effect of the probe on the impedance of the system must be taken into consideration when using the VP-1.

An impedance-matched tee connector with 16.7 ohms in each of three legs will divide an input signal into two equal, $\frac{1}{2}$-amplitude signals for signal input and triggering. A 100-mv signal would thus provide 50 mv for viewing and 50 mv for triggering.

THRESHOLD AND RECOVERY TIME CONTROLS

The Type 5T1 is sensitive to trigger signals in excess of 5 mv. The THRESHOLD control determines the signal level (over a $\pm$200 mv range) required to trigger the system. Set the POLARITY switch at + to trigger on positive-going signals; at — to trigger on negative-going signals. To trigger the unit with the THRESHOLD control, start with the control turned well into the polarity region indicated by the POLARITY switch. This will hold off the trigger operation for normal-amplitude signals. Then turn the THRESHOLD control toward the opposite polarity region. Proper triggering occurs as the extreme portion of the triggering signal passes through the threshold voltage. Turning the THRESHOLD control further will produce multiple traces and finally a free running sweep when the trigger signal base line reaches the threshold voltage. Set the THRESHOLD control for stable triggering with minimum jitter.

For viewing the Delayed Pulse output signal, the THRESHOLD control may be set to the free running position (for INT. or EXT.), if desired, or the SOURCE switch may be set to FREE RUN position. In FREE RUN the THRESHOLD control is disconnected from the trigger circuit.

The repetition rate of the trigger recognition circuit is controlled by the hold-off circuit and is set primarily by the rate of operation of the fast ramp circuit at the slower sweep rates, and by the maximum repetition rate of the hold-off at the faster sweep rates. The RECOVERY TIME control can increase the recovery time of the hold-off circuit (or decrease the repetition rate) by about 30%. In general, the RECOVERY TIME control should be left at the MIN. position unless unstable triggering is encountered. When the repetition rate of the triggering signals is approximately equal to that of the hold-off circuit, the RECOVERY TIME control can often improve triggering stability by decreasing the hold-off repetition rate.

VIEWING THE DISPLAY

Turn on the oscilloscope and allow a few minutes warm-up while connecting the necessary signal and triggering cables. Be sure the input voltage limitations of the sampling unit and the Type 5T1 have been complied with. Set the front-panel controls as follows:

Type 661 Oscilloscope

Horizontal Display	X1
Position and Vernier	Centered
Calibrator	Off (unless Calibrator signal is being viewed).

Sampling Unit

Millivolts/Cm	Set for 3 or 4 cm of deflection.
Vertical Position	Centered
Mode	Channel receiving input signal.
Triggering (if used)	AC, set to signal channel.
Smoothing	Normal

Type 5T1

SWEEP TIME/CM	Sweep rate that will present a few cycles of the input waveform. If unknown, start at 10 nSEC/CM.
SWEEP MODE	REPETITIVE
TIME DELAY (nSEC)	0
SAMPLES/CM	50. Sample density can be changed later to suit signal characteristics.
TRIGGERING SOURCE	EXT. for triggering through external trigger cable;
	INT. for internal triggering from sampling unit with trigger takeoff.

	FREE RUN for triggering from Delayed Pulse signal.
TRIGGERING POLARITY	Same polarity as input signal, for external or internal trigger operation; CAL. for viewing Calibrator waveform.
RECOVERY TIME	MIN.
THRESHOLD	For triggered operation, turn toward polarity selected with POLARITY switch (+ for +; — for —). Rotate control far enough to hold off sweep, then turn back toward 0 for stable triggering of display.

Adjust the vertical and horizontal positioning controls and the TIME DELAY control to display the input waveform on the oscilloscope screen. Readjust the deflection factor, sweep rate and sample density as desired for best display of the signal. Generally, the best setting of the SAMPLES/CM switch is for the highest density with a reasonable display repetition rate. When using smoothing, be sure the dot density is sufficient to adequately display the waveform. If the shape of the waveform changes when the SAMPLES/CM switch is moved to a higher value, the display is being modified by the low sample density.

Triggering Problems

If triggering difficulties occur, the cause can usually be determined by operating the SWEEP TIME/CM switch and the THRESHOLD and RECOVERY TIME controls. (First be sure that the TRIGGERING switches on the Type 5T1 and sampling unit are set correctly). Establish whether the trouble is due to:

a. Too high or too low trigger amplitude;

b. Too low a rate of rise (or fall) of trigger-signal voltage;

c. Too high a trigger-signal repetition rate;

d. Interference due to hold-off recovery repetition rate.

Inability to hold off the sweep with the THRESHOLD control indicates too large a trigger signal. Use an attenuator to reduce the amplitude. If advancing the THRESHOLD control causes the sweep to free run before obtaining a stable display, either the trigger amplitude is too low, or the rate of rise is too low. Decrease trigger signal attenuation or locate a larger amplitude triggering source if signal amplitude is inadequate.

For signals with a low rate of rise, a faster rising trigger signal must be found, or a different triggering method used. Use dc trigger coupling for internal triggering. Fig. 2-2 gives rate-of-rise requirements.

If the problem is high repetition rate of the triggering signal, adjust the RECOVERY TIME control to obtain a stable display. A Type 280 Trigger Countdown unit may be needed if the RECOVERY TIME control cannot stabilize the display.

The use of a triggering rate equal to, or synchronous with, the hold-off repetition rate may result in unstable triggering. Increase the hold-off time with the RECOVERY TIME control to produce a stable display.

CHECK DELAYED PULSE ADJUSTMENT

For the Type 5T1 to operate properly, the oscilloscope Delayed Pulse generator bias must be set correctly. This may be done by the following procedure:

Connect a short length of 50-ohm coaxial cable between the Delayed Pulse output and the sampling unit input. Set the sweep rate to 2 nsec/cm and the deflection factor to 100 mv/cm. Adjust the TIME DELAY control and the vertical position control to display the negative-going step. If the signal is not stable, remove the right side panel of the Type 661 Oscilloscope and adjust the Delayed Pulse Gen. Bias control, located at the lower front corner of the right side.

Slowly withdraw the cable from the sampling unit input connector until the display shows only one-half to one centimeter of capacitively-coupled signal. If the signal shifts horizontally more than two millimeters from the original step position, the Delayed Pulse generator is free running. Readjust the Delayed Pulse Gen. Bias control until the cable can be alternately connected and disconnected with essentially no shift in horizontal position of the pulse.

"FALSE" DISPLAYS

Due to the nature of the crt display in a sampling-type oscilloscope, it is possible to obtain a false display when using a low sample density and when the sweep rate is set so that a very large number of cycles of the waveform should be displayed. This type of display appears as a waveform of much lower frequency than the input signal, and is caused by sampling at such a slow rate that the sampling occurs on widely-spaced portions of the signal. Each sample represents the correct amplitude at the sampling instant, but there are not enough samples to trace out each cycle of the waveform. The effect is similar to plotting a graph with insufficient information points. Check for a false display by increasing the sample density with the SAMPLES/CM control. If the display is found to be incorrect, increase the sweep rate to provide a proper display.

A false display may be observed by viewing a 10 μsec/cycle Calibrator signal with the sweep rate set at 100 μsec/cm and the sample dot density set at 5 samples/cm. Trigger the display with the SWEEP TIME/CM switch set at 2 μSEC/CM, then turn the switch to 100 μSEC/CM.

NOTES

SECTION 3
CIRCUIT DESCRIPTION

GENERAL INFORMATION

The Type 5T1 is a sampling-type timing unit providing a horizontal deflection voltage for the Type 661 Oscilloscope, and simultaneously controlling the time at which the sampling unit takes a sample. The Type 5T1 is triggered either by the input signal or by another waveform that is time-related to the input signal. One trigger pulse is required for each sample to be displayed (rather than one trigger for each sweep of the trace as in conventional oscilloscopes). The horizontal position of each dot on the crt screen is proportional to the duration of time between triggering and the taking of the sample. By taking a series of samples, each one occurring a little later on the input waveform, the display reconstructs a representation of the repetitive input signal.

This circuit description will be limited to a discussion of the various circuits. Anyone not familiar with the general concept and principles of sampling may also wish to refer to some introductory material such as the Tektronix publication, "Sampling Notes."

SIMPLIFIED BLOCK DIAGRAM

The Type 5T1 has three major functional sections shown in the simplified block diagram, Fig. 3-1. Front-panel operational controls are also indicated in the diagram. The main sections of the unit are: the Trigger and Hold-Off circuit; the Fast Ramp and Comparator, and the Staircase Generator. More detailed block diagrams of the circuitry are included with the descriptions of the individual circuits and at the beginning of the Schematics section of this manual.

The pulse that triggers the Trigger Recognition circuit may be supplied by the sampling unit, if the unit has provision for trigger takeoff, or it may be applied from an external source. Regardless of the source, the triggering signal must be time-related to the input signal. The Trigger circuit then triggers the operation of the remainder of the timing unit. Each time the Trigger circuit responds to a signal, it provides an output pulse to the time base (Fast Ramp) and a pulse to the Delayed Pulse generator in the oscilloscope. The trigger Hold-Off circuit allows the Trigger Recognition circuit to operate only when the system is prepared for a new sample; never more often than once every 10 microseconds.

Each trigger pulse received from the Trigger circuit causes the Fast Ramp to send a voltage ramp output to the Comparator circuit. The voltage run-down has a constant calibrated slope controlled by the SWEEP TIME/CM switch. In the Comparator circuit the output ramp voltage is compared to the horizontal deflection voltage (inverted prior to com-

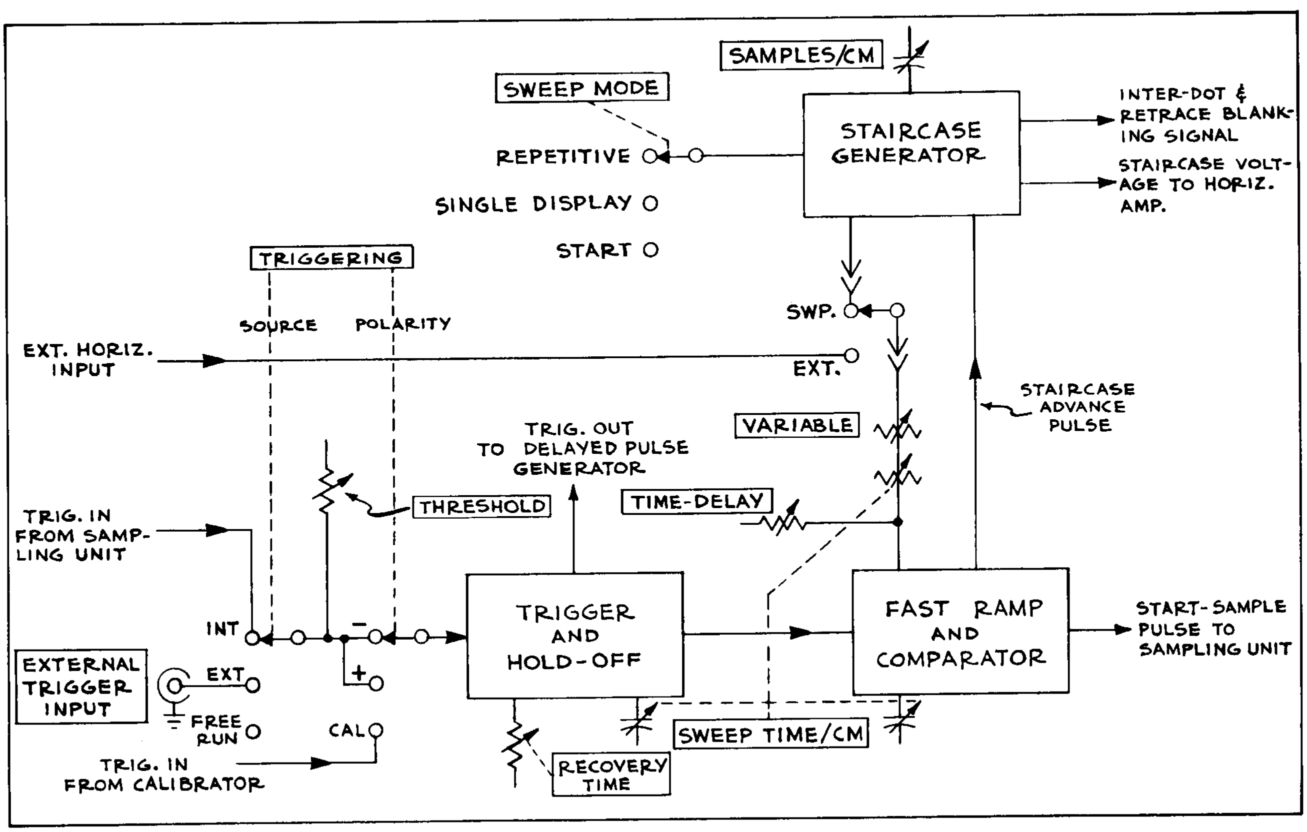


Fig. 3-1. Simplified block diagram of the Type 5T1.

parison). When the two voltages are equal, the Comparator provides an output pulse to the sampling unit, and another output pulse to the Staircase Generator to cause the staircase to step up one increment. Since the voltage ramp is linear, the output level at any time is proportional to the time elapsed since the ramp was triggered. Thus, the horizontal deflection voltage at the time the Comparator is triggered and a dot is displayed represents a calibrated interval of time following the operation of the Trigger circuit.

The Staircase Generator provides the horizontal deflection signal to the oscilloscope horizontal amplifier when the oscilloscope is set for internal sweep, and also provides the comparison voltage for initiating the sampling pulse. The horizontal deflection caused by the staircase voltage represents the time that the ramp takes to run down to the same voltage level as that of the staircase. Since the staircase applied to the Comparator advances one voltage increment downward after each sample has been taken, the fast ramp voltage must run down farther for each succeeding sample. Thus, each sample is taken at a later time than the preceding one, and the input signal is reconstructed from dots spaced in equivalent time on the crt screen.

The size of the staircase voltage increments, controlled by the SAMPLES/CM switch, determines the equivalent-time spacing between samples (dot density). The number of samples displayed per centimeter is inversely proportional to the rate of horizontal deflection. One sample is taken each time the Fast Ramp run-down occurs. If the ramp runs 100 times in the time the horizontal signal moves the crt beam across 1 cm of the screen, there will be 100 samples in the centimeter traversed. When enough increments have been taken to complete a full sweep, the Staircase Generator resets and is ready to repeat the display. A Sweep Lockout circuit permits viewing one display of the trace, if desired.

When the oscilloscope Horizontal Display switch is set for an external horizontal input, the staircase voltage is not used. Instead, the externally applied voltage determines both the horizontal position of the displayed sample and the length of time between triggering and sampling. Thus, for example, if the SWEEP TIME/CM switch is set to 10 nSEC, and if the left edge of the graticule represents a specific time, T_1, the vertical deflection of the crt beam at the 5th graticule mark represents the signal amplitude 50 nsec after T_1. An equivalent-time display is also produced using manual scan mode (horizontal voltage provided by the oscilloscope Horizontal Position control). Note that the crt display always represents equivalent time whether the horizontal deflection voltage is internally or externally derived.

The TIME DELAY control in the input circuit to the Comparator can delay the time at which the Comparator causes the sampling unit to take a sample, over a 0- to 100-nsec range. This is done by raising or lowering the comparison voltage level to which the fast ramp voltage must run. The effect of operating the TIME DELAY control is to shift the "time window" of the observed display.

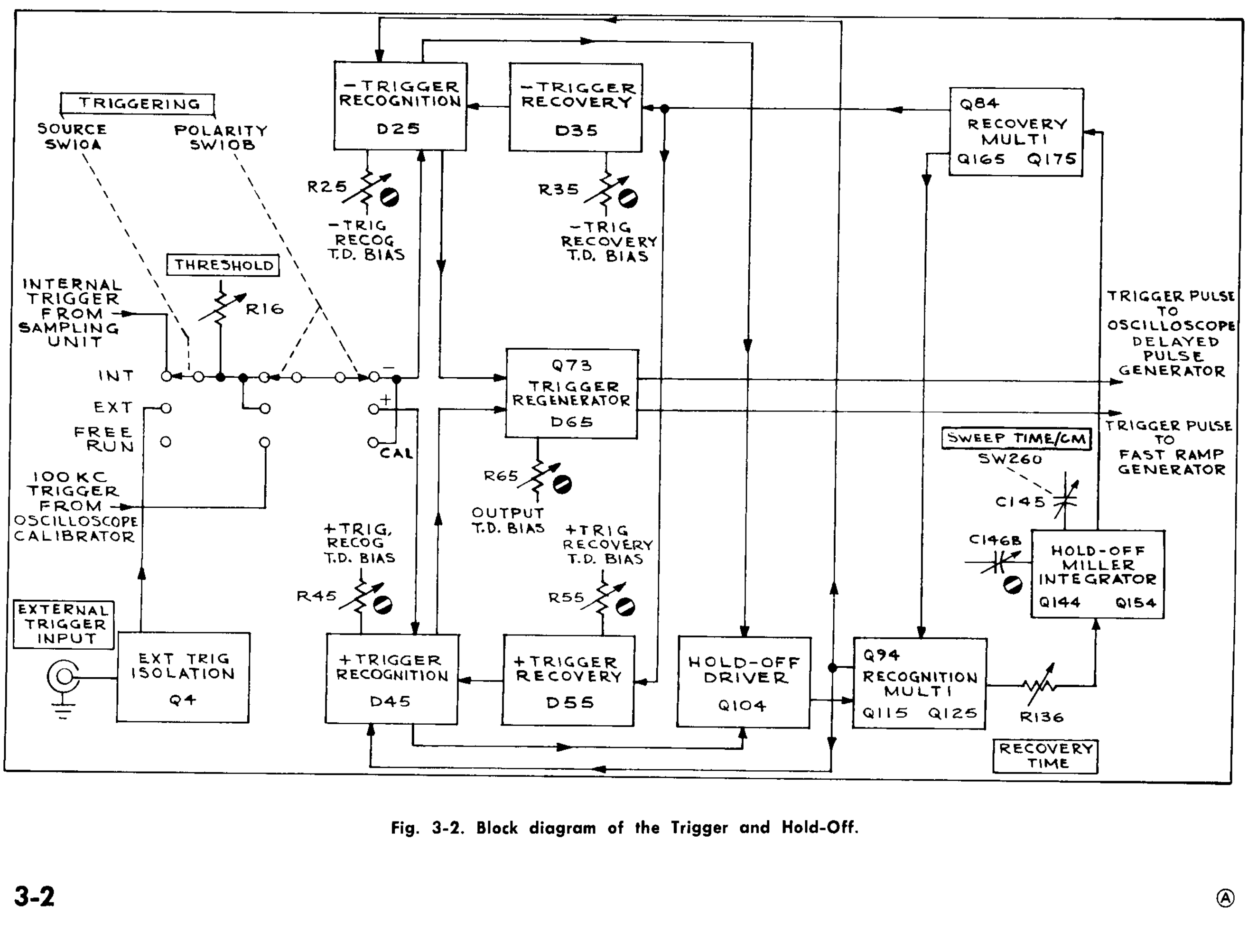


Fig. 3-2. Block diagram of the Trigger and Hold-Off.

TRIGGER AND HOLD-OFF

General

The Trigger and Hold-Off circuit consists of + and − trigger recognition tunnel diodes, + and −trigger recovery tunnel diodes, a trigger regenerator circuit, and a hold-off circuit made up of a driver transistor, a Miller integrator circuit, and recognition and recovery multivibrators. Instruments with serial numbers 494 and above also include an external trigger isolation circuit next to the trigger input. The sections of the trigger and hold-off are shown in the block diagram in Fig. 3-2. During the detailed circuit description, refer also to the Trigger and Hold-Off diagram and the Timing Switch diagram in the Schematics section.

After receiving a triggering signal, one of the recognition circuits pulses the Trigger Regenerator, which sends output pulses to the Fast Ramp Generator and to the Delayed Pulse generator in the oscilloscope. The recognition circuit also pulses the Hold-Off Driver, which switches the Hold-Off Recognition Multivibrator. When this multivibrator switches, the Recognition tunnel diode is reset and the Miller Integrator circuit runs down. This run-down voltage switches the Recovery Multivibrator, which resets the Recognition Multivibrator, and also switches the Recovery tunnel diode. When the Recognition Multivibrator resets, it allows the Miller circuit to run back up. When the Miller has completed its run, the Recovery Multivibrator reverts and resets the Recovery tunnel diode, making the circuit ready to be triggered by the next incoming trigger pulse.

The hold-off period is required to allow the Fast Ramp to run for a time equivalent to a full display and then reset, or to limit the sampling repetition rate to 100 kc.

The Hold-Off circuit counts down to 100 kc or less if the input triggering signal is above this frequency. Duration of the hold-off period is variable over a 1-to-1.3 range from the MIN. to the MAX. positions of the front-panel RECOVERY TIME control. This may be adjusted to stabilize the triggering if the triggering input frequency is equal to the hold-off repetition rate, or if a "false" display occurs at lower input repetition rates.

External Trigger Isolation S/N's 494 and up:

The External Trigger Isolation transistor, Q4, isolates the external input from the Trigger circuit so that large pulses generated by the tunnel diodes will not be transmitted out through the EXTERNAL TRIGGER INPUT connector. Instruments with serial numbers 101 through 493 can be modified with kit #040-332 to provide this isolation feature.

Under all normal conditions Q4 is turned on, with the bias current provided by the positive voltage connected to the emitter through R4, R5 and R6. A positive pulse applied to the Input is inverted by T2 and capacitively-coupled to the forward bias of the transistor, rapidly decreasing current through it. A negative pulse is formed at the collector, and is connected through C10 to the TRIGGERING SOURCE switch, SW10A. If the SOURCE switch is set to EXT., the external trigger pulse is then applied to the Trigger circuit selected by the POLARITY switch.

Likewise, a negative pulse applied to the input is inverted by T2, then applied to the emitter of Q4 as a positive pulse. The transistor turns on harder, producing a positive pulse at the collector. The positive trigger pulse is then applied to the Trigger circuit through C10 and the TRIGGERING switches.

Trigger Recognition and Regenerator

Two Trigger recognition circuits are used in the Type 5T1. D25, the —Trigger Recognition tunnel diode, responds to positive-going trigger information, and D45, the +Trigger Recognition tunnel diode, responds to negative-going trigger information. The reason for the apparent inversion of polarities is that the triggering information is already inverted in relation to the signal at the Input of the sampling unit. (T2 in the external input trigger circuit inverts externally applied trigger signals). In order to avoid confusion in operation of the instrument, the trigger circuit that operates on the rising portion of the input signal is labeled "+Trigger," and the circuit operating on the falling slope is labeled "—Trigger," even though the pulses that trigger the circuits are actually inverted.

The particular circuit to be used is selected with the TRIGGERING POLARITY switch, SW10B. When the POLARITY switch is in the CAL. position, a 100-kc triggering signal from the oscilloscope Calibrator circuit is applied to the —Trigger circuit. Since the two Trigger Recognition circuits are quite similar, except for the use of opposite supply and input polarities, only the operation of the —Trigger circuit will be described. D45 and D55 are connected opposite to D25 and D35 to allow for the reversed polarities.

The source of the trigger signal (other than Calibrator) is selected with the TRIGGERING SOURCE switch, SW10A. Either internal signals received from the sampling unit (INT.) or external signals applied through the front-panel EXTERNAL TRIGGER INPUT connector (EXT.) may be used, or the unit may be operated in the free run mode, with the SOURCE switch at FREE RUN. Internal triggering applies only when using a sampling unit provided with trigger takeoff. The required amplitude of input trigger signals ranges from 5 mv to 250 mv for either Trigger Recognition circuit, whether the signals are applied from an internal or external source. However, for internal triggering on pulses from the sampling unit, the signal amplitude at the vertical Input connector will usually need to be several times greater than the required trigger amplitude, since only a portion of the input is taken off for triggering. See the sampling unit instruction manual for the relative amplitude of the takeoff signal.

The SOURCE switch sends the input trigger signals to the POLARITY switch, which directs them to one of the Trigger Recognition circuits (+ POLARITY for positive-going input signals; —POLARITY for negative-going input). The THRESHOLD control, R16, sets the triggering level over a ±200 millivolt range. When the SOURCE switch is in the FREE RUN position, a bias voltage is applied to the input of the selected Trigger Recognition circuit, causing that circuit to free run when no trigger signal is present.

To trace one of the Trigger Recognition circuits through one trigger cycle, assume that the TRIGGERING switches are set to — INT. and that the THRESHOLD control is set far enough into the — region to hold off the Trigger circuit. Also assume that the Trigger circuit is ready to be retriggered. Tunnel diodes D25 (recognition) and D65 (regenerator) are in the low state (see Fig. 3-3). The recovery tunnel diode, D35, is in the high state, drawing current through L35, R32, R31 and R30. D25 is near the switching point due to bias current from two sources. One current path is through L25, R22, R21 and R20, and the other path is through D35 and R33. If we move the THRESHOLD control to a triggerable position and apply a positive pulse to the circuit, the small amount of additional current supplied to D25 switches it to its high state. This action sends a fast positive pulse to the regenerator transformer, T65, through R60 and C60. The + Trigger Recognition circuit remains locked out by the positive voltage applied through the POLARITY switch.

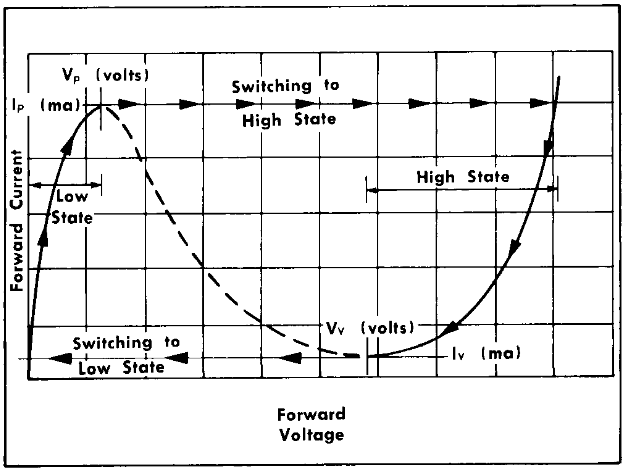


Fig. 3-3. Tunnel Diode characteristic curve.

The pulse through the drive winding of T65 causes enough additional current in D65 to cause it to switch to its high state, sending a regenerated trigger pulse to the Fast Ramp Generator. Since the bias current for D65, adjusted by the OUTPUT TD BIAS control, R65, is set for monostable operation, D65 switches back to its low state following the pulse. A separate winding on T65 drives the base of Q73 to produce a negative gate signal for use by the Delayed Pulse generator in the oscilloscope. The negative step from T65 passes through D72 to the output terminal, then when the field in T65 collapses, D72 becomes reverse biased and Q73 turns on momentarily until the output voltage returns to ground, ending the gate signal.

The positive pulse at the anode of D25 also pulses the emitter of the Hold-Off Driver, Q104, starting the operation of the Hold-Off circuit. The hold-off assures that the sampling cycle will not recur before the system is ready to take another sample. As the Recovery Multivibrator in the Hold-Off switches, D35 is switched to its low state and held there by Q84 until after the hold-off circuit has completed its operation. The recognition circuit will not re-trigger until D25 and D35 are returned to their initial states as the Hold-Off Multivibrators reset. When set for triggered operation as described above, D25 will trigger again on the first positive pulse after D35 has returned to the high state. With the THRESHOLD control set so the circuit free runs, or with the SOURCE switch set at FREE RUN, D25 will not wait for a trigger, but will re-trigger immediately when D35 returns to the high state.

Under normal triggered operation, on either internal or external trigger signals, the THRESHOLD control adjusts the dc voltage level on the anode of D25 that determines the amplitude of trigger signal required to switch D25 to its high state. Then when a trigger pulse is received, the Trigger and Hold-Off circuits pass through one cycle of operation and return to quiescence until another trigger pulse is received. When the SOURCE switch is at FREE RUN, the THRESHOLD control is switched out of the circuit. The additional positive voltage required at the anode of D25 to start and maintain operation of the circuit is supplied by the +19-volt supply connected to the input through R15.

Hold-Off and Recovery

The Hold-Off circuit consists of a Hold-Off Driver, two bistable multivibrators and a reversible Miller Integrator. The Miller circuit, operating partially through a diode gate, causes the multivibrators to switch, then later to reset. The recognition multivibrator, Q115-Q125, drives Q94 which shunts supply current away from the recognition tunnel diodes. The Recovery Multivibrator, Q165-Q175, operates Q84 which shunts current from the recovery diodes.

Assume operation of the —Trigger circuit as before. When the emitter of the Hold-Off Driver, Q104, receives a positive pulse from D25, the transistor becomes forward biased, producing a positive-going signal on its collector. This signal is applied to the base of Q115, in the Recognition Multivibrator, causing the multivibrator to switch. The collector of Q115 goes negative, forward biasing D92 and turning on Q94. This action shunts current from D25, returning this tunnel diode to its low state and holding it there.

When the Recognition Multivibrator switched, the collector voltage at Q125 went positive, supplying current through R132 and R136, the RECOVERY TIME control, to forward bias Q144. The voltage on the collector of Q144, which had been held at +19 volts by Q154, now starts to drop, turning off Q154. The voltage on the collector of Q154 decreases to ground level. The negative-going signal on the collector of Q144 is coupled back to the base of Q144, through hold-off capacitors C145 and C146. The current through R132 and R136 that is charging the hold-off capacitors remains essentially constant, and the slope of the voltage run-down at the collector of Q144 is quite linear. The capacitance value of C145 is changed with the SWEEP TIME/CM switch to change the slope of the run-down for the required hold-off time for that particular sweep rate. The slope of the Miller output ramp is also variable over a 1-to-1.3 range with the RECOVERY TIME control, R136.

When the collector of Q144 reaches ground level, D144 becomes forward biased, lowering the voltage at the base of Q165 in the Recovery Multivibrator. This causes the Recovery Multivibrator to switch, turning Q165 off and Q175 on. The negative-going voltage at the collector of Q175 forward biases D82, turning on Q84 which shunts the current supply for the recovery tunnel diodes and causes D35 to switch to its low state. Q84 holds D35 in the low state, preventing D25 from being triggered until the hold-off cycle has been completed.

The positive-going voltage at the collector of Q165 forward biases D164 and couples the voltage through C164 and R164 to the base of Q125. This signal causes the Recognition Multivibrator to switch and revert to its initial state, with Q115 turned off and Q125 turned on. The positive-going voltage at the collector of Q115 then reverse biases D92, causing Q94 to turn off, restoring the current source to D25. Since D35 is now in the low state, D25 cannot draw current through D35 and R33, and therefore is not triggerable.

When the Recognition Multivibrator reverted, the negative-going voltage at the collector of Q125 was applied to the base of Q144 through R132 and R136. The collector voltage of Q144 starts to go positive, but the rise is coupled back to the base through the hold-off capacitors, limiting the base swing as before. The collector voltage rises linearly to +19 volts, then Q144 turns off and Q154 turns back on. As the current is restored through Q154, the positive-going voltage on its collector forward biases D146, limiting the negative excursion at the base of Q144. The positive signal at the collector of Q154 is also coupled to the base of Q165, causing the Recovery Multivibrator to revert to its initial state, with Q165 turned on and Q175 turned off. The negative voltage at the collector of Q165 reverse biases D164, therefore does not affect the Recognition Multivibrator. The rise on the collector of Q175 reverse biases D82, causing Q84 to turn off, restoring the supply current to the recovery tunnel diodes. D35 switches to its high state, restoring the second bias current source to D25 through D35 and R33. D25 is again ready to be triggered to start a new sampling cycle.

FAST RAMP AND COMPARATOR

General

The Fast Ramp and Comparator circuit consists of a Fast Ramp Generator, a Comparison-Voltage Amplifier, a Comparator, and a Comparator Pulse Generator. A block diagram of the circuit is illustrated in Fig. 3-4. During the detailed circuit description refer also to the Fast Ramp and Comparator diagram and the Timing Switch diagram in the Schematics section.

The Fast Ramp Generator operates each time a trigger signal is received from the Trigger Regenerator. The negative-going ramp output voltage has a constant calibrated slope that is used as the internal real-time base for timing the sampling pulses. The voltage ramp is sent to the Comparator circuit where it is compared to a reference voltage received through the SWEEP TIME/CM attenuator and the Comparison-Voltage Amplifier. The comparison voltage may be supplied by the Staircase Generator circuit, or through the oscilloscope from an external source or the Horizontal Position control (manual scan). In the following discussion the oscilloscope Horizontal Display switch is assumed to be in the X1 position.

When the fast ramp and comparison voltages are equal, the Comparator circuit causes the Comparator Pulse Generator to send time-oriented pulses to the sampling unit, to the Staircase Generator, and back to the Fast Ramp Generator

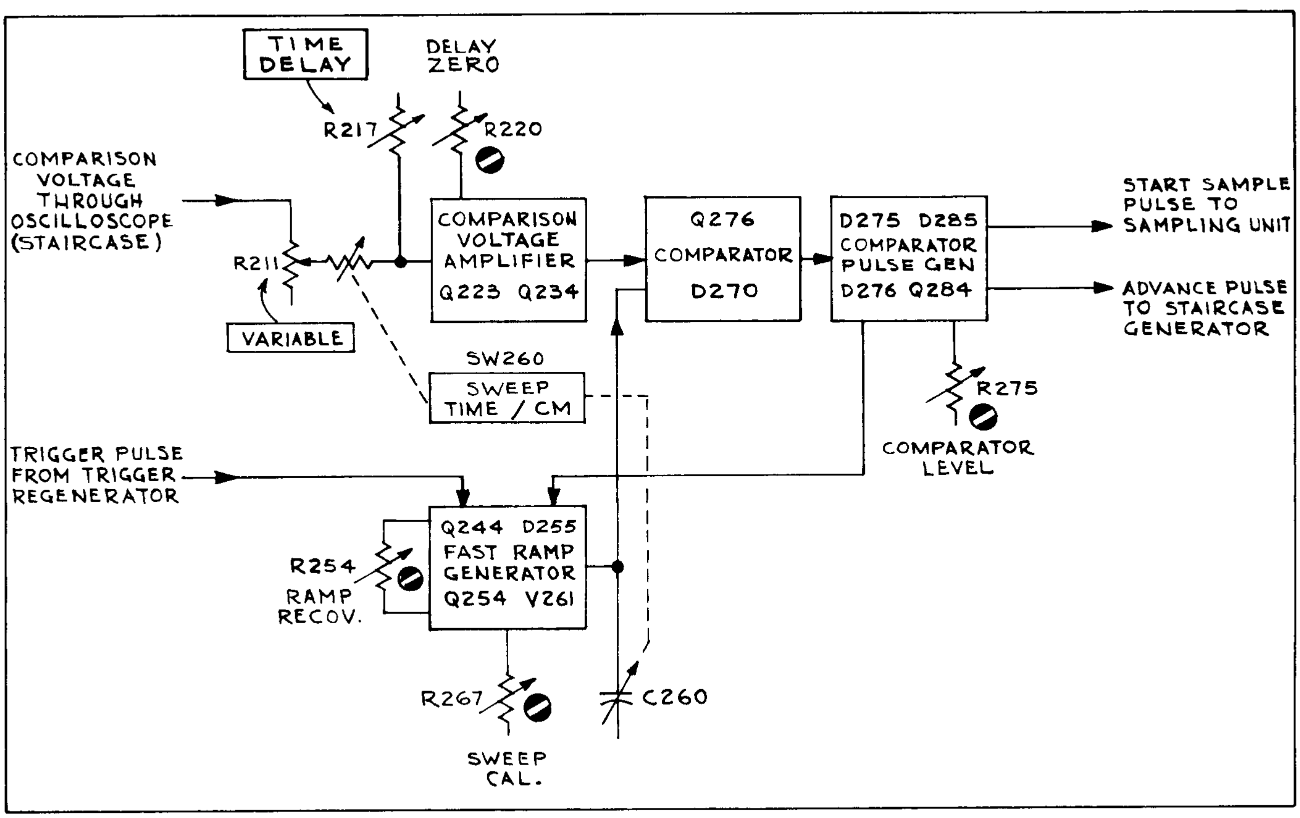


Fig. 3-4. Block diagram of the Fast Ramp and Comparator.

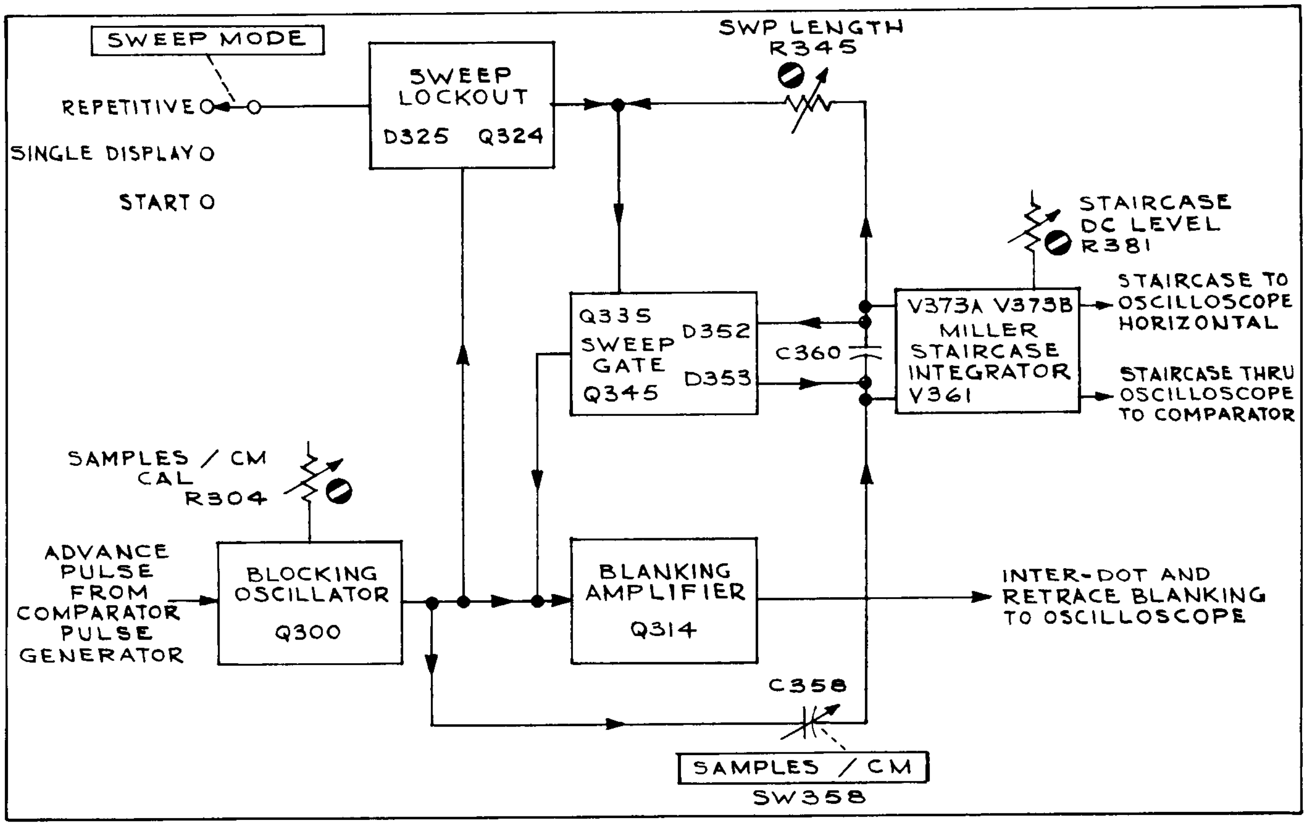


Fig. 3-5. Block diagram of the Staircase Generator.

to reset it. The pulse to the sampling unit initiates the sampling cycle, causing the unit to sample the input signal. The pulse sent to the Staircase Generator advances the staircase voltage one increment, causing both the deflection voltage and the comparison voltage to advance one step.

For each dot displayed, the fast ramp runs through its full excursion, representing a full sweep of the crt. As the staircase comparison voltage steps down incrementally, the fast ramp *voltage* has to run a little farther each time before it coincides with the comparison voltage. Thus, for each succeeding run-down, the fast ramp runs for a little longer *time* between triggering and sampling. Each sample, therefore, is taken at a later point on the waveform than the previous sample, and is displayed proportionately farther across the crt screen.

Fast Ramp Generator

The Fast Ramp Generator produces a linear voltage ramp output for use by the Comparator. V261 is the constant-current supply for the generator, with the constant voltage on its grid provided through the decoupling filter, R263 and C261, and the voltage divider, R261 and R262. Very little change in current through the tube is caused by a voltage change in the plate circuit. The cathode current, which comes from the —100-volt supply through R265 and R267 (SWEEP CAL.) sets the current through the tube.

Quiescently, before a trigger signal is received, tunnel diode D255 is held in the high state by current through R244, and Q254 is turned on. Input transistor Q244 is also turned on, drawing current through R244. Current from V261 passes through Q254 and holds the ramp slope capacitor, C260, near ground voltage.

A positive trigger pulse from the Trigger Regenerator is received at the emitter of Q244, causing it to conduct more heavily. The increased current in Q244 diverts current from D255, causing it to switch to its low state. As D255 switches, Q254 turns off. After the trigger pulse has passed, Q254 is held in cutoff by D255, which is not able to reset due to lack of current. With the current path through Q254 now open, the current through V261 flows into the ramp slope capacitor, C260.

The rate of fall of the fast ramp voltage is determined by the capacitance value of C260, selected with the SWEEP TIME/CM switch, SW260. Six capacitors provide five rates of fall, or ramp slopes. In the fastest sweep ranges, C260E, C260F and circuit stray capacitance determine the slope of the ramp. C260F is adjusted during calibration for the correct slope at these rates.

The effective portion of the fast ramp voltage to be used depends on the range of the comparison voltage applied to the base of Q276. The effective ramp length ranges from 1 volt to 10 volts, as shown in Table 3-1. Because the Fast Ramp is triggered by a signal related in time to the input signal, the comparison voltage determines the real-time instant at which coincidence occurs and a Comparator pulse is sent to the sampling unit.

TABLE 3-1
SWEEP TIME/CM Switch

Sweep Time/Cm Switch Setting	Fast Ramp Slope	Attenuator Ratio	Duration of Fast Ramp Voltage = 10 cm Sweep
100 μSEC	0.01 volt/μsec	X1	10 volts
50 μSEC		X2	5 volts
20 μSEC		X5	2 volts
10 μSEC	0.1 volts/μsec	X1	10 volts
5 μSEC		X2	5 volts
2 μSEC		X5	2 volts
1 μSEC	1.0 volt/μsec	X1	10 volts
.5 μSEC		X2	5 volts
.2 μSEC		X5	2 volts
.1 μSEC	10 volts/μsec	X1	10 volts
50 nSEC		X2	5 volts
20 nSEC		X5	2 volts
10 nSEC	50 volts/μsec	X2	5 volts
5 nSEC		X4	2.5 volts
2 nSEC		X10	1 volt
1 nSEC	500 volts/μsec	X2	5 volts

After the ramp output voltage has been sent to the Comparator and comparison has taken place, a negative reset pulse is received by the Fast Ramp Generator from the Comparator Pulse Generator. The pulse is applied through D256 to D255, switching D255 back to its high state. Q254 turns on again and draws current from V261 and C260, quickly discharging C260. The RAMP RECOV. control, R254, sets the bias current at the base of Q254 to limit the current through the transistor to a safe value, but still allow quick recovery. The circuit has adequate time to return to quiescence before another pulse is received from the Trigger circuit.

Comparison Voltage Amplifier

The comparison voltage applied to the base of Q276 and the anode of D270 (S/N 305 and up) in the Comparator is determined by the current applied to the operational amplifier (Q223-Q234) preceding it. The amplifier has an emitter follower at the input and a collector-loaded output, thus it is current driven and provides voltage output (transimpedance amplifier). The feedback resistor, R231, sets the current-to-voltage gain of the circuit.

There are three sources of current for this amplifier: from the comparison voltage attenuator; from the TIME DELAY control circuit, and from the DELAY ZERO control, R220, which is adjusted during calibration. The comparison voltage is applied through attenuator R214-R215, which attenuates the current to Q223, and retains a fixed loading impedance on the comparison voltage source. With the oscilloscope Horizontal Display control in one of the Sweep Magnifier positions, the comparison voltage is received from the Staircase Generator. The SWEEP TIME/CM switch controls the values of R214 and R215. Table 3-1 gives the current attenuation and the resulting Comparison-Voltage Amplifier output corresponding to 10 cm of horizontal deflection, at each position of the switch. The VARIABLE (Sweep Time/Cm), when not in CALIBRATED position, increases attenuation of the input signal, producing a smaller swing of the comparison voltage into the Comparator. This causes the samples to be taken closer together on the waveform, but since the horizontal-display voltage steps are not changed, the waveform display becomes stretched out, resulting in an increase in the equivalent-time sweep rate.

The TIME DELAY control, R217, is a variable current supply at the input to the Comparison-Voltage Amplifier, for shifting the level of its output voltage. The effect of this voltage shift is to change the triggering time of the sampling cycle. Since all samples are delayed or advanced by the same amount, the whole display is moved horizontally, in equivalent time, on the crt. Current through the TIME DELAY control passes through R218. The value of R218 is selected by the SWEEP TIME/CM switch so that with the TIME DELAY control set fully clockwise, the sampling-cycle time-delay will remain at 100 nsec as the sweep rate is changed.

Comparator

S/N's 305 and up: The output of the Comparison Voltage Amplifier is applied to the anode of D270 through the base-emitter path of Comparator transistor Q276. A small quiescent current flows through Q276 to enable it to accept Fast Ramp coincidence current through D270. This small current is derived from zener diode D234 through R271, R270 and R237. Prior to coincidence, D270 is reverse biased and isolates the comparator from the Fast Ramp. Thus, before coincidence, all the current from V261 flows into the ramp slope capacitor. As soon as the fast ramp voltage has run down far enough to forward bias D270, current from V261 passes through D270 and increases the current through Q276. The voltage at the collector of Q276 goes negative, decreasing the current through D272 and allowing more current to flow in tunnel diode D275 in the Comparator Pulse Generator circuit.

S/N's 101 through 304: The comparison voltage is applied through R270 to the base of the Comparator transistor, Q276. The output of the Fast Ramp Generator is connected to the emitter of Q276 and keeps the transistor cut off prior to the time of coincidence. (Diode D270 provides overvoltage protection for Q254 in case Q276 should fail to operate). Coincidence occurs when the emitter-base junction of Q276 becomes forward biased, turning on the transistor. The resulting negative-going voltage at the collector decreases the current through D272, allowing more current to flow in tunnel diode D275 in the Comparator Pulse Generator circuit.

Comparator Pulse Generator

The low-state current through D275 before coincidence is set just below its switching level by R275, the COMPARATOR LEVEL adjustment. When the current increases in D275 following coincidence, as a result of the decrease in current through D272 in the Comparator, D275 switches to its high state. A negative step is applied to D285 through D276, and is also sent as a reset pulse through D256 back to the Fast Ramp Generator. Low-state current through D285 is set by divider R288 and R289. As D275 switches, a reverse bias is applied to D276, causing it to conduct, and coupling the voltage step from D275 to D285. D285 switches to the high state, sending a fast step to the doubling transformer, T284.

The output of T284 turns on Q284, producing a positive voltage pulse at its collector. This pulse is connected through a coax cable in the oscilloscope to the sampling unit where it triggers the sampling pulse. It is also sent through the isolation resistance network, R285, R286 and R287, to the Staircase Generator, advancing that circuit one increment. When the field in T284 collapses, D285 is returned to the low state and Q284 turns off, ending the pulse. D275 is reset to its low state through D276, to be ready for the next coincidence.

STAIRCASE GENERATOR

The Staircase Generator circuit includes a Blocking Oscillator, a Sweep Lockout circuit, a Sweep Gate circuit, a Miller Staircase Integrator and a Blanking Amplifier. Fig. 3-5 is a block diagram of the circuit. Refer also to the Staircase Generator and Timing Switch diagrams in the Schematic section during the detailed discussion of the circuitry.

Each time the Comparator Pulse Generator sends a start-sample signal to the sampling unit, it also pulses the Blocking Oscillator circuit at the input of the Staircase Generator. The Blocking Oscillator then sends gate pulses to the Sweep Lockout circuit, the Miller Staircase Integrator and the Blanking Amplifier. The Sweep Lockout triggers the Sweep Gate after receiving the first pulse from the Blocking Oscillator. Further pulses applied to the Sweep Gate through the Sweep Lockout do not affect the gate until it has been reset following completion of a sweep. The Sweep Gate, when triggered, disconnects the Miller staircase capacitor (C360) from its discharge path and allows subsequent pulses from the Blocking Oscillator to charge up the capacitor, producing the staircase output voltage. The size of the voltage steps is set by the capacitor (C358) selected with the front-panel SAMPLES/CM switch. The staircase output produces the horizontal deflection for the crt beam, and also provides the comparison voltage for advancing the sampling delay so the sample will be taken later each time. When the staircase output reaches a certain value, it resets the Sweep Gate, causing the Miller capacitor to discharge, and the circuit is ready to start another sweep with the next input trigger pulse.

When the SWEEP MODE switch is turned to SINGLE DISPLAY, then START, the Sweep Lockout circuit permits a single trigger pulse to initiate a full sweep of the crt display, but locks out subsequent triggering pulses.

Each time a pulse is applied to the Miller circuit to step up the staircase voltage, the Blanking Amplifier is also pulsed by the Blocking Oscillator to blank the crt while the output voltage is taking its step (inter-dot blanking). While the Sweep Gate is holding off the sweep during retrace, it also applies a voltage to the Blanking Amplifier to blank the crt (retrace blanking).

Blocking Oscillator

Each pulse from the Comparator Pulse Generator passes through C300 into the collector winding of T300 in the Staircase Generator Blocking Oscillator circuit. The current induced in the base winding is applied to the base of Q300, returning through D306. Q300, the Blocking Oscillator transistor, turns on hard and normal blocking oscillator saturation follows. As the backswing begins, D300 (across the collector winding) becomes forward biased and conducts the backswing current, diverting it from the transformer to allow the Blocking Oscillator to recover quickly.

The SAMPLES/CM CAL. control, R304, is adjusted during calibration to set the size of the output pulses that are applied to the other circuits of the Staircase Generator.

Sweep Lockout

The pulses from the Blocking Oscillator are sent through Q324 in the Sweep Lockout circuit to switch the Sweep Gate. Quiescently, with the SWEEP MODE switch at REPETITIVE, tunnel diode D325 is in the low state and Q324 is cut off. Each negative pulse transmitted to the Sweep Lockout circuit through C303 and R324 switches D325 to its high state. As the diode switches, Q324 is turned on rapidly, producing a fast 6-volt negative pulse at its collector. The negative trigger pulse is sent through C322 and R336 to the Sweep Gate circuit. At the end of each blocking oscillator pulse, D325 switches back to its low state and Q324 turns off again.

A single sweep of the crt is obtained when the SWEEP MODE switch, SW325, is set to SINGLE DISPLAY, then turned to START position. At SINGLE DISPLAY, R325 is connected to the —19-volt supply, holding D325 in its high state after being triggered once. With D325 in the high state, Q324 remains in conduction, locking out the negative sweep-gating pulses that are produced when Q324 turns on. This prevents the Sweep Gate from being triggered, and locks the staircase output at zero. When the SWEEP MODE switch is then turned to START, the junction of R310 and C310, which had been at —19 volts, is connected to ground. C310 sends a positive pulse through R312 and R315 to D325, causing it to switch to its low state, turning off Q324. D325 then remains in its low state until a pulse is received from the Blocking Oscillator. The first negative pulse switches D325 to its high state, turns on Q324, and pulses the Sweep Gate, causing a sweep to be initiated. At the end of the single sweep, the Sweep Gate is returned to a triggerable state, but cannot be triggered until a pulse is received from the Sweep Lockout. Since D325 is still in the high state and Q324 is still turned on, no pulse will be sent to the Sweep Gate until the Sweep MODE switch is turned to START again (or to REPETITIVE).

Sweep Gate

The Sweep Gate circuit (Q335-Q345) is a bistable multivibrator of a type that operates with both transistors either turned on or turned off simultaneously. During the sweep, the transistors are on, and during retrace they are off.

At the end of the retrace period, just prior to a new sweep, the voltage at the base of Q335 returns to a level slightly above ground, with Q335 held in cutoff. When the SWEEP MODE switch is set to REPETITIVE, negative pulses are continuously being applied from the Sweep Lockout circuit to the Sweep Gate through C322 and R336. The first negative pulse that forward biases the base-emitter junction of Q335 turns on the transistor, switching the multivibrator. The collector of Q335 goes positive, turning on Q345. The collector of Q345 then goes negative, and the regenerative action of the circuit causes both transistors to saturate. The negative voltage at the collector of Q345 reverse biases D353, disconnecting the Staircase Integrator from the Sweep Gate, allowing the Miller circuit to run up and the sweep to progress as the staircase capacitor charges.

The output signal from the Miller circuit is applied to the Sweep Gate circuit through R346, D345, R345 (SWP. LENGTH) and R344. As the staircase voltage rises, more current is drawn through the Sweep Length network, diverting current from the base of Q335. Current is adjusted with the SWP. LENGTH contol. When the base current to Q335 has been reduced to about 0.1 ma, the transistor cuts off. The resulting negative step at its collector turns on the Blanking Amplifier transistor and turns off Q345, allowing the collector of Q345 to go positive. This positive-going collector voltage forward biases D353, and the staircase capacitor begins to discharge. The resulting rise on the grid of V361 operates through the Miller circuit, causing the staircase output voltage to drop quickly to near ground voltage. When the negative-going output forward biases D352, the diode conducts, and a state of clamped equilibrium exists. D353 remains forward biased and conducting current away from the grid of V361 until the Sweep Gate is triggered and the multivibrator switches.

When the output voltage drops during the discharge of the staircase capacitor, D345 becomes reverse biased, disconnecting the Sweep Gate from the staircase output. C345, which had charged up to the staircase voltage, then discharges through the SWP. LENGTH control and R344, setting the hold-off time of the circuit. The current source is restored to the base of Q335 as C345 discharges; however, Q335 is held in cutoff by the slightly positive voltage at its base set by current through D337 and R337. The next negative trigger from the Sweep Lockout will then trigger the Sweep Gate to initiate a new sweep.

Miller Staircase Integrator

The negative output signal from the Blocking Oscillator is sent through C358 and D360 to C360 and the grid of V361 in the Miller Staircase Integrator circuit. The value of C358, selected with the SAMPLES/CM switch, SW358, determines the amount of charge that is transferred from the Blocking Oscillator to the staircase capacitor, C360.

The negative pulses passed through C358 reverse bias D361 and forward bias D360. When the Sweep Gate circuit is holding off the sweep, the pulse energy passes through disconnect diode D353 into the Sweep Gate. As soon as a trigger pulse has switched the Sweep Gate, disconnecting the discharge path, the pulse energy starts to charge C360. The voltage on the grid of V361 begins to drop, producing an amplified positive signal at the plate of the tube. This signal is coupled to the grid of cathode follower V373B, raising the voltage on its cathode, which is connected through R375, C378 and zener diode D378 to the staircase output and the output side of C360. The degenerative feedback to C360 keeps the grid side of the capacitor nearly stationary, and any energy applied to the grid of V361 appears only as an amplified signal on the opposite side of C360. The amount of charge that C360 receives from each Blocking Oscillator pulse is proportional to the capacitance value of C358.

The staircase voltage at the cathode of V373B is sent through a resistance divider to the output connector of the Type 5T1, to be applied to the oscilloscope horizontal deflection circuitry. This voltage output runs from about zero to about +50 volts. The dc level of the output is set by the STAIRCASE DC LEVEL control, R381. When the oscilloscope Horizontal Display switch is set to one of the Sweep Magnifier positions, the staircase voltage is also sent back to the Comparator circuit in the Type 5T1 to be used as a comparison voltage.

When enough pulses have been received to raise the charge on C360, and thus the staircase output voltage, high enough to reset the Sweep Gate, the gate switches, causing C360 to discharge again. C360 remains discharged until the Sweep Gate is again triggered, and D353 disconnects the current path. Then the Miller circuit is ready to begin another sweep.

During the operation of the Miller circuit, the plate current of V361 is kept constant over the operating range of the tube by means of a positive feedback loop through V373A. As the voltage at the cathode of V373B changes, producing the staircase runup and retrace, the voltage changes are transferred to the grid of V373A through C377 and zener diode D377. The cathode of V373A follows the grid and keeps the current through R371 and V361 essentially constant, assuring good linearity and response.

Blanking Amplifier

The Blanking Amplifier, Q314, is driven by both the Blocking Oscillator and the Sweep Gate, to provide crt blanking signals to the oscilloscope. The collector of Q335 in the Sweep Gate circuit is connected through R331 to the base of Q314. While the staircase is being generated, the voltage applied to Q314 from the Sweep Gate circuit is set slightly positive, so that the Blanking Amplifier will be turned off except when a negative pulse is applied from the Blocking Oscillator through C309 and R309. During retrace, while the Miller capacitor is being discharged and the horizontal deflection voltage is returning the crt beam to the left side of the screen, the negative voltage from the Sweep Gate keeps Q314 turned on. The collector circuit of Q314 is completed in the oscilloscope, so that whenever Q314 is turned on, current through the transistor produces blanking of the crt. Thus, no sample dot is displayed on the screen while the beam is retracing to the left side of the crt or while the dot position is changing.

NOTES

SECTION 4
MAINTENANCE

PREVENTIVE MAINTENANCE

Recalibration

The Type 5T1 Timing Unit will not require frequent recalibration. However, to insure that the unit is operating properly at all times we suggest that you check the calibration after each 500-hour period of operation, or every six months if used only intermittently. A complete step-by-step procedure for calibrating the unit and checking its operation is included in the Calibration section of this manual.

The accuracy of measurements made with the Type 5T1 depends not only on the calibration of the Type 5T1, but also on the calibration of the associated oscilloscope and sampling unit. The entire system must be well calibrated for proper operation.

If, during the operation of the Type 5T1, the instrument appears to be functioning poorly, the difficulty may be due to improper calibration of some part of the system, or to a malfunction resulting from improper operation or component failure. Check the calibration of the instruments before troubleshooting the Type 5T1.

Visual Inspection

Certain types of trouble can be found by a visual inspection of the unit. For this reason, a complete visual check should be made each time the instrument is repaired or recalibrated. Look for such apparent defects as loose or broken connections, damaged connectors, scorched parts, broken terminal strips and improperly seated tubes, transistors or tunnel diodes. Corrective measures for most of these troubles are obvious, except in the case of heat damage. Quite often, heat damage is the result of other less apparent trouble. It is essential that the cause of the overheating, as well as the apparent damage, be corrected before attempting to operate the unit. Otherwise the damage may be repeated.

REMOVAL AND REPLACEMENT OF PARTS

General

Procedures required for replacement of most parts in the Type 5T1 are simple and straightforward. The following paragraphs contain information that may be helpful when replacing some of the parts that are more difficult to remove, or require special care. It will be necessary to recalibrate portions of the instrument after replacing certain parts. Refer to the Calibration section of this manual for the procedures required.

Many components in the Type 5T1 are mounted in a particular position to reduce stray inductance and capacitance. Therefore, carefully install replacement components to duplicate lead length, lead dress, and location of the original component.

Maintenance is made easier by the use of special extension cables that permit the Type 5T1 to be operated outside the oscilloscope. These extensions are in the Calibration section illustrated in Fig. 5-1.

CAUTION

BE SURE THE OSCILLOSCOPE POWER IS TURNED OFF WHENEVER REMOVING OR REPLACING THE TYPE 5T1 PLUG-IN UNIT.

Replacement of Switches

Only a normal amount of care is required for the removal of a defective switch. When a switch is removed, the leads should be identified as they are detached in order to assure connecting the new switch properly. If one section of a wafer switch is defective, the entire switch should be replaced. Wafers are not normally replaced separately. Some switches may be ordered from Tektronix either with associated components wired in place, or unwired. Check the Parts List for the appropriate part numbers.

Soldering Precautions

In the production of Tektronix instruments, a silver-bearing solder is used to establish a bond with the ceramic terminal strips. This bond may be broken by the application of too much heat or by the repeated use of ordinary 40-60 tin-lead solder. However, occasional use of ordinary solder is permissible. For general repair work on Tektronix instruments, solder containing about 3% silver should be used. Silver-bearing solder is available locally from electronics distributors, or may be purchased through your Tektronix Field Office (Tektronix part number 251-514).

Because of the shape of the terminal notches in the ceramic strips, it is advisable to use a wedge-shaped tip on your soldering iron when installing or removing parts. A wedge-shaped tip permits the application of heat directly to the solder in the terminals and reduces the amount of heat required. It is important to avoid excessive heating. A 50-watt iron is adequate.

The proper technique for soldering and unsoldering short-lead components requires: (1) the use of needle-nose pliers to act as a heat shunt between the soldering point and the component; (2) the use of a hot iron for a short time; and (3) careful manipulation to avoid damage to small components. Use only enough solder to make a good bond.

When soldering to etched-circuit boards, use a low-heat iron (about 30 watts) and apply the minimum amount of heat required. Application of excess heat to a conducting strip can cause it to separate from the circuit board. Silver-bearing solder should be used for this work.

Ceramic Strip Replacement

To replace a damaged ceramic terminal strip, first unsolder all connections, then remove the mounting clips and nylon spacers from the chassis. This may be done by prying the mounting clips, attached to the strip, out of the chassis. If the spacers do not come out with the clips, they can be left in the chassis or pulled out separately. If they are not damaged, the spacers may be used with the new ceramic strip assembly. Replacement strips are supplied with mounting clips already attached, so it is not necessary to salvage the old clips.

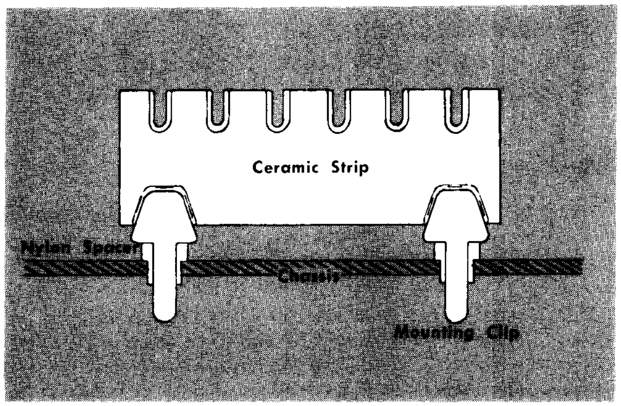


Fig. 4-1. The assembled ceramic terminal strip.

When the damaged strip and clip assembly have been removed, place the spacers into the mounting holes in the chassis and press the mounting clips of the new strip assembly into the spacers. It may be necessary to tap lightly or apply some pressure to the ceramic strip to make the clips seat down on the spacers. To avoid damage to the terminal strip, use a soft-tipped tool for any tapping, and apply force only to the part of the strip directly above the mounting clips. Fig. 4-1 shows the assembled terminal strip. Cut off any excess length of the clips extending beyond the end of the spacers on the reverse side of the chassis. Resolder all components and wires in place, as they were previously arranged. (Note soldering precautions given above).

Checking Tubes and Semiconductors

Commercial testers are not recommended for checking the tubes and transistors used in the Type 5T1. Tube testers often fail to indicate defects that affect the performance of the circuits, or they may indicate a tube to be defective when it is operating satisfactorily in the circuit. The same applies to similar tests made on transistors. If a tube or transistor is operating properly in the circuit, it should not be replaced. Unnecessary replacement may require that the instrument be needlessly recalibrated.

Direct substitution is usually the best means of checking a tube or semiconductor. A characteristic curve display instrument, such as a Tektronix Type 570 or 575, may also be useful in checking a tube, transistor or tunnel diode that is suspected of being defective. Be careful when handling tunnel diodes. Due to their shape and their small size, it is easy to apply excessive physical force to them. If tunnel diodes are checked frequently, a mounting clip should be set up for convenience in attaching leads.

Often a transistor or common junction diode can be checked for an open or shorted condition merely by making an ohmmeter check between terminals. Measure the dc resistance first in one direction, then the other, and note the effect of polarity reversal.

CAUTION

Use of high-resistance scales of the ohmmeter should be avoided, because the internal voltage source of the ohmmeter can damage the semiconductor being checked.

Before installing a new component, be sure that the circuit voltages applied to it are normal. If replacement is made without checking out the circuit, the new component may be damaged by some defect in the circuit.

REPLACEMENT PARTS

Replacements for all parts used in the Type 5T1 can be purchased directly from Tektronix at current net prices. However, many of the electrical components can be obtained locally in less time. Before ordering or purchasing parts, be sure to consult the parts list to determine the tolerances and ratings required. Most mechanical parts and certain selected or specially manufactured components should be ordered directly from Tektronix since they are not available from other sources.

All parts can be ordered through the local Tektronix Field Office. When ordering parts be sure to include: (1) the complete description of the part as given in the parts list; (2) the type of instrument (Type 5T1); and (3) the Serial Number of your instrument. Some parts may have been superseded by improved components since the production of your instrument. In such cases, the new part may be shipped in place of the part ordered.

TROUBLESHOOTING

General Information

The Type 5T1 derives all of its operating voltages from the oscilloscope, and operates with the oscilloscope and the sampling unit to produce the display. Therefore, if trouble develops, determine which unit is causing the trouble before proceeding further. If more than one instrument is available, a quick check for isolating the trouble to a particular unit can be made by trying different combinations of the oscilloscopes, sampling units and timing units.

If trouble occurs in the Type 5T1, try to isolate it by quick operational and visual checks. First check the settings of all controls. Then operate the controls to see what effect, if any, they have on the trouble symptoms. The normal or abnormal operation of each control may help locate the trouble. Be sure the oscilloscope Delayed Pulse Generator Bias Control is correctly adjusted (See Operating Instructions section of this manual). Many apparent troubles are caused by the improper setting of one or more controls, or by improper calibration of the unit. One of the first steps should be to check the calibration of the suspected circuit. The type of trouble will generally indicate what further checks to make. The cause of a trouble that occurs only in certain positions of a control can usually be determined immediately from the symptoms.

In general, a troubleshooting procedure consists of two parts: circuit isolation and circuit troubleshooting. It will probably be necessary to read the circuit description in conjunction with a study of the schematics to determine the location of the source of trouble. Knowing the functions of the various circuits and controls, the operational checks will usually isolate the trouble to a particular circuit. Then, after the circuit causing the trouble has been established, detailed troubleshooting procedures can be performed.

Circuit Tracing

For the purpose of circuit tracing, the wires in the Type 5T1 are all color-coded. Most power leads are coded with colored tracers indicating significant figures of the voltage, using the same color code as is used for composition resistors. The widest tracer on the lead represents the first figure. Tracers on signal leads are for identification only.

Where the circuit diagram shows more than one section to a wafer switch, each section is coded to indicate its position on the switch. Wafers are numbered from the front panel to the rear of the switch. The letters F and R indicate whether the front or rear of the wafer is used to perform the particular switching function. For example, the code designation 3R means the rear side of the third wafer.

Circuit Isolation

In general, the easiest way to isolate a trouble to a particular circuit in the Type 5T1 is to check the input and output signals of the various circuits. To do this conveniently, the unit should be operated outside the oscilloscope, as suggested in the Calibration procedure. Use a test oscilloscope with a bandpass of at least 15 Mc, and a high impedance voltmeter for making the checks.

For checking the Trigger and Hold-Off circuit, set the TRIGGERING SOURCE switch to INT. and operate the THRESHOLD and RECOVERY TIME controls and the POLARITY switch to see their effect on the waveforms. The other circuits can usually be checked best by setting the controls for triggerable operation, as shown on the Schematic diagrams. When checking for the waveforms on the Schematics, note the conditions given on the diagrams for the illustrated waveforms. Also operate the front-panel controls to observe the effects they produce on the waveforms in the related circuitry.

Component Failure

Most troubles that occur in the Type 5T1 are caused by tube or semiconductor failure due to normal aging and use. Therefore, when trouble has been isolated to a particular circuit, the tubes and semiconductors in that circuit should be checked first. Be sure that all tubes, transistors and tunnel diodes are returned to their original sockets or clips if they are found to be good.

Another common cause of trouble is misuse or improper operation. That is, the system has been subjected to excessive loads or has been damaged by careless operational or maintenance procedures. Be sure to observe the given limits of input voltages, etc., when operating the unit. Also be careful when checking inside of the instrument with meter leads or probe tips. Careless shorting of leads can cause abnormal voltages or transients to be applied to the semiconductors and other small components, and can result in the destruction of the components.

NOTES

SECTION 5
CALIBRATION

General Information

A complete procedure is provided in this section for checking the operation and calibration of the Type 5T1, and for making adjustments where necessary. These checks will assure the operator that the instrument is operating within specification limits. The steps of the procedure are arranged in convenient sequence to avoid unnecessary repetition.

The step-by-step instructions also furnish an orderly approach to the isolation of malfunctions that may develop, providing information to aid in troubleshooting and repairing the instrument.

Test equipment used in a particular step should remain connected at the end of that step unless the instructions state otherwise. Similarly, controls not mentioned are to remain in the positions previously used.

Always attach the probe ground clip to the Type 5T1 chassis when checking waveforms in the circuitry.

Do not preset internal controls unless the instrument has been repaired or is known to be seriously out of adjustment. If repairs have been made, preset internal controls in the affected circuits to the positions given in Table 5-1.

Tunnel Diodes

The tunnel diodes used in the Type 5T1 should not be handled unnecessarily. Do not connect a probe directly to the body of a tunnel diode. The cathode side of the stripline type used in the Type 5T1 is identified by a small external disc and sometimes also with color-coding dots.

TABLE 5-1

Internal Control Presets, after Repair.

COMPARATOR LEVEL, R275	Counterclockwise
OUTPUT T.D. BIAS, R65	Clockwise
—TRIG. RECOG. T.D. BIAS, R25	Clockwise
+TRIG. RECOG. T.D. BIAS, R45	Clockwise
—TRIG. RECOVERY T.D. BIAS, R35	Clockwise
+TRIG. RECOVERY T.D. BIAS, R55	Clockwise
RAMP RECOV., R254	Clockwise
DELAY ZERO, R220	Clockwise
STAIRCASE D.C. LEVEL, R381	Counterclockwise

RECOMMENDED EQUIPMENT

The following items of equipment, or equivalents, are required for the calibration of the Type 5T1. The numbers in parentheses are Tektronix Part Numbers.

1. One oscilloscope, Tektronix Type 661, with '4'-Series sampling plug-in unit.
2. One test oscilloscope, Tektronix 530- or 540-Series, with Type L vertical plug-in unit and 10X attenuator probe; dc to 15 Mc or greater bandpass.
3. One time-mark generator, Tektronix Type 180A.
4. One 50-ohm pretrigger pulse generator, Tektronix Type 111.
5. One volt-ohmmeter, with sensitivity of at least 20,000 ohms/volt.
6. One nanosecond timing standard (013-028).
7. Insulated adjustment tools.
8. One 2XT attenuator with 50-ohm GR-874 connectors (017-003).
9. One 5XT attenuator with 50-ohm GR-874 connectors (017-002).
10. Two 10XT attenuators with 50-ohm GR-874 connectors (017-001).
11. One 50-ohm GR-874 tee connector (017-069).
12. One connector adapter, 50-ohm GR-874 to UHF jack (017-022), or 50-ohm GR-874 to BNC plug (017-025), depending on type of output connectors on the time-mark generator.
13. One 10-nsec coaxial cable with 50-ohm GR-874 connectors (017-501).
14. Two 5-nsec coaxial cables with 50-ohm GR-874 connectors (017-502).

PROCEDURE

CAUTION

Do not turn on oscilloscope power without plug-ins installed. If plug-in extensions are used for calibrating the Type 5T1, be sure to connect them correctly. Cross-connecting extension cables can cause damage to the oscilloscope. The power plug for the Type 5T1 is the blue-ribbon connector nearest the center of the oscilloscope. The outer connector is for readout and programming.

1. Check Resistances to Ground

This check is necessary only after failure or repair of the instrument. Before plugging the Type 5T1 into the oscilloscope, use the volt-ohmmeter to check for the typical dc resistances given in Table 5-2. Connect the common lead to chassis ground and take the measurements at the indicated terminals on the power plug (P1).

TABLE 5-2

Typical resistance-to-ground measurements at pins of power plug (nearest center of oscilloscope).

Pin	3	5	8	9	10	11	12	15	17	18	20	21	22	23	24
Res.	180 Ω	10 k	50 Ω	0	20 Ω	10 k	0	60 k	60 k	10 Ω	0	10 k	0	0	7 k

All other pins have infinite resistance.

2. Preset Front-Panel Controls

Install the plug-in units in the Type 661 Oscilloscope. The right side panel of the Type 661 oscilloscope must be removed for calibrating the Type 5T1, or the Type 5T1 may be extended from the oscilloscope as in Fig. 5-1 if desired.

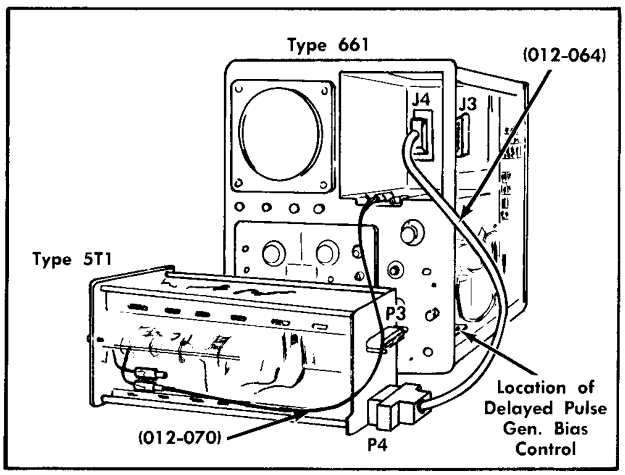


Fig. 5-1. The Type 5T1 extended from the oscilloscope, for convenience of calibration.

Switch on the power to the oscilloscope and the test instruments and allow them to warm up for a few minutes. Install the 10X probe on the input of the test oscilloscope. Do not connect an input signal to the sampling plug-in unit. Set front-panel controls as follows:

Type 5T1

SAMPLES/CM	100
TIME DELAY (nSEC)	0
SOURCE	EXT.
POLARITY	—
RECOVERY TIME	MIN.
SWEEP MODE	REPETITIVE
SWEEP TIME/CM	10 nSEC
VARIABLE	CALIBRATED

Type 661 Oscilloscope

Horizontal Display	X1
Position and Vernier	Centered
Amplitude/Time Calibrator	Off

Sampling Unit

Deflection Factor	200 mv/cm
Vertical Position	Centered
DC Offset	Set to zero volts
Display	Normal
Smoothing	Normal

Test Oscilloscope

Sweep Rate	2 μsec/cm
Vertical Deflection	.05 volt/cm, AC
Triggering	AC, + Internal

3. Check Threshold Zero

Connect the dc voltmeter between the center terminal of the THRESHOLD control (potentiometer nearest the front panel) and ground. See Fig. 5-2. Adjust the THRESHOLD control for zero volts on the meter. The dot on the control knob should be aligned with the 0 on the front panel; if not, loosen and reposition the knob.

4. Check Delayed Pulse Generator Q73

Connect the test oscilloscope probe to the emitter of Q73. Set the THRESHOLD control between 0 and +. Adjust the Delayed Pulse Gen. Bias control, R990, (located on the right side of the Type 661 Oscilloscope) until a —0.4- to —0.5-volt pulse appears on the crt (Fig. 5-4). Connect a cable from the Delayed Pulse output connector to the sampling unit input connector. The pulse at Q73 should remain stable while connecting and disconnecting the cable. Readjust R990 if necessary.

5. Adjust —Threshold

Disconnect the test probe. Set R35, the —TRIG. RECOVERY T. D. BIAS control, and R25, the —TRIG. RECOG. T.D. BIAS control, fully clockwise. With the THRESHOLD control set between 0 and +, turn R65, the OUTPUT T.D. BIAS control, fully counterclockwise, then adjust it clockwise about 30° past the point where a trace appears on the crt of the Type 661 Oscilloscope. Set R35 halfway between the clockwise position and the point where the trace disappears. Adjust R25 so that the sweep begins to freerun at the 0 position when the THRESHOLD control is turned clockwise.

6. Adjust +Threshold

Set the POLARITY switch to + and the THRESHOLD control between — and 0. Set R55, the +TRIG. RECOVERY T.D. BIAS control, and R45, the +TRIG. RECOG. T.D. BIAS control, fully clockwise. Adjust R55 to a point halfway between the clockwise position and the point where the trace disappears. Adjust R45 so that the sweep begins to freerun at the 0 position when the THRESHOLD control is turned counterclockwise. Leave the THRESHOLD control between — and 0.

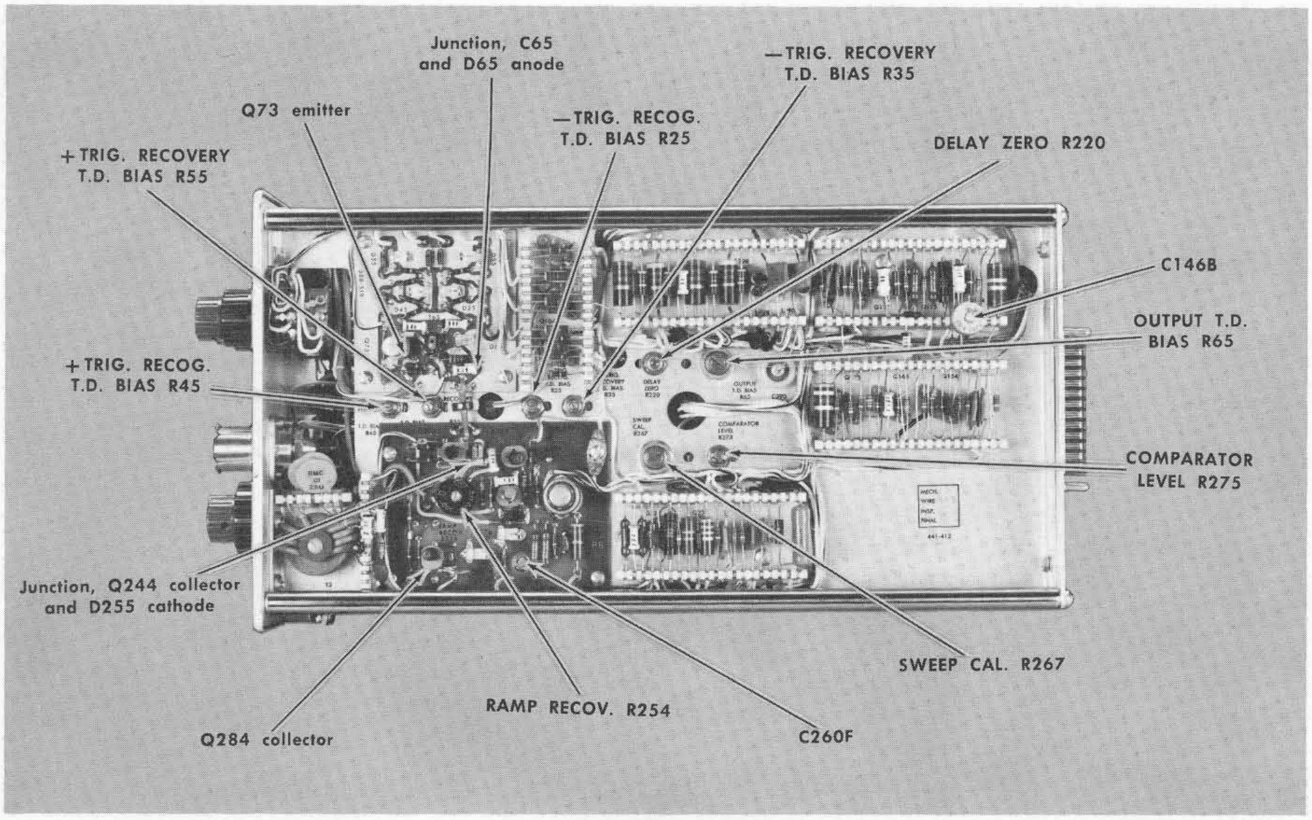


Fig. 5-2. Internal adjustments and calibration test points on right side of Type 5T1.

7. Adjust Output T. D. Bias

Connect the test probe to the junction of C65 and the anode of D65. See Fig. 5-2. Adjust R65, the OUTPUT T.D. BIAS control, for a stable display on the test oscilloscope. The display should show a +0.4-volt pulse that disappears when the THRESHOLD control is turned fully clockwise.

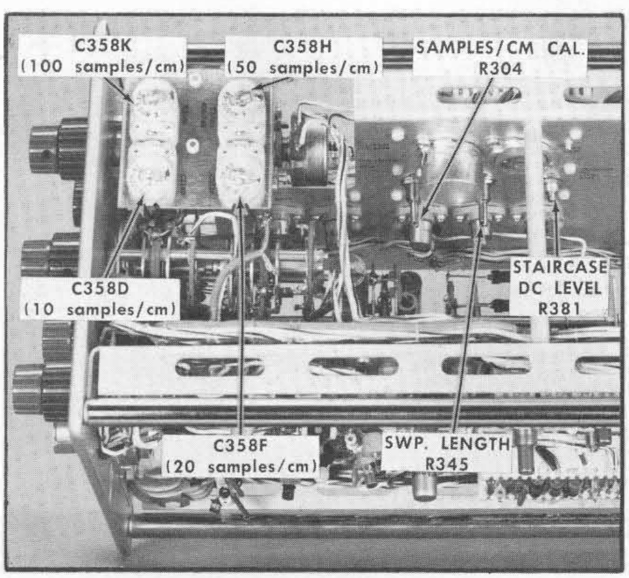


Fig. 5-3. Top view of Type 5T1 (with V361 and V373 removed) showing internal adjustments.

8. Adjust Ramp Recovery

Connect the test probe to the junction of the collector of Q244 and the cathode of D255. Set the test oscilloscope Volts/Cm switch to .02 and the sweep rate to .1 μsec/cm. Set the THRESHOLD control fully counterclockwise. Turn

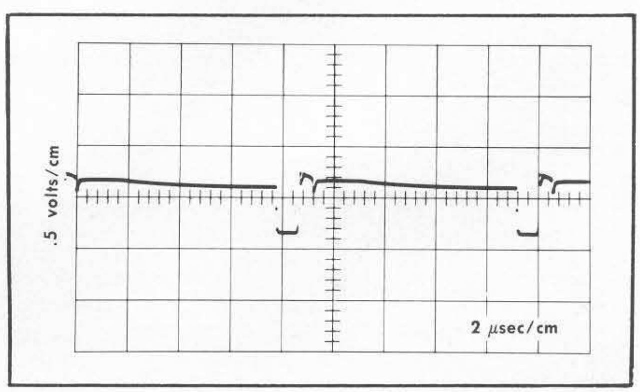


Fig. 5-4. Waveform at Q73 emitter with Delayed Pulse Gen. Bias control correctly adjusted.

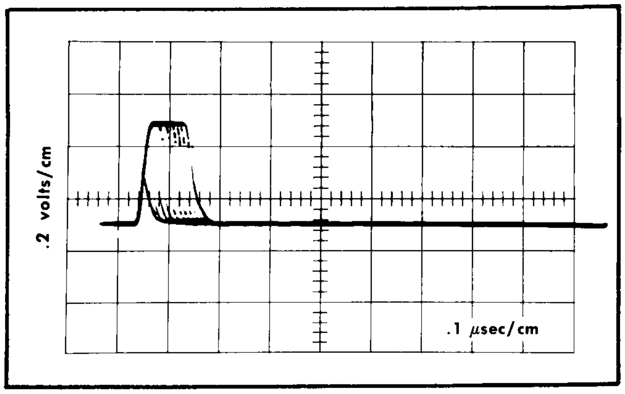


Fig. 5-5. Waveform at junction of Q244 collector and D255 cathode with RAMP RECOV. control (R254) correctly adjusted.

R254, the RAMP RECOV. control, fully counterclockwise, then adjust it clockwise until the height of the displayed pulse stops increasing. The display should be a stable +0.4-volt pulse similar to Fig. 5-5. You may have to adjust R275, the COMPARATOR LEVEL control, for a stable display.

9. Adjust Lockout Time (S/N's 377 and up)

Leave the probe connected as in step 8. Set the test oscilloscope sweep rate to 10 μsec/cm, and adjust C146B for a display of exactly 1 pulse/cm. Rotate the RECOVERY TIME control to MAX. Check for at least 1.3 cm between pulses (13 μsec recovery). Return the control to MIN. position.

10. Adjust Comparator Level

Connect the test oscilloscope probe to the collector of Q284. Set the Volts/Cm switch to .2 and the sweep rate to 2 μsec/cm. Adjust R275, the COMPARATOR LEVEL control, for a stable +5.5-volt to +6-volt pulse, about 750 nsec wide at the top. This is the comparator pulse to the sampling unit. A similar 3-volt pulse should appear at the opposite end of R285 (a 560-ohm resistor). Disconnect the test probe.

11. Adjust Sweep Length

Adjust the SWEEP LENGTH control, R345, through the hole in the Type 5T1 chassis for a 10.5-cm sweep length on the screen of the Type 661 Oscilloscope.

12. Adjust Sweep Rate

Set the SWEEP TIME/CM switch to 1 μSEC, and apply 1-μsec markers from the time-mark generator to the sampling unit input, through 5X attenuation. Set the SOURCE switch to INT.* Trigger the display. Adjust R267, the SWEEP CAL. control, for 1 marker/cm between the 1st and 9th cm graticule lines. Timing should be within 3% (1.6 mm through the 8 cm) on all ranges from 20 nsec/cm to 100 μsec/cm (Table 5-3). Rotate the VARIABLE (SWEEP TIME/CM) control through its entire range and check that it provides a 3:1, or greater, increase in sweep rate. Return the VARIABLE to CALIBRATED position.

*When using a sampling unit without internal triggering, set the SOURCE switch to EXT. and connect an external trigger source as described in the Operating Instructions.

TABLE 5-3

Sweep Rate Check

SWEEP TIME/CM switch setting	TIME-MARK Generator	DISPLAY
100 μSEC	100 μsec	1 mark/cm
50 μSEC	50 μsec	1 mark/cm
20 μSEC	50 μsec	1 mark/ 2½ cm
10 μSEC	10 μsec	1 mark/cm
5 μSEC	5 μsec	1 mark/cm
2 μSEC	5 μsec	1 mark/ 2½ cm
1 μSEC	1 μsec	1 mark/cm
.5 μSEC	1 μsec	1 mark/ 2 cm
.2 μSEC	5 Mc	1 cycle/cm
.1 μSEC	10 Mc	1 cycle/cm
50 nSEC	10 Mc	1 cycle/ 2 cm
20 nSEC	50 Mc	1 cycle/cm

13. Adjust Sweep Delay and Registration

Remove the time-marker input and connect the Amplitude/Time Calibrator output to the sampling unit input connector. Preset controls as follows:

Type 5T1

STAIRCASE DC LEVEL (R381)	Counterclockwise
DELAY ZERO (R220)	Clockwise
SAMPLES/CM	100
TRIGGERING	CAL.
SWEEP TIME/CM	.5 μSEC
TIME DELAY	0

Type 661 Oscilloscope

Amplitude/Time Calibrator	1000 mv, 1 μsec/cycle
Sweep Magnifier	X5

Set the sampling unit deflection factor to 200 mv/cm. Display the start of the sinewave by adjusting the THRESHOLD, RECOVERY TIIME, COMPARATOR LEVEL (R275), and positioning controls. Adjust R275 for the best corner transition from the straight line to the sinewave curve. Dots should be continuous. See Fig. 5-6.

Switch the SWEEP TIME/CM between 1, .5 and .2 μSEC positions. Adjust R220, the DELAY ZERO control, so that the sinewave starts at the same place on the crt at each of these positions of the SWEEP TIME/CM switch. Set the SWEEP TIME/CM switch to 1 μSEC. Adjust R381, the STAIRCASE DC LEVEL control, to remove the straight line of dots preceding the start of the sinewave. Disregard any dots that may appear at other dc levels.

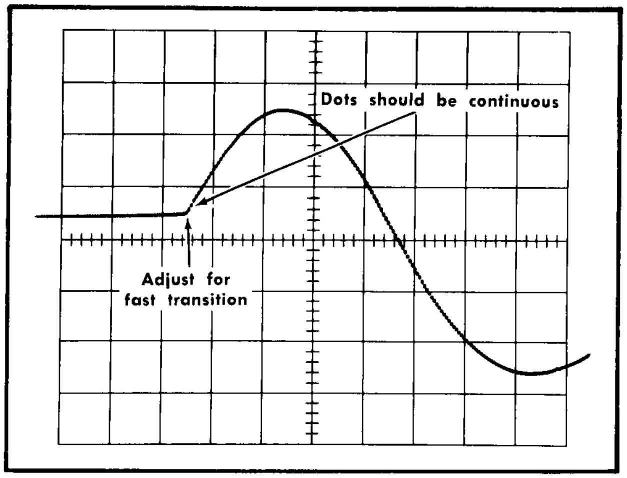


Fig. 5-6. Transition from line to sinewave with COMPARATOR LEVEL (R275) correctly adjusted.

14. Adjust Fast Sweep Rate

Return the Sweep Magnifier to X1. Apply a 2-nsec pulse from the pulse generator to the Nanosecond Timing Standard. Set the Timing Standard for 1 nsec/cycle and connect its output to the sampling unit INPUT. Set the TRIGGERING SOURCE switch to EXT. Pretrigger the Type 5T1 from the pulse generator pretrigger output through the EXTERNAL TRIGGER INPUT connector. Approximately 100X attenuation is required. Set the SWEEP TIME/CM switch to 1 nSEC, the vertical deflection factor to about 5 mv/cm, and locate a uniform section of the ringing waveform on the crt screen with the variable time-difference control on the pulse generator and the TIME DELAY control on the Type 5T1. Adjust C260F, through the oscilloscope chassis, for exactly 1 cycle/cm. Check the timing on the 2, 5 and 10 nSEC positions of the SWEEP TIME/CM switch, using the 2, 5 and 10 nsec/cycle settings on the timing standard. Readjust C260F slightly, if necessary, to bring the accuracy of all four positions within 3%.

15. Adjust Samples/Cm

Disconnect the input cables. Set the SOURCE switch to FREE RUN, SAMPLES/CM switch to 5, SWEEP TIME/CM switch to 1 μSEC, and the Type 661 Horizontal Display switch to X5. Adjust the SAMPLES/CM CAL., R304, through the hole in the Type 5T1 chassis, for 1 dot/cm. Leave the SWEEP TIME/CM at 1 μSEC and make the preliminary adjustments of the internal samples/cm controls (Fig. 5-3), as given in Table 5-4.

TABLE 5-4

Preliminary Adjustment of Samples/Cm.

Type 661 Horizontal Display Switch Setting	Samples/CM Switch Setting	Adjust	Dots/Cm
X10	10	C358D	1
X20	20	C358F	1
X50	50	C358H	1
X100	100	C358K	1

Set the SAMPLES/CM switch to 100, SWEEP TIME/CM to 1 μSEC, TRIGGERING to INT.* +, and the oscilloscope Horizontal Display switch to X1. Set the sampling unit vertical deflection to 200 mv/cm. Connect the output of the time-mark generator to the sampling unit input, through 5X attenuation, and set the generator for 1-μsec markers. Adjust the THRESHOLD control to trigger the Type 5T1. With the TIME DELAY control at mid-range, set the SAMPLES/CM to 5. A dot should occur at each major graticule mark, above the base line, in a nearly level line across the crt. If not, readjust the SAMPLES/CM CAL. control, R304. Rotating the TIME DELAY control should cause the row of dots to rise and fall in unison.

Set the time-mark generator for 50-Mc sinewaves, and use Table 5-5 for the final samples/cm adjustments. The display should consist of 2.5 to 5 cycles across the crt, changing to one or two lines of dots at the right edge.

TABLE 5-5

Final Adjustment of Samples/Cm.

Samples/cm Switch Setting	Adjust	Rows of Dots	Maximum Number of Cycles or Crossovers
10	C358D	1	2.5 cycles
20	C358F	2	5 crossovers
50	C358H	1	2.5 cycles
100	C358K	2	5 crossovers

Apply a 500-mv pulse from the pulse generator to the sampling unit (through about 10X attenuation). Switch the SWEEP TIME/CM to 10 nSEC. Adjust the THRESHOLD control to trigger the Type 5T1. Set the repetition rate of the pulse generator for 100 kc. Set the RECOVERY TIME control at MIN. and the SAMPLES/CM switch at 5. Turn the TIME DELAY control to display only a straight line of dots. Carefully note the dot spacing. Then change the repetition rate of the pulse generator to 50 cps. The samples (dots)/cm spacing should not change more than ±2%.

16. Check Time Delay

Set the SAMPLES/CM switch to 100 and the SOURCE switch to EXT. Set the pulse generator repetition rate to about 10 kc. Connect a cable from the pretrigger output of the pulse generator to the EXTERNAL TRIGGER INPUT connector on the Type 5T1, through 100X attenuation. Trigger the display with the THRESHOLD control. Turn the TIME DELAY control to 100. With the pulse generator variable time-difference control, position the leading edge of the pulse on the left edge of the graticule. Rotate the TIME DELAY control to 0. The leading edge of the pulse should move at least 10 cm across the crt, representing at least 100 nsec of delay.

17. Check Single Display

Switch the SWEEP MODE from REPETITIVE to SINGLE DISPLAY. Turn the SWEEP MODE switch to START and release it; one sweep of the trace should occur. Return the MODE switch to REPETITIVE.

*See footnote, page 5-4.

18. Check External Trigger and Time Jitter

Apply a 500-mv 2-nsec pulse from the pulse generator to the vertical input (approximately 10X attenuation), through a GR tee connector installed on the input. Connect a second cable to the tee and apply this signal through 100X attenuation to the EXTERNAL TRIGGER INPUT connector on the Type 5T1. Set the pulse generator for a repetition rate of 100 kc. Set the SOURCE switch to EXT., the SWEEP TIME/CM to 1 nSEC, and trigger the display. Position the display on the crt with the TIME DELAY and positioning controls. Check both + and — triggering, using positive-going and negative-going pulses from the pulse generator. Decrease the repetition rate to 1 kc and check the triggering. Adjust the sweep rate, the vertical deflection and magnification to display a rising portion of the waveform on the crt screen. Check for less than 300 psec time-jitter with the 5 mv trigger signal. Decrease the 100X attenuation to 10X and check for less than 50 psec time-jitter with 50 mv trigger. Disconnect the cables, then connect a 1000 mv .01 μsec/cycle sinewave signal from the oscilloscope Amplitude/Time Calibrator through the tee at the input of the sampling unit. Also connect the signal from the tee through 10X attenuation to the EXTERNAL TRIGGER INPUT connector. Set the SWEEP TIME/CM to 5 nSEC and the oscilloscope Horizontal Display to X1. Check for + and — triggering, and check for less than 300 psec time-jitter with the 100 mv signal. Remove the 10X attenuator and place it between the tee and the input connector. With the cable connected to the EXTERNAL TRIGGER INPUT as before, check for less than 50 psec time-jitter on 1000 mv of trigger.

S/N's 101 through 332 only: If triggering is difficult, remove R308, located on the bottom left of the Type 5T1.

19. Check External Trigger Isolation (S/N's 494 and up)

Remove the attenuators and cables, then connect a cable from the EXTERNAL TRIGGER INPUT connector to the sampling unit input. Leave the SOURCE switch at EXT. Trigger the display and check for less than 8 mv of kickout from the trigger circuit.

S/N's 101 to 493 only: Tektronix Mod kit 040-300 reduces external trigger kickout to less than 8 mv.

SECTION 6

PARTS LIST and DIAGRAMS

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.

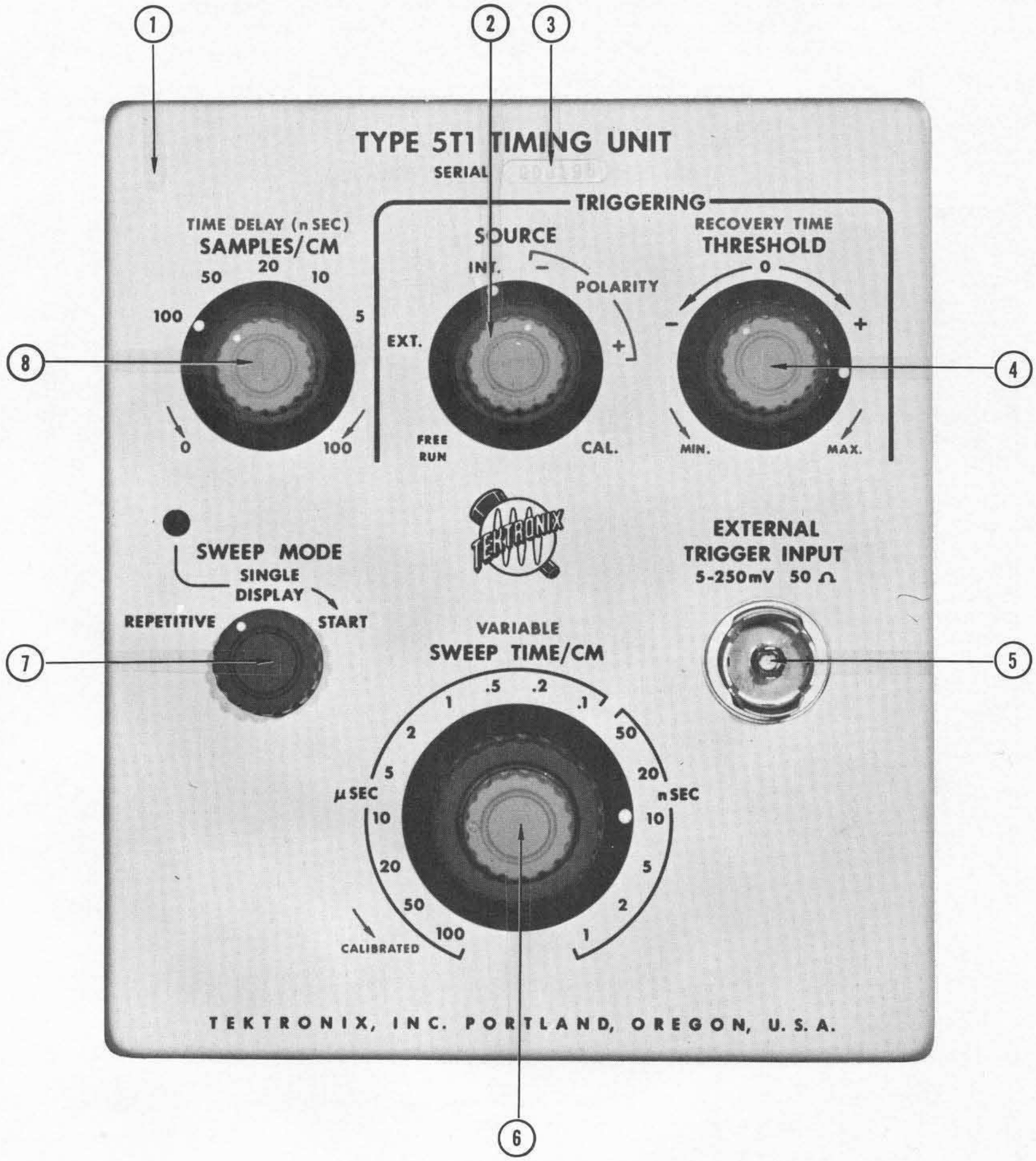
ABBREVIATIONS AND SYMBOLS

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



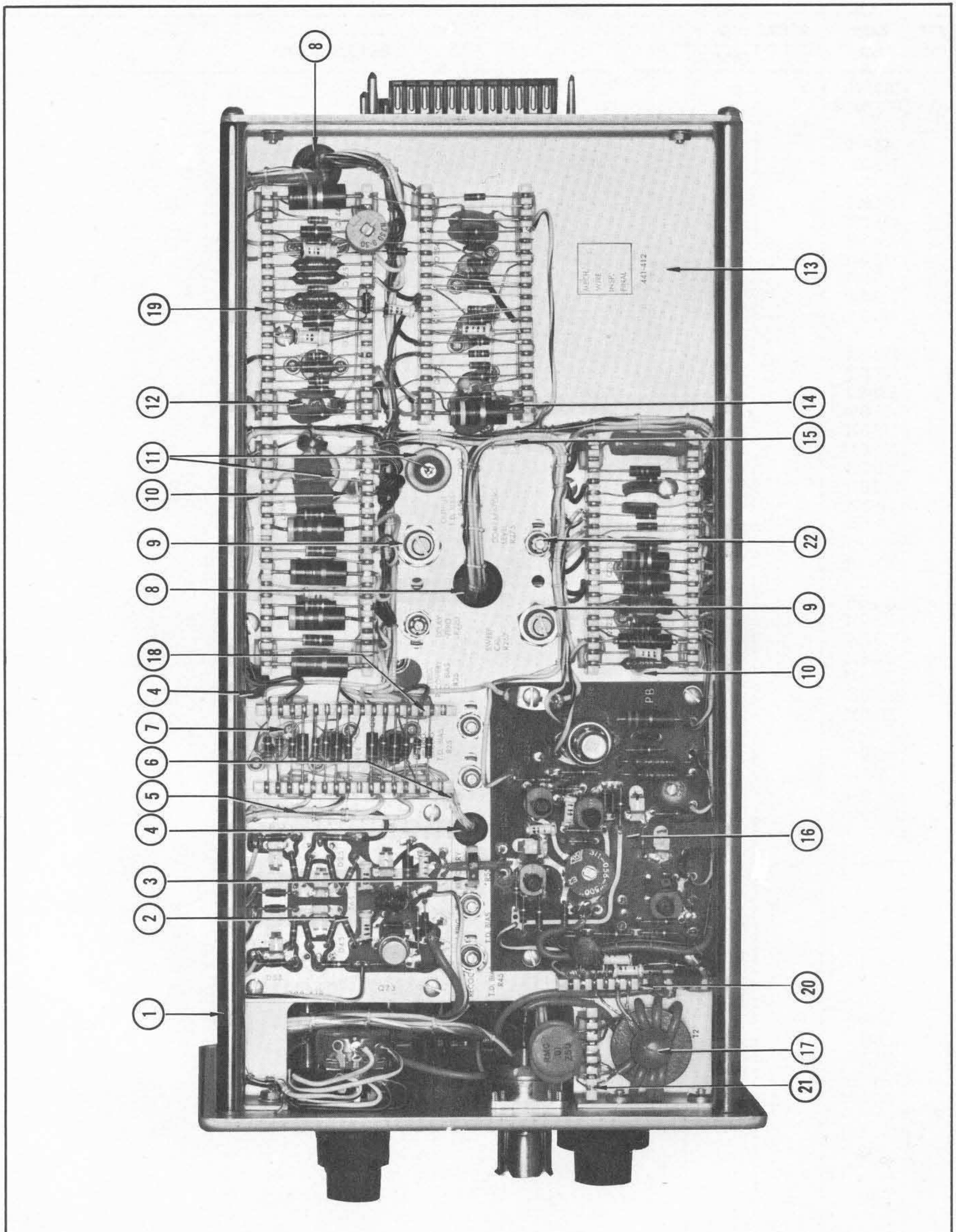
1
2
3
TYPE 5T1 TIMING UNIT
SERIAL
TRIGGERING
TIME DELAY (n SEC)
SAMPLES/CM
50
20
10
100
5
0
100
SOURCE
INT.
−
POLARITY
+
EXT.
FREE RUN
CAL.
RECOVERY TIME
THRESHOLD
0
−
+
MIN.
MAX.
8
4
TEKTRONIX
SWEEP MODE
SINGLE DISPLAY
START
REPETITIVE
EXTERNAL TRIGGER INPUT
5-250mV 50 Ω
7
5
VARIABLE
SWEEP TIME/CM
1
.5
.2
.1
2
50
5
20
µSEC
nSEC
10
10
20
5
50
2
100
1
CALIBRATED
TEKTRONIX, INC. PORTLAND, OREGON, U. S. A.
6

Ⓐ

FRONT

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	333-688			1	PANEL, front
	387-597			1	PLATE, front subpanel
2	366-142			1	KNOB, SOURCE, charcoal
	366-031			1	KNOB, POLARITY, small red
3	334-679			1	TAG, metal serial number insert
4	366-146			1	KNOB, THRESHOLD, charcoal
	366-032			1	KNOB, RECOVERY TIME, small red
	210-413			1	NUT, hex, $^3/_8$-32 x $^1/_2$ inch
	210-840			1	WASHER, .390 inch ID x $^9/_{16}$ inch OD
	210-012			1	LOCKWASHER, int., $^3/_8$ x $^1/_2$
5	132-001			1	COUPLING, nut
	132-002			1	SLEEVE, conductor, outer
	132-007			1	SNAP RING
	132-016			1	NUT, retaining
	132-026			1	TRANSITION, outer
	132-027			1	TRANSITION, inner
	132-028			1	INSULATOR
	132-029			1	CONDUCTOR, inner
	166-221			1	TUBE, ferrule
	132-040			1	ADAPTER
					Mounting Hardware: (not included)
	211-038			4	SCREW, 4-40 x $^5/_{16}$ inch PHS phillips slot
6	366-144			1	KNOB, SWEEP TIME/CM, large charcoal
	366-038			1	KNOB, VARIABLE, small red
7	366-113			1	KNOB, SWEEP MODE, small charcoal
	210-413			1	NUT, hex, $^3/_8$-32 x $^1/_2$ inch
	210-840			1	WASHER, .390 inch ID x $^9/_{16}$ inch OD
	210-012			1	LOCKWASHER, int., $^3/_8$ x $^1/_2$ inch
8	366-142			1	KNOB, SAMPLES/CM, charcoal
	366-031			1	KNOB, TIME DELAY (NSEC), small red

RIGHT SIDE



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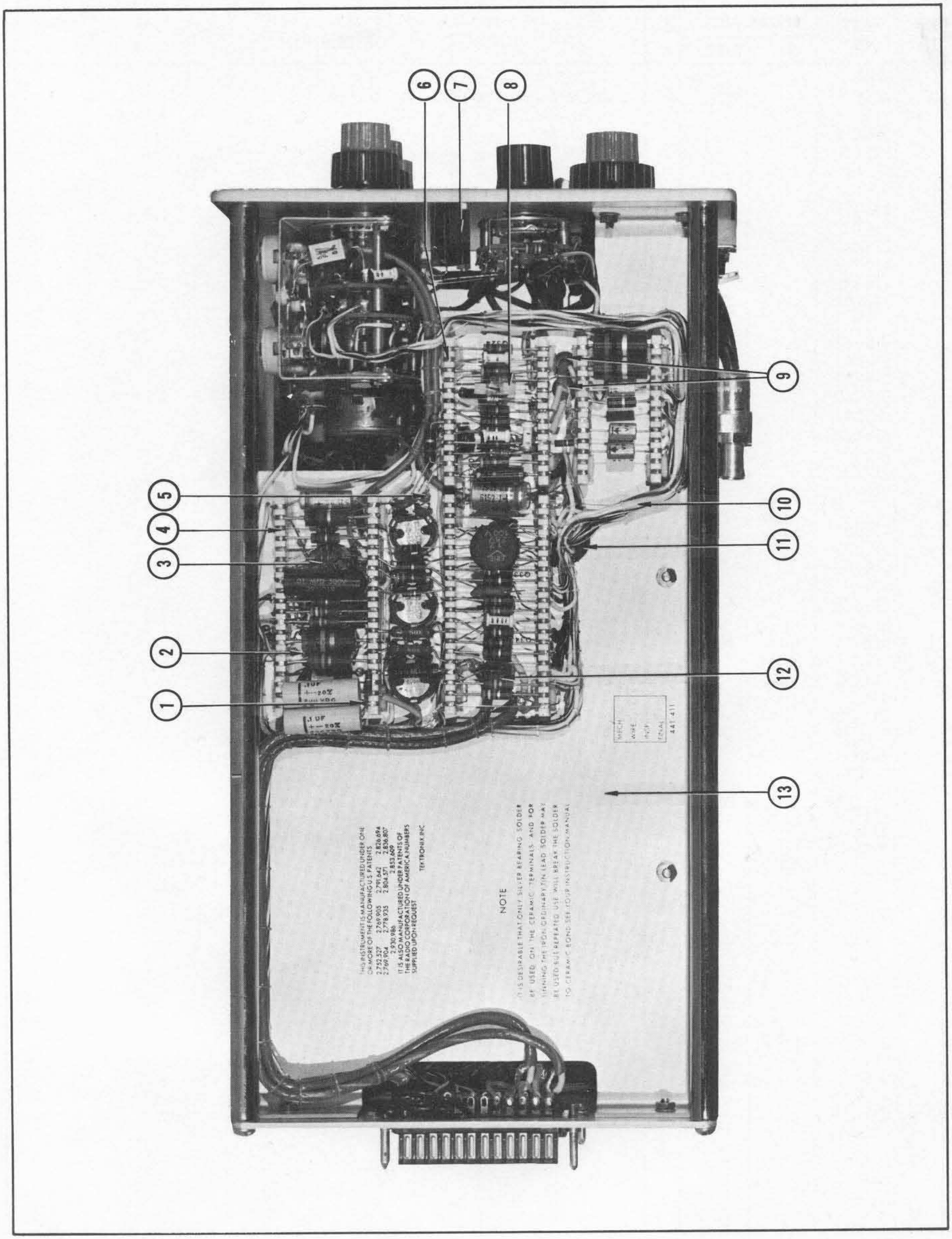
RIGHT SIDE

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	384-566			4	ROD, frame, spacing
2	605-008			1	ASSEMBLY, Trigger Board
					Includes:
	136-062			1	SOCKET, 4 pin tube
	352-041			5	HOLDER, tunnel diode
					Mounting Hardware: (not included)
	211-008			4	SCREW, 4-40 x 1/4 inch PHS
3	426-121			1	MOUNT, toroid
	361-007			1	SPACER, nylon, molded
4	348-003			2	GROMMET, rubber, 5/16 inch
5	179-599			1	CABLE harness, etched circuit board
6	179-639			1	CABLE harness, pot
7	136-095			11	SOCKET, 4 pin transistor
					Mounting Hardware For Each: (not included)
	213-113			2	SCREW, 2-32 x 5/16 inch RHS phillips slot
8	348-005			2	GROMMET, rubber, 1/2 inch
9	210-413			2	NUT, hex, 3/8-32 x 1/2 inch
	210-840			2	WASHER, .390 ID x 9/16 inch OD
10	348-031			3	GROMMET, poly. snap-in
11	354-068			2	RING, securing
12	210-204			1	LUG, solder,
	213-044			1	SCERW, thread cutting, 5-32 x 3/16 inch PHS phillips slot
13	441-412				CHASSIS, ramp amplifier
					Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
	211-538			3	SCREW, 6-32 x 5/16 inch FHS 100° phillips slot
	210-006			3	LOCKWASHER, int. #6
	210-407			3	NUT, hex, 6-32 x 1/4 inch
14	210-201			1	LUG, solder, SE 4
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips slot
15	179-598	101	304	1	CABLE harness, ramp amplifier
	179-675	305		1	CABLE harness, ramp amplifier
16	050-073	101	304	1	KIT, replacement
	605-007	305		1	ASSEMBLY, Fast Ramp Board
					Includes:
	136-062			4	SOCKET, 4 pin tube
	136-125			1	SOCKET, 5 pin tube
	387-603			1	PLATE, insulation, socket
	352-041			3	HOLDER, tunnel diode
					Mounting Hardware: (not included)
	211-008			4	SCREW, 4-40 x 1/4 inch
	210-204			1	LUG, solder,
17	385-107			1	ROD, nylon (core mounting)
	211-040			1	SCREW, 4-40 x 1/4 inch BH nylon
	210-810			1	WASHER, fiber, 1/8 inch ID x 1/2 inch OD
	211-011			1	SCREW, 4-40 x 5/16 inch BHS
18	124-146			2	STRIP, ceramic, 7/16 inch x 16 notches
	361-007			4	SPACER, nylon, molded
19	124-145			8	STRIP, ceramic, 7/16 inch x 20 notches
	361-007			16	SPACER, nylon, molded
20	124-147	494		1	STRIP, ceramic, 7/16 inch x 13 notches
	361-007	496		2	SPACER, nylon, molded
21	124-149			1	STRIP, ceramic, 7/16 inch x 7 notches
	361-007			2	SPACER, nylon, molded
22	- - - - -			-	MINIATURE POT MOUNTING HARDWARE:
	210-583			6	NUT, hex, 5/16 inch, brass
	210-940			6	WASHER, steel, 1/4 inch ID x 3/8 inch OD
	210-046			6	LOCKWASHER, steel

LEFT SIDE



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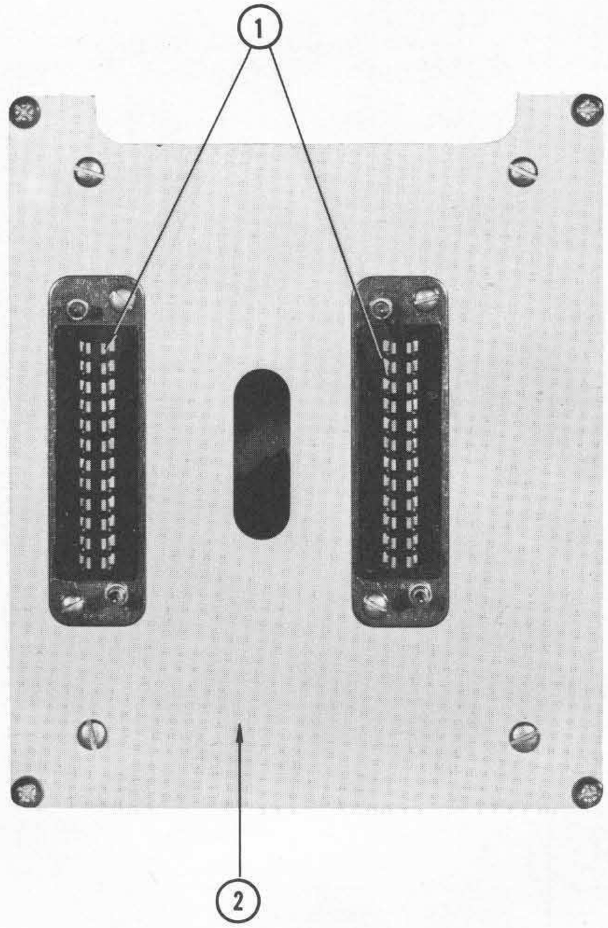
LEFT SIDE

REF. NO.	PART NO.	SERIAL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	210-201			1	LUG, solder, SE 4
	213-044			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips slot
2	136-014			1	SOCKET, STM9
					Mounting Hardware: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 PHS phillips slot
3	136-085			1	SOCKET, 9 pin, shielded base
					Mounting Hardware: (not included)
	213-044			2	SCREW, thread cutting, 5-32 x 3/16 PHS phillips slot
4	124-145			4	STRIP, ceramic, 7/16 x 20 notches
	361-007			8	SPACER, nyion, molded
5	210-223			3	LUG, solder, 1/4
6	124-147			4	STRIP, ceramic, 7/16 x 13 notches
	361-007			8	SPACER, nylon, molded
7	352-008			1	HOLDER, neon, single
					Mounting Hardware: (not included)
	211-031			1	SCREW,. 4-40 x 1 in. FHS
	210-406			2	NUT, hex, 4-40 x 3/16
8	136-127			1	SOCKET, diode
9	348-002			2	GROMMET, rubber, 1/4
10	179-579			1	CABLE harness, stair-step
11	348-005			1	GROMMET, rubber, 1/2
12	136-095			5	SOCKET, 4 pin transistor
					Mounting Hardware: (not included)
	213-113			2	SCREW, 2-32 x 5/16 BHS phillips slot
13	441-411			1	CHASSIS, stair-step
					Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 BHS
	211-559			2	SCREW, 6-32 x 3/8 FHS 100° phillips slot
	210-006			4	LOCKWASHER, int. #6
	210-407			4	NUT, hex, 6-32 x 1/4

REAR



REF. NO.	PART NO	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	131-149			2	CONNECTOR, chassis mt., 24 contact, male
					Mounting Hardware For Each: (not included)
	211-008			2	SCREW, 4-40 x 1/4 BHS
	210-004			1	LOCKWASHER, int. #4
	210-201			1	LUG, solder, SE 4
	210-406			2	NUT, hex, 4-40 x 3/16
2	387-598			1	PLATE, rear
					Mounting Hardware: (not included)
	212-044			4	SCREW, 8-32 x 1/2 RHS phillips slot

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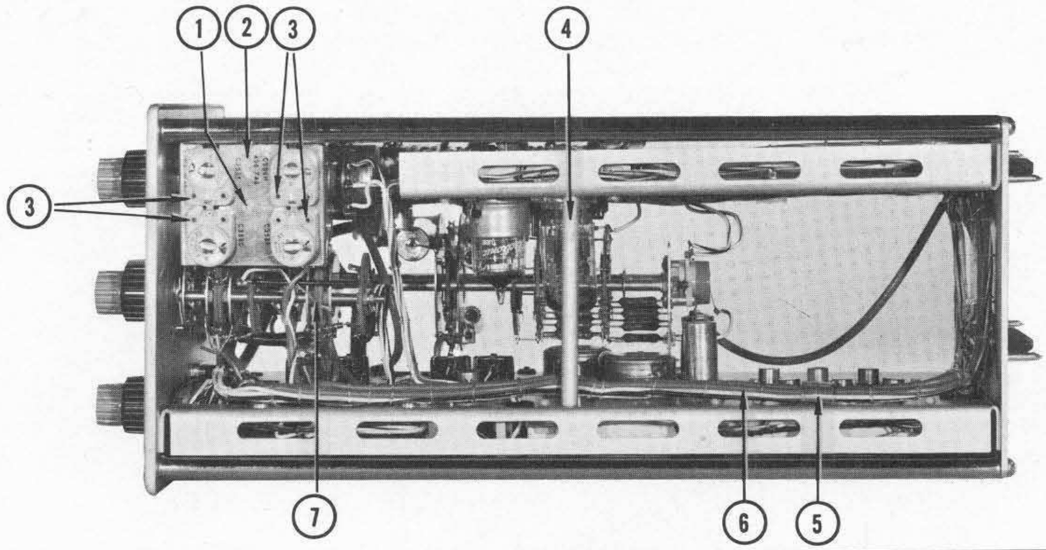
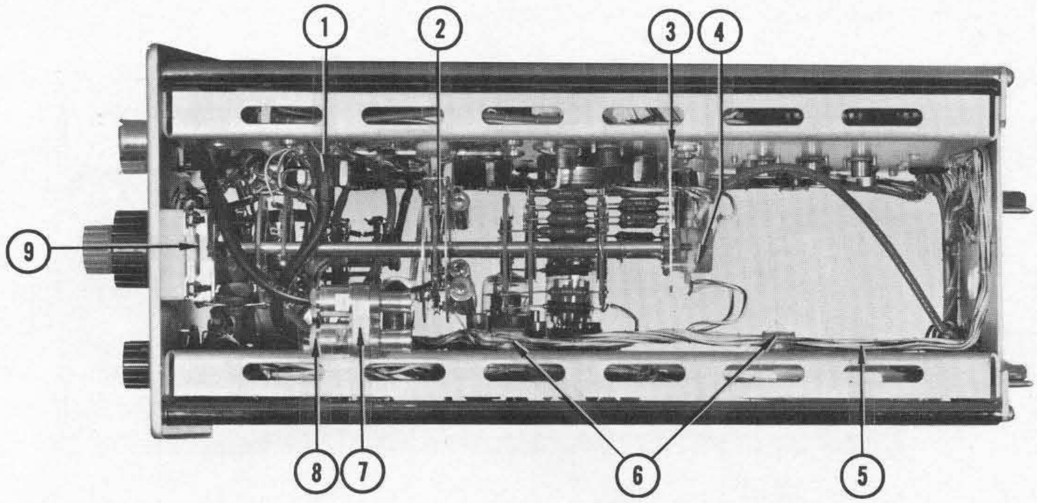
TOP



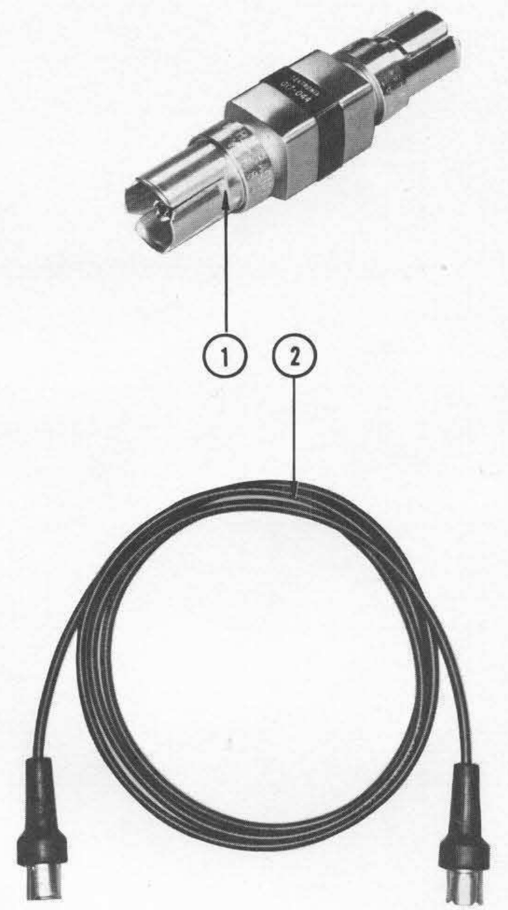
REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	262-451			1	SWITCH, SAMPLES/CM, wired
					Includes:
	260-437			1	SWITCH, SAMPLES/CM, unwired
	131-180			2	CONNECTOR, terminal stand-off
	358-135			2	BUSHING, teflon
	384-249			1	ROD, extension
	376-014			1	COUPLING, wire
	210-413			2	NUT, hex, $^3/_8$-32 x $^1/_2$
	210-012			1	LOCKWASHER, int, $^3/_8$ x $^1/_2$
2	406-748			1	BRACKET, switch, capacitor
					Mounting Hardware:
	211-008			4	SCREW, 4-40 x $^1/_4$ BHS
	210-004			4	LOCKWASHER, int. #4
	210-406			4	NUT, hex, 4-40 x $^3/_{16}$
3	214-153			4	FASTENER, snap, double pronged
					Mounting Hardware For Switch: (not included)
	210-413			1	NUT, hex, $^3/_8$-32 x $^1/_2$
	210-840			1	WASHER, .390 ID x $^9/_{16}$ OD
	210-012			1	LOCKWASHER, int, $^3/_8$ x $^1/_2$
4	384-135			1	ROD, spacing
					Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x $^5/_{16}$ BHS
5	343-042			1	CLAMP, cable, $^5/_{16}$" (half)
					Mounting Hardware: (not included)
	211-507			1	SCREW, 6-32 x $^5/_{16}$ BHS
	210-803			1	WASHER, 6L
	210-006			1	LOCKET, int. #6
	210-407			1	NUT, hex, 6-32 x $^1/_4$
6	179-640			1	CABLE harness, connecting
7	262-452			1	SWITCH, TRIGGERING, wired
					Includes:
	260-438			1	SWITCH, TRIGGERING, unwired
	131-221			1	CONNECTOR, push on bulkhead jack
	358-172			1	BUSHING, rod
	166-204			1	TUBE, coaxial adapter
	132-032			1	FERRULE
					Mounting Hardware For Switch: (not included)
	210-413			1	NUT, hex, $^3/_8$-32 x $^1/_2$
	210-840			1	WASHER, .390 ID x $^9/_{16}$ OD
	210-012			1	LOCKWASHER, int, $^3/_8$ x $^1/_2$

BOTTOM



REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	Q T Y.	DESCRIPTION
1	166-240			1	TUBE, coaxial adapter
	132-032			1	FERRULE
2	262-449			1	SWITCH, SWEEP TIME/CM, wired
					Includes:
	260-440			1	SWITCH, SWEEP TIME/CM, unwired
3	406-747			1	BRACKET, sweepspeed switch
					Mounting Hardware: (not included)
	211-504			2	SCREW, 6-32 x 1/4 BHS
	348-031			1	GROMMET, poly. snap-in
	210-449			2	NUT, hex, 5-40 x 1/4
	210-006			2	LOCKWASHER, int. #6
4	211-014			2	SCREW, 4-40 x 1/2 BHS (pot mounting)
	166-025			2	TUBE, spacer
5	179-600			1	CABLE harness, SWEEP TIME/CM
					Mounting Hardware For Switch: (not included)
	210-413			1	NUT, hex, 3/8-32 x 1/2
	210-840			1	WASHER, .390 ID x 9/16 OD
	210-012			1	LOCKWASHER, int, 3/8 x 1/2
6	343-042			2	CLAMP, cable, 5/16" (half)
					Mounting Hardware For Each: (not included)
	211-507			1	SCREW, 6-32 x 5/16 BHS
	210-803			1	WASHER, 6L
	210-006			1	LOCKWASHER, int. #6
	210-407			1	NUT, hex, 6-32 x 1/4
7	426-150			1	MOUNT, 50 Ω line connector
					Mounting Hardware: (not included)
	211-511			2	SCREW, 6-32 x 1/2 BHS
	406-779			1	BRACKET, casting support (not shown)
					Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 BHS
	210-006			2	LOCKWASHER, int. #6
	210-407			2	NUT, hex, 6-32 x 1/4
8	131-221			1	CONNECTOR, push on bulkhead jack
	358-172			1	BUSHING, rod
9	214-222			1	SPRING, striker
	361-029			1	SPACER, latch spring
					Mounting Hardware: (not included)
	211-082			2	SCREW, 4-40 x 3/4 FHS socket head
	210-004			2	LOCKWASHER, int. #4
	210-406			2	NUT, hex, 4-40 x 3/16

ACCESSORIES



REF. NO.	PART NO	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	017-044			2	ATTENUATOR, 50 Ω 10X
2	017-501			1	CABLE, 50 Ω 10 nsec

NOTES

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range
		Bulbs					
B319	150-002	Neon, NE-2					

Capacitors

Tolerances ±20% unless otherwise indicated.
Tolerance of all electrolytic capacitors are as follows (with exceptions):

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

Ckt. No.	Tektronix Part No.		Description			S/N Range
C1	283-002	.01 μf	Disc Type	500 v		
C2	283-002	.01 μf	Disc Type	500 v		
C3	283-002	.01 μf	Disc Type	500 v		
C4	283-003	.01 μf	Disc Type	150 v		X494-up
C5	281-557	1.8 pf	Cer	500 v		X494-up
C7	281-544	5.6 pf	Cer	500 v	10%	X494-up
C9	283-003	.01 μf	Disc Type	150 v		X494-up
C10	283-010	.05 μf	Disc Type	50 v		X494-up
C20	283-026	.2 μf	Disc Type	25 v		
C21	281-580	470 pf	Cer	500 v	10%	X494-up
C30	283-026	.2 μf	Disc Type	25 v		
C40	283-026	.2 μf	Disc Type	25 v		
C50	283-026	.2 μf	Disc Type	25 v		
C60	281-504	10 pf	Cer	500 v	10%	
C61	281-504	10 pf	Cer	500 v	10%	
C65	281-549	68 pf	Cer	500 v	10%	
C75	283-000	.001 μf	Disc Type	500 v		
C110	283-010	.05 μf	Disc Type	50 v		
C116	281-523	100 pf	Cer	350 v		101-146X
C120	283-010	.05 μf	Disc Type	50 v		
C126	281-519	47 pf	Cer	500 v	10%	X147-up
C140	283-002	.01 μf	Disc Type	500 v		
C145A	283-012	.1 μf	Disc Type	100 v		
C145B	283-010	.05 μf	Disc Type	50 v		
C145C	283-004	.02 μf	Disc Type	150 v		
C145D	283-003	.01 μf	Disc Type	150 v		
C145E	283-001	.005 μf	Disc Type	500 v		
C145F	283-051	.0033 μf	Disc Type	100 v	5%	
C145G	283-000	.001 μf	Disc Type	500 v		
C145H	283-032	470 pf	Disc Type	500 v	5%	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C146	281-528	82 pf	Cer		500 v	10%	101-376X
C146A	281-512	27 pf	Cer		500 v	10%	X377-up
C146B	281-022	8-50 pf	Cer	Var			X377-up
C155	283-000	.001 μf	Disc Type		500 v		
C160	283-010	.05 μf	Disc Type		50 v		
C164	281-511	22 pf	Cer		500 v	10%	X147-up
C166	281-523	100 pf	Cer		350 v		
C200	283-026	.2 μf	Disc Type		25 v		
C201	283-026	.2 μf	Disc Type		25 v		
C202	283-002	.01 μf	Disc Type		500 v		
C224	283-000	.001 μf	Disc Type		500 v		
C231	281-518	47 pf	Cer		500 v		
C232	283-002	.01 μf	Disc Type		500 v		
C241	283-000	.001 μf	Disc Type		500 v		
C254	281-550	120 pf	Cer		500 v	10%	
C260A	*295-065	1 μf	Timing Series				
C260B		.1 μf					
C260C		.01 μf					
C260D		.001 μf					
C260E	use 283-587	160 pf	Mica		500 v	5%	
C260F	281-022	8-50 pf	Cer	Var.			
C261	283-000	.001 μf	Disc Type		500 v		
C270	281-518	47 pf	Cer		500 v		
C274	283-028	.0022 μf	Disc Type		50 v		
C288	283-000	.001 μf	Disc Type		500 v		
C300	283-000	.001 μf	Disc Type		500 v		
C301	290-107	25 μf	Littl-Lytics		25 v		
C302	283-003	.01 μf	Disc Type		150 v		
C303	281-551	390 pf	Cer		500 v	10%	
C305	283-000	.001 μf	Disc Type		500 v		
C309	281-504	10 pf	Cer		500 v	10%	
C310	283-003	.01 μf	Disc Type		150 v		
C322	281-551	390 pf	Cer		500 v	10%	
C332	281-523	100 pf	Cer		350 v		
C335	283-003	.01 μf	Disc Type		150 v		
C341	283-024	.1 μf	Disc Ttype		30 v		
C342	283-000	.001 μf	Disc Type		500 v		X516-up
C345	283-004	.02 μf	Disc Type		150 v		
C358A	283-581	510 pf	Mica		300 v	5%	
C358C	283-580	220 pf	Mica		500 v	5%	
C358D	281-012	7-45 pf	Cer	Var			
C358E	283-579	100 pf	Mica		500 v	5%	
C358F	281-012	7-45 pf	Cer	Var			
C358G	283-578	27 pf	Mica		500 v	5%	
C358H	2831-012	7-45 pf	Cer	Var			

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C358J	281-542	18 pf	Cer		500 v	10%	
C358K	281-007	3-12 pf	Cer	Var			
C358L	281-547	2.7 pf	Cer		500 v	10%	
C360	*291-019	.01 μf	Polystyrene		500 v	5%	
C362	283-012	.1 μf	Disc Type		100 v		
C365	283-003	.01 μf	Disc Type		150 v		
C370	283-000	.001 μf	Disc Type		500 v		
C373	283-000	.001 μf	Disc Type		500 v		
C374	283-001	.005 μf	Disc Type		500 v		
C377	285-572	.1 μf	PTM		200 v		
C378	285-572	.1 μf	PTM		200 v		
C390	290-015	100 μf	EMT		25 v		
C391	283-026	.2 μf	Disc Type		25 v		
C396	290-026	5 μf	EMT		25 v		
C397	290-015	100 μf	EMT		25 v		
C398	283-026	.2 μf	Disc Type		25 v		

Diodes

Ckt. No.	Tektronix Part No.	Description	S/N Range
D7	152-008	Germanium T12G	X494-up
D25	152-043	Tunnel 1N3129 20 MA	
D35	152-043	Tunnel 1N3129 20 MA	
D45	152-043	Tunnel 1N3129 20 MA	
D55	152-043	Tunnel 1N3129 20 MA	
D65	152-043	Tunnel 1N3129 20 MA	
D72	152-026	Germanium Q6-100	
D82	152-008	Germanium T12G	
D92	152-008	Germanium T12G	
D122	152-061	Silicon 6061	X147-up
D132	152-008	Germanium T12G	
D144	152-008	Germanium T12G	
D146	152-045	Silicon 6045	
D147	152-008	Germanium T12G	
D164	152-008	Germanium T12G	X147-up
D234	152-076	Zener 3 v ¼ w 10%	
D255	152-074	Tunnel 1N3128 5 MA	
D256	152-071	Germanium ED2007	
D270	152-065	Silicon HD5000	101-304
	152-071	Germanium ED2007	305-up
D271	152-008	Germanium T12G	
D272	152-058	Stabistor SG22	
D275	152-073	Tunnel 10 MA	
D276	152-077	Back BD1	
D285	152-043	Tunnel 1N3129 20 MA	

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
D300	152-025	Germanium 1N634	
D306	152-025	Germanium 1N634	
D324	152-071	Germanium ED2007	
D325	152-074	Tunnel 1N3128 5 MA	
D336	152-025	Germanium 1N634	
D337	152-025	Germanium 1N634	
D345	152-045	Silicon 6045	
D352	152-045	Silicon 6045	
D353	152-045	Silicon 6045	
D360	152-045	Silicon 6045	
D361	152-045	Silicon 6045	
D362	152-045	Silicon 6045	
D377	152-069	Zener 75 v 1 w 10%	
D378	152-069	Zener 75 v 1 w 10%	
D420	152-066	Silicon 1N3194	
D421	152-066	Silicon 1N3194	
D422	152-066	Silicon 1N3194	

Inductors

L25	*108-182	.3 μh	
L35	*108-182	.3 μh	
L45	*108-182	.3 μh	
L55	*108-182	.3 μh	
L300	*108-200	40 μh	
L390	*120-261	Toroid 5T TD58	
L398	*120-261	Toroid 5T TD58	

Resistors

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

R4	317-201	200 Ω	1/10 w		5%	X494-up
R5	316-222	2.2 k	¼ w			X494-up
R6	317-510	51 Ω	1/10 w		5%	X494-up
R7	317-510	51 Ω	1/10 w		5%	X494-up
R8	316-152	1.5 k	¼ w			X494-up
R9	317-510	51 Ω	1/10 w		5%	X494-up
R10	302-101	100 Ω	½ w			
R11	302-101	100 Ω	½ w			
R12	302-470	47 Ω	½ w			
R14	316-472	4.7 k	¼ w			
R15	302-223	22 k	½ w			
R16†	311-299	100 k		Var	THRESHOLD	
R17	316-472	4.7 k	¼ w			
R18	302-470	47 Ω	½ w			
R19	316-472	4.7 k	¼ w			

† Concentric with R136. Furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
R20	307-023	4.7 Ω	½ w			
R21	305-621	620 Ω	2 w		5%	
R22	301-471	470 Ω	½ w		5%	
R24	316-561	560 Ω	¼ w			
R25	311-171	5 k		Var	—TRIG. RECOG. T.D. BIAS	
R27	315-750	75 Ω	¼ w		5%	
R28	315-750	75 Ω	¼ w		5%	
R29	316-103	10 k	¼ w			
R30	307-023	4.7 Ω	½ w			
R31	305-471	470 Ω	2 w		5%	
R32	301-361	360 Ω	½ w		5%	
R33	316-560	56 Ω	¼ w			
R34	316-681	680 Ω	¼ w			
R35	311-171	5 k		Var	—TRIG RECOVERY T.D. BIAS	
R40	307-023	4.7 Ω	½ w			
R41	305-621	620 Ω	2 w		5%	
R42	301-471	470 Ω	½ w		5%	
R44	316-561	560 Ω	¼ w			
R45	311-171	5 k		Var	+TRIG. RECOG. T.D. BIAS	
R47	315-750	75 Ω	¼ w		5%	
R48	315-750	75 Ω	¼ w		5%	
R49	316-103	10 k	¼ w			
R50	307-023	4.7 Ω	½ w			
R51	305-471	470 Ω	2 w		5%	
R52	301-361	360 Ω	½ w		5%	
R53	316-560	56 Ω	¼ w			
R54	316-681	680 Ω	¼ w			
R55	311-171	5 k		Var	+TRIG. RECOVERY T.D. BIAS	
R60	316-101	100 Ω	¼ w			
R61	316-101	100 Ω	¼ w			
R65	311-004	200 Ω	2 w	Var	OUTPUT T.D. BIAS	
R66	306-391	390 Ω	2 w			
R67	307-053	3.3 Ω	½ w		5%	
R73	315-510	51 Ω	¼ w		5%	
R74	316-122	1.2 k	¼ w			
R75	316-122	1.2 k	¼ w			
R83	316-471	470 Ω	¼ w			101-146
	316-472	4.7 k	¼ w			147-up
R93	316-471	470 Ω	¼ w			101-146
	316-472	4.7 k	¼ w			147-up
R101	316-181	180 Ω	¼ w			
R103	316-181	180 Ω	¼ w			
R110	316-220	22 Ω	¼ w		5%	
R115	301-752	7.5 k	½ w			
R116	316-393	39 k	¼ w			

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R117	316-683	68 k	¼ w				
R120	316-220	22 Ω	¼ w				
R122	309-316	4.75 k	½ w		Prec	1%	101-146
	302-222	2.2 k	½ w				147-up
R125	309-317	7.45 k	½ w		Prec	1%	
R126	316-473	47 k	¼ w				
R127	316-154	150 k	¼ w				
R132	309-317	7.45 k	½ w		Prec	1%	
R133	309-154	30 k	½ w		Prec	1%	
R136†	311-299	5 k		Var		RECOVERY TIME	
R140	316-100	10 Ω	¼ w				
R144	306-154	150 k	2 w				
R145	316-560	56 Ω	¼ w				
R147	302-222	2.2 k	½ w				
R154	315-472	4.7 k	¼ w			5%	
R155	316-271	270 Ω	¼ w				
R157	316-223	22 k	¼ w				
R160	316-220	22 Ω	¼ w				
R164	316-473	47 k	¼ w				
R165	316-472	4.7 k	¼ w				
R166	316-393	39 k	¼ w				
R167	316-683	68 k	¼ w				
R175	315-472	4.7 k	¼ w			5%	
R176	316-393	39 k	¼ w				
R177	316-104	100 k	¼ w				
R200	316-100	10 Ω	¼ w				
R201	316-100	10 Ω	¼ w				
R202	316-100	10 Ω	¼ w				
R211††	*311-295	10 k		Var	WW	VARIABLE	
R212	309-159	5 k	½ w		Prec	1%	
R214A	309-193	25 k	½ w		Prec	1%	
R214B	309-090	50 k	½ w		Prec	1%	
R214C	309-376	125 k	½ w		Prec	1%	
R214D	309-090	50 k	½ w		Prec	1%	
R214E	309-260	100 k	½ w		Prec	1%	
R214F	309-162	250 k	½ w		Prec	1%	
R214G	309-140	500 k	½ w		Prec	1%	
R215B	309-090	50 k	½ w		Prec	1%	
R215C	309-037	31.1 k	½ w		Prec	1%	
R215D	309-090	50 k	½ w		Prec	1%	
R215E	309-375	33.3 k	½ w		Prec	1%	
R215F	309-339	27.4 k	½ w		Prec	1%	
R215G	309-335	26.3 k	½ w		Prec	1%	
R216	315-151	150 Ω	¼ w			5%	X356-up
R217	311-016	10 k	2 w	Var		TIME DELAY (nSEC)	

† Concentric with R16. Funished as a unit.

†† Concentric with SW21. Furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R218B	309-157	9 meg	½ w		Prec	1%	
R218C	309-142	900 k	½ w		Prec	1%	
R218D	309-195	90 k	½ w		Prec	1%	
R218E	309-036	18 k	½ w		Prec	1%	
R220	311-125	50 k	.2 w	Var		DELAY ZERO	
R223	309-049	150 k	½ w		Prec	1%	
R224	301-153	15 k	½ w			5%	
R227	309-036	18 k	½ w		Prec	1%	
R231	309-229	5.55 k	½ w		Prec	1%	
R232	316-100	10 Ω	¼ w				
R233	304-334	330 k	1 w				
R234	303-223	22 k	1 w			5%	
R237	316-101	100 Ω	¼ w				
R240	316-562	5.6 k	¼ w				
R241	316-122	1.2 k	¼ w				
R243	316-124	120 k	¼ w				
R244	315-682	6.8 k	¼ w			5%	
R254	311-056	500 Ω	.1 w	Var		RAMP RECOV.	
R260A	301-510	51 Ω	½ w			5%	
R260F	316-100	10 Ω	¼ w				
R261	309-375	33.3 k	½ w		Prec	1%	
R262	309-375	33.3 k	½ k		Prec	1%	
R263	316-270	27 Ω	¼ w				
R264	316-101	100 Ω	¼ w				
R265	303-362	3.6 k	1 w			5%	
R267	311-071	2.25 k		Var		SWEEP CAL.	
R270	316-101	100 Ω	¼ w				
R271	318-084	10 k	⅛ w		Prec	1%	X305-up
R272	316-103	10 k	¼ w				
R274	316-122	1.2 k	¼ w				
R275	311-060	1 k		Var		COMPARATOR LEVEL	
R285	316-561	560 Ω	¼ w				
R286	316-332	3.3 k	¼ w				
R287	316-682	6.8 k	¼ w				
R288	307-057	5.1 Ω	½ w			5%	
R289	308-067	750 Ω	5 w		WW	5%	
R303	301-152	1.5 k	½ w			5%	
R304	311-170	20 k		Var		SAMPLES/CM CAL.	
R305	302-270	27 Ω	½ w				
R306	301-472	4.7 k	½ w			5%	
R308	316-223	22 k	¼ w				
R309	302-393	39 k	½ w				
R310	302-105	1 meg	½ w				
R312	317-910	91 Ω	1/10 w			5%	
R314	317-910	91 Ω	1/10 w			5%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R315	301-102	1 k	½ w			5%	
R319	302-474	470 k	½ w				
R322	301-332	3.3 k	½ w			5%	
R323	302-101	100 Ω	½ w				
R324	301-222	2.2 k	½ w			5%	
R325	301-472	4.7 k	½ w			5%	
R330	301-274	270 k	½ w			5%	
R331	302-393	39 k	½ w				
R332	301-103	10 k	½w			5%	
R333	301-272	2.7 k	½ w			5%	
R334	302-104	100 k	½ w				
R335	302-101	100 Ω	½ w				
R336	301-472	4.7 k	½ w			5%	
R337	302-393	39 k	½w				
R340	301-123	12 k	½ w			5%	
R341	302-270	27 Ω	½ w				
R342	301-512	5.1 k	½ w			5%	
R343	301-332	3.3 k	½ w			5%	
R344	301-473	47 k	½ w			5%	
R345	311-170	20 k		Var.		SWP. LENGTH	
R346	302-101	100 Ω	½ w				
R349	316-223	22 k	¼ w				
R358	301-102	1 k	½ w			5%	
R362	303-223	22 k	1 w			5%	
R364	316-101	100 Ω	¼ w				
R365	302-101	100 Ω	½ w				
R370	316-101	100 Ω	¼ w				
R371	301-393	39 k	½ w			5%	
R372	316-101	100 Ω	¼ w				
R373	316-101	100 Ω	¼ w				
R374	316-101	100 Ω	¼ w				
R375	303-273	27 k	1 w			5%	
R376	305-153	15 k	2 w			5%	
R377	301-124	120 k	½ w			5%	
R381	311-125	50 k	.2 w	Var		STAIRCASE DC LEVEL	
R382	309-090	50 k	½ w		Prec	1%	
R383	309-090	50 k	½ w		Prec	1%	
R384	309-115	1 k	½ w		Prec	1%	
R386	316-101	100 Ω	¼ w				
R393	306-560	56 Ω	2 w				
R394	306-560	56 Ω	2 w				
R395	304-101	100 Ω	1 w				
R420	302-275	2.7 meg	½ w				

Switches

Ckt. No.	Tektronix Part No. Unwired	Wired	Description		S/N Range
SW10A†	260-438	*262-452	Rotary	TRIGGERING SOURCE	
SW10B			Rotary	TRIGGERING POLARITY	
SW211††					
SW260	260-440	*262-449	Rotary	SWEEP TIME/CM	
SW325	260-439	*262-450	Rotary	SWEEP MODE	
SW358	260-437	*262-451	Rotary	SAMPLES/CM	

Transformers

T2	*120-262	Toroid 1T TD59			
T65	*120-263	Toroid 3T TD60			
T284	*120-264	Toroid 3T TD61			
T300	*120-265	Toroid 7T TD62			

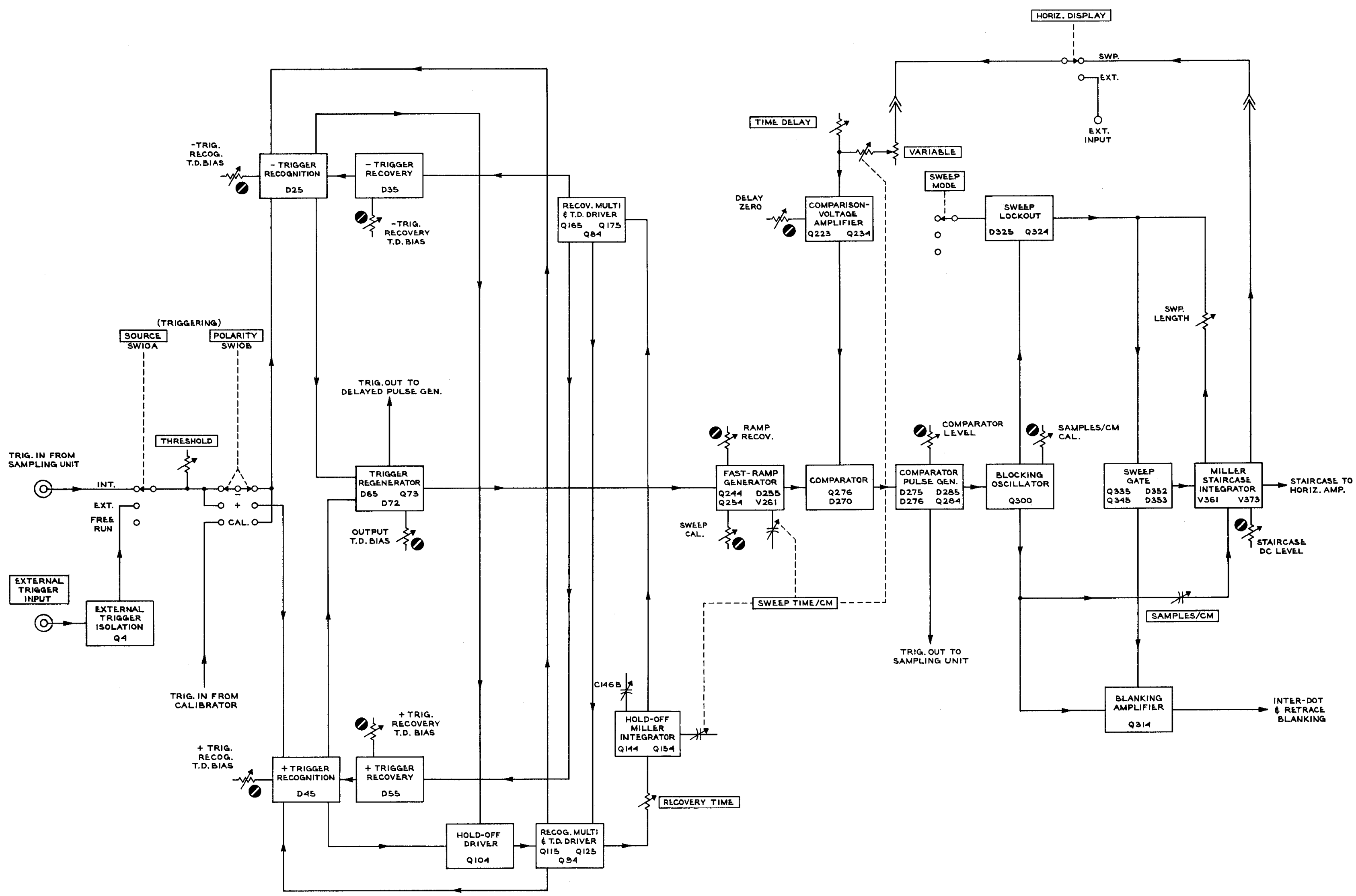
Transistors

Q4	*153-513	2N700	Checked		X494-up
Q73	151-068	2N636			
Q84	151-010	2N404			101-146
	151-065	2N1991			147-up
Q94	151-010	2N404			101-146
	151-065	2N1991			147-up
Q104	151-015	2N1516			
Q115	151-072	2N1308			
Q125	151-072	2N1308			
Q144	151-072	2N1308			
Q154	151-071	2N1305			
Q165	151-072	2N1308			
Q175	151-072	2N1308			
Q223	151-035	2N1592			
Q234	151-065	2N1991			
Q244	151-075	2N769			
Q254	151-075	2N769			
Q276	151-077	2N797			101-304
	151-080	2N706B			305-up
Q284	151-075	2N769			
Q300	use *153-511	OC170	checked		
Q314	151-054	2N1754			
Q324	151-068	2N636			
Q335	151-015	2N1516			
Q345	151-040	2N1302			

Electron Tubes

V261	154-306	7586			
V361	154-215	E18OF/6688			
V373	154-187	6DJ8/ECC88			

† Concentric switches. Furnished as a unit.
†† Concentric with R211. Furnished as a unit.

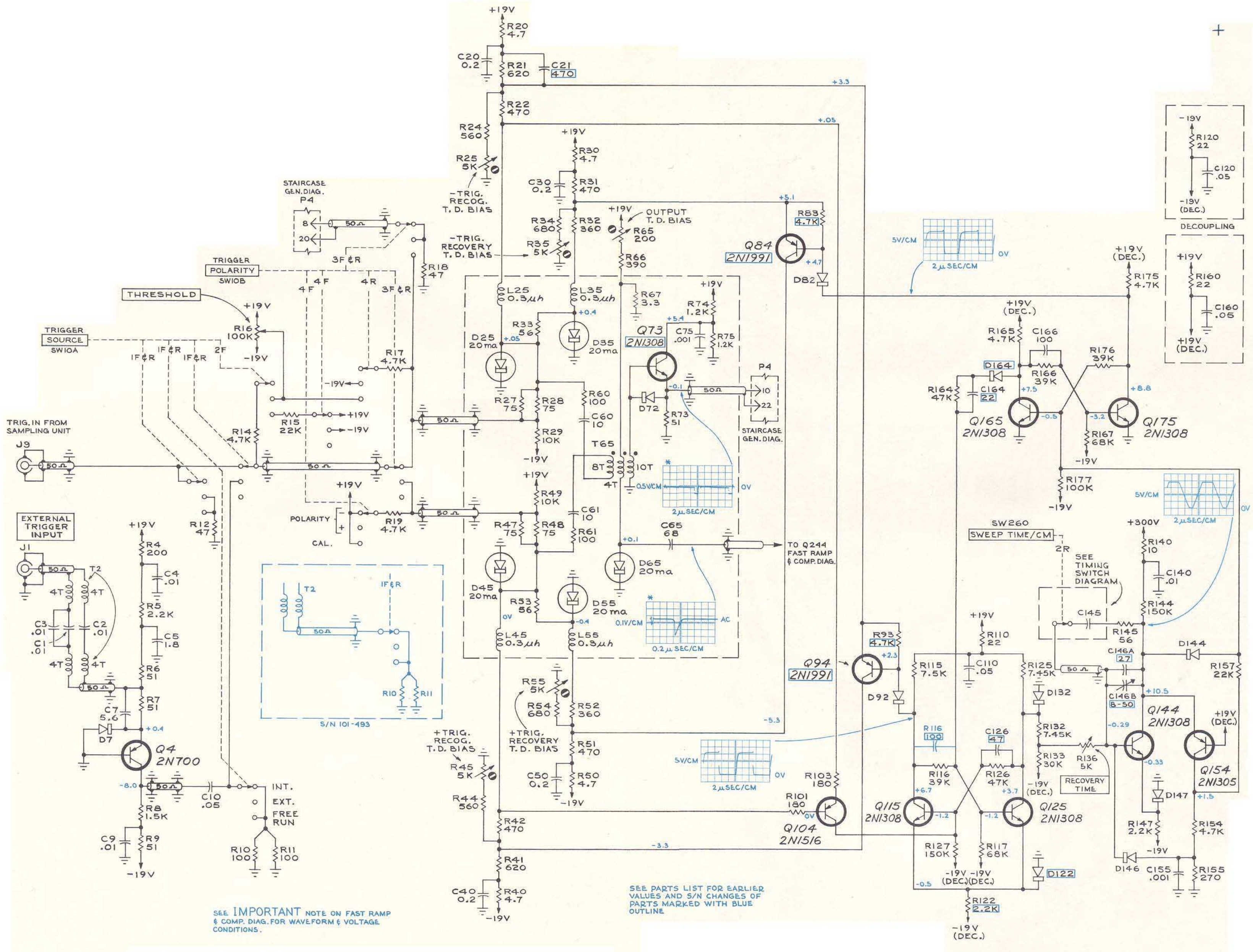


CMD
963

TYPE 5T1

A

BLOCK DIAGRAM

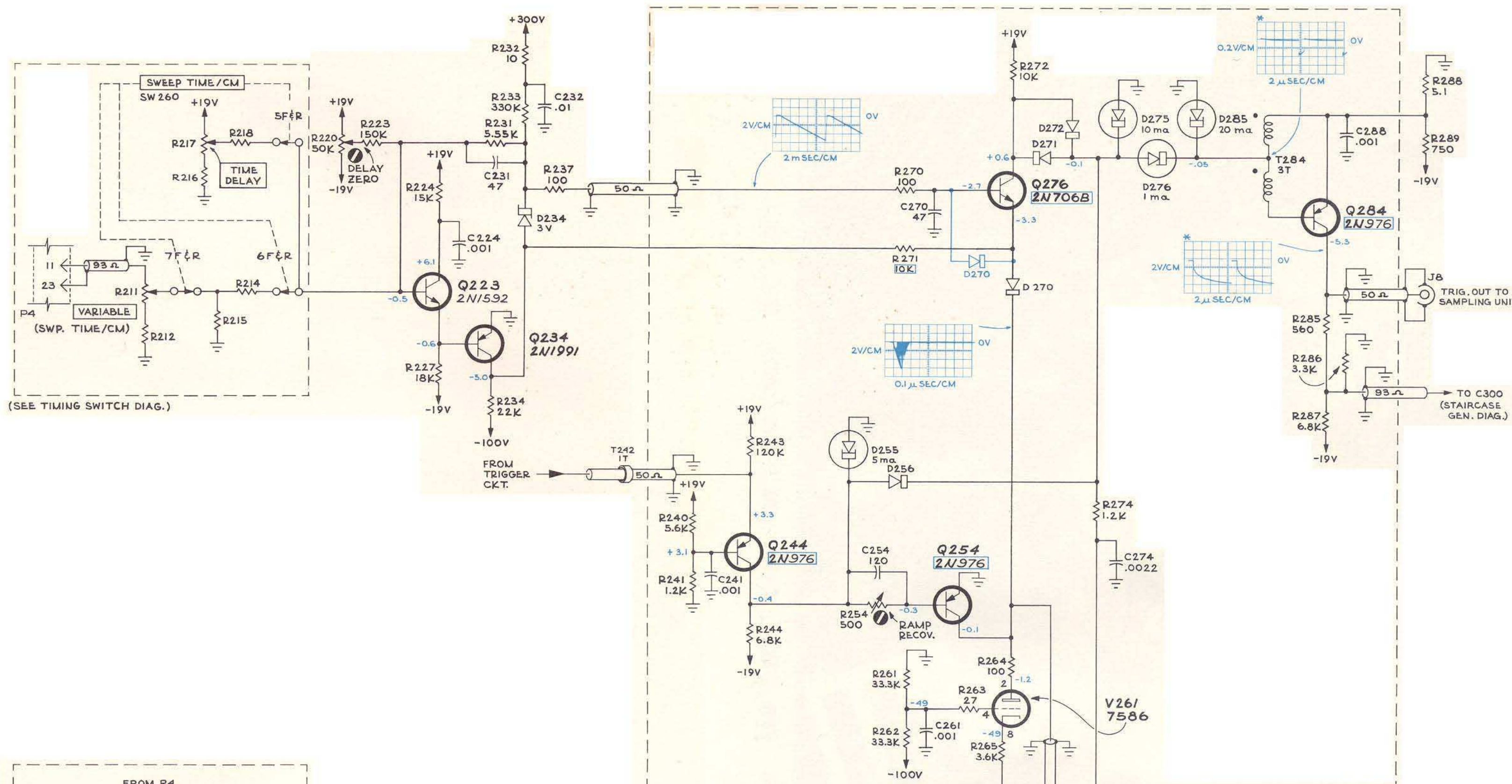


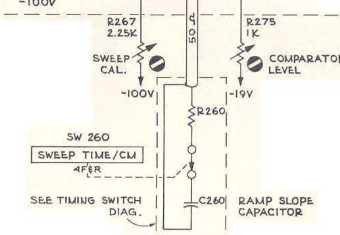
SEE IMPORTANT NOTE ON FAST RAMP & COMP. DIAG. FOR WAVEFORM & VOLTAGE CONDITIONS.

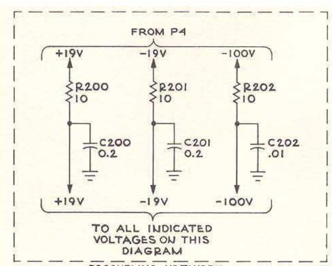
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

MRH 963

TYPE 5T1 A TRIGGER & HOLD-OFF







IMPORTANT:

ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.

VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.

ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.

ALL WAVEFORMS MARKED WITH AN ASTERISK (*) WERE TAKEN WITH THE TYPE 5T1 INSTALLED.

TYPE 661 HORIZ. DISPLAY SWITCH IS SET AT X1.

TYPE 5T1 VOLTAGES & WAVEFORMS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

Trigger input	None
SWEEP TIME/CM	10 nSEC
SOURCE	INT.
POLARITY	–
THRESHOLD	Between 0 and +
RECOVERY TIME	MIN.
SAMPLES/CM	100
SWEEP MODE	REPETITIVE
TIME DELAY	0

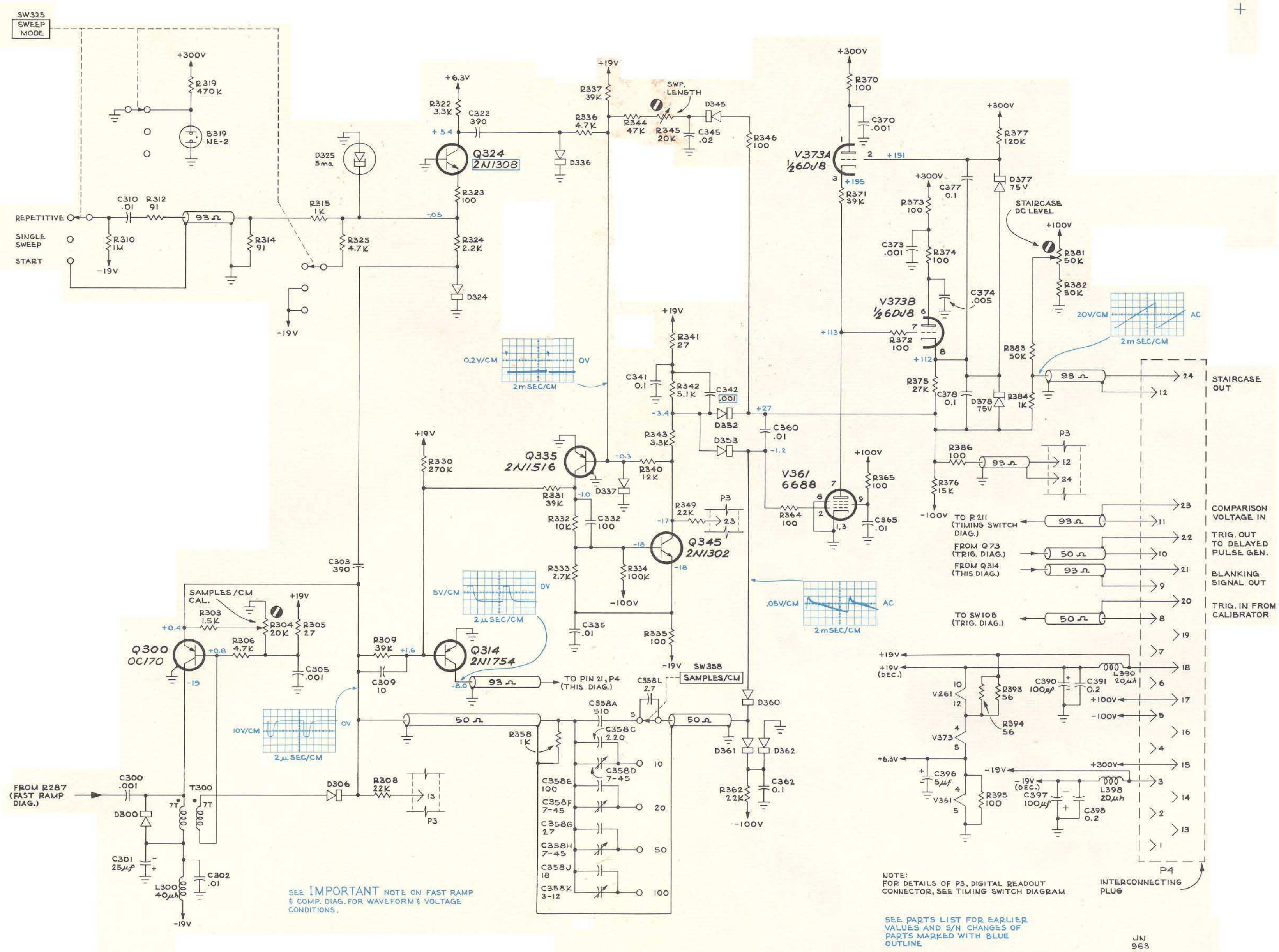
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE.

TYPE 5T1

A

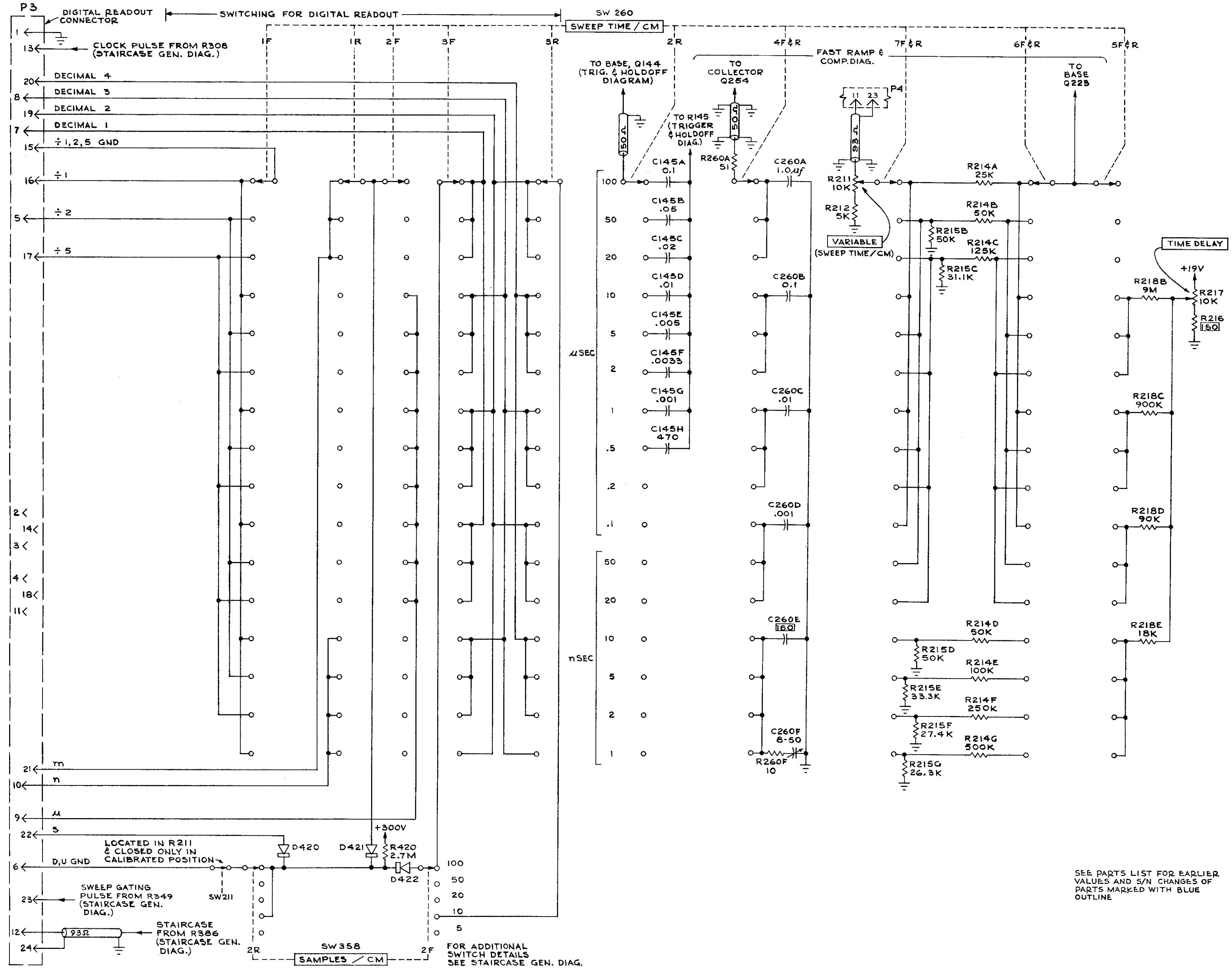
JJH
963

FAST RAMP & COMPARATOR



A

STAIRCASE GENERATOR



TYPE 5T1

A

TIMING SWITCH