

INSTRUCTION MANUAL

TYPE 3T77 SAMPLING SWEEP UNIT

Tektronix, Inc.

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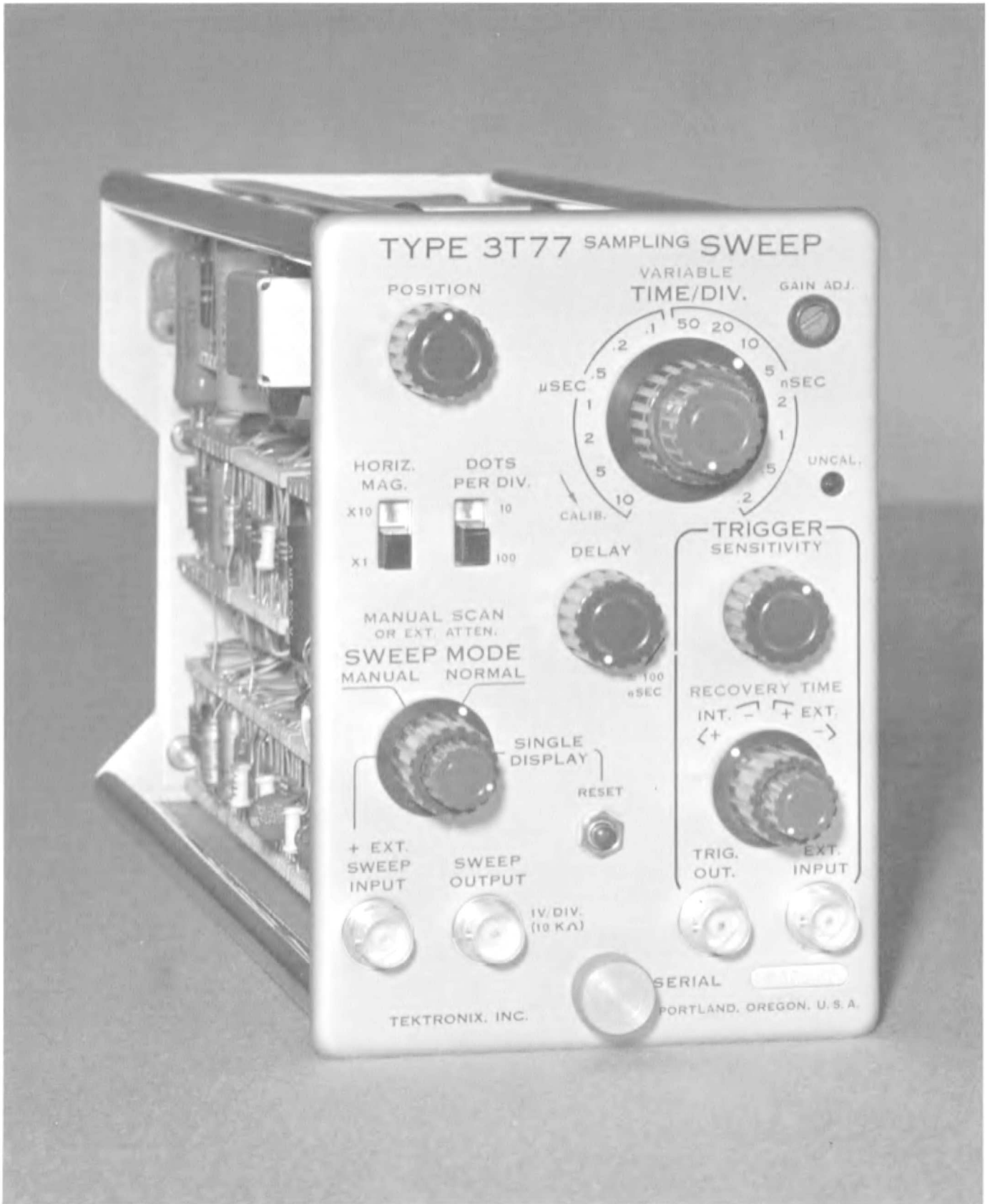


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A list of abbreviations and symbols used in this manual will be found on page 7-1.



The Type 3T77 Sampling Sweep Unit.

Type 3T77

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SECTION 1

CHARACTERISTICS

General Information

The Type 3T77 Sampling Sweep Plug-In Unit is designed for use with all Tektronix Type 560-Series Oscilloscopes except the Type 560 and Type 565. The Type 3T77 is equipped to drive a digital unit in the Type 567 Readout Oscilloscope.

The Type 3T77 must be inserted into the right-hand plug-in compartment of the oscilloscope and a vertical sampling plug-in unit (such as the Type 3S76) must be inserted into the left-hand plug-in compartment to complete the composite sampling system.

Equivalent Sweep Rates

Variable in fifteen steps from 0.2 nsec/div to 10 μ sec/div (0.02 nsec/div to 1 μ sec/div with HORIZ. MAG. switch at X10). Accuracy typically within 1%, and in all cases within 3% of the indicated sweep rate with HORIZ. MAG. switch at X1. With HORIZ. MAG. switch at X10, accuracy is within 5%. The sweep rate at any given setting of the TIME/DIV. switch can be increased by about 3 times with the VARIABLE control.

Samples Per Division

10/div or 100/div.

External Triggering

Pulse Repetition Rate: Up to 3×10^8 pulses/second (300 megacycles). Trigger circuitry counts down to a maximum sampling rate of about 100 kilocycles/second.

Minimum Pulse Amplitude and Width: 10 millivolts, peak-to-peak, with at least a 2-nanosecond width. With larger pulse amplitudes (up to 800 millivolts) minimum pulse width decreases. Overload damage occurs at 5 volts and above.

Sinusoidal Frequency Range: 100 kilocycles to 300 megacycles; 10 to 800 millivolts amplitude.

Low Frequency Response (to trigger pulses): 300 kilocycles (3-db down point).

Jitter: 50 picoseconds or $0.001 \times$ fast ramp duration, whichever is greater (for 50-millivolt amplitude, 2-nanosecond width pulses with a repetition rate less than 10 megacycles). Jitter increases as pulse amplitude and/or width decreases when repetition rates exceed 10 megacycles.

Internal Triggering

Same characteristics as External Triggering but modified by vertical plug-in unit used. When used with the Type 3S76, all characteristics are the same except five times more amplitude is required at the Type 3S76 INPUT A or INPUT B connectors and the low-frequency response is 3-db down at 450 kilocycles.

External Sweep Input

Sensitivity: Adjustable from 5 to 25 volts per horizontal division (50 volts required for a full 10-division display, 250 volts maximum).

Input Resistance: 28 to 100 kilohms, depending on setting of EXT. ATTEN. control.

Sweep Output

Amplitude: 1 volt/div from a source impedance of 10 kilohms.

Delay

Variable through 100 nsec.

Mechanical

Construction: Aluminum alloy chassis.

Finish: Photo-etched, anodized front panel.

Weight: 5 pounds.

Accessories Supplied With the Type 3T77

	Tektronix Part Number
2 50 Ω , 10-nsec cables RG-58/AU with General Radio connectors.	(017-501)
1 Adapter, BNC-to-GR	(017-025)
1 Adapter, male BNC-to-female UHF	(103-032)
2 Attenuators, 10XT, 50 Ω with GR connectors	(017-044)
2 Instruction manuals	(070-333)

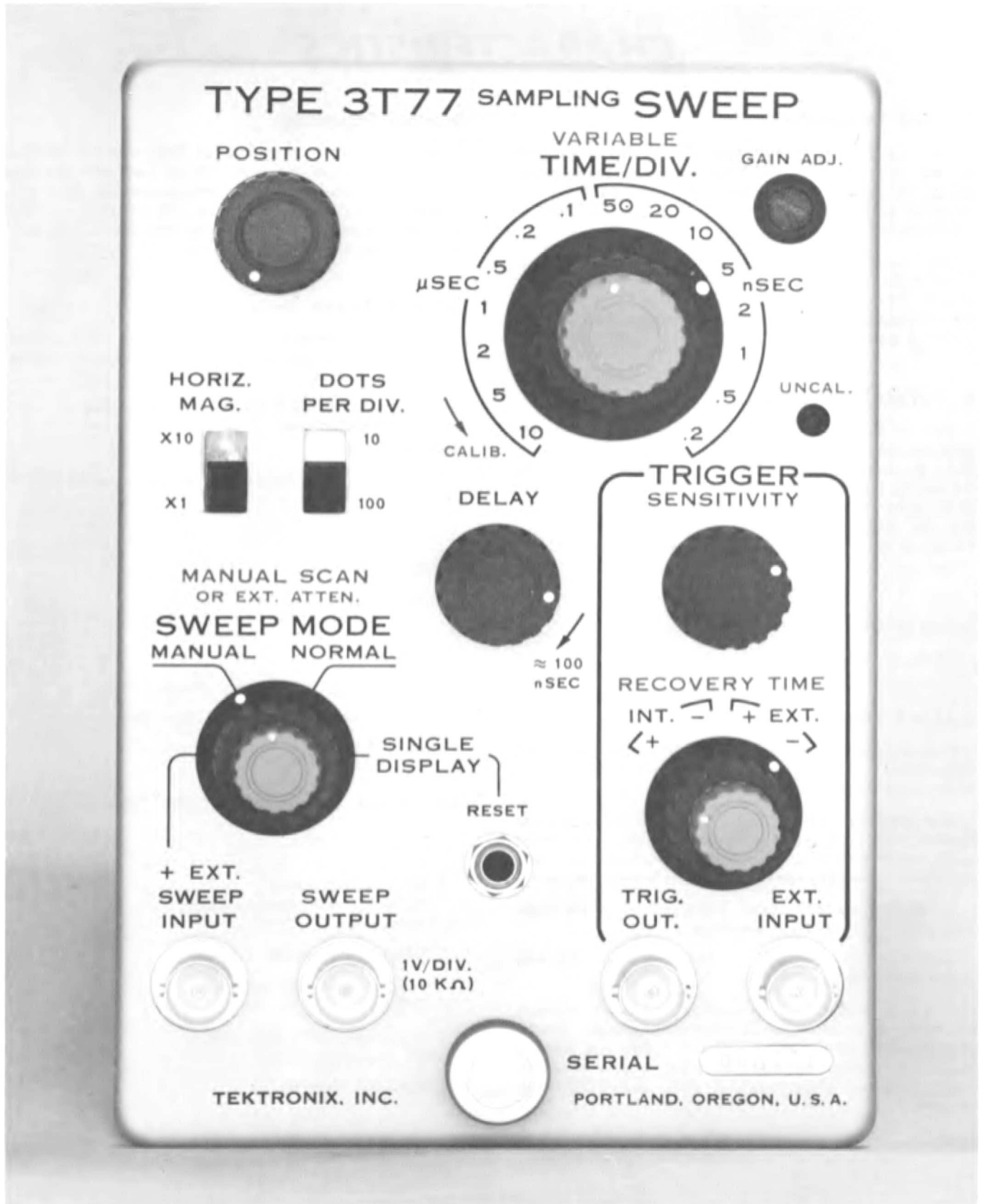


Fig. 2-1. Front panel of the Type 3T77.

SECTION 2

OPERATING INSTRUCTIONS

Introduction

The Type 3T77 Sampling Sweep Plug-In Unit (with a vertical sampling plug-in unit) equips any Type 561A, RM561A, 564, 567, or RM567 Oscilloscope for sampling-type operation. Front-panel operation of the Type 3T77 resembles that of non-sampling (real time) time-base units.

This section of the manual covers the operation of the front-panel controls and connectors (see Fig. 2-1).

Function of Front-Panel Controls and Connectors

POSITION Control

Positions the display horizontally.

HORIZ. MAG. Switch

Selects X1 or X10 horizontal display magnification.

DOTS PER DIV. Switch

Selects either 10 or 100 samples per division.

SWEEP MODE Switch

NORMAL position: Permits automatic dot-by-dot advancement through the oscilloscope display.

SINGLE DISPLAY position: Permits one display after the RESET button is pressed. (Useful for photographing the display.)

+EXT. SWEEP INPUT position: Permits control of the scanning function with an external voltage.

MANUAL position: Permits manual dot-by-dot advancement through the display by turning the MANUAL SCAN control. (For recorder applications.)

MANUAL SCAN OR EXT. ATTN. Control

Provides an internal semi-integrated, variable voltage for scanning when the SWEEP MODE switch is in the MANUAL position, and serves as a variable attenuator when the SWEEP MODE switch is in the +EXT. SWEEP INPUT position.

+EXT. SWEEP INPUT Connector

For applying an external scanning voltage. Sensitivity variable from 5 to 25 volts/div; input impedance variable from 28 to 100 kilohms. Maximum input voltage 250 volts, peak.

SWEEP OUTPUT Connector

For monitoring the sweep voltage. (Output variable from about 3.5 vdc to about 15 vdc; 1-volt change equals 1 division of horizontal deflection with 10-kilohm source impedance.)

TRIG. OUT Connector

For externally monitoring a positive trigger pulse after each trigger event. The pulse width is at least 0.4 microsecond at 0.15-volt amplitude.

EXT. INPUT Connector

For applying an external trigger. Input impedance: 50 ohms shunted by 12 microhenries.

INT.-EXT. Switch

Selects either an internal trigger (INT. position) from the vertical plug-in unit, or an external trigger (EXT. position) from the EXT. INPUT connector, and determines whether triggering takes place on the positive (+) or negative (−) slope of the input signal.

DELAY Control

Allows the start of the display to be varied through 100 nanoseconds with respect to the trigger event.

TRIGGER SENSITIVITY Control

Varies the sensitivity of the triggering circuit. Also causes the trigger circuit to free-run when turned fully clockwise.

RECOVERY TIME Control

Varies the holdoff time of the trigger circuits to assure stable triggering.

TIME/DIV. Switch

Sets the equivalent sweep rate of the display.

VARIABLE Control

Varies the sweep rate (uncalibrated) between TIME/DIV. steps. The equivalent sweep rate at any given setting of the TIME/DIV. switch can be increased about 3 times.

GAIN ADJ. (a front-panel screwdriver adjustment)

Adjusts gain to match oscilloscope deflection factor.

Installing the Type 3T77 into the Oscilloscope

CAUTION

Turn off oscilloscope power while inserting or removing plug-in units. Otherwise, power supplies in the oscilloscope may fail to regulate momentarily as plug-in units are removed or replaced.

The Type 3T77 is designed to drive the horizontal deflection plates of the crt; it must be used in the right-hand plug-in compartment. When inserting the Type 3T77 into the plug-in compartment, first check that the latch at the bottom of the front panel is in a horizontal position. Then make sure the interconnecting plugs are properly aligned. The Type 3T77 should then slip easily into the compartment.

Once the plug-in has been properly seated, turn the aluminum knob of the plug-in unit a few turns clockwise until it is hand-tight. To remove the plug-in unit, turn the aluminum knob counterclockwise as far as it will go and pull the plug-in unit straight out.

Displaying a Signal

The following procedure covers first-time operation of the Type 3T77. It will enable you to display a signal on the crt. Use this procedure in conjunction with the vertical plug-in unit instructions.

1. Set the Type 3T77 front-panel controls as follows:

POSITION	Midrange
TIME/DIV.	5 nSEC
VARIABLE	CALIB.
DELAY	Fully counterclockwise
TRIGGER SENSITIVITY	Fully counterclockwise
HORIZ. MAG.	X1
DOTS PER DIV.	100
SWEEP MODE	NORMAL
INT.-EXT.	INT. (Set to polarity of signal you wish to observe)
RECOVERY TIME	Fully counterclockwise

2. Insert the Type 3T77 into the right-hand plug-in compartment of the oscilloscope and the vertical sampling plug-in unit into the left-hand compartment. Turn on the oscilloscope power and allow a few minutes for warm-up.

3. Apply the signal you wish to observe to the input connector of the vertical sampling plug-in unit. (Note: Make sure the signal meets the triggering requirements described in Section 1.)

4. Slowly advance the TRIGGER SENSITIVITY control for a stable display. The RECOVERY TIME control may also help stabilize the display.

5. Set the TIME/DIV. switch to the position where the displayed signal covers the desired amount of horizontal graticule divisions.

6. With the POSITION control, move the display horizontally to the desired point on the graticule.

7. Turn the DELAY control and notice its effect on the display. The action of the DELAY control is most significant at faster sweep rates. The DELAY control varies the position of the displayed pulse with respect to the start of the trace. The position of the pulse with respect to the start of the trace can be varied 100 nanoseconds with the DELAY control.

8. Set the SWEEP MODE switch to MANUAL and turn the MANUAL SCAN control. Note the horizontal scanning of the electron beam on the crt.

9. Set the SWEEP MODE switch to SINGLE DISPLAY. Press the RESET button. After pressing the RESET button, the Type 3T77 allows one complete scan of the electron beam across the crt. This is particularly useful for photographing displays at slow pulse repetition rates.

Gain Adjust

The basic oscilloscope crt deflection factor varies slightly from one oscilloscope to another. For this reason, the GAIN ADJ. (a front-panel screwdriver adjustment) should be checked and adjusted as necessary each time the Type 3T77 is used in a different oscilloscope. Also, check the

GAIN ADJ. occasionally during regular use of the instrument.

Checking or setting the GAIN ADJ. requires the use of an accurate frequency source, such as the Tektronix Type 180A Time-Mark Generator. The frequency standard used must have a frequency output of at least 100 kilocycles, and preferably above 1 megacycle.

To check or adjust the Type 3T77 GAIN ADJ. control, proceed as follows:

1. Insert the Type 3T77 and the associated vertical sampling plug-in unit into the oscilloscope, turn on the power and allow the instrument to warm up for at least 2 minutes before proceeding.

2. Set the front-panel controls of the Type 3T77 as follows:

POSITION	Midrange
DOTS PER DIV.	100
TRIGGER SENSITIVITY	Fully clockwise
VARIABLE	CALIB.
SWEEP MODE	NORMAL
HORIZ. MAG.	X1
INT.-EXT.	+ INT.

Other controls may be set to any position.

3. From an accurate frequency source, apply a signal to the Input connector of the vertical sampling plug-in unit and adjust for a vertical deflection of 2 to 6 divisions.

4. Determine the time duration of one cycle of the signal from the frequency source (time duration of one cycle (in seconds) is the reciprocal of the frequency (in cycles per second)).

5. Set the TIME/DIV. switch for a sweep rate that will display one-half to one cycle of the applied signal per division of deflection.

6. Set the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display.

7. Check for the proper number of cycles per division. If the number of cycles per division does not exactly agree with the setting of the TIME/DIV. switch, set the GAIN ADJ. for the proper timing. Use the POSITION control to align the display with the graticule markings.

Triggering the Type 3T77

The Type 3T77 can be triggered either internally or externally. Internal triggering requires no signal connections to the Type 3T77 since the triggering signal is coupled internally from the vertical sampling plug-in unit.

However, external triggering is more sensitive (see Section 1). External triggering is also independent of the displayed waveform. Thus, when signals of different amplitudes are applied to the vertical plug-in unit, the triggering controls do not require resetting for a stable display. However, an external triggering signal must be related in time to the displayed signal to maintain stable triggering.

The + and — positions of the INT.-EXT. switch determine whether triggering takes place on the positive- or negative-

going slope of the triggering signal. The INT. or EXT. positions determine whether the triggering signal comes from the vertical sampling plug-in unit or from the EXT. INPUT connector.

Selecting the Equivalent Sweep Rate

The Type 3T77 TIME/DIV. switch selects equivalent sweep rates from 0.2 nanosecond per division to 10 microseconds per division. These rates, in turn, provide an equivalent 10-division display width from 2 nanoseconds to 100 microseconds. Setting the HORIZ. MAG. switch to X10 increases the equivalent sweep rate 10 times at any setting of the TIME/DIV. switch. This expands the display in both directions from the center graticule division to cover the entire graticule (horizontally).

The VARIABLE control increases the equivalent sweep rate at any setting of the TIME/DIV. switch about 3 times (uncalibrated) when the control is fully clockwise.

Selection of sweep rate depends on the duration of the applied signal and the specific portion of the signal you wish to observe. The DELAY control aids in observing a specific portion of the applied signal.

The equivalent sweep rates of the Type 3T77 are accurate within 3% of the TIME/DIV. control setting when the VARIABLE control is set to CALIB. and the HORIZ. MAG. switch is set to X1. This permits accurate time measurements directly from the oscilloscope display.

Selecting the Dots Per Division

In a sampling system, the applied signal is displayed as a series of dots distributed across the crt. With a greater number of dots in the display, the trace appears more continuous. With less dots in the display, there is less continuity in the trace and the individual dots become more apparent (see Fig. 2-2). The DOTS PER DIV. switch selects either 10 dots per division or 100 dots per division. Proper setting of the DOTS PER DIV. switch is a choice between good trace continuity and flicker. Flicker will become apparent with signals of low repetition rate when the DOTS PER DIV. switch is set to 100. By changing the setting of the DOTS PER DIV. switch to 10, flicker will become less apparent. However, with 10 dots per division, make sure the SMOOTH-NORMAL switch of the vertical sampling plug-in unit is set to NORMAL. Otherwise, the display may be distorted. Signals with fast repetition rates cause less flicker; thus the DOTS PER DIV. switch may be set to 100 for best trace continuity.

When making time measurements from the crt, the individual dots can serve as time markers. For example, suppose the Type 3T77 TIME/DIV. switch is set to 1 nSEC and the DOTS PER DIV. switch is set to 10. In this case, each dot

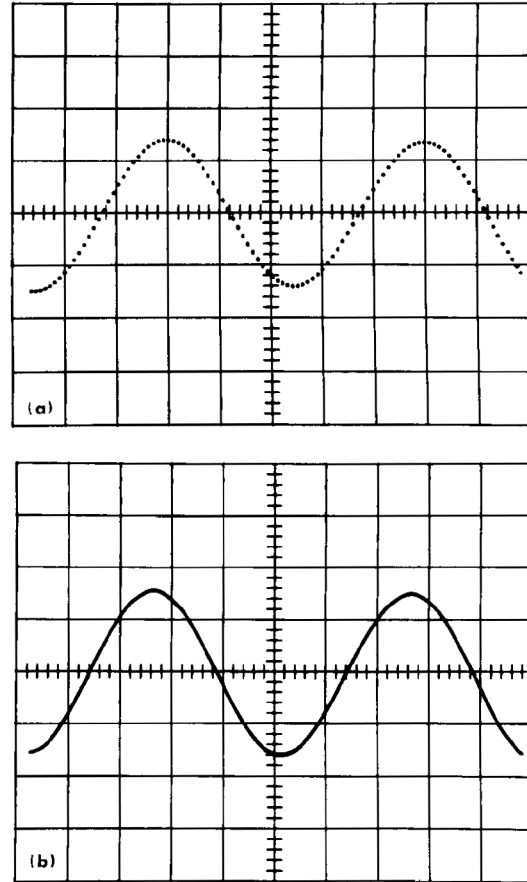


Fig. 2-2. (a) A typical display with the DOTS PER DIV. switch set to 10. (b) The same signal with the DOTS PER DIV. switch set to 100.

represents 0.1 nanosecond in equivalent time (1 nanosecond per division divided by the 10 dots per division). This application is easiest when the display contains 10 dots per division (i.e., the DOTS PER DIV. switch must be set to 10 or the HORIZ. MAG. switch must be set to X10).

Under certain conditions it is possible to get a false display when using a sampling-type system. This happens when certain relationships exist between the frequency of the applied signal and the equivalent time between dots. A false display can be detected by changing the setting of the DOTS PER DIV. switch or the TIME/DIV. switch. With a valid display, a change in the equivalent time between dots should not affect the displayed waveform. However, if the display is false, it will change in apparent repetition rate or disappear when the equivalent time per dot changes.

SECTION 3

APPLICATIONS

The procedures in this section describe some basic applications for the Type 3T77.

Time and Frequency Measurements

The Type 3T77 is accurately calibrated to indicate equivalent time per division along the horizontal axis of the oscilloscope display. Thus, the following procedures concern measuring time and frequency of electrical events.

Time Duration. To measure the time duration of an electrical event, proceed as follows:

1. Obtain a stable display of the event you wish to measure.
2. Set the TIME/DIV. switch so the distance between the two points you wish to measure covers a large portion of the graticule.
3. To get the time duration, count the number of graticule divisions between the two points, multiply by the TIME/DIV. switch setting, then divide the result by the HORIZ. MAG. switch setting.

To illustrate this procedure, assume the TIME/DIV. switch is set to 5 nSEC and the HORIZ. MAG. switch to X1. Then, assume the distance between the two points on the display is 4.8 major graticule divisions. Thus, the time duration would be 4.8 divisions multiplied by 5 nanoseconds/division (TIME/DIV. switch setting), or 24 nanoseconds.

Risetime. The risetime of a pulse is, by definition, the time required for the pulse to rise from 10% to 90% of

its maximum amplitude. To measure pulse risetime or fall-time proceed as follows:

1. Set the TIME/DIV. switch and the DELAY control to display the leading edge of the pulse. (Or, for falltime measurement, display the falling edge.) For best accuracy, the rising portion of the pulse should span at least two horizontal graticule divisions.
2. Set the vertical plug-in unit so the display covers two to eight vertical graticule divisions.
3. Measure the horizontal distance between the 10% and 90% amplitude points on the waveform. See Fig. 3-1.
4. The risetime is the number of divisions in step 3 multiplied by the setting of the TIME/DIV. switch (divided by the HORIZ. MAG. switch setting).

Frequency or Repetition Rate. Frequency or repetition rate is the number of complete electrical events occurring in a second. To measure the frequency or repetition rate of the displayed signal in cycles (or pulses) per second, proceed as follows:

1. Find the time duration of a complete event as described under "Time Duration".
2. The frequency or repetition rate of the applied signal is the reciprocal of step 1.

To illustrate this procedure, assume the TIME/DIV. switch is set to 20 nSEC and the HORIZ. MAG. switch to X10. Then, assume one event covers 6.4 major graticule divisions. Thus, the frequency or repetition rate would be 6.4 divisions multiplied by 20 nanoseconds/division (TIME/DIV. switch setting) divided by 10 (the HORIZ. MAG. switch setting), or 12.8 nanoseconds. The frequency is then the reciprocal of 12.8 nanoseconds, or about 78.1 megacycles.

An alternative method for measuring frequency or repetition rate is as follows:

1. Set the TIME/DIV. switch for a 2- to 10-cycle display of the input signal.
2. Count the exact number of cycles (including fractional cycles) occurring in 10 major graticule divisions.
3. Multiply the number of cycles obtained in step 2 by the Frequency Multiplier value opposite the appropriate TIME/DIV. switch setting in Table 3-1.

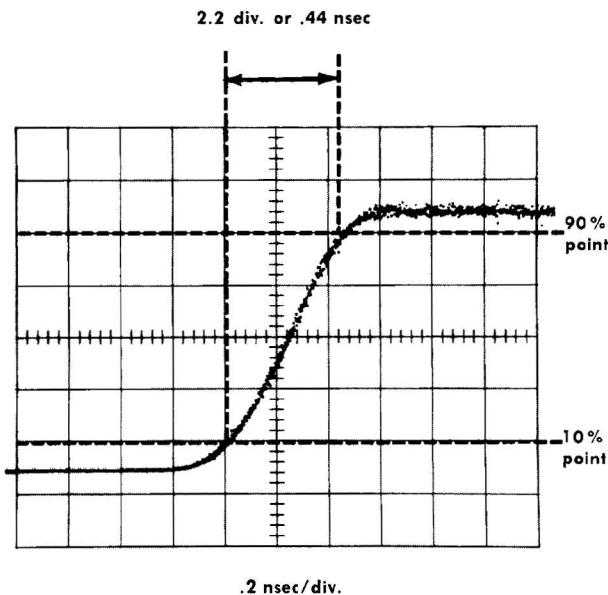


Fig. 3-1. Determining pulse risetime.

TABLE 3-1

TIME/DIV. Setting	Frequency Multiplier
1 nSEC	100 mc
10 nSEC	10 mc
.1 μSEC	1 mc
1 μSEC	100 kc
10 μSEC	10 kc

Single Display Mode

The Type 3T77 has a RESET button that provides a single display of the signal. This feature is helpful for taking photographs of low repetition-rate signals when the actual sweep rate is slow. With the SINGLE DISPLAY feature, it is easy to obtain even exposure over a photograph. Without SINGLE DISPLAY, it is necessary to take a time exposure to minimize the effects of interaction between shutter time and the instantaneous location of the scanning beam.

To use the SINGLE DISPLAY feature, set up the Type 3T77 for a normal triggered display with the SWEEP MODE switch set to NORMAL. Then set the SWEEP MODE switch to SINGLE DISPLAY. Push the RESET button, and the crt beam will produce a single display. To make a photographic recording of the single display, open the camera shutter, press the RESET button and, after allowing sufficient time for a complete display, close the camera shutter. Consult the camera instruction manual for further information on photographic recording.

Paper Recorder Operation

The voltage at the SWEEP OUTPUT connector provides a convenient source for controlling the X or T (time) axis of a paper recorder. The SWEEP OUTPUT connector supplies a total open-circuit voltage change of 10 volts (+3.5 volts to about +13.5 volts) when the electron beam sweeps the full 10 horizontal graticule divisions (one volt per division). Source impedance of the SWEEP OUTPUT connector is 10 kilohms.

When the SWEEP MODE switch is set to MANUAL, the voltage at the SWEEP OUTPUT connector is set by the MANUAL SCAN control. The MANUAL Sweep Mode allows manual control of horizontal scanning. In recorder operation, this permits operation with slow response recorders.

+Ext. Sweep Input Mode

In this mode of operation, an external sweep voltage may be used to control horizontal scanning in the sampling system. To do this, the externally applied sweep voltage must swing between zero and at least +50 volts for a

horizontal deflection of 10 divisions. The EXT. ATTEN. control provides for signals that have peak amplitude to +250 volts.

This feature is useful in recorder applications where the recorder has its own sweep voltage and a sweep output. In such a case, the sweep output of the recorder is used as the scanning voltage for the Type 3T77. Then, the vertical (or Y axis) information is coupled to the recorder from the vertical sampling plug-in unit.

Since most conventional oscilloscopes have a sweep output, a monitoring oscilloscope can be used in this application as a "slave" in place of a recorder.

To use the +Ext. Sweep Input Mode for a recorder or "slave" oscilloscope application, proceed as follows:

1. Set the SWEEP MODE switch to NORMAL and obtain a stable display of the applied signal.
2. Connect the sawtooth of the "slave" oscilloscope or recorder to the +EXT. SWEEP INPUT connector.
3. Set the SWEEP MODE switch to +EXT. SWEEP INPUT.
4. Connect the vertical amplifier output signal to the vertical input connector of the "slave" oscilloscope or recorder.
5. Set the triggering controls of the "slave" oscilloscope for a free-running display, or initiate the recorder motion.
6. For the "slave" oscilloscope, select a slow sweep which produces a well defined display on both oscilloscopes.
7. Set the EXT. ATTEN. control (red knob concentric with SWEEP MODE switch) so that 10 divisions of horizontal deflection on the sampling oscilloscope matches the desired divisions on the "slave" oscilloscope or recorder.

As long as the EXT. ATTEN. control is adjusted for 10 divisions of horizontal deflection on both instruments, the equivalent sweep rates are the same as the Type 3T77 TIME/DIV. switch setting. For example, if the EXT. ATTEN. control is set for 5 divisions of sampling oscilloscope deflection, the equivalent sweep rate of the "slave" oscilloscope is one-half the numerical setting of the Type 3T77 TIME/DIV. switch. Thus, a decrease in horizontal deflection on the sampling oscilloscope results in an increase in the equivalent sweep rate of the conventional oscilloscope or recorder.

SECTION 4

CIRCUIT DESCRIPTION

General Operation

The Type 3T77 contains four main circuits: the Trigger and Holdoff circuit, the Fast Ramp circuit, the Staircase Generator circuit, and the Horizontal Amplifier.

The Type 3T77 provides horizontal deflection potentials to the crt. In addition, it controls the exact time that the vertical plug-in unit samples the applied signal. The following discussion describes the basic technique involved.

Basic Sampling Technique

To recreate a repetitive signal using the sampling technique, samples must be taken over the portion of the signal

you wish to display. When sampling a fixed point on a waveform, a trigger circuit trips the sampling gate in the vertical system and allows a sample of the incoming signal to pass through. A block diagram of this system appears in Fig. 4-1.

In actual practice, the system shown in Fig. 4-1 could not take a sample on the leading edge of the signal because of the finite time delay in the Trigger circuit. Therefore, if a delay is introduced in the input circuit of the vertical system, the Trigger circuit will have time to open the sampling gate in the vertical system just as the leading edge of the incoming signal reaches the gate. Fig. 4-2 shows a block diagram with a delay circuit added in the vertical system.

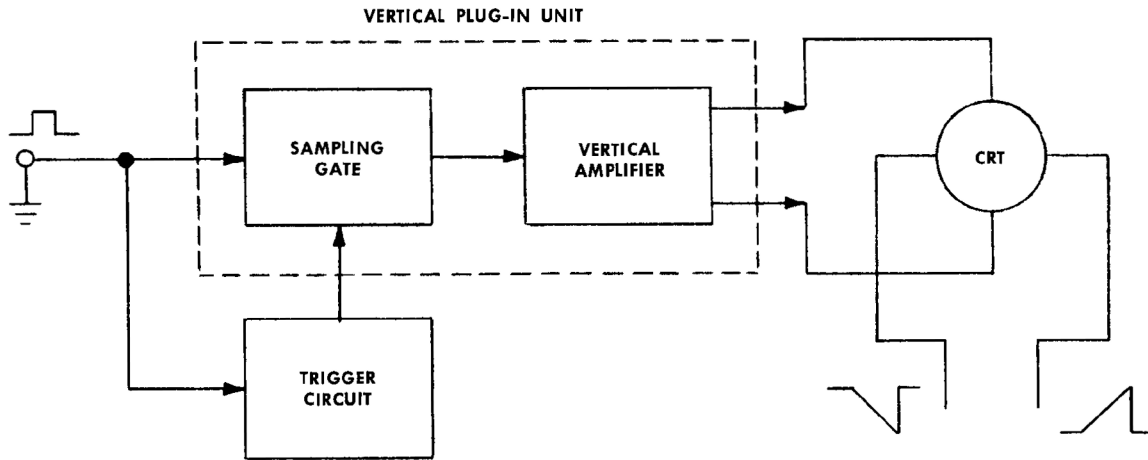


Fig. 4-1. Circuit required for sampling at a fixed point on an input signal.

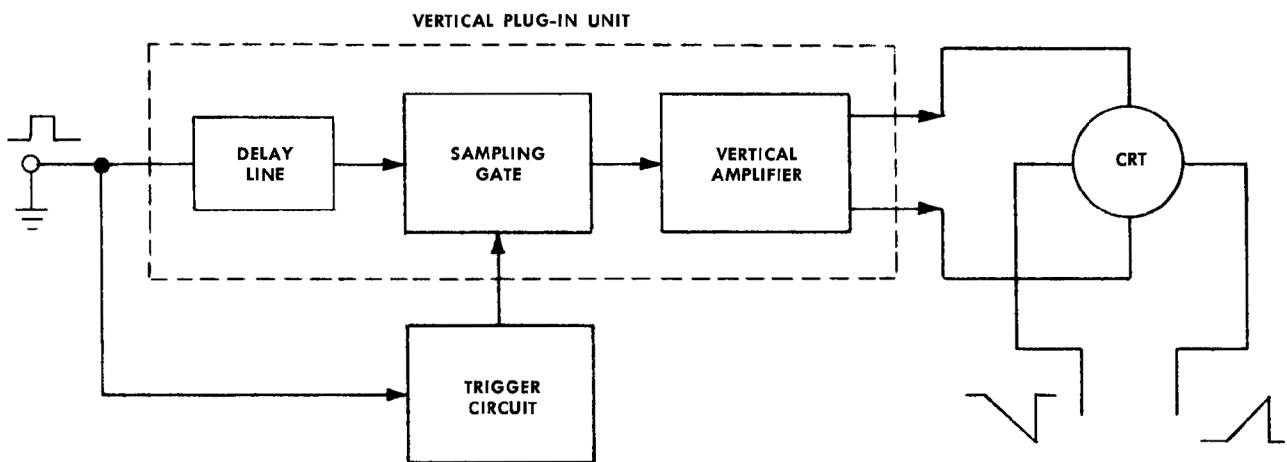


Fig. 4-2. Delay line added to the circuit of Fig. 4-1 so sampling takes place on the leading edge of the input signal.

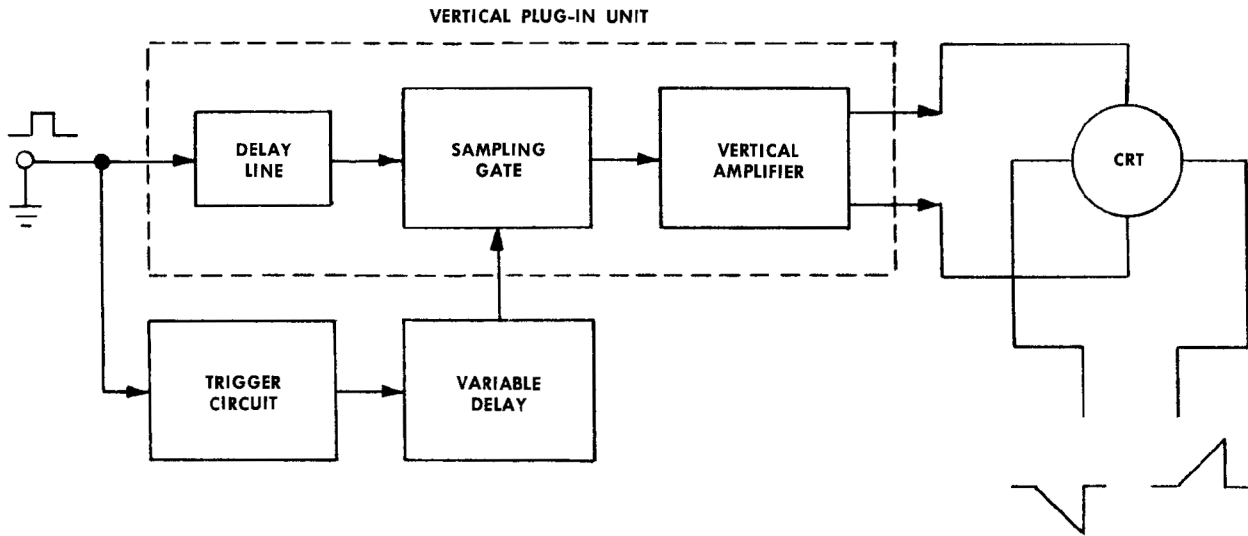


Fig. 4-3. Variable delay circuit added so sampling takes place at various points on the input signal.

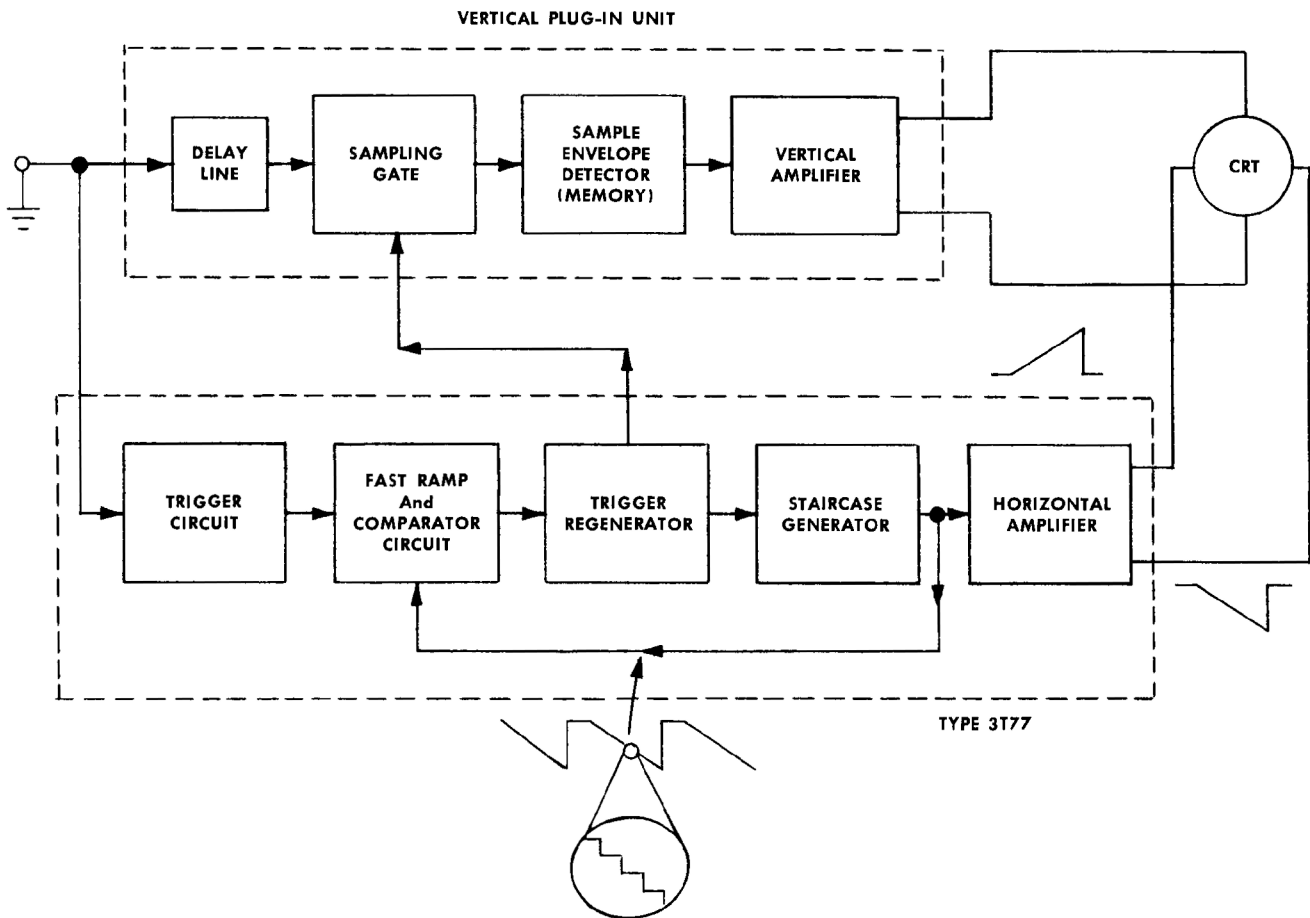


Fig. 4-4. Complete block diagram of the sampling system.

Although the system represented in Fig. 4-2 could sample an incoming signal at one point on its leading edge, it could not sample the signal over its entire duration. Instead, it would consistently sample the same point on the signal each time it was triggered.

In order to sample over the entire duration of the signal, a varying delay must be introduced so the samples can be taken at various points on the signal. This system would resemble Fig. 4-3. The variable delay we introduce must produce fairly long delays (up to 0.1 millisecond) and must continuously vary the amount of delay.

The variable delay circuit used in the Type 3T77 produces an electronic delay by a method called "trigger slewing". The trigger circuit initiates a fast-rising voltage ramp when triggered by the incoming signal. This ramp voltage must fall to the slewing voltage level of the comparator, then a new pulse (slewed trigger) is generated to operate the sampling gate. How long the slewed trigger is delayed depends upon the rate of the fast ramp and the level of the slewing voltage. The slewing voltage, and thus the time delay, is directly proportional to horizontal crt deflection. Horizontal deflection voltage and slewing voltage may be obtained manually but are normally obtained from the Staircase Generator, which automatically increases the voltage after each sample is taken. Thus, the sampling gate will open slightly later and the incoming signal will be sampled at a different point. Fig. 4-4 shows the improved sampling system with the comparator circuit replacing the variable delay block.

In the discussion of a sampling system the terms "real time" and "equivalent time" are often used. To understand the meanings of these terms, consider the following case: If we recreate a repetitive pulse 50 nanoseconds wide by taking 50 samples (one sample per incoming pulse) the real time between successive samples depends on the repetition rate of the signal. However, by using 50 samples to reconstruct a waveform display, we are, in effect, pretending that all of the samples were taken from a single input pulse. If this were true, the time between samples in the example would be one nanosecond (50 samples along a 50-nano-

second pulse). This is the equivalent time between samples and a 10-division display would have an equivalent rate of 5 nanoseconds per division. Fig. 4-5 illustrates the relationship between real time, equivalent time, and an input signal.

CIRCUIT ANALYSIS

The basic operation of the sampling system is covered previously in this section. This portion of the circuit description contains a detailed discussion of each of the major circuits of the Type 3T77. Refer to the schematics at the rear of the manual as you read through this discussion.

Tunnel Diodes

Since tunnel diodes are used in several circuits of the Type 3T77, their basic operation is discussed here, rather than under the operation of a specific circuit.

Tunnel diodes have low inductance and capacitance, and therefore make good switching devices. Fig. 4-6 shows the voltage-current characteristics of a typical 20-ma tunnel diode. Notice that as the current is increased from zero to the 20-ma point, the terminal voltage increases slowly to about 75 millivolts (the "low-voltage" state). Then suddenly, a further increase in current causes an abrupt switch in terminal voltage to about 500 millivolts (the "high-voltage" state). The current must then be reduced to about 2 ma to switch the tunnel diode from the "high-voltage" state back to the "low-voltage" state.

Trigger and Holdoff Circuit

When the Type 3T77 is waiting to be triggered, tunnel diodes D22 and D42 are in the "low-voltage" state and D25 is in its "high-voltage" state. With D22 in its low state, there is about +50 millivolts on the base of Q24 not enough to turn it on. Q34 and Q44 are also off.

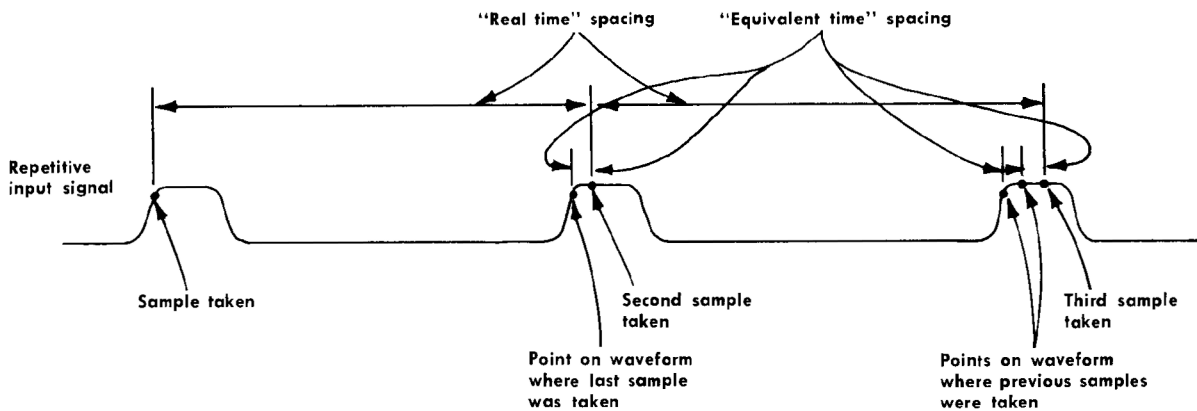


Fig. 4-5. Relationship between real time, equivalent time, and the input signal.

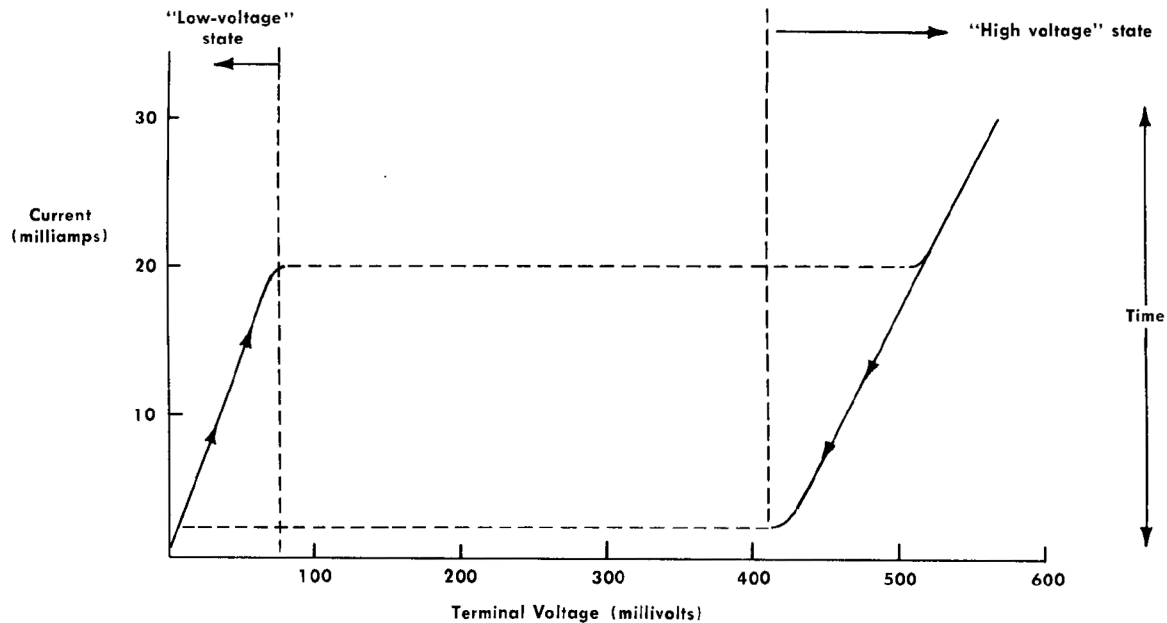


Fig. 4-6. Voltage-current characteristics of a typical 20-ma tunnel diode.

Triggering is initiated by bringing D22 from its low state to its high state. Therefore, a positive-going signal is required from the collector of Q14 to produce a trigger. The size of the positive signal required to switch D22 to its high state is determined by the setting of SENSITIVITY control R19, and TRIG. SENS. RANGE adjustment R21.

A portion of the input signal from the vertical plug-in unit is coupled to Q14 for internal triggering via pin 3 of the interconnecting plug. T5 provides trigger slope selection. Q14 is a grounded-base (non-inverting) amplifier with a current gain of nearly 1.

A portion of the Q14 collector current passes through D22. When the collector current of Q14 passes a certain value set by the SENSITIVITY control, D22 switches to its high state of about +500 millivolts. This positive switching pulse from D22 passes through R40 and C40 to D42 and switches D42 from its low state to its high state. The switching pulse of D42 drives the Fast Ramp circuit.

The positive switching pulse from D22 also passes to the base of Q24 and turns it on, and the collector voltage of Q24 drops toward ground. As a result, D27 turns on and the increased drop across R26 reduces the current through D25 and switches it to its low state. Also, current through D28 increases the voltage drop across R22 and causes D22 to return to its low state. D22 is then held in its low state as long as D25 remains in its low state. Therefore, D25 serves as a trigger holdoff because D22 cannot be triggered until D25 changes states. Q34 and Q44 and associated circuitry hold D25 in its low state for a period determined by the time constant of C30, C31, R31, and RECOVERY TIME control R30. The holdoff time is considerably greater than the amount of equivalent time displayed on the crt. In the fast sweep rates it is greater than 10 microseconds and increases to about 300 microseconds at the slowest sweep rate.

Q24 turns off almost immediately after it is turned on. However, during the time it is turned on, C30 and C31 discharge. Then, when Q24 turns off, C30 and C31 must charge through R30, R31, and Q34. This charging current turns Q34 on and Q34 supplies current to hold D22 and D25 in their low state. Current through Q34 also discharges C34. Charging current through C30 stops when D31 becomes forward biased. This allows Q34 to turn off and Q44 to turn on from the charging of C34 through R34 and the base of Q44. At the same time, Q34 turns off and allows current from R21 and R22 to pass through D22. However, D22 still cannot be triggered since D25 is still in its low state. The current through Q44 holds D25 in its low state until C34 completes its charge. At this point, Q44 will turn off and allow more current to pass through D25 and switch it to its high state. D22 can then be triggered again.

With R19 set to maximum resistance (fully clockwise) the circuit free-runs. In this case, D22 switches to its high state each time D25 switches to its high state following the holdoff period.

Fast Ramp

This circuit generates a fast-ramp waveform, compares it with an existing slow-ramp voltage from the Staircase Generator, and produces a positive-polarity slewed pulse. The fast-ramp waveform is developed across Ramp Slope Capacitor C88. Comparison with the slow-ramp waveform takes place at Q93. The slewed pulse is generated at D93 and appears, inverted and amplified, at the collector of Q94. The positive trigger from the Trigger and Holdoff circuit initiates the action of the Fast Ramp circuit. It is coupled through Q74 whose collector current switches D74 from its quiescent high state to its low state. The resulting fast positive step turns Q84 off. Current from constant-

current tube V61 is now diverted into the Ramp Slope Capacitor. Charging of this capacitor carries the emitter of Q93 negative.

The Staircase Generator and the DELAY control set the output voltage level of the Slow Ramp Inverter, which, in turn, sets the voltage on the base of Q93. (Slow Ramp is another name for the staircase waveform.)

When the fast ramp starts, the base of Q93 is negative with respect to its emitter, so Q93 is not conducting. It remains cut off until the fast-ramp voltage at the emitter falls below the base voltage of Q93. Q93 then turns on, passing current through D93 which is quiescently in its low state.

When this happens, D93 switches to its high state, developing a negative step. This negative output is stepped up through T95 and is applied to the base of Q94. The resulting positive step at the collector of Q94 is the slewed pulse. It is differentiated through C97 and applied through pin 18 of the interconnecting plug to the vertical plug-in unit to start the sampling process, and is passed through R99 to the Staircase Generator to advance the staircase one step.

The negative step at the cathode of D93 is also coupled back through D75 to switch D74 to its high state. This turns Q84 on again, ends the fast ramp, and discharges the Ramp Slope Capacitor.

With the load impedance made up basically of R95 and the inductance of T95, D93 is monostable. Therefore, it will automatically reset itself to its low state before the next fast ramp is generated.

The output of the Staircase Generator is applied to the top of R51. At this point, this is about a 50-volt positive-going staircase of 100 or 1000 steps. Thus, each step is either 0.5 or 0.05 volt in amplitude. Q63 and Q64 form an inverting amplifier with 20 k feedback resistance. The gain of this stage, from the input of R53 to the output of R90, ranges from 0.2 to 0.004 depending upon the value of R53 selected by the TIME/DIV. switch. R54 maintains a constant load on R51 and R52. The steps at the Q93 base are negative-going steps of 0.1-volt to 0.2-millivolt amplitude. The smaller the steps, the less the equivalent time between samples, and the faster the equivalent sweep rate.

The CALIB. position of R51 (counterclockwise position of the VARIABLE control) is with the wiper at the top of R51. Thus, as you move the control away from CALIB., you decrease the size of the steps at the base of Q93, decrease the equivalent time between samples, and consequently increase the equivalent rate.

The slope of the fast ramp is changed between ranges by changing the size of the Ramp Slope Capacitor. The steeper the ramp, the less difference there will be in the time required for the ramp to reach successive levels of the staircase at Q93. Thus, the equivalent time per division is controlled by varying both the size of the steps at the base of Q93 and the slope of the fast ramp at the emitter of Q93.

Staircase Generator

This circuit develops either a 0.5-volt per step or 0.05-volt per step positive-going staircase signal of about 50 volts

amplitude and applies it to the Horizontal Amplifier and to the Slow Ramp Inverter circuit. It also develops a sweep gate voltage, a positive gate lasting for the duration of one complete staircase signal.

First, consider the Staircase Generator in its quiescent condition, when no staircase is being generated. Assume the SWEEP MODE switch is in the NORMAL position. Both Q135 and Q145 are off, so Disconnect Diodes D152 and D153 are conducting and the Miller Tube V161 is on. D125 is in its low state.

The positive slewed pulse fires the Miller-Stepping Blocking Oscillator Q110. The collector of Q110 is held constant by C111 and C110, and the base and emitter of Q110 move with current. The resulting negative swing at the emitter momentarily increases current through tunnel diode D125 and switches it to its high state. This turns on Q124. The resulting negative swing at the collector of Q124 passes through C127 and R127 to the base of Q135. Q135 turns on, and the resulting positive swing at its collector turns Q145 on. The negative swing at the collector of Q145 back biases the Disconnect Diodes releasing the Miller-Capacitor C160 so it can be charged. Conduction through Q145 also holds Q135 on through R140, so both transistors remain on during the entire staircase.

At the same time, the negative gating voltage at the collector of Q145 is inverted and amplified by V194A and is applied to the crt unblanking deflection plate to unblank the crt.

The negative-going voltage step at the Miller-Stepping Blocking Oscillator (emitter of Q110) also transfers a charge from Miller-Stepping Capacitors C156 or C158 through D160 to C160. This raises the output level of the Miller Integrator one step. The positive-going trailing edge of the Miller-Stepping Blocking Oscillator then recharges the selected Miller-Stepping Capacitor through D161 and C162 in preparation for the next pulse. The size of the charge, and therefore the size of the steps, is determined by the size of the Miller-Stepping Capacitors and the output voltage swing from the Miller-Stepping Blocking Oscillator.

Each successive slewed pulse causes an identical charge to transfer from the selected Miller-Stepping Capacitor to C160, and thus raise the Miller Integrator output in identical increments. The output of the Miller Integrator, then, is a positive staircase that goes to the Horizontal Amplifier and to the Fast Ramp Generator.

D177 couples the output voltage of the Miller Integrator through V173A to the top of the V161 plate load resistor R172. Thus, as the plate voltage of V161 changes, the voltage at the top of its plate load resistor (R172) changes a like amount and the current through R172 remains constant. The gain of the Miller Integrator approaches the amplification factor of V161, and the circuit operates with very small changes in grid voltage. Cathode follower V173B provides large output current capability. D178 changes the dc level of the Miller output from +75 volts to about zero volts.

The STAIRCASE DC LEVEL adjustment R181 sets the start of the staircase to exactly zero volts.

When the staircase voltage reaches about +50 volts it pulls the base of Q135 positive and turns off both transistors in the Staircase-Gating Multivibrator. This turns on the

Circuit Description — Type 3T77

Disconnect Diodes and discharges C160 which resets the Miller Integrator.

D145 disconnects from the staircase during reset while C145 holds the base of Q135 positive for sufficient time to allow complete recovery of the Miller Integrator.

In the SINGLE DISPLAY position of the SWEEP MODE switch, the cathode of tunnel diode D125 is connected through 3.9 k to -12.2 volts. This provides about 3 ma through the tunnel diode so it may be in either its high state or its low state. Assume that it is in its high state.

This puts about -0.5 volt at the D125 cathode, and Q124 will be turned on. This draws the collector of Q124 to ground and the negative blocking oscillator pulses arriving at its emitter will have no effect. Thus, with D125 in its high state, the Staircase Generator is locked out and cannot be started.

When the reset button is pushed, current to D125 is momentarily interrupted by the positive pulse at the top of R125, and D125 switches to its low state. Once the reset pulse has passed, the current through D125 is again 3 ma, but D125 remains in its low state. This cuts off Q124, and the next pulse from the blocking oscillator Q110 will pass through Q124 to start the staircase runup. The same blocking oscillator pulse will also reset D125 to its high state so the Staircase Generator cannot be started again without a reset pulse. The result is a single staircase.

The +EXT. SWEEP INPUT and MANUAL positions of the SWEEP MODE switch disable the Miller-Stepping Blocking Oscillator by removing collector voltage from Q110. They

also turn off Q135 and Q145, thereby turning on the Disconnect Diodes to prevent the Miller Integrator from running up.

The MANUAL SCAN control supplies voltage to RC filter R304-C304 (Horizontal Amplifier Schematic) for smoothing the scan.

Horizontal Amplifier

With the SWEEP MODE switch set to NORMAL, the staircase passes through R319 to the base of Q334. Q334 and Q333 form a feedback amplifier through R330. The output of this amplifier is coupled either directly, or through a 10X divider, to paraphase amplifier V364-V354, and then through cathode followers V373A-V373B to the crt deflection plates via pins 17 and 21 of the interconnecting plug.

Note the leads at pins 11 and 12 of the interconnecting plug. Normally D327 is conducting 1 ma through R328, and pin 12 of the interconnecting plug is grounded. When the vertical plug-in unit is set for X-Y operation (Vertical Mode switch in A VERT. B. HORIZ. on Type 3S76), pin 11 is switched from -100 volts through 47 k to $+300$ volts through 47 k (in the vertical plug-in unit). This cuts off D327 and drives Q334 into saturation so the staircase signal cannot get through. At the same time, pin 12 is switched from ground to the output of channel B in the vertical plug-in unit. The channel B signal is then applied to the horizontal deflection plates rather than the staircase waveform. Meanwhile, the channel A signal is coupled to the vertical deflection plates. This produces X-Y operation.

SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Visual Inspection

The Type 3T77 Plug-In Unit should occasionally be inspected for such visual defects as poor connections, broken or damaged ceramic strips, improperly seated tubes or transistors, and heat-damaged parts. The remedy for most visual defects is obvious; however, particular care must be taken if heat-damaged parts are detected. Overheating can be caused by other, less apparent troubles in the circuit. For this reason, it is essential to determine the actual cause of overheating before the parts are replaced; otherwise, the damage may be repeated.

Recalibration

The Type 3T77 Plug-In Unit is a stable instrument and will provide many hours of trouble-free operation. To maintain the measurement accuracy of the Type 3T77, however, we suggest a check of the calibration after each 500 hours of operation (or every six months if used intermittently). The calibration procedure also includes steps which will help check for proper operation of various circuits. Minor troubles not apparent during regular operation will often be revealed during calibration. Also, major troubles in the instrument can often be isolated or eliminated by calibrating the instrument. Complete calibration instructions are contained in Section 6 of this manual.

PARTS REMOVAL AND REPLACEMENT

General Information

Removal or replacement procedures for most parts in the Type 3T77 are obvious. However, some parts require special procedures. Removal and replacement of these parts are discussed in the following paragraphs.

Many components in the Type 3T77 are mounted in a particular way to reduce stray inductance and capacitance. Therefore, carefully install replacement components to duplicate lead length, lead dress, and location of the original component.

After replacing any electrical components, be sure to check the calibration of the instrument. Components of the same type usually exhibit slightly different characteristics and will often affect calibration.

Tubes and Transistors

Tubes or transistors should not be replaced unless they are actually defective. If tubes or transistors are removed and found to be acceptable, be sure to return them to their original sockets. This will avoid recalibration because of different tube or transistor characteristics.

The best way to check a tube or transistor is by substitution. That is, replace the tube or transistor that you wish to check with a tube or transistor of the same type and of known good quality. Then, check to see if proper operation is restored. If not, return the original tube or transistor to its socket.

Wafer Switches

Individual wafers are normally not replaced in the switch assemblies used in the Type 3T77. If one wafer is defective, the entire switch assembly should be replaced. Switches can be ordered from Tektronix, either wired or unwired.

The wafer switches shown on the schematics are coded to indicate the position of the wafer on the switch. The wafers are numbered from front to rear (i.e., the number 1 wafer is always closest to the front panel). The letter F and R indicate the front or rear of the wafer. For example, a code designation of 3R would mean the rear side of the third wafer from the front panel.

Soldering Precautions

In the production of Tektronix instruments, a silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by repeated use of ordinary tin-lead solder, and by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary solder is permissible if applied with moderate heat. For general repair work, however, solder used for the ceramic strips should contain about 3% silver. If this type of solder is not available locally, it may be purchased directly from Tektronix in one-pound rolls (part number 251-514).

A wedge-shaped tip on the soldering iron is best for soldering or unsoldering parts on the ceramic strip. This type of tip allows you to apply heat directly to the solder-slot in the strip, reducing the overall heating effect. Use as little heat as possible to establish a good solder bond.

To properly solder and unsolder the short-lead components, the following procedure is recommended. (1) Use long-nose pliers for a heat sink. Attach the pliers between the component and the point where the heat is applied. (2) Use a hot soldering iron for a short time. (3) Carefully manipulate the leads to prevent lead or insulation damage. (4) Use only a small amount of solder; just enough to make a good bond.

Ceramic Terminal Strips

To remove a ceramic terminal strip, first unsolder all leads and components connected to it. Then pry the strip, with yokes attached, out of the chassis. The spacers may come out with the yokes. If not, the spacers can be pulled out separately. However, if they are not damaged, they may be used with the new strip assembly.

Maintenance — Type 3T77

Another way to remove a strip from the chassis is to use diagonal cutters to cut off one side of each yoke holding the strip. This frees the strip and the remainder of the yokes can then be pulled free of the chassis with a pair of pliers. Ceramic strips are supplied with yokes attached so it is not necessary to salvage the old yokes.

After removing a damaged strip and yoke assembly, place the spacers into the holes in the chassis and insert the yokes into the spacers. Be sure the yokes are completely seated in the spacers. If necessary, use a soft-faced mallet to tap the yokes into the spacers. Fig. 5-1 shows the assembled ceramic strip.

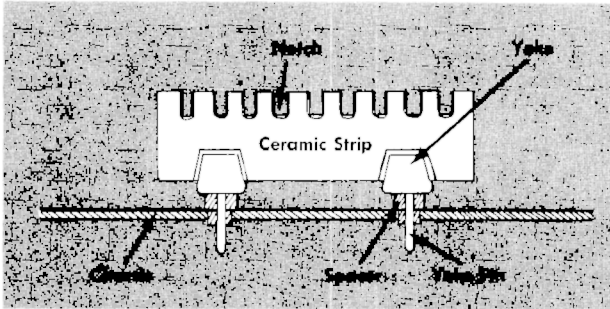


Fig. 5-1. Ceramic strip assembly.

Test Points

The test points shown on the schematics aid in troubleshooting and calibrating the Type 3T77. They simplify reference to particular locations in the circuitry. Each test point is indicated by a bracketed number at its location in the circuit. The test points are numbered consecutively starting with the Trigger and Holdoff circuit. Physical location of the test points on the chassis of the Type 3T77 are shown in Figs. 6-2 and 6-3.

TROUBLESHOOTING

General Information

If trouble develops in the sampling system, first check for proper control settings. A control set to the wrong position can cause trouble symptoms. Improper calibration can also cause faulty operation. By attempting to calibrate the instrument, some troubles can be isolated to a given circuit; if the trouble is due to calibration, the trouble will be corrected.

Unusual troubles can be caused by a failure in one of the oscilloscope power supplies. This should be considered any time the sampling system fails to operate properly. The oscilloscope manual contains information for checking power supply voltages.

If you suspect that a tube or transistor in the instrument is defective, replace it with a good tube or transistor of the same type. Then check to see if the trouble symptom is eliminated. If not, the original tube or transistor is probably good and should be returned to its original socket. This will avoid recalibrating the instrument because of different tube or transistor characteristics.

Tunnel diodes can best be checked by substitution. In some instances, however, a faulty tunnel diode can be detected with a voltmeter. For example, if the voltage across any tunnel diode in the Type 3T77 measures in the range of 100 to 300 millivolts, it is defective and should be replaced. However, a tunnel diode may be faulty and not necessarily have a voltage in the defective range.

Fig. 5-2 demonstrates the polarity of the strip-line tunnel diodes used in the Type 3T77.

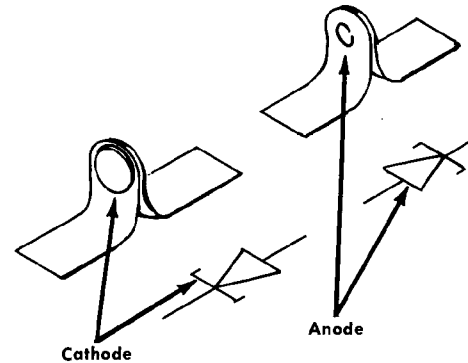


Fig. 5-2. Two views of the strip-line type of tunnel diode used in the Type 3T77.

TROUBLESHOOTING PROCEDURE

The following troubleshooting procedure covers "Plug-In Unit Isolation" and "Circuit Isolation". The first portion (Plug-In Unit Isolation) will help you determine which plug-in unit is faulty, since a failure in either plug-in unit can cause complete loss of the display. The second portion (Table 5-3) covers circuit isolation for the Type 3T77. This table will help you locate a faulty circuit within the Type 3T77.

Equipment Required

The following equipment is recommended for troubleshooting the Type 3T77:

1. Test oscilloscope, having the following minimum specifications:

Deflection Factor (not considering probe attenuation)	0.05 v/cm
Bandpass	dc to 10 megacycles
Sweep Rate (fastest)	5 μ sec/cm

2. Dc volt-ohmmeter, 20,000 ohms/volt sensitivity.

3. Plug-In Extension, Tektronix part number 012-066.

4. Tektronix Type 109, 110, or 111 Fast-rise Pulse Generator. (A 50 Ω 10XT attenuator is required for use with the Type 111.)

Preliminary Setup

Before proceeding with the troubleshooting procedure, perform the following steps:

1. With the Type 3T77 removed from the oscilloscope, check the resistance to ground at both rear interconnecting plugs. See Tables 5-1 and 5-2 for typical resistance readings. The readings in the tables are not absolute and may vary between instruments and with different ohmmeters and ohmmeter scales.

2. Insert the Type 3T77 into the right-hand plug-in compartment of the oscilloscope and the vertical sampling plug-in unit into the left-hand compartment.

3. Preset the front-panel controls of the Type 3T77 as follows:

POSITION	Centered
TIME/DIV.	.1 μ SEC
HORIZ. MAG.	X1
DOTS PER DIV.	100
SWEEP MODE	NORMAL
INT.-EXT.	INT. +

Other controls may be set to any position.

Leave the controls of the Type 3T77 at these settings (unless otherwise noted) throughout this section of the manual.

4. Apply a + signal from the fast-rise pulse generator to the Input connector of the vertical plug-in unit. (For the Type 3S76, apply a + signal to the INPUT A connector and set the INTERNAL TRIGGER switch to A.) Turn on the oscilloscope power and allow about 2 minutes for warmup.

**TABLE 5-1
Typical Resistance To Chassis, P21**

Pin Number	Resistance	Pin Number	Resistance
1	20 k	13	20 k
2	20 k	14	8 - 10 k
3	0	15	8 - 10 k
4	0	16	11 Ω
5	infinite	17	150 k
6	20 k	18	infinite
7	infinite	19	0
8	infinite	20	8 - 10 k
9	0	21	150 k
10	17 k	22	0
11	*50 k & 100 k	23	2.3 k
12	3 k	24	infinite

*Reverse ohmmeter leads to get both resistance values.

**TABLE 5-2
Typical Resistance To Chassis, P22**

Pin Number	Resistance	Pin Number	Resistance
1	infinite	13	6.4 k
2	infinite	14	infinite
3	infinite	15	infinite
4	infinite	16	infinite
5	infinite	17	infinite
6	infinite	18	infinite
7	infinite	19	infinite
8	infinite	20	11 k
9	infinite	21	2 k
10	infinite	22	infinite
11	infinite	23	infinite
12	infinite	24	infinite

Plug-In Unit Isolation

If trouble in the sampling system makes it impossible to obtain a display on the crt, the following steps will help you determine which plug-in unit is faulty.

1. Turn the Type 3T77 TRIGGER SENSITIVITY control fully clockwise and (with the test oscilloscope) check the signal at test point [8] in the Type 3T77. The waveform on the test oscilloscope should resemble that shown on the schematic (Staircase Generator). If there is no waveform at test point [8], the Type 3T77 is faulty.

2. With the test oscilloscope, check the signals at test points [23] and [24]. The waveforms should resemble those shown on the Horizontal Amplifier schematic. If the waveforms are not proper, the trouble is in the Type 3T77. If the waveforms at test points [23] and [24] are proper, the trouble is in the vertical sampling plug-in unit.

3. Apply a signal to the Input connector of the vertical sampling plug-in unit. Set the necessary controls to trigger the Type 3T77 from the applied signal.

4. Connect the input of the test oscilloscope to the Type 3T77 TRIG. OUT. connector. Starting from the extreme counterclockwise position, slowly turn the Type 3T77 TRIGGER SENSITIVITY control until a waveform first appears at the TRIG. OUT. connector.

5. Remove the signal from the input of the vertical unit; the signal at the TRIG. OUT. connector should disappear. If not, the internal triggering signal is not triggering the Type 3T77. The fault is either in the trigger take-off circuitry of the vertical plug-in unit, or in the coupling between the trigger takeoff circuitry and the Type 3T77. If the signal at the TRIG. OUT. connector is present regardless of the setting of the TRIGGER SENSITIVITY control, the trouble is in the Type 3T77.

TABLE 5-3
CIRCUIT ISOLATION

Check	If Normal	If Abnormal
1. Connect the test oscilloscope to test point [1]. Turn the TRIGGER SENSITIVITY control clockwise from midrange. A waveform should appear on the test oscilloscope. Then turn the control counterclockwise; the waveform should disappear before the control reaches midrange.	Go to step 2.	R21 (TRIG. SENS. RANGE) is out of adjustment, or the trouble is in the Trigger Holdoff circuit. If there is a signal at test point [1] at any setting of the TRIGGER SENSITIVITY control, check R14, R16, R19, L14, and Q14. If there is no signal at test point [1], check D22, D25, D26, D27, D28, D31, D34, Q14, Q24, Q34, and Q44.
2. Apply a trigger signal to the EXT. INPUT connector. Set the TRIGGER SENSITIVITY control fully counterclockwise and the INT.-EXT. switch to +EXT. Check for the trigger signal (amplified) at test point [1].	Go to step 3.	Trigger signal is not reaching D22. Check the trigger input circuitry and Q14.
3. Connect the test oscilloscope to test point [2]. Turn the TRIGGER SENSITIVITY control back and forth. A waveform should appear and disappear as in step 1.	Go to step 4.	R44 (2ND. TRIG. REGEN. SENS.) out of adjustment. D42 faulty.
4. Set the TRIGGER SENSITIVITY control fully clockwise. Connect the test oscilloscope to test point [6] and check for the proper signal. Leave the TRIGGER SENSITIVITY control fully clockwise for the remainder of the procedure.	Go to step 14.	If there is a signal at test point [6] but it is not modulated with the sawtooth waveform, the trouble is in the Staircase Generator or Slow-Ramp Inverter circuit; go to step 5. If there is no signal at test point [6], measure the drop across R83 with a dc voltmeter; it should be one volt. If not, the trouble is in the V61 circuitry. (Note: The heaters of V161 and V61 are in series.) If one volt is measured across R83, the trouble is probably Q74, D74, D75, Q84, Q93, or D93.
5. Set the SWEEP MODE switch to MANUAL and vary the MANUAL SCAN control while observing the signal at test point [6]. The signal amplitude should vary as the MANUAL SCAN control is turned.	Trouble is in Staircase Generator circuit or Q94. Check for signal at test point [8]. No signal indicates faulty operation of Q94. A signal at test point [8] indicates the trouble is in the Staircase Generator circuit. Go to step 6 to troubleshoot the Staircase Generator circuit.	Trouble is in the Slow-Ramp Inverter (Q63 and Q64) circuit.
6. Check for proper signal at test point [9].	Go to step 7.	Check D105 and D110.
7. Check for proper signal at test point [10].	Go to step 8.	Miller-Stepping Blocking Oscillator is not operating; check Q110, D114, etc.
8. Check for proper signal at test point [12].	Go to step 9.	Trouble is in Staircase Start-Pulse Shaper circuit; check Q124 and D125.
9. Check for proper signal at test point [16].	Go to step 10.	Trouble is in SW157 (DOTS PER DIV.) or Charging Diodes D160, D161, or D162.
10. Remove Q135 from its socket. The dc voltage at test point [14] should be about -0.8 volt.	Go to step 11.	Check Q145.

TABLE 5-3 (Cont'd)

Check	If Normal	If Abnormal
11. With Q135 removed, the voltage at test point [15] should be about -1.5 volts.	Go to step 12.	Trouble is in Miller Integrator or Disconnect Diodes; check D145, D153, V161, and V173. Also check for a 75-volt drop across D177 and D178.
12. At the socket of Q135, short the collector connection to ground. The voltage at test point [14] should be about -20 volts.	Go to step 13.	Check Q145.
13. With the collector connection of Q135 still shorted to ground, the voltage at test point [15] should be about $+160$ volts. Remove short at Q135 socket and replace Q135.	Q135 is probably defective if steps 5 through 12 have been completed and no other trouble has been detected.	Trouble is in Miller Integrator or Disconnect Diodes; check D145, D153, V161, and V173. Also, check for a 75-volt drop across D177 and D178.
14. Check for a blanking signal at test point [17].	Go to step 15.	Trouble is in V194A circuitry.
15. Check for a sawtooth waveform at test point [18].	Go to step 16.	SWEEP MODE switch is probably not passing the signal. Check continuity of SWEEP MODE switch.
16. Check for a sawtooth waveform at test point [19].	Go to step 17.	Check the voltage across D327; it should measure about -0.6 volt. If not, D327 is faulty or there is a trouble in the vertical plug-in unit. If voltage across D327 is proper, the trouble is in the Q333/Q334 stage.
17. Check for a sawtooth waveform at test point [20]. Set the HORIZ. MAG. switch first to X1, then to X10. Waveform amplitude should be 10 times greater in X10 position.	Go to step 18.	Trouble is in Q333/Q334 circuitry or HORIZ. MAG. switch.
18. Set SWEEP MODE switch to MANUAL. Turn the MANUAL SCAN control through its full range. The dc voltage change between test points [21] and [22] should vary at least 200 volts around an average dc level determined by the setting of the POSITION control. Also, with the POSITION control set at midrange, the voltage should be variable through zero.	Go to step 19.	Trouble is in V354/V364 stage or R341 (MAG. REGIS.) is out of adjustment.
19. Turn the MANUAL SCAN control throughout its range. The dc voltage change between test points [23] and [24] should vary the same as in step 18.	Troubleshooting is complete.	Trouble is in V373 stage.

Calibration — Type 3T77

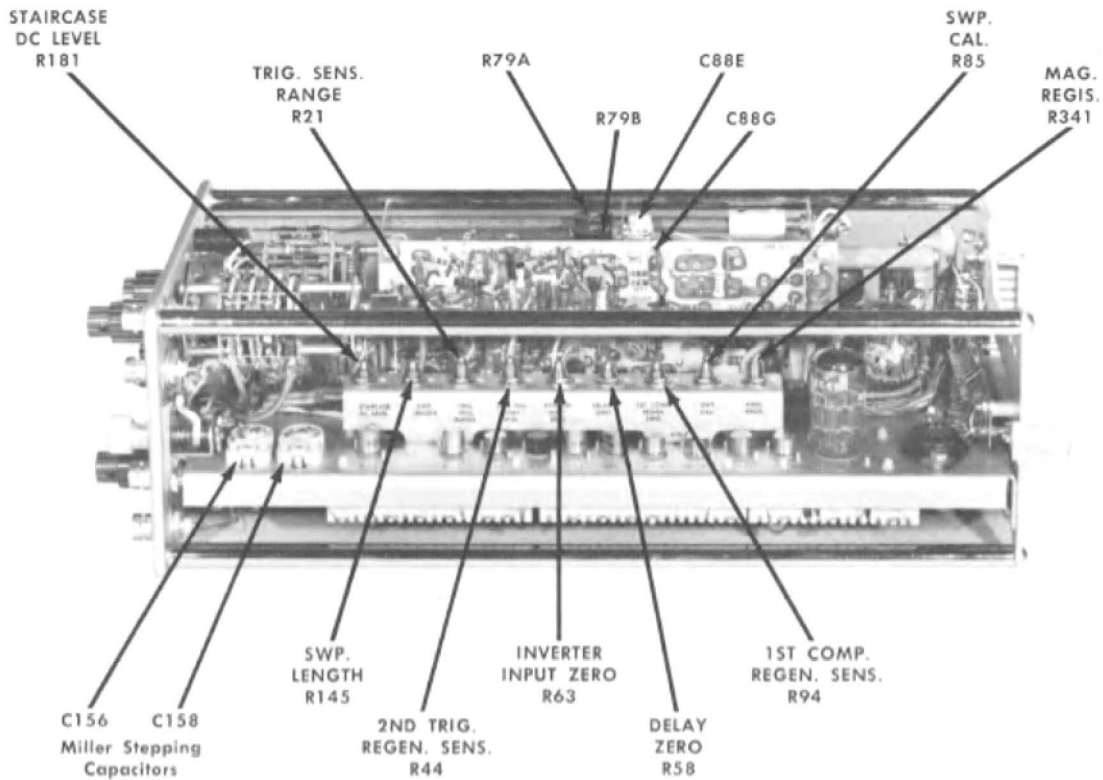


Fig. 6-1. Bottom view of Type 3T77 showing internal adjustments.

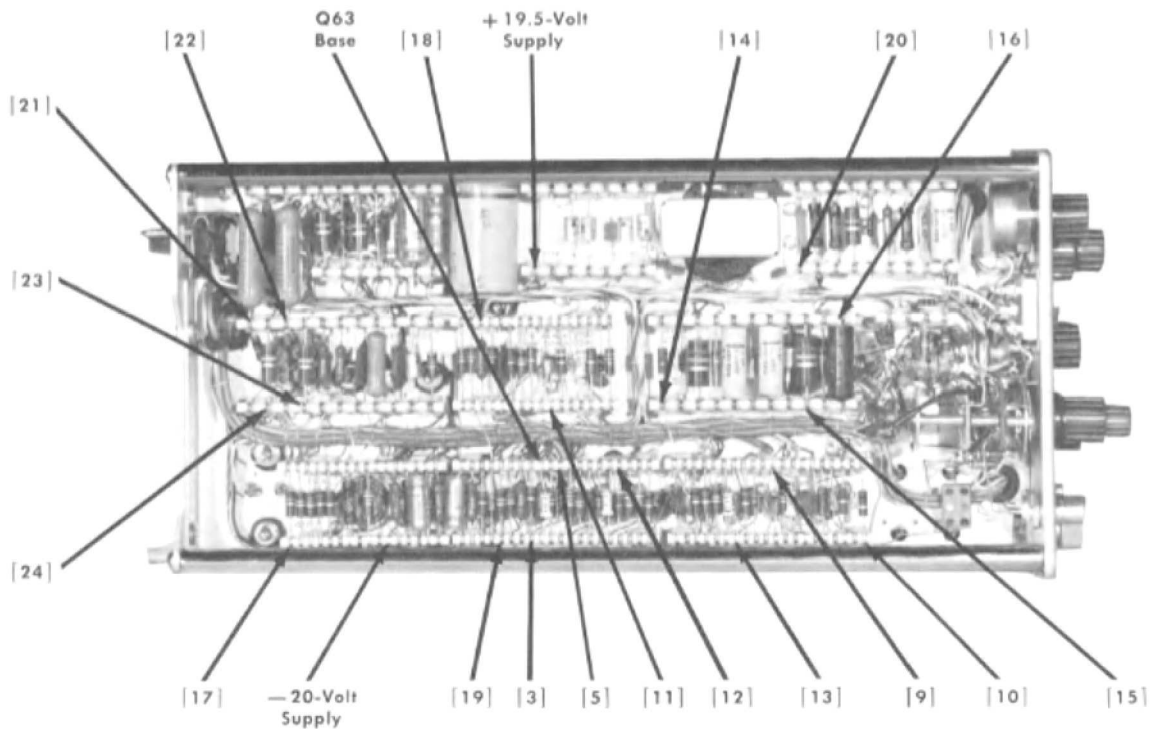


Fig. 6-2. Left-side view of Type 3T77 showing test points.

SECTION 6

CALIBRATION

Introduction

This section of the manual contains a complete calibration procedure for the Type 3T77 Sampling Sweep Plug-In Unit. In addition to setting up the calibration, this procedure may also help in troubleshooting the instrument. For example, if trouble exists, the faulty circuit may be isolated by calibration.

The Type 3T77 is a stable instrument and will not require frequent calibration. However, we recommend a check of the calibration after each 500 hours of operation (or every six months if used intermittently). Also, the calibration should be checked whenever components are replaced.

In addition to making internal adjustments, this procedure contains various circuit operation checks. These checks insure that the Type 3T77 is performing functions that may or may not be apparent during regular use of the instrument. If desired, you may neglect these checks as they are not necessary for proper calibration.

Each adjustment or circuit check in this section appears in the proper sequence for a complete calibration. The steps are arranged to avoid unnecessary repetition of checks or adjustments.

Figs. 6-1, 6-2, and 6-3 show the location of the internal adjustments and test points.

Equipment Required

The following equipment is required for a complete calibration of the Type 3T77.

1. Tektronix Type 561, 561A, RM561, RM561A, 567, or RM567 Oscilloscope. It is best to use the oscilloscope normally used with the Type 3T77.

2. Vertical sampling plug-in unit such as the Tektronix Type 3S3 or Type 3S76. If a Type 3S3 is used, provision must be made for externally triggering the Type 3T77 with a pre-trigger pulse. A Tektronix Type 113 delay cable and a VP-2 voltage pickoff is recommended for deriving the pre-trigger pulse.

3. Test oscilloscope; Tektronix Type 530/540-Series Oscilloscope with a Type L Plug-In Unit and a 1X and 10X attenuator probe. An equivalent instrument must have the following specifications.

Bandpass: Dc to at least 10 mc.

Deflection Factor: 5 mv/cm (including probe attenuation).

Sweep Rate (fastest): 0.1 μ sec/cm.

4. Tektronix Type 180A Time-Mark Generator. An equivalent instrument must have the following specifications.

Time-Mark Outputs: 1, 5, and 10 μ sec.

Sine-Wave Outputs: 5, 10, and 50 mc.

Timing Accuracy: At least 1%.

Output Amplitude: 40 mv (or more), peak, into a 50-ohm load.

5. Tektronix Type 109 or 110 Pulse Generator.

6. Tektronix 1, 2, 5, and 10 nsec/cycle Timing Standard (Tektronix part number 013-028).

7. An autotransformer with a variable output voltage between 105 and 125 volts (or between 210 and 250 volts if the oscilloscope in item 1 is wired for 234-volt operation). Minimum wattage rating: 180 watts.

8. 50-ohm 10XT attenuator with GR connectors (Tektronix part number 017-044).

9. A General Radio "T" connector (GR 874-T)

10. Type 561 Plug-In Unit Extension (Tektronix part number 012-066)*.

11. Dc voltmeter 20,000 ohms/volt, accuracy at least 1%.

PRELIMINARY PROCEDURE

Insert the vertical sampling plug-in unit into the left-hand opening of the oscilloscope and the Type 3T77 (with plug-in extension) into the right-hand opening. Connect the autotransformer to the oscilloscope, turn on the power, and allow at least a 5-minute warmup before proceeding. Set the output voltage of the autotransformer to the nominal operating voltage of the oscilloscope.

Set the Type 3T77 front-panel controls as follows:

POSITION	Midrange
TIME/DIV.	10 nSEC
VARIABLE	CALIB.
HORIZ. MAG.	X1
DOTS PER DIV.	10
DELAY	Fully counterclockwise
TRIGGER SENSITIVITY	Fully clockwise
SWEEP MODE	NORMAL
GAIN ADJ.	Fully clockwise

Set the vertical sampling plug-in unit front-panel controls as follows:

Vertical Mode Switch	A ONLY
A POSITION	Midrange
A MV/DIV.	200
A 2-200 VAR.	CALIB.
A NORM.-INV.	NORM.
A DC OFFSET	Midrange
INTERNAL TRIGGER	A
SMOOTH-NORMAL	NORMAL

Other controls may be set to any position.

* A Type 561 Plug-In Unit Extension, Tektronix part number 013-034, may be used if it is modified as follows: (1) Remove the connections from pins 3, 4, 18, and 19 at both ends of the extension. (2) Connect a twisted pair of #27 AWG magnet wires from pins 3 and 4 on one end of the extension to the corresponding pins on the opposite end. Use magnet wire insulated with a heavy enamel or varnish coating. (3) Connect a length of 50-ohm coaxial cable from pins 18 and 19 to the corresponding pins on the opposite end of the extension. (4) Connect the center conductor of the coaxial cable to pin 18 at both ends, and the shield to pin 19 at both ends.

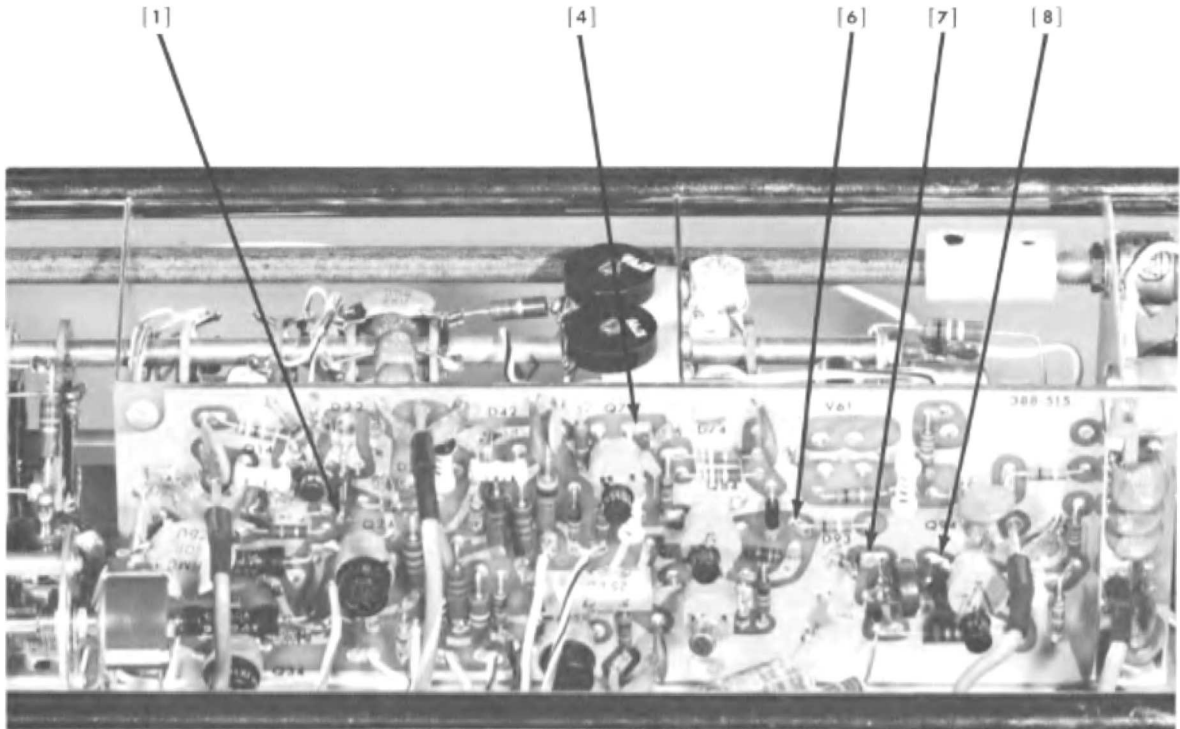


Fig. 6-3. Test point locations on printed circuit board.

If you suspect that the Type 3T77 is extremely misadjusted, turn the 2ND TRIG. REGEN. SENS. and 1ST COMP. REGEN. SENS. controls fully clockwise, and all other internal adjustments to midrange. For routine calibration of the Type 3T77, the internal adjustments are probably near their calibrated positions and should not require preadjustment.

Check and Adjustment Procedure

In the following procedure, all references to "test oscilloscope" will mean the oscilloscope described in item 3 under "Equipment Required". All references to "oscilloscope" will mean the oscilloscope described in item 1 under "Equipment Required".

Trigger Sensitivity Range

1. Connect the test oscilloscope to test point [1] (see Fig. 6-3). The waveform shown at test point [1] on the schematic should appear with the test oscilloscope set at the sweep rate and deflection factor (including probe) indicated.
2. Turn the TRIG. SENS. RANGE control fully counterclockwise.
3. Slowly turn the TRIG. SENS. RANGE control clockwise just to the point where the second small step on the leading edge of the waveform appears.
4. Turn the front-panel TRIGGER SENSITIVITY control counterclockwise through its midrange point to insure that the waveform at test point [1] disappears.
5. Turn the TRIGGER SENSITIVITY control fully clockwise and note the repetition rate of the signal. This will be referred to under "Trigger Regenerator Sensitivity".

D25 CURRENT RANGE (S/N 2000 and higher only)

1. With the test oscilloscope connected to test point [1] and the TRIGGER SENSITIVITY control fully clockwise, pull out the PULL FOR SYNC knob on the RECOVERY TIME control.
2. Turn R24 (D25 CURRENT RANGE) clockwise just to the point where the signal appears at test point [1].
3. Back off R24 to about 10° past the point where the signal disappears. This is the proper setting of R24.
4. Disconnect the test oscilloscope from test point [1] and push in the PULL FOR SYNC knob.

Trigger Regenerator Sensitivity

1. Connect the test oscilloscope to the TRIG. OUT. connector.
2. Set the test oscilloscope for a sweep rate of 5 μ sec/cm and a deflection factor (including probe) of 0.05 volt/cm.
3. Slowly turn the 2ND TRIG. REGEN. SENS. adjustment counterclockwise from its extreme clockwise position while observing the following four conditions on the test oscilloscope:
 - (a) No signal.
 - (b) Signal first appears at half the repetition rate of the signal obtained previously in the Trigger Sensitivity Range procedure.
 - (c) Signal increases in repetition rate up to the same frequency as the signal obtained in the Trigger Sensitivity

Range procedure. At this point, note the position of the 2ND TRIG. REGEN. SENS. shaft.

(d) Signal free-runs. Again note the position of the shaft. Position the 2ND TRIG. REGEN. SENS. control midway between conditions (c) and (d) (a few degrees clockwise from the free-running condition).

Power Supply Ripple and Regulation

1. With the dc voltmeter, measure the voltages of the +19.5- and -20-volt power supplies (see Fig. 6-2).
2. Vary the oscilloscope line voltage between 105 and 125 volts (210 to 250 volts if the oscilloscope is wired for 234-volt operation). Both supplies must stay within 3% of their nominal values.
3. Set the TRIGGER SENSITIVITY control fully counterclockwise.
4. Connect the test oscilloscope to each of the two supplies and measure the peak-to-peak ripple voltage. (Note: The input of the test oscilloscope must be ac-coupled at a deflection factor of 5 mv/cm, including probe.)
5. Vary the oscilloscope line voltage as described in step 2 and check the ripple. Maximum ripple is 2 millivolts, peak-to-peak.
6. Return the line to the nominal operating voltage and set the TRIGGER SENSITIVITY control fully clockwise before going to the next step.

Magnifier Registration

1. With a trace displayed on the crt, set the HORIZ. MAG. switch to X10 and the POSITION control so the first dot of the trace is aligned with the centerline of the graticule.
2. Return the HORIZ. MAG. switch to X1 and adjust the MAG. REGIS. control to return the start of the trace to the graticule centerline.
3. Repeat steps 1 and 2 several times, until there is no horizontal shift in the start of the trace as the HORIZ. MAG. switch is moved from X1 to X10. Then, set the HORIZ. MAG. switch to X1.

Gain

1. Set the vertical plug-in unit channel A positioning controls for a display on the crt.
2. Set the Type 3T77 front-panel controls as follows:

POSITION	Midrange
TIME/DIV.	10 nSEC
VARIABLE	CALIB.
HORIZ. MAG.	X10
DOTS PER DIV.	100
DELAY	Fully counterclockwise
TRIGGER SENSITIVITY	Fully clockwise
SWEEP MODE	+EXT. SWEEP INPUT
MANUAL SCAN OR EXT. ATTEN.	Fully counterclockwise
INT.-EXT.	+INT.

Other controls may be set to any position.

3. From the Amplitude Calibrator of the test oscilloscope, apply a 10-volt signal to the Type 3T77 +EXT. SWEEP INPUT connector. Connect the test oscilloscope to test

point [18]. Set the deflection factor of the test oscilloscope to 2 volts/cm (including probe).

4. Set the EXT. ATTEN. control for exactly 5 volts on the test oscilloscope. Bring the display (two dots) into the viewing area of the graticule with the Type 3T77 POSITION control.
5. Adjust the Type 3T77 GAIN ADJ. control for a horizontal display of exactly 10 major graticule divisions.
6. Set the Type 3T77 HORIZ. MAG. switch to X1 and increase the voltage from the test oscilloscope Amplitude Calibrator to 100 volts.
7. Set the EXT. ATTEN. control for exactly 50 volts on the test oscilloscope. Check for a horizontal deflection of 10 major graticule divisions.
8. Remove the Amplitude Calibrator signal from the Type 3T77.

Staircase Generator DC Level

1. Set the Type 3T77 SWEEP MODE switch to +EXT. SWEEP INPUT and the EXT. ATTEN. control fully counterclockwise.
2. Position the displayed dot to a point on one of the graticule lines. Use this point as a reference.
3. Set the SWEEP MODE switch to NORMAL and adjust STAIRCASE DC LEVEL control so the displayed trace starts at the reference point.

Sweep Length

1. Make sure the 1ST COMP. REGEN. SENS. control is set fully clockwise.
2. With the Type 3T77 POSITION control, move the display so the trace starts at the first graticule line.
3. Adjust the SWP. LENGTH control for a trace length of about 10.5 major graticule divisions.

Inverter Amplifier Input Zero

1. Set the SWEEP MODE switch to +EXT. SWEEP INPUT.
2. Connect the dc voltmeter to the center stud of the DELAY ZERO control and adjust the control for zero volts on the meter.
3. Connect the voltmeter to the base of Q63 (Fig. 6-2) and adjust the INVERTER INPUT ZERO control for zero volts on the meter.

Timing

1. Set the Type 3T77 front-panel controls as follows:

POSITION	Midrange
TIME/DIV.	5 μSEC
VARIABLE	CALIB.
HORIZ. MAG.	X1
DOTS PER DIV.	100
DELAY	Fully counterclockwise
TRIGGER SENSITIVITY	Fully clockwise
SWEEP MODE	NORMAL
MANUAL SCAN OR EXT. ATTEN.	Midrange
INT.-EXT.	+INT.
RECOVERY TIME	Midrange

Calibration — Type 3T77

2. Set the vertical unit front-panel controls as follows:

Vertical Mode Switch	A ONLY
A POSITION	Position for a display
A DC OFFSET	Position for a display
A MV/DIV.	200
A 2-200 VAR.	CALIB.
A NORM.-INV.	NORM.
INTERNAL TRIGGER	A
SMOOTH-NORMAL	NORMAL

3. From the time-mark generator, apply 5- μ sec time markers to the vertical plug-in unit channel A input.

4. Set the TRIGGER SENSITIVITY control for a stable display.

5. Adjust the SWP. CAL. control for exactly 1 time mark per division on the crt. Use the Type 3T77 POSITION control to align the time marks with the graticule divisions. (Note: If the display is nonlinear and the SWP. CAL. control cannot be properly adjusted, the DELAY ZERO control may require slight adjustment.)

6. Set the TIME/DIV. switch to 1 μ SEC and apply 1- μ sec time markers from the time-mark generator to the vertical unit channel A input.

7. Set the TRIGGER SENSITIVITY control for a stable display of the time markers.

8. Adjust R79A (Fig. 6-1) for exactly one time mark per division. Use the Type 3T77 POSITION control to align the time marks with the graticule divisions. (Note: If the display is nonlinear and R79A cannot be properly adjusted, the DELAY ZERO control may require slight adjustment.)

9. Set the TIME/DIV. switch to .1 μ SEC and apply a 10-mc signal from the time-mark generator to the vertical plug-in unit channel A input. The signal from the time-mark generator may require attenuation.

10. Set the TRIGGER SENSITIVITY control for a stable sine-wave display.

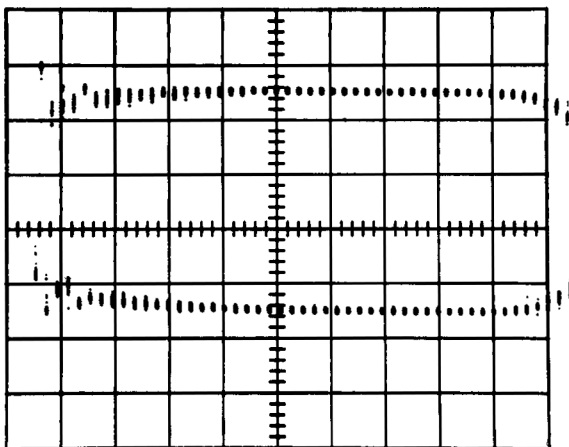


Fig. 6-4. Typical display with C156 properly adjusted.

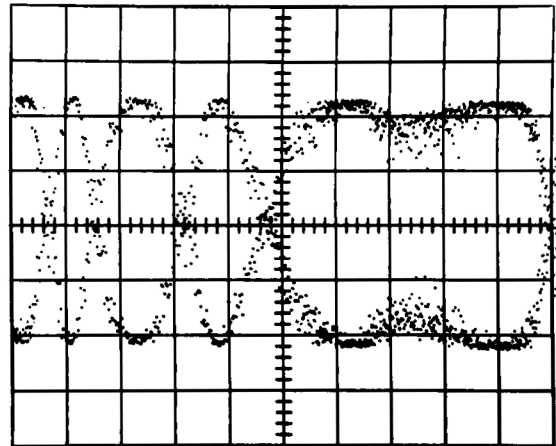


Fig. 6-5. Typical display with C158 properly adjusted.

11. Adjust R79B (Fig. 6-1) for exactly one cycle per division. Leave the TIME/DIV. switch at .1 μ SEC for the next step.

12. Set the DOTS PER DIV. switch to 10 and apply a 50-mc sine wave from the time-mark generator to the vertical plug-in unit channel A input.

13. Set the TRIGGER SENSITIVITY control for a stable display on the crt. Adjust C156 (Fig. 6-1) for two parallel lines of dots on the crt (see Fig. 6-4).

14. Set the DOTS PER DIV. switch to 100 and the TIME/DIV. switch to 1 μ SEC.

15. Adjust C158 (Fig. 6-1) for two lines of dots. (Note: This step is quite critical and will require careful adjustment of C158.) Fig. 6-5 shows a typical display when C158 is properly adjusted.

The following chart provides a timing check of the positions set on the TIME/DIV. switch thus far. In each case, set the TRIGGER SENSITIVITY control for a stable display.

Time-Mark Generator Signal	TIME/DIV.	Display
10- μ sec markers	10 μ SEC	1 mark/div.
5- μ sec markers	5 μ SEC	1 mark/div.
1- μ sec markers	2 μ SEC	2 marks/div.
1- μ sec markers	1 μ SEC	1 mark/div.
1- μ sec markers	.5 μ SEC	1 mark/2 div.
5-mc sine wave	.2 μ SEC	1 cycle/div.
10-mc sine wave	.1 μ SEC	1 cycle/div.
10-mc sine wave	50 nSEC	1 cycle/2 div.
50-mc sine wave	20 nSEC	1 cycle/div.

16. To check the VARIABLE TIME/DIV. control, set the TIME/DIV. switch to 1 μ SEC.

17. Apply 1- μ sec markers to the vertical plug-in unit channel A input and set the TRIGGER SENSITIVITY control for a stable display of 1 mark/division.

18. Turn the Type 3T77 VARIABLE control fully clockwise; there should be at least 2.5 divisions between each mark.

Also, check that the UNCAL. lamp is on at all times except when the VARIABLE control is in the CALIB. position.

19. Turn the VARIABLE control to CALIB.

The final two timing adjustments require the use of the pulse generator and timing standard described in items 5 and 6 under "Equipment Required".

20. Set the pulse generator for maximum output amplitude (the timing standard must be driven with at least a 35-volt, peak, pulse).

21. Connect between the output of the pulse generator and one of the connectors of the timing standard.

22. From the opposite connector of the timing standard, connect to the vertical plug-in channel A input. Set the timing standard for 2 nsec/cycle.

23. Set the vertical plug-in unit for 100 mv/div.

24. Set the TIME/DIV. switch to 2 nSEC and set the TRIGGER SENSITIVITY control for a stable display of the sine wave produced by the timing standard. The RECOVERY TIME control may aid in obtaining a stable display.

25. Adjust C88E (Fig. 6-1) for exactly one cycle per division on the crt.

26. Set the timing standard for 1 nsec/cycle.

27. Set the TIME/DIV. switch to 1 nSEC and set the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display.

28. Adjust C88G (Fig. 6-1) for exactly one cycle per division on the crt.

Comparator Regenerator Sensitivity

1. Apply the 5-mc sine-wave output of the time-mark generator to the channel A input of the vertical plug-in unit through a 10XT attenuator.

2. Set the vertical plug-in unit channel A MV/DIV. switch to 100, and the INTERNAL TRIGGER switch to A.

3. Set the Type 3T77 TIME/DIV. switch to .1 μ SEC, the DELAY control fully counterclockwise, and adjust the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display of the 5-mc sine wave.

4. Set the internal DELAY ZERO (R58) control of the Type 3T77 fully clockwise.

5. Slowly turn the 1ST COMP. REGEN. SENS. (R94) control counterclockwise just to the point where the sine-wave display disappears.

6. Very slowly turn the 1ST COMP. REGEN. SENS. control clockwise just to the point where the display is stable. If R94 is set too far clockwise, the linearity of the first cycle on the display will suffer. If R94 is set too far counterclockwise instability will result (this type of instability should not be confused with that caused by the settings of the TRIGGER SENSITIVITY and RECOVERY TIME controls). Remove all connections.

Inverter Amplifier Delay Zero

1. Set the Type 3T77 TIME/DIV. switch to 10 nSEC and the DELAY control fully counterclockwise.

2. Set the vertical plug-in unit channel A MV/DIV. switch to 50.

3. Connect a short (2-10 nsec) coaxial cable between the Type 3T77 TRIG. OUT. connector and the channel A input of the vertical plug-in unit.

4. Turn the Type 3T77 TRIGGER SENSITIVITY control fully clockwise and use the channel A POSITION and DC OFFSET controls of the vertical plug-in unit to bring the display into the viewing area of the graticule.

5. Set the Type 3T77 POSITION control so the start of the trace is aligned with the extreme left-hand graticule line.

6. Count the number of divisions between the start of the trace and the start of the displayed pulse. (Note: The leading edge of the displayed pulse should be within 2 to 7 major graticule divisions from the start of the trace. If not, adjust the DELAY ZERO (R58) control.)

7. Set the Type 3T77 TIME/DIV. switch to 20 nSEC and adjust the DELAY ZERO (R58) control so the leading edge of the pulse appears in half the number of graticule divisions as in step 6.

8. Repeat the procedure by switching between the 10 and 20 nSEC positions of the TIME/DIV. switch until no further adjustment of the DELAY ZERO control is necessary.

9. Turn the TIME/DIV. switch from 2 nSEC to 1 μ SEC. Make sure the leading edge of the pulse moves to the left between each position. If not, the INVERTER INPUT ZERO (R63) control may require slight readjustment. Remove all connections.

Trigger Sensitivity

1. Apply a 50-mv, 2-nsec pulse from the pulse generator to the vertical plug-in unit channel A input.

2. Set the INT.-EXT. switch to +INT.

3. Set the pulse generator for a positive pulse output.

4. Set the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display.

5. Set the pulse generator for a negative pulse output and set the INT.-EXT. switch to -INT.

6. Reset the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display.

7. Connect the output of the pulse generator through the GR "T" connector to the vertical plug-in unit channel A input.

8. Connect a 10XT attenuator to the third connector of the GR "T" connector.

9. Connect the 10XT attenuator to the Type 3T77 EXT. INPUT connector.

10. Set the INT.-EXT. switch to +EXT. and set the pulse generator for a positive output.

11. Set the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display. (Output amplitude of the pulse generator must be 100 mv or more for sufficient triggering.)

Calibration — Type 3T77

12. Decrease the output amplitude of the pulse generator for a 100-mv (peak) display on the crt. Reset the TRIGGER SENSITIVITY and RECOVERY TIME controls for a stable display.

Sweep Output

1. Turn the TRIGGER SENSITIVITY control fully clockwise.
2. With the test oscilloscope, check for a sawtooth output signal at the SWEEP OUTPUT connector. Peak-to-peak amplitude of the sawtooth must be 1 volt for each division of horizontal deflection (10.5 volts if the SWP. LENGTH control is set for a sweep length of 10.5 divisions).

Manual Scan

1. Apply the pulse from the TRIG. OUT. connector to the vertical plug-in unit channel A input. Set the Type 3T77 triggering controls for a stable display.

2. Set the SWEEP MODE switch to MANUAL and turn the MANUAL SCAN control to see if the electron beam is scanning properly.

3. Quickly turn the MANUAL SCAN control between its extreme positions. The electron beam should take about one second to travel across the crt.

4. Set the SWEEP MODE switch to SINGLE DISPLAY for the next check.

Single Display

1. Check the crt; there should be no display with the SWEEP MODE switch set to SINGLE DISPLAY.

2. Depress the Type 3T77 RESET button. The electron beam should make one complete display on the crt each time the RESET button is depressed.

SECTION 7

PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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


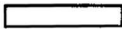
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

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

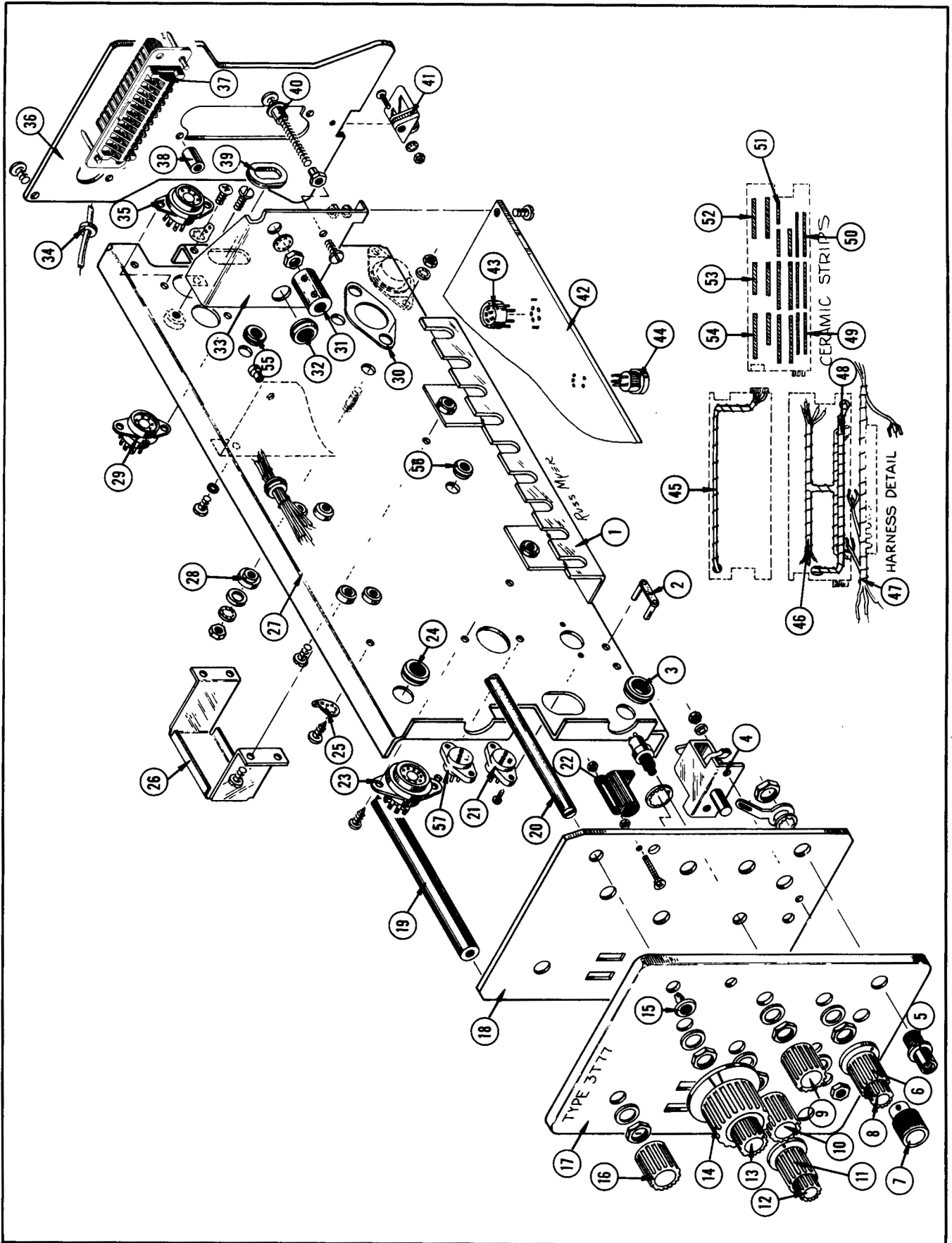
ABBREVIATIONS AND SYMBOLS

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

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.

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	406-0744-00			1	BRACKET, pot alum.
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
2	214-0153-00			2	FASTENER, snap, double pronged, delrin
3	348-0005-00			1	GROMMET, rubber, 1/2 inch
4	214-0052-00			1	FASTENER, right with stop
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0004-00			2	LOCKWASHER, steel, internal #4
	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch
5	131-0106-00			4	CONNECTOR, chassis mount, coax. 1 contact, with nut
	210-0255-00			2	LUG, solder, pot
6	366-0175-00	101	1459	1	KNOB, INT.-EXT., charcoal
	366-0250-00	1460	1999	1	KNOB, INT.-EXT., charcoal
	366-0175-00	2000		1	KNOB, INT.-EXT., charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
7	366-0109-00			1	KNOB, plug-in securing, 9/16 inch alum.
	- - - - -			-	Each Includes:
	213-0006-00			1	SCREW, set, 8-32 x 3/16 inch HSS
8	366-0140-00	101	1999	1	KNOB, RECOVERY TIME, red
	366-0281-00	2000		1	KNOB, RECOVERY TIME, red
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
9	366-0148-00			1	KNOB, SENSITIVITY, charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
10	366-0148-00			1	KNOB, DELAY, charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
11	366-0175-00	101	1459	1	KNOB, SWEEP, MODE, charcoal
	366-0250-00	1460		1	KNOB, SWEEP, MODE, charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
12	366-0140-00			1	KNOB, MANUAL SCAN, red
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
13	366-0031-00	101	679	1	KNOB, VARIABLE, red
	366-0081-00	680		1	KNOB, VARIABLE, red
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
14	366-0142-00	101	679	1	KNOB, TIME/DIV., charcoal
	366-0208-00	680		1	KNOB, TIME/DIV., charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
15	358-0178-00			1	BUSHING, front panel, charcoal
16	366-0148-00			1	KNOB, POSITION, charcoal
	- - - - -			-	Each Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS

EXPLODED VIEW (Cont)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
17	333-0677-00			1	PANEL, front
18	387-0594-00			1	PLATE, subpanel, front
19	384-0566-00	101	1459	4	ROD, frame spacing
	384-0615-00	1460		4	ROD, frame spacing
	-----			-	Mounting Hardware For Each: (not included)
	212-0044-00			1	SCREW, 8-32 x 1/2 inch RHS phillips slot
20	384-0238-00			1	ROD, extension, bakelite, 1/4 inch dia.
21	136-0095-00	101	2359	3	SOCKET, 4 pin, transistor
	136-0182-00	2360		3	SOCKET, 4 pin transistor
	-----			-	Mounting Hardware For Each: (not included)
	213-0113-00	101	2359	2	SCREW, 2-32 x 5/16 inch RHS thread forming
	354-0234-00	2360		1	RING, locking, transistor socket
22	352-0008-00			1	HOLDER, neon bulb, single
	-----			-	Mounting Hardware For Each: (not included)
	211-0031-00			1	SCREW, 4-40 x 1 inch FHS
	210-0406-00			2	NUT, hex, brass 4-40 x 3/16 inch
23	136-0015-00			4	SOCKET, STM9G
	-----			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 inch Pan H thread cutting
24	348-0004-00			1	GROMMET, rubber, 3/8 inch
25	210-0201-00			6	LUG, solder, SE 4
	213-0044-00			6	SCREW, 5-32 x 3/16 inch Pan H thread cutting
26	406-0594-00			1	BRACKET, transformer, alum.
	-----			-	Mounting Hardware For Each: (not included)
	211-0008-00			4	SCREW, 4-40 x 1/4 inch BHS
27	441-0410-00			1	CHASSIS, alum.
	-----			-	Mounting Hardware For Each: (not included)
	211-0504-00			3	SCREW, 6-32 x 1/4 inch BHS
	211-0538-00			4	SCREW, 6-32 x 1/4 inch FHS 100° phillips slot
28	-----			-	Transistor Mounting Hardware: (not included)
	129-0049-00	101	1329	4	POST, terminal
	211-0513-00	1330		4	SCREW, 6-32 x 5/8 inch BHS
	210-0900-00			4	WASHER, bakelite
	210-0804-00	101	1329	4	WASHER, 8s x 3/8 inch
	210-0803-00	1330		4	WASHER, 6L x 3/8 inch
	210-0008-00	101	1329X	4	LOCKWASHER, internal, #8
	210-0409-00	101	1329X	4	NUT, hex, 8-32 x 5/16 inch
	210-0407-00			4	NUT, hex, 6-32 x 1/4 inch
	210-0006-00			6	LOCKWASHER, internal, #6
	210-0202-00	X1330		2	LUG, solder, SE 6
29	136-0008-00			1	SOCKET, STM7G
	-----			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 inch thread cutting Pan H
30	386-0978-00	101	1329	2	PLATE, mica, transistor insulating
	387-0345-00	1330		2	PLATE, insulator
31	376-0008-00			1	COUPLING, alum.
	-----			-	Each Includes:
	213-0005-00			2	SCREW, set, 8-32 x 1/8 inch HSS
32	348-0005-00			1	GROMMET, rubber, 1/2 inch

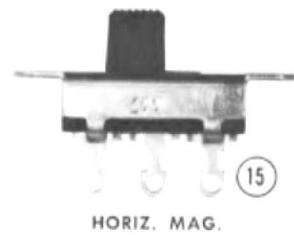
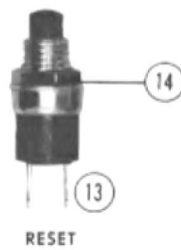
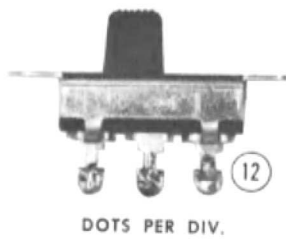
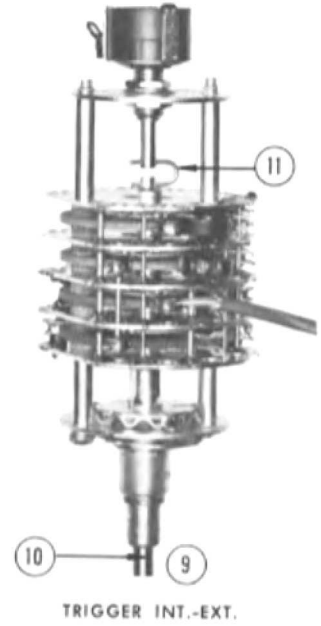
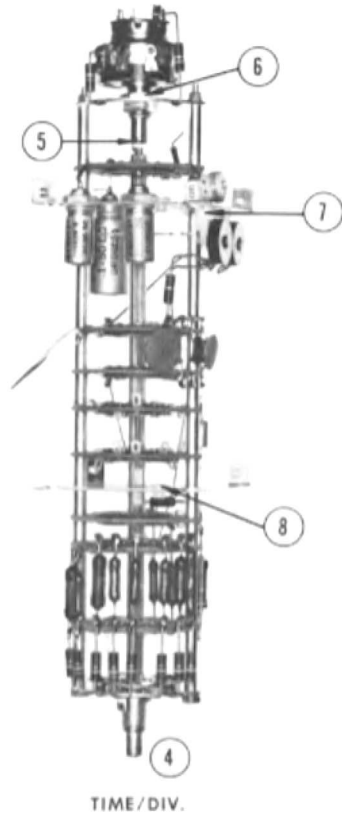
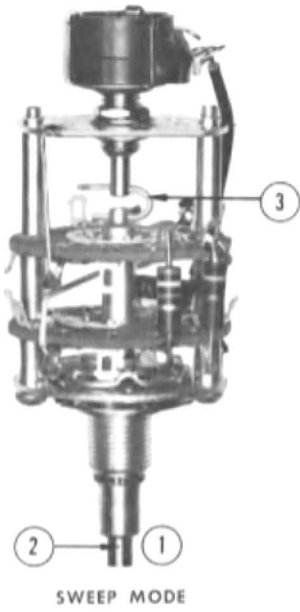
EXPLODED VIEW (Cont)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
33	406-0745-00			1	BRACKET, pot gain adjust
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0008-00			3	SCREW, 4-40 x 1/4 inch BHS
34	276-0517-00			3	CORE, powdered iron
35	136-0007-00			1	SOCKET, STM7
	- - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 inch thread cutting Pan H
36	387-0595-00			1	PLATE, panel, rear
37	131-0149-00			2	CONNECTOR, chassis mount, 24 contact
	- - - - -			-	Mounting Hardware For Upper Connector: (not included)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch BHS
	210-0201-00			1	LUG, solder, SE 4
	210-0004-00			1	LOCKWASHER, steel, internal #4
	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch
	- - - - -			-	Mounting Hardware For Lower Connector: (not included)
	211-0016-00			2	SCREW, 4-40 x 5/8 inch RHS
	210-0004-00			2	LOCKWASHER, steel, internal #4
	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch
	200-0174-00			1	CAP, screw, poly. protective
38	166-0032-00			2	TUBE SPACER, alum.
39	348-0006-00			1	GROMMET, rubber, 3/4 inch
40	- - - - -			-	Resistor Mounting Hardware: (not included)
	211-0553-00			2	SCREW, 6-32 x 5/16 inch BHS
	210-0601-00			2	EYELET, brass
	210-0478-00			2	NUT, hex, alum. 5-10 W resistor mounting
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
41	351-0037-00			1	GUIDE, plug-in, delrin
	- - - - -			-	Mounting Hardware For Each: (not included)
	211-0013-00			1	SCREW, 4-40 x 3/8 inch RHS
	210-0004-00			1	LOCKWASHER, steel, internal #4
	210-0406-00			1	NUT, hex, brass, 4-40 x 3/16 inch
42	670-0016-00	101	402	1	ASSEMBLY, circuit board, w/transistors
	670-0027-00	403	839	1	ASSEMBLY, circuit board, w/transistors
	670-0033-00	840	1999	1	ASSEMBLY, circuit board, w/transistors
	670-0066-00	2000		1	ASSEMBLY, circuit board, w/transistors
	- - - - -			-	assembly includes:
	388-0515-00	101	839	1	BOARD, etched circuit
	388-0533-00	840	1999	1	BOARD, etched circuit
	388-0605-00	2000		1	BOARD, etched circuit
43	136-0125-00			1	SOCKET, 5 pin
44	136-0062-00	101	839	7	SOCKET, 4 pin transistor
	136-0183-00	840	1999	10	SOCKET, 3 pin transistor
	136-0183-00	2000		8	SOCKET, 3 pin transistor
	344-0089-00	101	1999	5	CLIP, tunnel diode
	352-0041-00	2000		6	HOLDER, tunnel diode
	387-0603-00	101	3219X	1	PLATE, teflon insulating
	- - - - -			-	mounting hardware: (not included w/assembly)
	211-0008-00	101	3369	6	SCREW, 4-40 x 1/4 inch BHS
	211-0116-00	3370		6	SCREW, sems, 4-40 x 5/16 inch PHB
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch

EXPLODED VIEW (Cont)

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
45	179-0595-00			1	CABLE harness, switch
	- - - - -			-	Includes:
	348-0003-00			2	GROMMET, rubber, 5/16 inch
46	179-0593-00	101	839	1	CABLE harness, chassis
	179-0799-00	840		1	CABLE harness, chassis
47	179-0592-00	101	839	1	CABLE harness, pot bracket A
	179-0800-00	840		1	CABLE harness, pot bracket A
48	179-0594-00			1	CABLE harness, pot bracket B
49	124-0146-00			4	STRIP, ceramic, 7/16 inch, small notch, 16 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0009-00			2	SPACER, nylon, 3/8 inch high
50	124-0145-00			4	STRIP, ceramic, 7/16 inch, small notch, 20 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0009-00			2	SPACER, nylon, 3/8 inch high
51	124-0120-00			1	STRIP, ceramic, 7/16 inch, small notch, 20 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0007-00			2	SPACER, nylon, 3/8 inch high
52	124-0095-00			2	STRIP, ceramic, 7/16 inch, 4 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0007-00			2	SPACER, nylon, 5/32 inch high
53	124-0094-00			3	STRIP, ceramic, 7/16 inch, 9 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0007-00			2	SPACER, nylon, 5/32 inch high
54	124-0106-00			5	STRIP, ceramic, 7/16 inch, 7 notches
	- - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon, short
	361-0007-00			2	SPACER, nylon, 5/32 inch high
55	348-0003-00			1	GROMMET, rubber, 5/16 inch
56	348-0002-00			1	GROMMET, rubber, 1/4 inch
57	136-0095-00	101	2359	7	SOCKET, 4 pin transistor
	136-0181-00	2360		7	SOCKET, 3 pin transistor
	- - - - -			-	mounting hardware for each: (not included w/socket)
	213-0113-00	101	2359	2	SCREW, thread forming, 2-32 x 5/16 inch RHS phillips
	354-0234-00	2360		1	RING, locking, transistor socket

SWITCHES



SWITCHES

REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	262-0445-00			1	SWITCH, SWEEP MODE, wired
	- - - - -			-	Each Includes:
2	384-0256-00			1	ROD, extension
3	376-0014-00			1	COUPLING, pot, wire steel
	260-0426-00			1	SWITCH, SWEEP MODE, unwired
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0413-00			1	NUT, hex, brass, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, steel
	210-0012-00			1	LOCKWASHER, steel pot, internal, 3/8 x 1/2 inch
4	262-0527-00	101	402	1	SWITCH, TIME/DIV., wired
	262-0539-00	403	1489	1	SWITCH, TIME/DIV., wired
	262-0637-00	1490		1	SWITCH, TIME/DIV., wired
	- - - - -			-	Each Includes:
5	376-0014-00			1	COUPLING, pot, wire steel
6	210-0413-00			2	NUT, hex, brass, 3/8-32 x 1/2 inch
7	406-0635-00			2	BRACKET, pot mounting delrin
	213-0088-00			4	SCREW, thread forming, 4-40 x 1/4 inch PHS, phillips
8	348-0031-00	101	2829	3	GROMMET, polypropylene, snap-in
	348-0083-00	2830		3	GROMMET, poly., snap-in
	260-0425-00			1	SWITCH, TIME/DIV., unwired
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0413-00			1	NUT, hex, brass, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, steel
	210-0012-00	X120		1	LOCKWASHER, steel pot, internal, 3/8 x 1/2 inch
9	262-0463-00	101	1999	1	SWITCH, TRIGGER INT.-EXT., (source), wired
	262-0667-00	2000		1	SWITCH, TRIGGER INT.-EXT., (source), wired
	- - - - -			-	Each Includes:
10	384-0213-00	101	1999	1	ROD, extension
	384-0292-00	1460	1999	1	ROD, extension
	384-0324-00	2000		1	ROD, extension
11	376-0014-00			1	COUPLING, pot, wire steel
	213-0075-00	X2000		1	SCREW, set, 4-40 x 3/32 inch HSS
	- - - - -			1	POT
	- - - - -			-	Mounting hardware: (not included w/pot)
	210-0046-00	101	1999	1	LOCKWASHER, internal, .4000 OD x .261 ID
	210-0012-00	X2000		1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0583-00	101	1999	1	NUT, hex, 1/4-32 x 5/16 inch
	210-0413-00	X2000		1	NUT, hex, 3/8-32 x 1/2 inch
	166-0354-00	X2000		1	TUBE, spacing
	260-0427-00			1	SWITCH, TRIGGER SOURCE, unwired
	260-0639-00	2000		1	SWITCH, TRIGGER SOURCE, unwired
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0413-00			1	NUT, hex, brass, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, steel
	210-0012-00			1	LOCKWASHER, steel pot, internal, 3/8 x 1/2 inch
12	260-0212-00			1	SWITCH, DOTS PER DIV., slide, unwired
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch
13	260-0247-00			1	SWITCH, RESET, push button
	- - - - -			-	mounting hardware: (not included)
14	210-0583-00			1	NUT, hex, brass, 5/16 inch
	210-0940-00			1	WASHER, steel, 1/4 inch ID
15	260-0145-00			1	SWITCH, HORIZ. MAG., slide
	- - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, brass, 4-40 x 3/16 inch

STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO.		QTY.	DESCRIPTION
		EFF.	DISC.		
1	017-0064-00	101 3090	3089	1	ADAPTER, BNC, (male) to GR
2	017-0044-00			2	ATTENUATOR, 50 Ω 10X
	017-0078-00			2	ATTENUATOR, 50 Ω 10X
3	017-0501-00			2	CABLE, 10 nsec delay
4	103-0032-00			1	ADAPTER, BNC male to UHF female
--	070-0333-00			2	MANUAL, instruction (not shown)

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range
Bulb			
B50	Use 150-027	Neon, NE-23	UNCAL.

Capacitors

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

Tolerance of electrolytic capacitors as follows (with exceptions):

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

C7	283-002	.01 μf	Disc Type	500 v		
C8	283-002	.01 μf	Disc Type	500 v		
C11	283-000	.001 μf	Disc Type	500 v		
C12	281-534	3.3 pf	Cer.	500 v	$\pm .25$ pf	
C13	283-023	.1 μf	Disc Type	10 v		
C14	281-509	15 pf	Cer.	500 v	10%	
C15	283-025	.0005 μf	Disc Type	500 v	5%	X2000-up
C25	281-523	100 pf	Cer.	350 v		X2000-up
C26	283-104	.002 μf	Disc Type	500 v	5%	X2000-up
C30	283-032	470 pf	Disc Type	500 v	5%	101-402
C30	283-067	.001 μf	Disc Type	200 v	10%	403-up
C31A	283-027	.02 μf	Disc Type	50 v		
C31B	283-001	.005 μf	Disc Type	500 v		101-402
C31B	283-003	.01 μf	Disc Type	150 v		403-up
C31C	283-051	.0033 μf	Disc Type	100 v	5%	101-402
C31C	283-001	.005 μf	Disc Type	500 v		403-up
C31D	283-000	.001 μf	Disc Type	500 v		101-402
C31D	283-028	.0022 μf	Disc Type	50 v		403-up
C31E	283-032	470 pf	Disc Type	500 v	5%	101-402
C31E	283-000	.001 μf	Disc Type	500 v		403-up
C34	283-047	270 pf	Disc Type	500 v	5%	101-402
C34	283-067	.001 μf	Disc Type	200 v	10%	403-1999X
C40	281-504	10 pf	Cer.	500 v	10%	
C41	283-003	.01 μf	Disc Type	150 v		
C43	290-158	50 μf	EMT	25 v		101-839X
C65	281-513	27 pf	Cer.	500 v		
C70	281-524	150 pf	Cer.	500 v		
C73	283-003	.01 μf	Disc Type	150 v		
C77	283-000	.001 μf	Disc Type	500 v		
C78	281-523	100 pf	Cer.	350 v		
C80	281-513	27 pf	Cer.	500 v		
C81	283-003	.01 μf	Disc Type	150 v		
C85	283-003	.01 μf	Disc Type	150 v		
C86	283-003	.01 μf	Disc Type	150 v		
C88A	285-594	.1 μf	PMC	50 v	1%	

Parts List — Type 3T77

Capacitors (Cont'd.)

Ckt. No.	Tektronix Part No.		Description			S/N Range
C88B	285-593	.01 μ f	PMC	50 v	1%	
C88C	285-592	980 pf	PMC	50 v	1%	
C88D	Use 285-007	160 pf	Glass	500 v	5%	
C88E	281-063	9-35 pf	Cer.			
C88F	Use 285-006	68 pf	Glass	500 v	5%	
C88G	281-063	9-35 pf	Cer.			
C90	283-051	.0033 μ f	Disc Type	100 v	5%	101-839
C90	283-067	.001 μ f	Disc Type	200 v	10%	840-up
C91	283-003	.01 μ f	Disc Type	150 v		
C92	283-067	.001 μ f	Disc Type	200 v	10%	X840-up
C95	283-000	.001 μ f	Disc Type	500 v		101-839
C95	283-001	.005 μ f	Disc Type	500 v		840-up
C97	281-513	27 pf	Cer.	500 v		
C98	283-003	.01 μ f	Disc Type	150 v		
C102	283-003	.01 μ f	Disc Type	150 v		
C105	281-536	.001 μ f	Cer.	500 v	10%	
C106	283-000	.001 μ f	Disc Type	500 v		
C110	Use 290-219	5 μ f	EMT	25 v		
C111	283-003	.01 μ f	Disc Type	150 v		
C116	281-543	270 pf	Cer.	500 v	10%	
C127	281-551	390 pf	Cer.	500 v	10%	
C131	281-523	100 pf	Cer.	350 v		
C133	283-003	.01 μ f	Disc Type	150 v		
C145	Use 285-650	.027 μ f	PTM	100 v	5%	
C156	281-012	7-45 pf	Cer.			
C157	Use 283-513	220 pf	Mica	500 v	5%	
C158	281-012	7-45 pf	Cer.			101-215
C158A	281-007	3-12 pf	Cer.			216-up
C158B	281-577	14 pf	Cer.	500 v	5%	216-up
C160	Use *291-038	0.01 μ f	Poly	300 v	5%	
C162	285-572	.1 μ f	PTM	200 v		
C165	283-003	.01 μ f	Disc Type	150 v		
C174	283-008	.1 μ f	Disc Type	500 v		
C177	285-572	.1 μ f	PTM	200 v		
C178	285-572	.1 μ f	PTM	200 v		
C304	290-149	5 μ f	EMT	150 v		
C702	283-003	.01 μ f	Disc Type	150 v		
C710	283-003	.01 μ f	Disc Type	150 v		
C712	Use 283-008	.1 μ f	Disc Type	500 v		
C714	Use 283-057	.1 μ f	Disc Type	200 v		
C716	Use 283-008	.1 μ f	Disc Type	500 v		
C720	283-001	.005 μ f	Disc Type	500 v		X2660-up
C722	290-165	250 μ f	EMT	50 v		
C723	283-003	.01 μ f	Disc Type	150 v		
C724	290-121	2 μ f	EMT	25 v		
C726	290-107	25 μ f	EMT	25 v		
C730	290-107	25 μ f	EMT	25 v		
C732	290-121	2 μ f	EMT	25 v		

Diodes

Ckt. No.	Tektronix Part No.	Description	S/N Range
D18	152-070	Back BD4	X2000-up
D22	152-043	Tunnel 1N3129 20 MA	
D25	152-043	Tunnel 1N3129 20 MA	
D26	*152-075	Germanium Tek Spec	
D27	*152-075	Germanium Tek Spec	
D28	*152-075	Germanium Tek Spec	
D31	*152-075	Germanium Tek Spec	
D32	*152-075	Germanium Tek Spec	
D34	*152-075	Germanium Tek Spec	101-1999X
D35	152-076	Zener 3 v 1/4 w 10%	X403-1999X
D36	*152-075	Germanium Tek Spec	101-1999X
D42	152-043	Tunnel 1N3129 20 MA	
D58	152-066	Silicon 1N3194	
D59	152-066	Silicon 1N3194	
D66	*152-075	Germanium Tek Spec	X487-839X
D68	152-034	Zener 1N753 6.2 v	
D74	152-074	Tunnel 1N3128 5 MA	
D75	Use 152-079	Germanium HD1841	
D80	*152-185	Silicon Replaceable by 1N3605	X2660-up
D84	152-065	Silicon HD5000	X840-up
D90	152-065	Silicon HD5000	
D91	152-058	Silicon SG22	101-839X
D92	152-008	Germanium	101-839
D92	152-076	Zener 3 V 1/4 w 10%	840-up
D93	152-043	Tunnel 1N3129 20 MA	
D94	152-034	Zener 1N753 6.2 v	X840-up
D105	152-008	Germanium	
D110	152-025	Germanium 1N634	
D114	152-025	Germanium 1N634	
D125	Use *050-109	Replacement Kit	101-549
D125	152-093	Tunnel 1N3716 4.7 MA	550-up
D126	*152-075	Germanium Tek Spec	
D127	152-025	Germanium 1N634	
D136	152-025	Germanium 1N634	
D145	*152-045	Silicon Selected 1N622A	
D152	*152-045	Silicon Selected 1N622A	
D153	*152-045	Silicon Selected 1N622A	101-2569
D153	*152-165	Silicon Selected from 1N3579	2570-up
D160	*152-045	Silicon Selected 1N622A	101-2569
D160	*152-219	GaAs Tek Made	2570-up
D161	*152-045	Silicon Selected from 1N622A	101-2349
D161	*152-185	Silicon Replaceable by 1N3605	2350-up
D162	*152-045	Silicon Selected from 1N622A	101-2349
D162	*152-185	Silicon Replaceable by 1N3605	2350-up
D177	152-069	Zener 1N3041A 75 v	
D178	152-069	Zener 1N3041A 75 v	
D324	152-008	Germanium	
D327	152-066	Silicon 1N3194	
D722A,B,C,D,	152-066	Silicon 1N3194	

Parts List — Type 3T77

Inductors

Ckt. No.	Tektronix Part No.	Description	S/N Range
L1	276-517	Core, Powder Iron	
L2	276-517	Core, Powder Iron	
L3	276-507	Core, Ferramic Suppressor	
L4	108-249	12 μ h	
L5	*120-250	Toroid 5T TD47	
L6	276-507	Core, Ferramic Suppressor	
L14	*108-182	.3 μ h	
L24	276-532	Core, Shield Bead	X2000-up
L90	276-532	Core, Shield Bead	X840-up
L110	*108-072	.75 μ h	
L702	276-517	Core, Powder Iron	

Resistors

Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.

R3	315-101	100 Ω	1/4 w		5%	
R4	315-101	100 Ω	1/4 w		5%	
R7	315-101	100 Ω	1/4 w		5%	
R8	315-101	100 Ω	1/4 w		5%	
R10	315-512	5.1 k	1/4 w		5%	
R11	315-132	1.3 k	1/4 w		5%	
R12	316-101	100 Ω	1/4 w			
R13	316-390	39 Ω	1/4 w			
R14	309-029	1.582 k	1/2 w		Prec.	1%
R15	316-120	12 Ω	1/4 w			101-839X
R16	309-029	1.582 k	1/2 w		Prec.	1%
R18	309-224	2.424 k	1/2 w		Prec.	1%
R19	311-016	10 k		Var.		
R21	311-066	500 Ω	.2 w	Var.		
R22	301-431	430 Ω	1/2 w			SENSITIVITY TRIG. SENS. RANGE 5% 101-402
R22	301-271	270 Ω	1/2 w			5% 403-1999
R22	303-561	560 Ω	1 w			5% 2000-up
R23	301-271	270 Ω	1/2 w			5% 101-402
R23	301-471	470 Ω	1/2 w			5% 403-up
R24	311-480	500 Ω		Var.		D25 CURRENT RANGE X2000-up
R25	315-750	75 Ω	1/4 w			5%
R26	Use 303-511	510 Ω	1 w			5%
R27	301-221	220 Ω	1/2 w			5% 101-1999
R27	301-361	360 Ω	1/2 w			5% 2000-up
R28	316-101	100 Ω	1/4 w			5% X2000-up
R30	311-170	20 k		Var.		RECOVERY TIME 101-1999
R30†	311-166	20 k		Var.		RECOVERY TIME 2000-up
R31	301-913	91 k	1/2 w			5% 101-402
R31	302-563	56 k	1/2 w			403-up
R32	316-473	47 k	1/4 w			
R33	316-101	100 Ω	1/4 w			X840-up
R34	302-124	120 k	1/2 w			101-402
R34	302-563	56 k	1/2 w			403-839
R34	Use 303-203	20 k	1 w			5% 840-1999X
R36	316-473	47 k	1/4 w			101-1999X
R40	316-101	100 Ω	1/4 w			
R41	307-057	5.1 Ω	1/2 w			5%
R43	Use 301-301	300 Ω	1/2 w			5%
R44	311-066	500 Ω	.2 w	Var.		2ND TRIG. REGEN. SENS. 101-402
R44	311-158	200 Ω		Var.		403-up

†Furnished as a unit with SW30.

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R50	302-104	100 k	1/2 w			
R51†	311-274	100 k		Var.		VARIABLE
R52	302-823	82 k	1/2 w			
R53A	309-045	100 k	1/2 w		Prec.	1%
R53B	309-051	200 k	1/2 w		Prec.	1%
R53C	309-140	500 k	1/2 w		Prec.	1%
R53D	309-051	200 k	1/2 w		Prec.	1%
R53E	309-126	400 k	1/2 w		Prec.	1%
R53F	309-148	1 meg	1/2 w		Prec.	1%
R53G	309-148	1 meg	1/2 w		Prec.	1%
R53H	309-023	2 meg	1/2 w		Prec.	1%
R53J	309-087	5 meg	1/2 w		Prec.	1%
R54B	301-204	200 k	1/2 w			5%
R54C	301-134	130 k	1/2 w			5%
R54D	301-204	200 k	1/2 w			5%
R54E	301-134	130 k	1/2 w			5%
R54F	301-114	110 k	1/2 w			5%
R54G	301-114	110 k	1/2 w			5%
R54H	301-104	100 k	1/2 w			5%
R54J	301-104	100 k	1/2 w			5%
R56	311-016	10 k		Var.		DELAY
R57A	301-475	4.7 meg	1/2 w			5%
R57B	309-126	400 k	1/2 w		Prec.	1%
R57C	309-108	80 k	1/2 w		Prec.	1%
R57D	309-155	40 k	1/2 w		Prec.	1%
R57E	301-226	22 meg	1/2 w			5%
R58	311-159	20 k		Var.		DELAY ZERO
R59	302-154	150 k	1/2 w			101-402
R59	302-224	220 k	1/2 w			403-up
R62	302-682	6.8 k	1/2 w			
R63	311-155	1 k		Var.		INVERTER INPUT ZERO
R64	302-274	270 k	1/2 w			
R65	309-392	20 k	1/2 w		Prec.	1%
R66	302-124	120 k	1/2 w			
R68	302-333	33 k	1/2 w			
R71	316-104	100 k	1/4 w			
R72	315-392	3.9 k	1/4 w			5%
R73	316-391	390 Ω	1/4 w			
R76	316-562	5.6 k	1/4 w			
R77	316-122	1.2 k	1/4 w			
R78	316-101	100 Ω	1/4 w			101-839
R78	316-100	10 Ω	1/4 w			840-up
R79A	311-074	5 k	.1 w	Var.		
R79B	311-074	5 k	.1 w	Var.		
R79C	302-222	2.2 k	1/2 w			
R80	316-333	33 k	1/4 w			
R81	316-333	33 k	1/4 w			

†Concentric with SW50 A,B. Finished as a unit.

Parts List — Type 3T77

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R82	316-101	100 Ω	1/4 w			
R83	316-101	100 Ω	1/4 w			
R84	305-432	4.3 k	2 w		5%	
R85	311-155	1 k		Var.	SWP. CAL.	
R87	315-510	51 Ω	1/4 w		5%	101-839
	315-750	75 Ω	1/4 w		5%	840-up
R89	315-273	27 k	1/4 w		5%	X2660-up
R90	316-101	100 Ω	1/4 w			
R91	316-103	10 k	1/4 w			
R92A	316-101	100 Ω	1/4 w			X840-up
R92B	316-103	10 k	1/4 w			X840-up
R93	302-471	470 Ω	1/2 w			101-839
R93	301-101	100 Ω	1/2 w		5%	840-up
R94	311-155	1 k		Var.	1ST COMP. REGEN. SENS.	101-839
R94	311-158	200 Ω		Var.		840-up
R95	307-057	5.1 Ω	1/2 w		5%	101-839
R95	301-101	100 Ω	1/2 w		5%	840-up
R96	Use 301-621	620 Ω	1/2 w		5%	101-839
R96	301-181	180 Ω	1/2 w		5%	840-up
R97	316-332	3.3 k	1/4 w			101-2659
R97	315-222	2.2 k	1/4 w		5%	X2660-up
R98	316-332	3.3 k	1/4 w			
R99	316-561	560 Ω	1/4 w			
R101	302-226	22 meg	1/2 w			
R102	302-103	10 k	1/2 w			101-486
R102	302-562	5.6 k	1/2 w			487-up
R105	302-103	10 k	1/2 w			
R106	302-562	5.6 k	1/2 w			
R107	316-391	390 Ω	1/4 w			
R113	302-102	1 k	1/2 w			
R114	302-222	2.2 k	1/2 w			
R116	302-222	2.2 k	1/2 w			
R120	301-103	10 k	1/2 w		5%	
R121	301-512	5.1 k	1/2 w		5%	
R124	302-101	100 Ω	1/2 w			
R125	302-392	3.9 k	1/2 w			101-402
R125	309-196	3.108 k	1/2 w		Prec. 1/2 %	403-up
R126	302-222	2.2 k	1/2 w			
R127	301-472	4.7 k	1/2 w		5%	
R131	302-103	10 k	1/2 w			
R132	302-272	2.7 k	1/2 w			
R133	302-101	100 Ω	1/2 w			
R135	302-104	100 k	1/2 w			
R136	302-393	39 k	1/2 w			
R140	301-123	12 k	1/2 w		5%	
R141	301-133	13 k	1/2 w		5%	
R142	301-682	6.8 k	1/2 w		5%	
R144	302-393	39 k	1/2 w			
R145	311-159	20 k		Var.	SWP. LENGTH	

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description		S/N Range
R146	301-101	100 Ω	$\frac{1}{2}$ w	5%	
R162	304-223	22 k	1 w		
R163	302-825	8.2 meg	$\frac{1}{2}$ w		X840-up
R164	302-101	100 Ω	$\frac{1}{2}$ w		
R165	302-101	100 Ω	$\frac{1}{2}$ w		101-839
	302-103	10 k	$\frac{1}{2}$ w		840-up
R166	302-563	56 k	$\frac{1}{2}$ w		X840-up
R171	302-101	100 Ω	$\frac{1}{2}$ w		
R172	302-393	39 k	$\frac{1}{2}$ w		
R174	302-101	100 Ω	$\frac{1}{2}$ w		
R175	306-273	27 k	2 w		
R176	306-183	18 k	2 w		
R177	301-104	100 k	$\frac{1}{2}$ w		
R181	311-156	200 k		Var.	5% STAIRCASE DC LEVEL
R182	302-104	100 k	$\frac{1}{2}$ w		
R184	301-242	2.4 k	$\frac{1}{2}$ w		5%
R193	302-223	22 k	$\frac{1}{2}$ w		
R194	302-823	82 k	$\frac{1}{2}$ w		
R196	302-272	2.7 k	$\frac{1}{2}$ w		
R197	302-822	8.2 k	$\frac{1}{2}$ w		
R198	302-563	56 k	$\frac{1}{2}$ w		
R301	311-173	100 k		Var.	MANUAL SCAN OR EXT. ATTEN.
R304	302-393	39 k	$\frac{1}{2}$ w		
R310	309-126	400 k	$\frac{1}{2}$ w		Prec. 1%
R311	309-356	103 k	$\frac{1}{2}$ w		Prec. 1%
R314	302-393	39 k	$\frac{1}{2}$ w		
R315	309-226	9.7 k	$\frac{1}{2}$ w		Prec. 1%
R318	301-101	100 Ω	$\frac{1}{2}$ w		5% X216-up
R319	309-045	100 k	$\frac{1}{2}$ w		Prec. 1%
R321	311-032	250 k		Var.	POSITION
R323	301-164	160 k	$\frac{1}{2}$ w		5%
R324	301-514	510 k	$\frac{1}{2}$ w		5%
R327	302-473	47 k	$\frac{1}{2}$ w		
R328	302-473	47 k	$\frac{1}{2}$ w		
R330	309-155	40 k	$\frac{1}{2}$ w		Prec. 1%
R332	302-154	150 k	$\frac{1}{2}$ w		
R334	302-563	56 k	$\frac{1}{2}$ w		
R335	309-195	90 k	$\frac{1}{2}$ w		Prec. 1%
R338	309-045	100 k	$\frac{1}{2}$ w		Prec. 1%
R339	318-003	11.1 k	$\frac{1}{8}$ w		Prec. 1%
R341	311-068	500 k	.2 w	Var.	MAG. REGIS.
R343	301-105	1 meg	$\frac{1}{2}$ w		5%
R344	309-045	100 k	$\frac{1}{2}$ w		Prec. 1%
R345	318-003	11.1 k	$\frac{1}{8}$ w		Prec. 1%
R346	309-106	8.89 k	$\frac{1}{2}$ w		Prec. 1%
R347	309-191	4.535 k	$\frac{1}{2}$ w		Prec. 1%

Parts List — Type 3T77

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R350	302-101	100 Ω	1/2 w			
R353	308-105	30 k	8 w		WW	5%
R355	304-223	22 k	1 w			
R356	311-095	500 Ω		Var.		GAIN ADJ.
R360	302-101	100 Ω	1/2 w			
R363	308-105	30 k	8 w		WW	5%
R365	304-223	22 k	1 w			
R370	302-101	100 Ω	1/2 w			
R371	302-101	100 Ω	1/2 w			
R374	304-154	150 k	1 w			
R375	304-154	150 k	1 w			
R701	302-123	12 k	1/2 w			
R702	302-104	100 k	1/2 w			
R704	308-091	2 k	5 w		WW	5%
R706	308-023	10 k	10 w		WW	5%
R710	308-142	30 Ω	3 w		WW	5%
R723	309-138	111 k	1/2 w		Prec.	1%
R724	309-392	20 k	1/2 w		Prec.	1%
R725	302-472	4.7 k	1/2 w			
R731	309-392	20 k	1/2 w		Prec.	1%
R732	309-051	200 k	1/2 w		Prec.	1% 101-839
R732	309-043	82 k	1/2 w		Prec.	1% 840-up
R734	302-123	12 k	1/2 w			
R738	308-018	2.5 k	10 w		WW	5%

Switches

	Unwired	Wired			
SW5	260-427	*262-463	Rotary	INT.-EXT.	101-1999
SW5	260-639	*262-667	Rotary	INT.-EXT.	2000-up
SW30	311-166††			SYNC	X2000-up
SW50A,B†	311-274				
SW88	260-425	*262-527	Rotary	TIME/DIV	101-402
SW88	260-425	*262-539	Rotary		403-1489
SW88	260-425	*262-637	Rotary		1490-up
SW100	260-247		Push Button	RESET	
SW145	260-426	*262-445	Rotary	SWEEP MODE	
SW157	260-212		Slide	DOTS PER DIV	
SW338	260-145		Slide	HORIZ MAG	

Transformers

T5	*120-247	Toroid 5T	TD43	
T42	Use *120-336	Toroid 5T	2T	
T95	*120-251	Toroid 3T	TD48	101-839X
T110	*120-249	Toroid 7T	TD46	
T720	*120-252	Power		

Transistors

Q14	151-027	2N700		
Q24	Use *050-186	Replacement Kit		101-839
Q24	*151-062	Selected from TIN101		840-up
Q33	151-071	2N1305		X840-up
Q34	Use 151-072	2N1308		101-839
Q34	Use *153-528	Planar Silicon NPN		840-up

†Concentric with R51. Furnished as a unit.

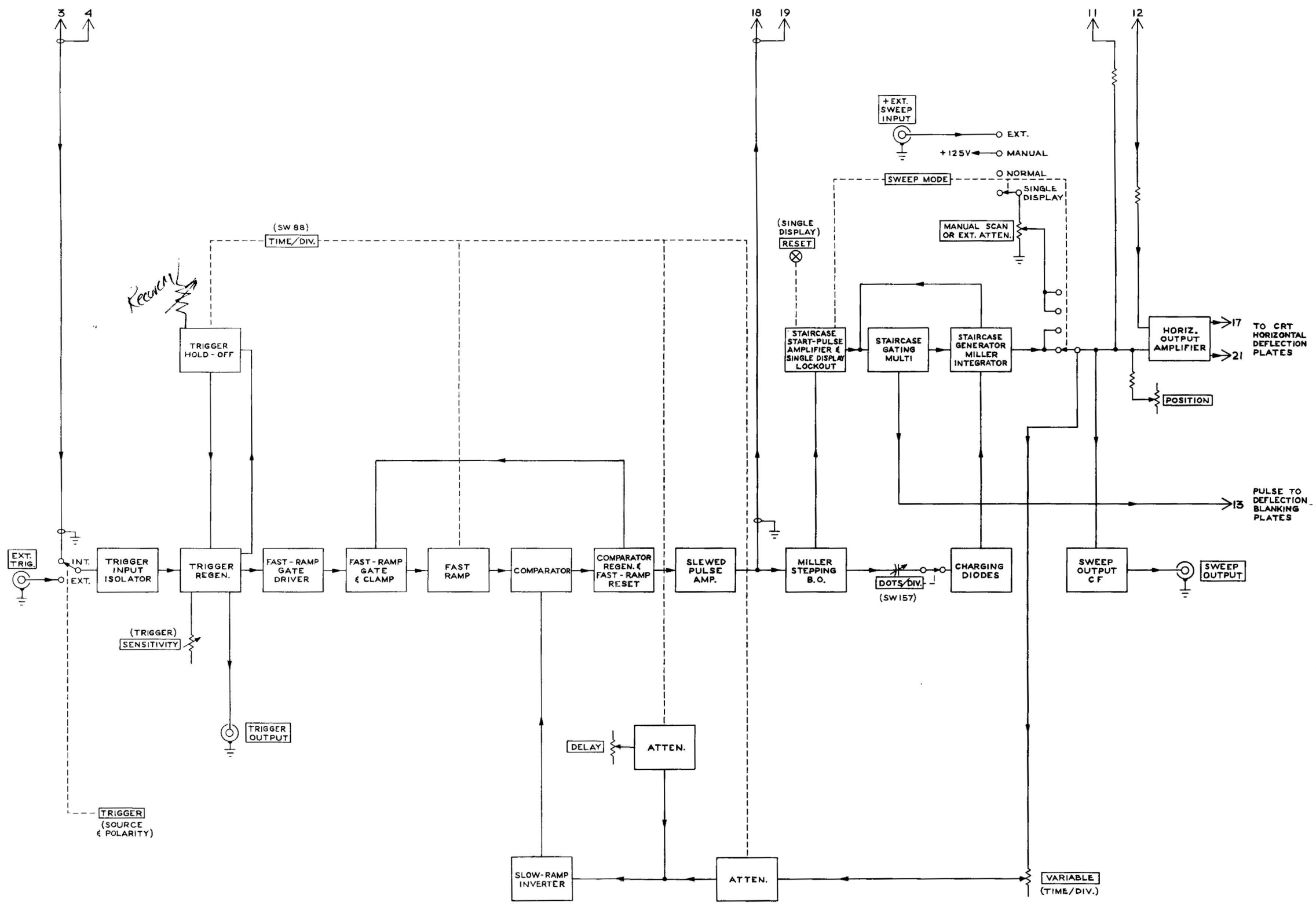
††Furnished as a unit with R30.

Transistors (Cont'd)

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q44	Use 151-072	2N1308	101-839
Q44	*151-103	Replaceable by 2N2219	840-1999X
Q63	Use *151-103	Replaceable by 2N2219	
Q64	151-015	2N1516	
Q74	Use 151-131	2N964	
Q84	Use 151-131	2N964	
Q93	Use *050-122	Replacement Kit	101-839X
Q93A	151-080	2N706	X840-up
Q93B	151-040	2N1302	X840-2659
Q93B	151-072	2N1308	2660-up
Q94	Use 151-123	2N976	
Q110	151-063	2N2207	
Q124	Use 151-072	2N1308	101-839
Q124	151-069	2N1304	840-up
Q135	151-015	2N1516	
Q145	151-040	2N1302	
Q333	151-070	2N1377	
Q334	151-058	RT5204	
Q724	151-070	2N1377	
Q727	151-060	2N1545	
Q734	151-069	2N1304	101-839
Q734	*151-103	Replaceable by 2N2219	840-up
Q737	151-060	2N1545	

Electron Tubes

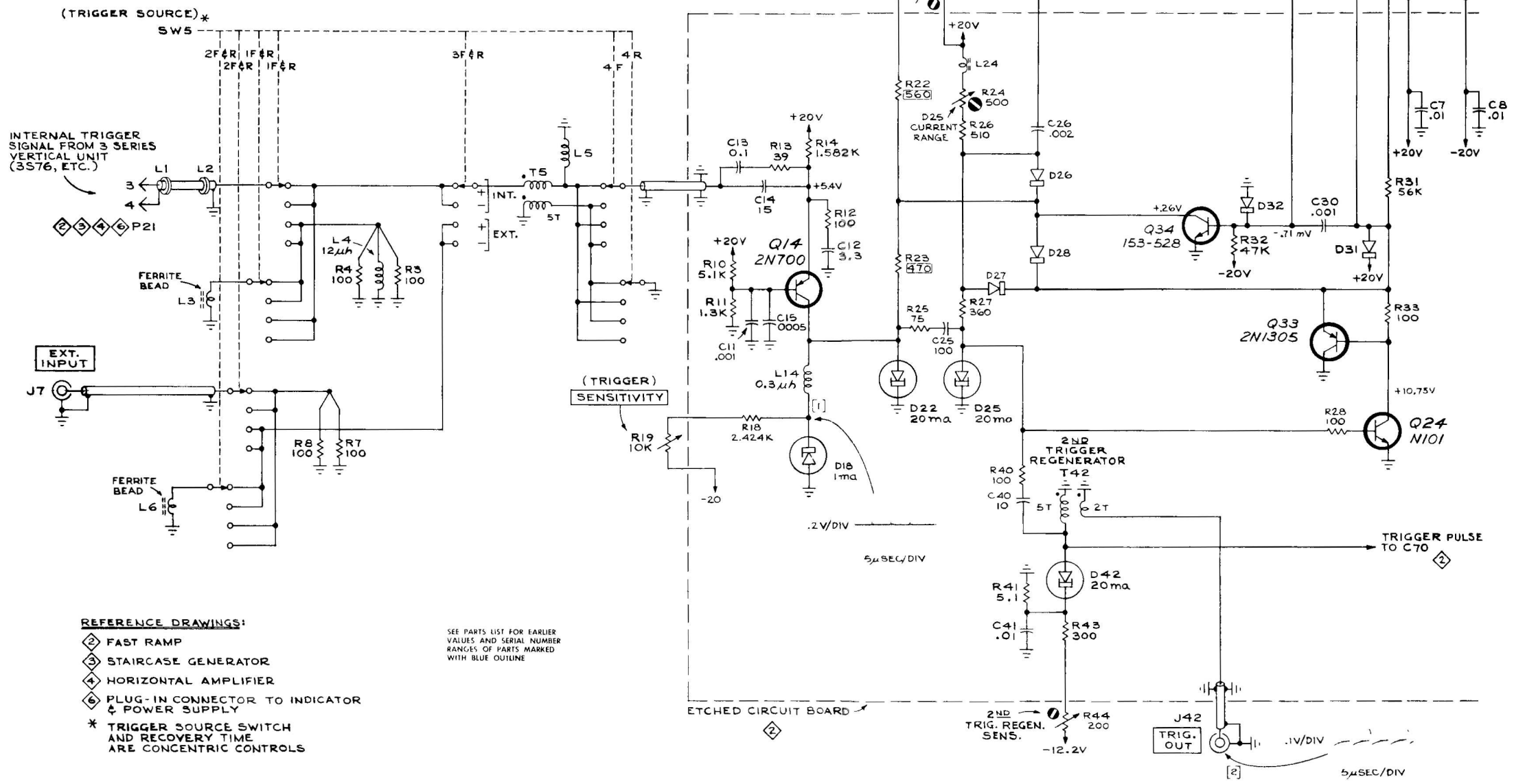
V61	Use 154-0306-02	7586, Aged
V161	154-215	6688
V173	154-187	6DJ8
V194	154-187	6DJ8
V354	154-212	6EW6
V364	154-212	6EW6
V373	154-0187-00	6DJ8



CMP
563

WAVEFORMS & VOLTAGE READINGS
 WERE OBTAINED UNDER FOLLOWING CONDITIONS:
 POSITION MIDRANGE
 TIME DIVISION2 μSEC
 VARIABLE CALIB.
 HORIZ. MAG. X1
 DOTS PER DIV. 100
 DELAY CCW
 RECOVERY TIME MIDRANGE
 TRIGGER SENSITIVITY CW
 SWEEP MODE NORMAL
 PULL FOR SYNC PUSHED IN
 OTHER CONTROLS ANY POSITION
 (SEE IMPORTANT NOTE ON THIS DIAG)

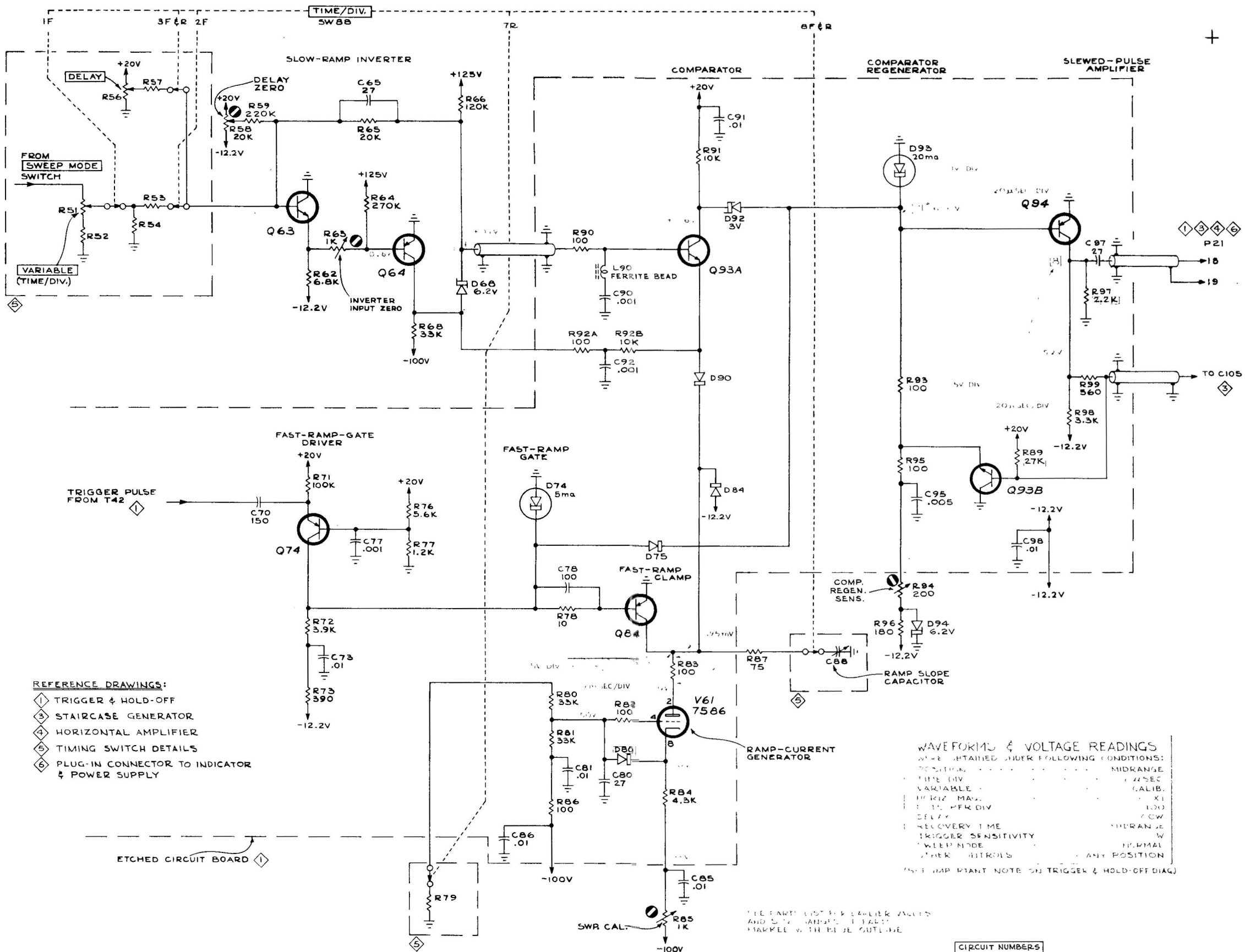
IMPORTANT:
 ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. ALL READINGS ARE IN VOLTS.
 VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.
 ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.



- REFERENCE DRAWINGS:**
- ② FAST RAMP
 - ③ STAIRCASE GENERATOR
 - ④ HORIZONTAL AMPLIFIER
 - ⑥ PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY
- * TRIGGER SOURCE SWITCH AND RECOVERY TIME ARE CONCENTRIC CONTROLS

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

CIRCUIT NUMBERS 1 THRU 49
 MRH 864
TRIGGER & HOLD-OFF
 S/N 2000-UP



REFERENCE DRAWINGS:

- ① TRIGGER & HOLD-OFF
- ② STAIRCASE GENERATOR
- ③ HORIZONTAL AMPLIFIER
- ④ TIMING SWITCH DETAILS
- ⑤ PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY

ETCHED CIRCUIT BOARD ①

WAVEFORMS & VOLTAGE READINGS

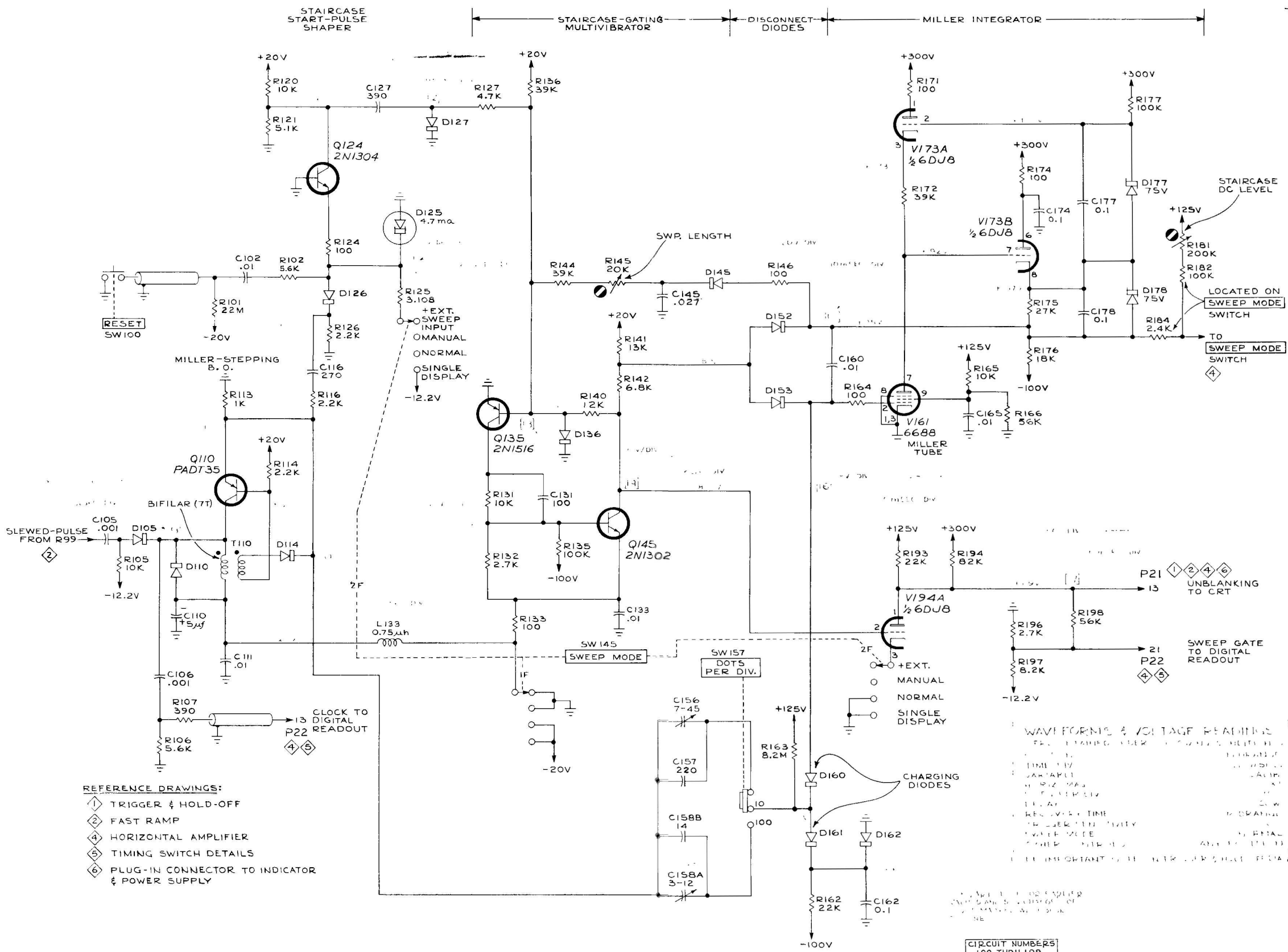
WERE OBTAINED UNDER FOLLOWING CONDITIONS:
 POSITION: MIDRANGE
 TIME DIV: 20 μSEC
 VARIABLE: CALIB.
 PERIZ. MAX. X1
 1.5 PER DIV 100
 DELAY: 20W
 RECOVERY TIME: MIDRANGE
 TRIGGER SENSITIVITY: 1W
 SLEW MODE: NORMAL
 OTHER CONTROLS: ANY POSITION
 (SEE ADJUSTMENT NOTE ON TRIGGER & HOLD-OFF DIAG)

THE PARTS LIST FOR RELATED VALUES AND SUPPLIERS ARE MARKED WITH THE OUTLINE

CIRCUIT NUMBERS 50 THRU 99

PLM 565
FAST RAMP

S/N 840-UP



- REFERENCE DRAWINGS:
- ① TRIGGER & HOLD-OFF
 - ② FAST RAMP
 - ④ HORIZONTAL AMPLIFIER
 - ⑤ TIMING SWITCH DETAILS
 - ⑥ PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY

WAVEFORMS & VOLTAGE READINGS

① TRIGGER & HOLD-OFF

② FAST RAMP

④ HORIZONTAL AMPLIFIER

⑤ TIMING SWITCH DETAILS

⑥ PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY

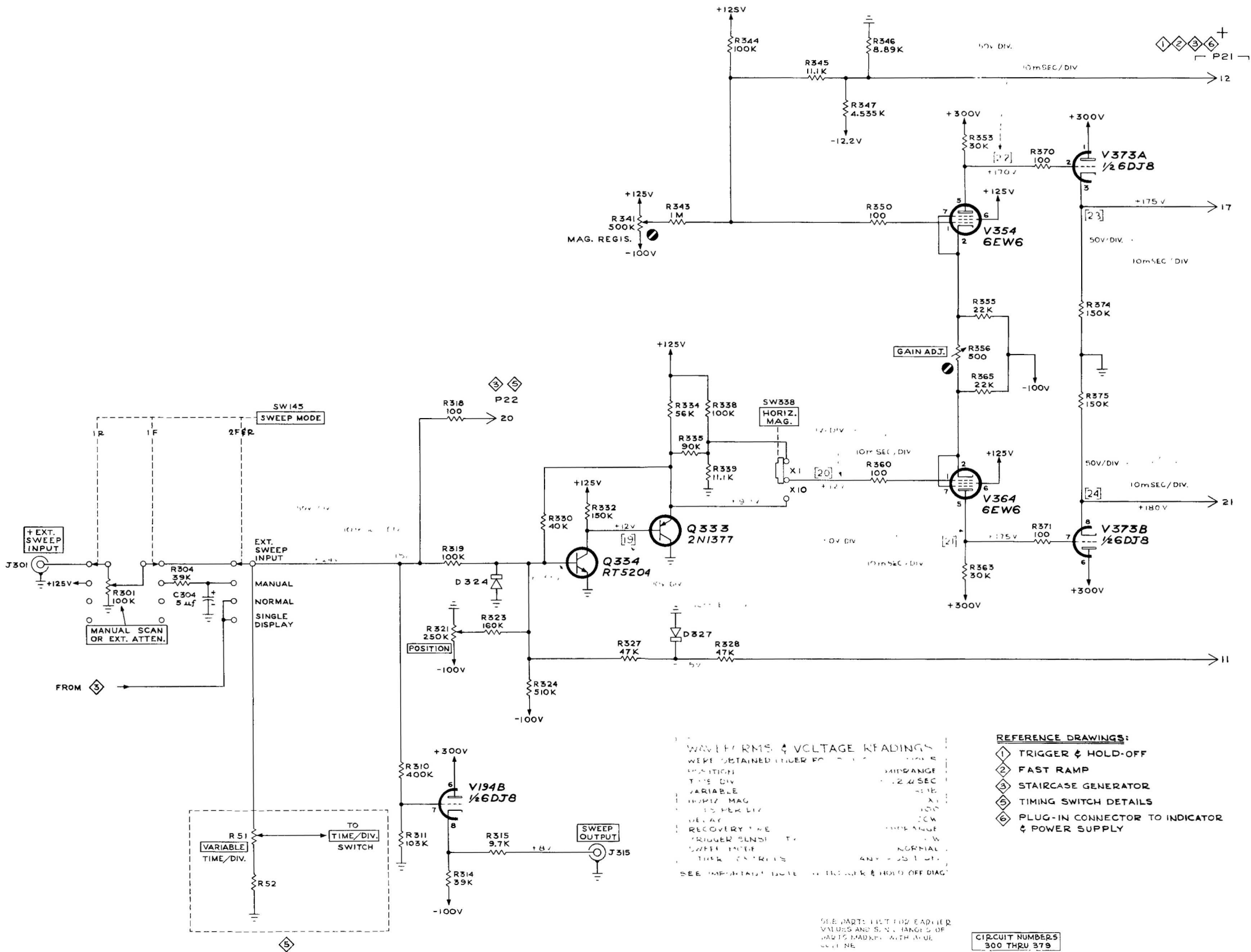
UNBLANKING TO CRT

SWEEP GATE TO DIGITAL READOUT

CIRCUIT NUMBERS 100 THRU 199

PLM 465

STAIRCASE GENERATOR



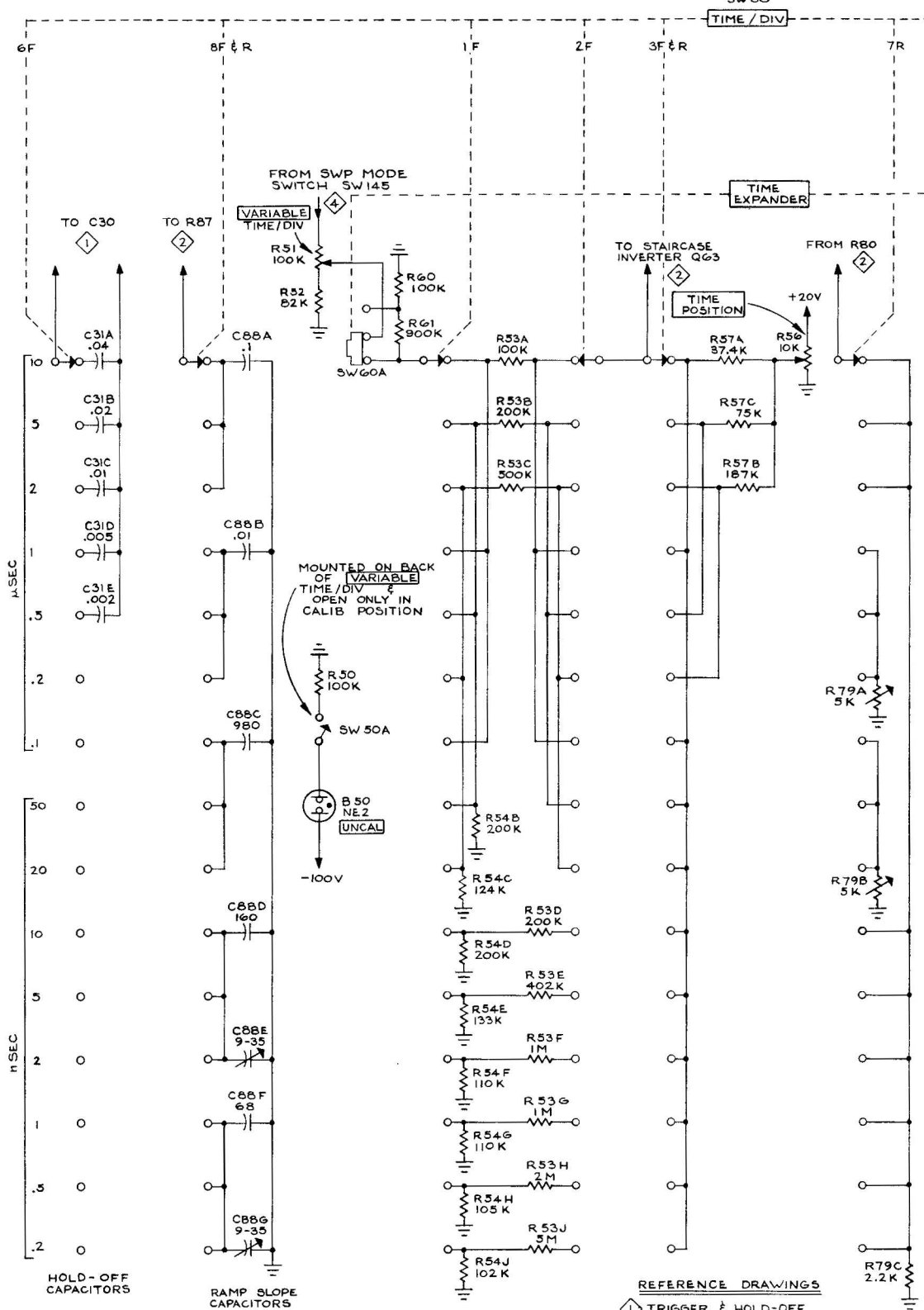
WAVEFORMS & VOLTAGE READINGS
 WERE OBTAINED UNDER FOLLOWING CONDITIONS:
 POSITION RANGE 100%
 TIME/DIV. 10m SEC/DIV.
 VARIABLE MAG. 100%
 DELAY 100%
 RECOVERY TIME 100%
 TRIGGER SENSITIVITY 100%
 SWEEP MODE NORMAL
 OTHER CONTROLS AS SHOWN
 SEE IMPORTANT NOTE ON TRIGGER & HOLD-OFF DIAG.

- REFERENCE DRAWINGS:**
- ① TRIGGER & HOLD-OFF
 - ② FAST RAMP
 - ③ STAIRCASE GENERATOR
 - ④ TIMING SWITCH DETAILS
 - ⑤ PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY

SEE PARTS LIST FOR EXACTER
 VALUES AND SERIAL RANGES OF
 PARTS MARKED WITH AN
 SUFFIX LETTER.

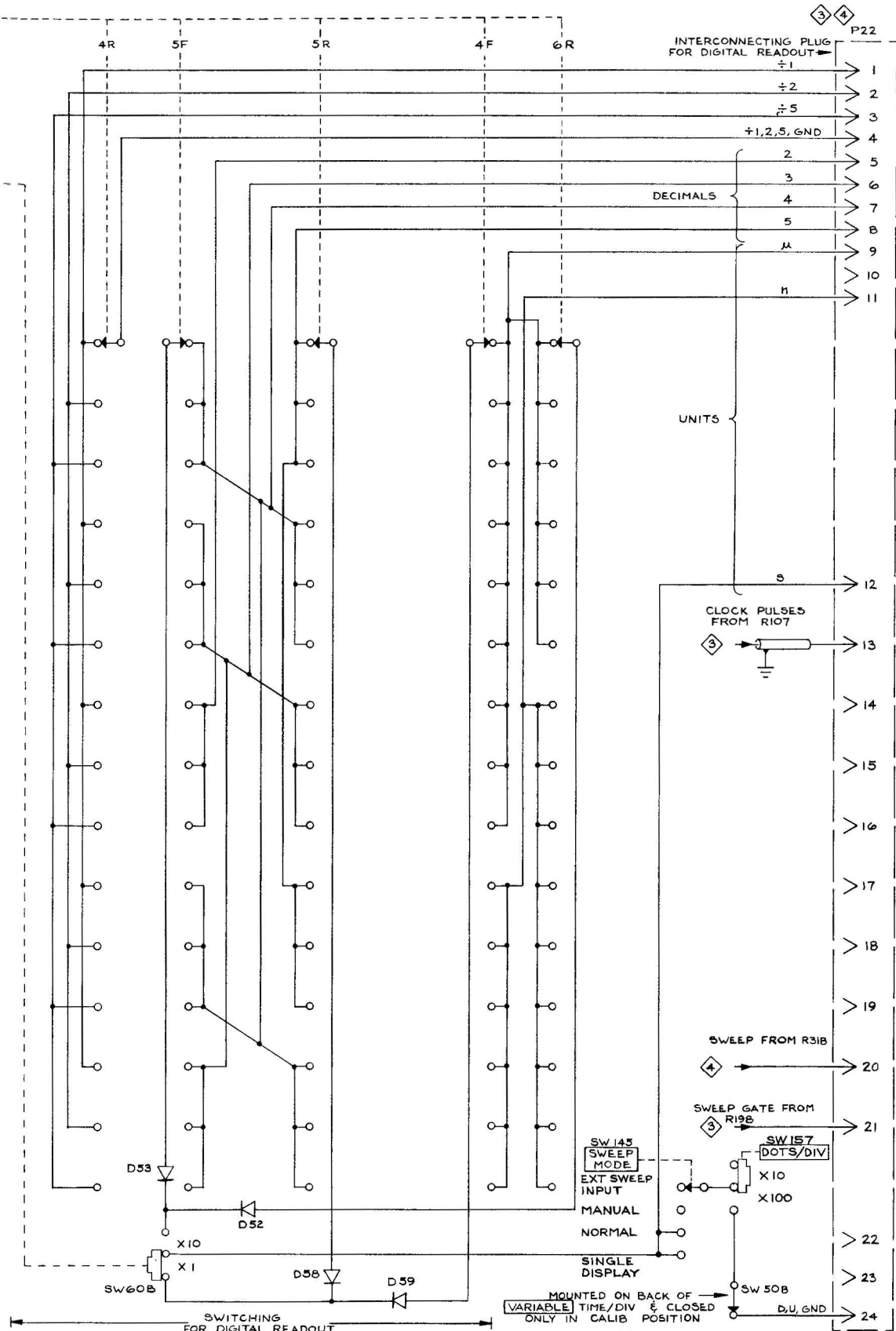
CIRCUIT NUMBERS
 300 THRU 379

CMP
 563

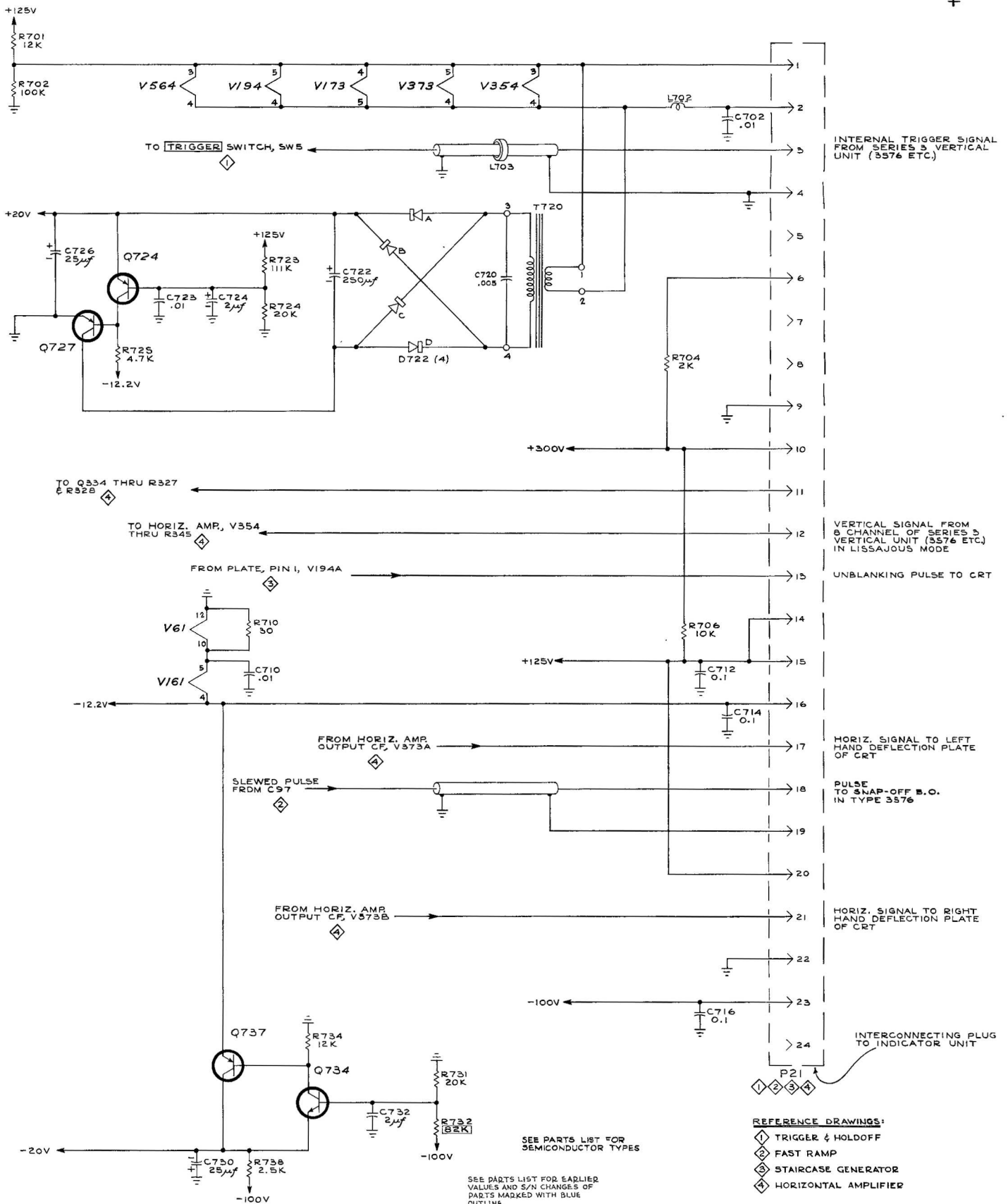


- REFERENCE DRAWINGS
- ① TRIGGER & HOLD-OFF
 - ② FAST RAMP
 - ③ STAIRCASE GENERATOR
 - ④ HORIZONTAL AMPLIFIER

TYPE 3T77A SAMPLING SWEEP UNIT
 SEE PARTS LIST FOR SEMICONDUCTOR TYPES



⑤ TIMING SWITCH
 266
 S/N 4000-UP



INTERNAL TRIGGER SIGNAL FROM SERIES 3 VERTICAL UNIT (3576 ETC.)

VERTICAL SIGNAL FROM B CHANNEL OF SERIES 3 VERTICAL UNIT (3576 ETC.) IN LISSAJOUS MODE

UNBLANKING PULSE TO CRT

HORIZ. SIGNAL TO LEFT HAND DEFLECTION PLATE OF CRT

PULSE TO SNAP-OFF B.O. IN TYPE 3576

HORIZ. SIGNAL TO RIGHT HAND DEFLECTION PLATE OF CRT

INTERCONNECTING PLUG TO INDICATOR UNIT

- REFERENCE DRAWINGS:
- ① TRIGGER & HOLDOFF
 - ② FAST RAMP
 - ③ STAIRCASE GENERATOR
 - ④ HORIZONTAL AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

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

CIRCUIT NUMBERS 100 THRU 133

PLM 565

TYPE 3T77 PLUG-IN UNIT

PLUG-IN CONNECTOR TO INDICATOR & POWER SUPPLY

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages. If it does not, your manual is correct as printed.

TYPE 3T77 -- TENT SN 3440*

CHANGE TO:

D22	152-0203-00	Tunnel	20 mA	
L14	108-0170-00	.5 μ H		
Q33	151-0162-00	Replaceable by 2N3324		
R33	316-0122-00	1.2 k Ω	1/4 W	10%

*Some instruments with earlier Serial Numbers may contain these changes. The modification may be identified by Part Number 388-0605-01 on the Trigger and Fast Ramp circuit board.

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TEXT CORRECTIONS

General Information

As a result of certain circuit improvements in the Type 3T77, the instrument designation has been changed to Type 3T77A to distinguish the new version from the older one.

In general, the new circuitry substitutes a Time Expander for the Horizontal Magnifier and substitutes a Time Position control for the Delay control. The Time Expander provides display expansion without decreasing the display dot density (dots/div), and the Time Position control provides display positioning that is commensurate with the sweep rate used, rather than a fixed-range delay. This permits the display to be positioned through at least one screen diameter on all equivalent sweep rates.

Control Name Changes

Because of possible confusion between names, the POSITION control has been renamed the HORIZONTAL POSITION control to distinguish it from the TIME POSITION control. Therefore, wherever the manual refers to the POSITION control, it should be interpreted as the HORIZONTAL POSITION control. This control positions the display with respect to the CRT graticule, whereas the TIME POSITION control positions the signal display through a "time window" that is referenced to the triggering signal.

Wherever the text refers to the HORIZ MAG switch, interpret this as the TIME EXPANDER switch. The same general function is accomplished by the TIME EXPANDER switch, with the following differences: (1) the dot density of the display is the same whether the TIME EXPANDER is at X1 or X10 (this means that there are actually 10 times as many dots per unit equivalent time on the displayed signal); (2) the display expands following the left edge of the display, rather than from the center of the display; (3) the trace length does not change and does not extend past the normal limits of the CRT screen.

Except where instructed otherwise, interpret any references to the DELAY control in the manual text as the TIME POSITION control. Please note, however, that the TIME POSITION control is display-oriented and operates in the opposite direction from that of the DELAY control described in the manual. That is,

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when the TIME POSITION control is turned toward the right (clockwise), the display moves toward the right. Minimum delay of the displayed signal, with respect to the triggering signal, is obtained with the TIME POSITION control turned fully clockwise. (With the former DELAY control, minimum delay was obtained when the control was turned fully counterclockwise, so that when the control was turned clockwise, increasing the delay with respect to the triggering signal, the display moved toward the left.) Wherever the instructions in the manual say to turn the DELAY control in a particular direction, it will be necessary to turn the TIME POSITION control in the opposite direction.

SECTION 1 -- CHARACTERISTICS

Page 1-1, column 1,
Substitute the following for the subsection titled

External Triggering:

Pulse Amplitude and Width Requirements -- 10 millivolts, peak to peak minimum amplitude, with at least 2 nanoseconds of pulse width. Maximum useable trigger pulse amplitude is approximately 800 millivolts. Overload damage may occur in the External Trigger Input circuit if a signal amplitude of 5 volts or more is applied.

Pulse Triggering Repetition Rate -- Up to 10^9 pulses/second (1 gigacycle). Trigger circuitry counts down to a sampling rate of approximately 100 kilocycles or less, depending on the sweep rate used. Pulse triggering jitter is typically no greater than 50 picoseconds or 0.1% of the fast ramp duration (whichever is greater) with a pulse signal of 50 millivolts amplitude and 2 nanoseconds pulse width.

Sine-Wave Triggering Frequency -- From 100 kilocycles through 1 gigacycle. (Trigger circuitry counts down as described under Pulse Triggering.) Sine-wave triggering jitter varies with signal amplitude, frequency and sweep rate. Typical jitter is less than 50 picoseconds on a 100-millivolt/50-megacycle sine wave. Synchronized triggering mode provides stable triggering above 30 megacycles.

Page 1-1, column 2,
Substitute the following for the subsection titled Delay:

Time Positioning

Adjustable to position the start of the display by at least one screen

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diameter (up to approximately 45 screen diameters at the fastest sweep rates) for a non-expanded display; permits the displayed signal to be positioned through at least 10 screen diameters (up to 450 diameters) with the TIME EXPANDER switch at X10.

Disregard the subsection titled Accessories Supplied With the Type 3T77 and refer to the Accessories list in the Mechanical Parts List.

SECTION 2 -- OPERATING INSTRUCTIONS

Page 2-1,

Under Function of Front-Panel Controls and Connectors, delete the paragraphs titled: POSITION Control; HORIZ MAG Switch; DELAY Control and RECOVERY TIME Control, and substitute the following:

HORIZONTAL POSITION Control

Positions the display horizontally on the CRT screen.

TIME EXPANDER Switch

Selects X1 or X10 time magnification of displayed signal without changing the dot density (dots/div).

TIME POSITION Control

Positions the start of the display through a time window of at least one screen diameter (with respect to the triggering signal) for a non-expanded display, or at least 10 screen diameters for a time-expanded display.

RECOVERY TIME Control and FULL FOR SYNC Switch

Control varies the trigger holdoff time over a range determined by the sweep rate to assure stable triggering; switch permits synchronized triggering on input signals between 30 megacycles and 1 gigacycle.

Page 2-2, column 1,

Under Displaying a Signal, replace step 7 with the following:

7. Turn the TIME POSITION control and notice its effect on the display. The TIME POSITION control varies the position of the displayed pulse with respect to the start of the trace. On this sweep rate (5 nSEC/DIV), the time position of the pulse can be varied over a range of approximately 150 nanoseconds.

Page 2-3, column 1,

At the end of the subsection titled Triggering the Type 3T77A (which starts on page 2-2), add the following two paragraphs:

Internal triggering of the Type 3T77A can be used only with a sampling unit such as the Type 3S76 which provides a triggering signal to the Type 3T77A from an internal trigger takeoff circuit. When using a sampling unit such as the Type 3S3 which has no trigger takeoff, an external trigger signal must be provided for the Type 3T77A.

For triggering on signals below 30 megacycles, leave the PULL FOR SYNC switch pushed in. Adjust the TRIGGER SENSITIVITY control and RECOVERY TIME control as described under Displaying a Signal in the Operating Instructions. For signals above 30 megacycles, pull out the PULL FOR SYNC knob and adjust the TRIGGER SENSITIVITY and RECOVERY TIME controls as follows: Start with the TRIGGER SENSITIVITY control turned fully clockwise (free run position) and the RECOVERY TIME control fully counterclockwise (minimum trigger holdoff), then adjust the TRIGGER SENSITIVITY control for a stable display. It is usually not necessary to adjust the RECOVERY TIME control for synchronized triggering (above 30 megacycles), but the control may be adjusted for increased stability on signal frequencies approaching 1 gigacycle.

Under Selecting the Equivalent Sweep Rate, delete the last two sentences in the first paragraph and substitute the following: Setting the TIME EXPANDER switch to X10 increases the equivalent sweep speed by a factor of 10 at any setting of the TIME/DIV switch without changing the dot density of the display. This expands the display from the starting point of the sweep so that the first major division of the display (at the left edge of the screen) covers the entire graticule horizontally. Time expansion takes place in this manner regardless of the time positioning of the non-expanded display.

Page 2-3, column 2,

Delete the phrase "or the HORIZ MAG switch must be set to X10" in the paragraph under Fig. 2-2.

SECTION 4 -- CIRCUIT DESCRIPTION

Page 4-3 and 4-4,

Substitute the following for the entire subsection titled Trigger and Holdoff Circuit:

When the Type 3T77A is in the triggerable condition, tunnel diodes D22, D25 and D42 are in the low-voltage state and transistors Q14, Q24, Q33 and Q34 are turned off. Back diode D18 is in the high-voltage stage, conducting approximately 100 μ A of current. With Q24 and Q33 turned off, diodes D27 and D28 are reverse biased and diode D31 is forward biased, holding the emitter of Q33 at +20 volts. The base of Q34 is clamped one junction below ground by current through D32, thus trigger holdoff capacitors C30 and C31 are charged to about 20 volts.

The input triggering signal is applied through the TRIGGER Source switch, SW5, to the emitter of common-base amplifier Q14, either from the trigger take-off circuit of the vertical sampling unit or from the TRIGGER EXT INPUT J7 on the front of the Type 3T77A. Triggering is initiated when the triggering signal increases current through Q14 and D22 to the switching point of the tunnel diode, causing D22 to switch to its high-voltage state. The amount of current increase through Q14 that is required to switch D22 is determined by the current setting of the SENSITIVITY control, R19, and the TRIG SENS RANGE adjustment, R21.

Pulse and Sine-Wave Triggering. For normal triggered operation (for signals below 30 megacycles), the PULL FOR SYNC switch is pushed in, effectively disconnecting C26 from the circuit. As D22 switches to its high-voltage state, the positive-going switching pulse passes through R25 and C25 to D25, switching D25 to its high-voltage state. A positive-going step is applied to the base of Q24 and to the anode of D42 when D25 switches to its high state, turning on Q24 and switching D42 to its high-voltage state. As D42 switches, a trigger pulse is sent to the Fast Ramp circuit to initiate the operation of that circuit.

As Q24 turns on, starting the holdoff cycle of the Trigger circuit, its collector drops toward ground, turning on Q33 and forward biasing D27 and D28. The increased current through R21 and R22 and through R24 and R26 causes D22 and D25 to reset to the low-voltage state. The negative-going voltage step that resets D25 is also applied to the base of Q24, turning that transistor off again. Even though Q24 is turned on for only a short period of time, it discharges trigger holdoff capacitors C30 and C31 during that time by means of the

low-impedance current path through D32. When Q24 then turns off, its collector voltage starts to go positive, turning on Q34 through the holdoff capacitors. As D32 becomes reverse biased, C30 and C31 have to charge through the relatively high impedance of R30 (RECOVERY TIME) and R31, so the voltage at the collector of Q24 rises slowly after the initial small fast step. The charging current for holdoff capacitors C30 and C31 is obtained through Q34, holding the transistor turned on for the period of time determined by the RC time constant of C30, C31, R30 and R31.

Diodes D27 and D28 are reverse biased as Q34 turns on, but tunnel diodes D22 and D25 are held in their low-voltage state for the remainder of the hold-off cycle by current through Q34 and D26. When C30 and C31 have charged to the point that the anode of D31 reaches +20 volts, this diode becomes forward biased again, clamping the voltage at +20 volts. With the charging current removed from Q34, the transistor turns off, ending the holdoff interval as bias is restored to D22 and D25. The circuit is then ready to be triggered by the next excursion of the input triggering signal.

If the TRIGGER SENSITIVITY control, R19, is set to its maximum resistance position (fully clockwise), the circuit free runs. In this case, D22 switches to its high state each time Q34 turns off at the end of the holdoff interval.

Synchronized Triggering. When the PULL FOR SYNC switch is pulled out, SW30 connects C26 to ground, slowing down the recovery of tunnel diode D25 at the end of the holdoff interval. This permits D22 to be triggerable for a short period of time before bias is restored to D25. For trigger signals above about 30 megacycles, back diode D18, inductor L14 and tunnel diode D22, in conjunction with R18 and R19, form a monostable multivibrator that synchronizes with the input signal during the time that D22 is triggerable and before bias has been restored to D25. During this short interval, D22 and D18 switch back and forth between the low-voltage state and the high-voltage state (about 3 to 9 times) as current through Q14 increases and decreases. The first trigger pulse produced by D22 after D25 has recovered to the triggerable bias level switches D25 to its high-voltage state, starting the operation of the holdoff circuit in synchronization with an excursion of the triggering signal. The cycle of operation of the holdoff circuit is then essentially the same as that for pulse or sine-wave triggered operation, except that C26 is discharged through D26 when Q34 turns on.

When Q3⁴ turns off at the end of the holdoff cycle, diode D22 becomes triggerable as its bias is restored, but the bias level returns more slowly to D25 as C26 becomes charged. Thus D22 again becomes synchronized with the input signal as D25 recovers to its triggerable level through an RC time constant of about 1 microsecond.

Pages 4-4 and 4-5,

Substitute the following for the entire subsection titled Fast Ramp:

This circuit generates a fast-ramp waveform, compares it with an existing slow-ramp voltage from the Staircase Generator, and produces a positive-polarity slewed pulse. The fast-ramp waveform is developed across Ramp Slope Capacitor C88 and compared with the slow-ramp (staircase) waveform at Q93A. The negative-going slewed pulse is generated by D93 and is inverted and amplified by Q94.

The action of the Fast Ramp circuit is initiated by the positive-going trigger from the Trigger and Holdoff circuit which is coupled through common-base amplifier Q74. The collector current of Q74 switches fast-ramp gate diode D74 from its quiescent high state to its low state. The resulting fast positive step turns off Q84, diverting the current from constant-current tube V61 into the Ramp Slope Capacitor. Charging of this capacitor carries the cathode of D90 in the negative direction.

The staircase voltage from the Staircase Generator is applied to the Slow-Ramp Inverter through an attenuator consisting of R51 (VARIABLE TIME/DIV), R52, R60, R61, R53 and R54 (see the Timing Switch schematic in this insert). At the input to this attenuator, the signal is a 50-volt positive-going staircase of 100 or 1000 steps, depending on the setting of the DOTS/DIV switch, SW157, shown on the Staircase Generator diagram. Thus, each step of the waveform (into the attenuator) is either 0.5 or 0.05 volt in amplitude. Transistors Q63 and Q64 form an inverting amplifier with a feedback resistance of 10 k Ω . The gain of this stage, from the input of R51 to the output of R90, ranges from 0.1 to 0.0002, depending on the value of R53 selected by the TIME/DIV switch, and by the position of the TIME EXPANDER switch, SW60A. When SW60A is switched from the X1 position to the X10 position, R61 is connected in series with R53, decreasing the gain of the Slow-Ramp Inverter by a factor of ten. Attenuator resistors R60 and R54 maintain a constant load on the Staircase Generator. The steps at the base of Q93A are negative-going steps of 50-millivolt to 0.01-millivolt amplitude. The smaller the steps, the

less the equivalent time between samples and the faster the equivalent sweep rate. When the TIME/DIV VARIABLE control is in the CALIB position, the wiper arm is at the top of R51, as shown on the schematic. Thus, as the control is moved away from the CALIB position, the resistance of R51 increases, decreasing the size of the steps at the base of Q93A and consequently increasing the equivalent sweep rate.

Each time the fast ramp starts, the base of Q93A is negative with respect to its emitter, so the transistor is not conducting. When the fast-ramp voltage at the cathode of D90 falls below the base voltage of Q93A, D90 and D93A turn on, increasing current through D93 which is quiescently in its low state.

When this happens, D93 switches to its high state, developing a negative step that is applied to the base of Q94. The resulting positive step at the collector of Q94 is the slewed pulse which is differentiated through C97 and applied through the interconnecting plug to the vertical plug-in unit to start the sampling process. The slewed pulse is also applied through R99 to the Staircase Generator to advance the staircase one step, and to the base of Q93B to reset tunnel diode D93 to its low state.

The negative step at the cathode of D93 is also coupled back through D75 and L75 to switch D74 back to its quiescent high state. This turns Q84 on again, ends the fast ramp, and discharges the Ramp Slope Capacitor.

The slope of the fast ramp is changed between timing ranges by changing the size of the Ramp Slope Capacitor. The steeper the ramp, the less difference there is in the time required for the ramp to reach successive levels of the staircase at Q93A. Thus, the equivalent time per division is controlled by varying both the size of the steps at the base of Q93A and the slope of the fast ramp at the emitter of Q93A.

The DC level of the Slow-Ramp Inverter output is varied by the TIME POSITION control, R58, to move the comparison level and thus the comparison time with respect to the triggering event.

SECTION 6 -- CALIBRATION

Refer to the General Information portion of this insert for changes in control names and operation of the controls. In addition to the name changes

given in the General Information, the following internal adjustment names have been changed: DELAY ZERO R58 is now TIME POSITION ZERO R58; MAG REGIS R341 is now SWEEP CENTERING R341. The locations of these controls in the instrument remain the same as those of the previous controls.

Page 6-1, column 1,

Delete item 6 of the Equipment Required list and substitute the following:

6. 1-Gigacycle Oscillator (e.g., General Radio Type 1361A). Frequency variable between 450 megacycles and 1 gigacycle with an accuracy within $\pm 1\%$; output amplitude approximately 100 millivolts into 50 ohms.

Page 6-1, column 2,

Add the following two items to the Equipment Required list:

12. 50-ohm 5XT attenuator with GR connectors (Tektronix Part Number 017-0079-00).

13. Coaxial cables and connector adapters as required for connecting between instruments.

Under Preliminary Procedure, change the warm-up time to 20 minutes. Also under Preliminary Procedure, add the following Type 3T77A control settings:

TRIGGER Source	+INT
RECOVERY TIME	Counterclockwise
FULL FOR SYNC	Pushed In

Page 6-2,

Delete the Trigger Sensitivity Range step given in the manual and substitute the following:

Trigger Sensitivity Range

1. Connect the test oscilloscope 10X probe to the junction of L14 and D22 (the outside end of L14 on the Trigger and Fast Ramp circuit board in the instrument, near test point 1 in Fig. 6-3).

2. Observe the waveform with a test oscilloscope sweep rate of 5 $\mu\text{sec}/\text{div}$ and a deflection factor of 0.2 volt/div, including probe. The waveform should be similar to that shown at the cathode of D18 on the Trigger and Holdoff schematic in the manual.

3. Turn the TRIGGER SENSITIVITY control counterclockwise and check that the waveform disappears when the control is turned counterclockwise through the

12 o'clock position (straight up).

4. Adjust R21 TRIG SENS RANGE if operation of the TRIGGER SENSITIVITY control is not correct as described in the previous step.

Page 6-2, column 2,

Delete the D25 CURRENT RANGE adjustment and substitute the following:

D25 Current Range Adjustment

1. Leave the test oscilloscope connected to the test point at the junction of L14 and D22.

2. Turn the TRIGGER SENSITIVITY control fully clockwise and pull out the PULL FOR SYNC knob.

3. Set the test oscilloscope sweep rate to 0.2 μ sec/division.

4. Adjust R24 (the potentiometer near D25 on the Trigger and Fast Ramp circuit board) for approximately 9 pulse cycles in the waveform on the test oscilloscope CRT screen. Push in the PULL FOR SYNC knob.

5. Disconnect the probe from the test point.

Perform the Trigger Regenerator Sensitivity Adjustment as given in the manual.

Page 6-3, column 1,

Perform the Power Supply Ripple and Regulation check as given in the manual, except that substep 3 should be moved to the start of the step (before substep 1).

Delete the entire step titled Magnifier Registration.

Before performing the Gain adjustment, turn off the oscilloscope and disconnect the extension cable. Insert the Type 3T77A into the oscilloscope and turn on the power again. Allow about 3 minutes warm up before proceeding.

Perform steps 1 and 2 of the Gain adjustment as given in the manual. Delete the remainder of the step and substitute the following:

3. From the Amplitude Calibrator of the test oscilloscope, apply a 100-volt signal to the Type 3T77A +EXT SWEEP INPUT connector.

4. Connect the test oscilloscope probe to test point 18 (shown on the Horizontal Amplifier schematic diagram). Set the test oscilloscope for a deflection factor of 10 volts/div, including probe.

5. Set the Type 3T77A EXT ATTEN control to produce 4 div of deflection (40 volts) on the test oscilloscope screen.

6. Adjust the GAIN ADJ control on the front panel of the Type 3T77A for a horizontal deflection of 8 div between dots on the test oscilloscope CRT screen.
7. Remove the Amplitude Calibrator signal from the Type 3T77A +EXT SWEEP INPUT.

Page 6-3, column 2,

Perform the Staircase Generator DC Level adjustment as given in the manual.

Delete step 1 of the Sweep Length adjustment and perform steps 2 and 3 as given in the manual.

Add the following step between the Sweep Length Adjustment and the Inverter Amplifier Input Zero adjustment:

Sweep Centering

1. Turn the HORIZONTAL POSITION control fully clockwise then fully counter-clockwise and note the display positioning as observed from the position of the end of the trace in the extreme positions of the control.
2. Adjust R341 SWEEP CENTERING so that the left end of the trace is the same distance to the right of the center vertical line with the HORIZONTAL POSITION control turned fully clockwise as the right end of the trace is to the left of the center vertical line with the HORIZONTAL POSITION control turned fully counter-clockwise.
3. Set the HORIZONTAL POSITION control to position the start of the trace to the left edge of the graticule.

Perform the Inverter Amplifier Input Zero adjustment as given in the manual. (The name of the DELAY ZERO is now TIME POSITION ZERO R58).

Perform the first 19 substeps of the Timing adjustments as given in the manual. In substep 1, set the TIME POSITION control fully clockwise. In substep 8, substitute R94 1st COMP REGEN SENS for DELAY ZERO in the parentheses. Delete substeps 20 through 28 and substitute the following:

The final two timing adjustments require the use of the 1-gigacycle oscillator described under Equipment Required.

20. Set the TIME/DIV switch to 5 nSEC and apply a 500-megacycle signal through a 5-nsec coaxial cable and a 5X attenuator to the Channel A Input of the vertical plug-in unit.

21. Adjust the signal amplitude for 6 divisions of vertical deflection on the CRT screen.

22. Refer to the following table to adjust C88E and C88G. These adjustments should be made on the first TIME/DIV setting given for each adjustment in the table, but may be readjusted slightly if necessary so that timing is correct on all three TIME/DIV settings that are affected.

TIME/DIV	Adjust	Display
5 nSEC	C88E	2.5 cycles/div
10 nSEC		5 cycles/div
2 nSEC		1 cycle/div
1 nSEC	C88G	1 cycle/2 div
.5 nSEC		1 cycle/4 div
.2 nSEC		1 cycle/10 div

23. Remove all connections.

Page 6-5,

Perform the remainder of the Calibration procedure as given in the manual. In substep 3 of the Comparator Regenerator Sensitivity adjustment, remember that the TIME POSITION control must be set fully clockwise for minimum delay.

PARTS LIST CORRECTION

REMOVE:

R57D	309-0155-00	40 k Ω	1/2 W	1%
R57E	301-0226-00	22 M Ω	1/2 W	5%
SW338	260-0145-00	Slide	HORIZ	MAG

ADD:

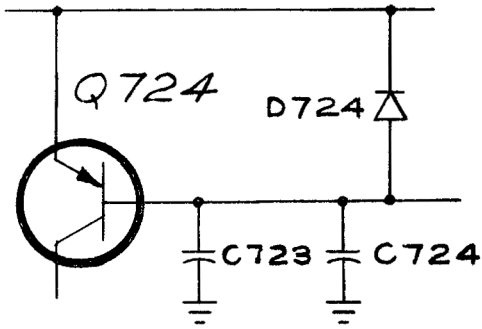
C155	283-0003-00	0.01 μ F	Cer	150 V
D52	152-0066-00	Silicon, Replaceable by 1N3194		
D53	152-0066-00	Silicon, Replaceable by 1N3194		
D95	152-0185-00	Silicon, Replaceable by 1N6185		
D96	152-0185-00	Silicon, Replaceable by 1N6185		
D724	152-0141-00	Silicon, Replaceable by 1N3605		
L75	108-0260-00	0.1 μ H		
R60	323-0611-00	900 k Ω	1/2 W	1%
R61	323-0385-00	100 k Ω	1/2 W	1%
R155	302-0121-00	120 Ω	1/2 W	5%
SW60A,B	260-0212-00	Slide	TIME EXPANDER	

CHANGE TO:

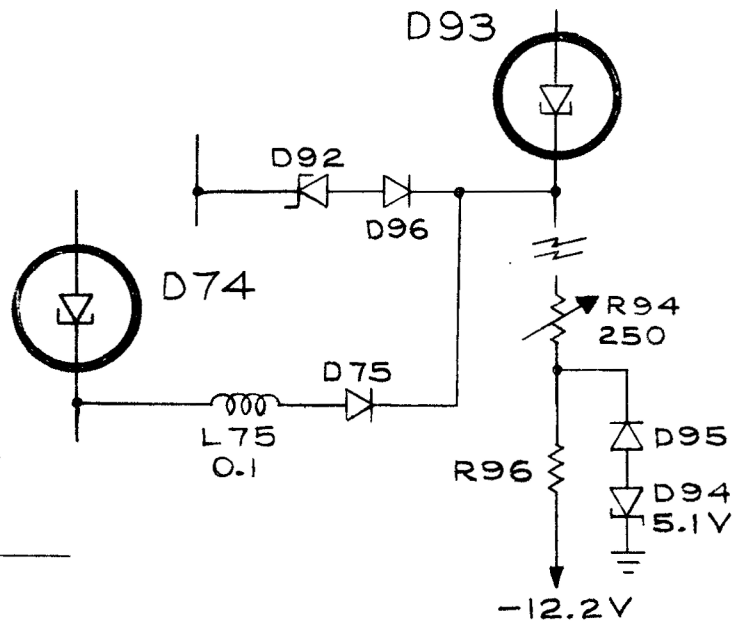
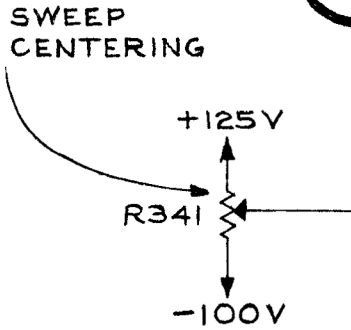
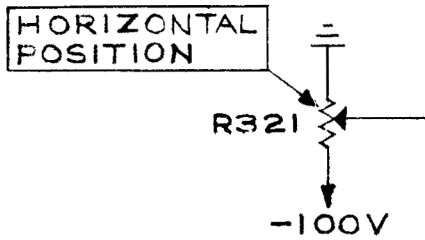
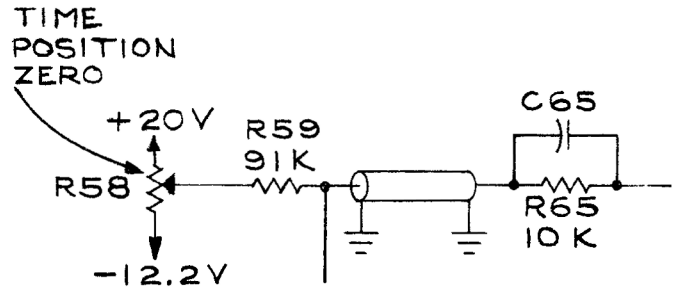
C30	283-0088-00	0.0011 μ F	Cer	5%
C31A	285-0629-00	0.047 μ F	P1M	100 V
C31B	283-0004-00	0.02 μ F	Cer	150 V
C31C	283-0003-00	0.01 μ F	Cer	150 V
C31D	283-0110-00	0.005 μ F	Cer	150 V
C31E	283-0104-00	0.002 μ F	Cer	500 V
D94	152-0139-00	Zener, 1N751, 5.1 V		
Q334	151-0136-00	Silicon, 2N3053		
Q724	151-0133-00	Silicon, Tek Spec		
Q727	151-0165-00	Replaceable by 2N3614		
Q737	151-0165-00	Replaceable by 2N3614		
R31	301-0563-00	56 k Ω	1/2 W	5%
R53A	323-0385-00	100 k Ω	1/2 W	1%
R53B	323-0414-00	200 k Ω	1/2 W	1%
R53C	323-0452-00	499 k Ω	1/2 W	1%
R53D	323-0414-00	200 k Ω	1/2 W	1%
R53E	323-0443-00	402 k Ω	1/2 W	1%
R53F	323-0481-00	1 M Ω	1/2 W	1%
R53G	323-0481-00	1 M Ω	1/2 W	1%
R54B	323-0414-00	200 k Ω	1/2 W	1%
R54C	323-0394-00	124 k Ω	1/2 W	1%
R54D	323-0414-00	200 k Ω	1/2 W	1%
R54E	323-0397-00	133 k Ω	1/2 W	1%
R54F	323-0389-00	110 k Ω	1/2 W	1%
R54G	323-0389-00	110 k Ω	1/2 W	1%
R54H	323-0387-00	105 k Ω	1/2 W	1%
R54J	323-0386-00	102 k Ω	1/2 W	1%

CHANGE TO:

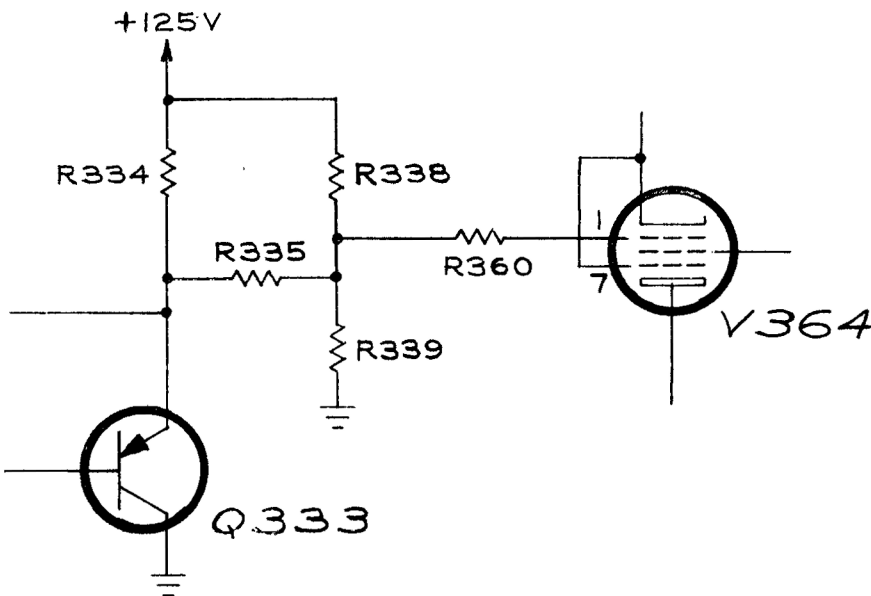
R57A	323-0344-00	37.4 k Ω	1/2 W	1%
R57B	323-0411-00	187 k Ω	1/2 W	1%
R57C	323-0373-00	75 k Ω	1/2 W	1%
R59	301-0913-00	91 k Ω	1/2 W	5%
R65	323-0289-00	10 k Ω	1/2 W	1%
R68	301-0303-00	30 k Ω	1/2 W	5%
R80	315-0333-00	33 k Ω	1/4 W	5%
R81	315-0333-00	33 k Ω	1/4 W	5%
R84	323-0284-00	8.87 k Ω	1/2 W	1%
R85	311-0120-00	2.5 k Ω	Var	
R87	316-0680-00	68 Ω	1/4 W	10%
R94	311-0485-00	250 Ω	Var	
R315	323-0288-00	9.76 k Ω	1/2 W	1%
SW88	262-0760-00	Rotary	TIME/DIV switch	



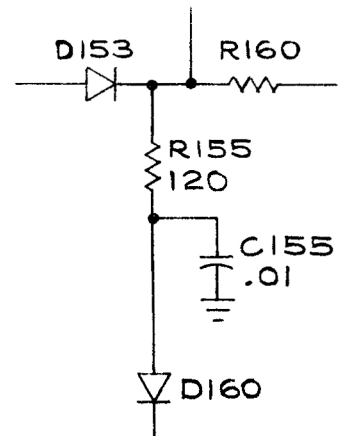
PARTIAL PWR SUPPLY



PARTIAL FAST RAMP



PARTIAL HORIZONTAL AMPLIFIER



PARTIAL STAIRCASE GEN

TYPE 3T77A TENT SN 4000

PARTS LIST CORRECTION

CHANGE TO:

D110

152-0071-00

Replaceable by ED2007

TYPE 3T77A TENT SN 4170

PARTS LIST CORRECTION

CHANGE TO:

D145	152-0061-00	Diode, Silicon, 6061
D152	152-0061-00	Diode, Silicon, 6061

TEXT CORRECTIONS

This information supplements and/or supersedes the information in your Manual.

The trigger circuit is changed to allow switching to a 'lock-on' type of operation when displaying high frequency sine waves. This eliminates the display break-up caused by drift in recovery time.

A new front-panel RECOVERY control with a push-pull switch replaces the old control. Pulling the switch to the ON position allows the RECOVERY control to synchronize the circuit on sine waves above approximately 30 mc. Pushed in, the same control is used to trigger on signals below 30 mc.

CIRCUIT DESCRIPTION

With the front-panel switch in the ON (pulled out) position, both D22 and D25 are off (in low state) during the hold-off interval between samples. At the end of the hold-off interval the collector of Q34 goes positive. This action restores the bias to D22 while at the same time the bias to D25 is allowed to 'crawl up' with an RC time constant of about a microsecond. D25 turns on after this interval, initiating a trigger pulse to the Fast Ramp. D22, L14 and BD-4 diode form a 50-nsec monostable multivibrator which can fire several times before D25 is finally triggered by D22. This allows the one-shot multivibrator to become better synchronized to the input sine wave with each succeeding cycle and thus provides a firmer lock than if the first cycle were used for triggering. The setting of potentiometer R24 (a form of recovery control) will determine the optimum triggering point for synchronized and pulse operation.

With the switch OFF, the capacitor of the hold-bias network is disconnected. This allows D25 to fire and generate a Fast Ramp pulse each time there is an input trigger to D22. This action corresponds to the pulse mode of operation.

CALIBRATION, Page 6-2

Change step 5 to read as follows:

5. Turn the TRIGGER SENSITIVITY control fully clockwise and note the repetition rate of the signal. This will be referred to under 'Trigger Regenerator Sensitivity'.

Following step 5 please add:

D25 CURRENT RANGE (S/N 2000 and higher only)

1. With the test oscilloscope connected to test point [1] and the TRIGGER SENSITIVITY control fully clockwise, pull out the PULL FOR SYNC knob on the RECOVERY TIME control.

2. Turn R2⁴ (D25 CURRENT RANGE) clockwise just to the point where the signal appears at test point [1].

3. Back off R2⁴ to about 10° past the point where the signal disappears. This is the proper setting of R2⁴.

4. Disconnect the test oscilloscope from test point [1] and push in the PULL FOR SYNC knob.