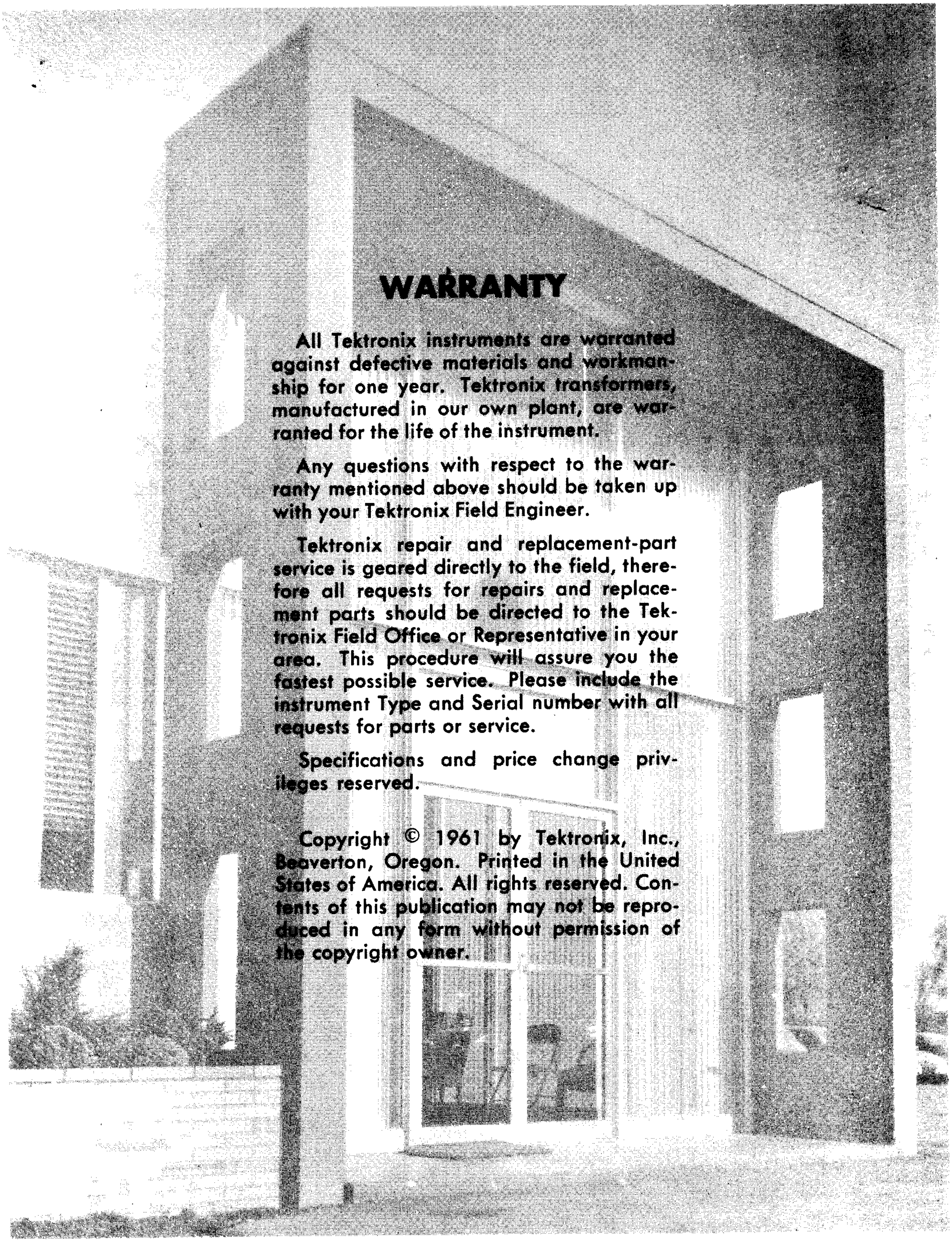
INSTRUCTION
MANUAL

TYPE 519
OSCILLOSCOPE

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix



WARRANTY

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

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

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial number with all requests for parts or service.

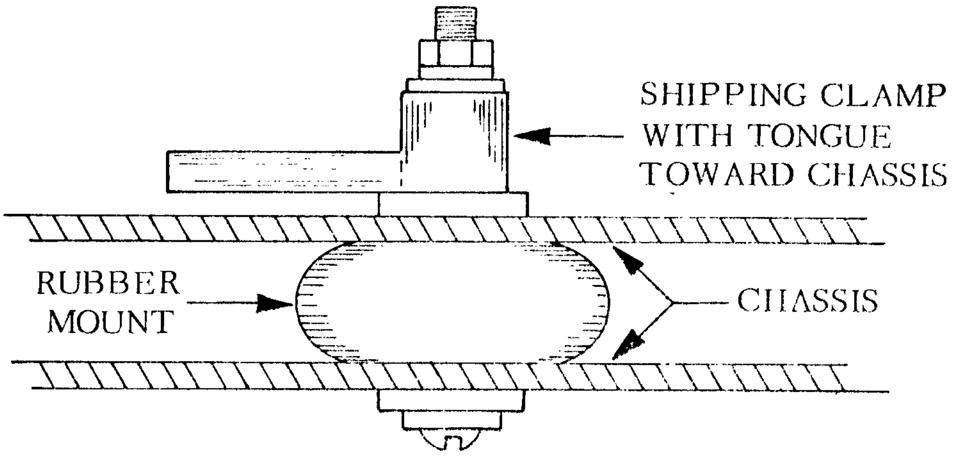
Specifications and price change privileges reserved.

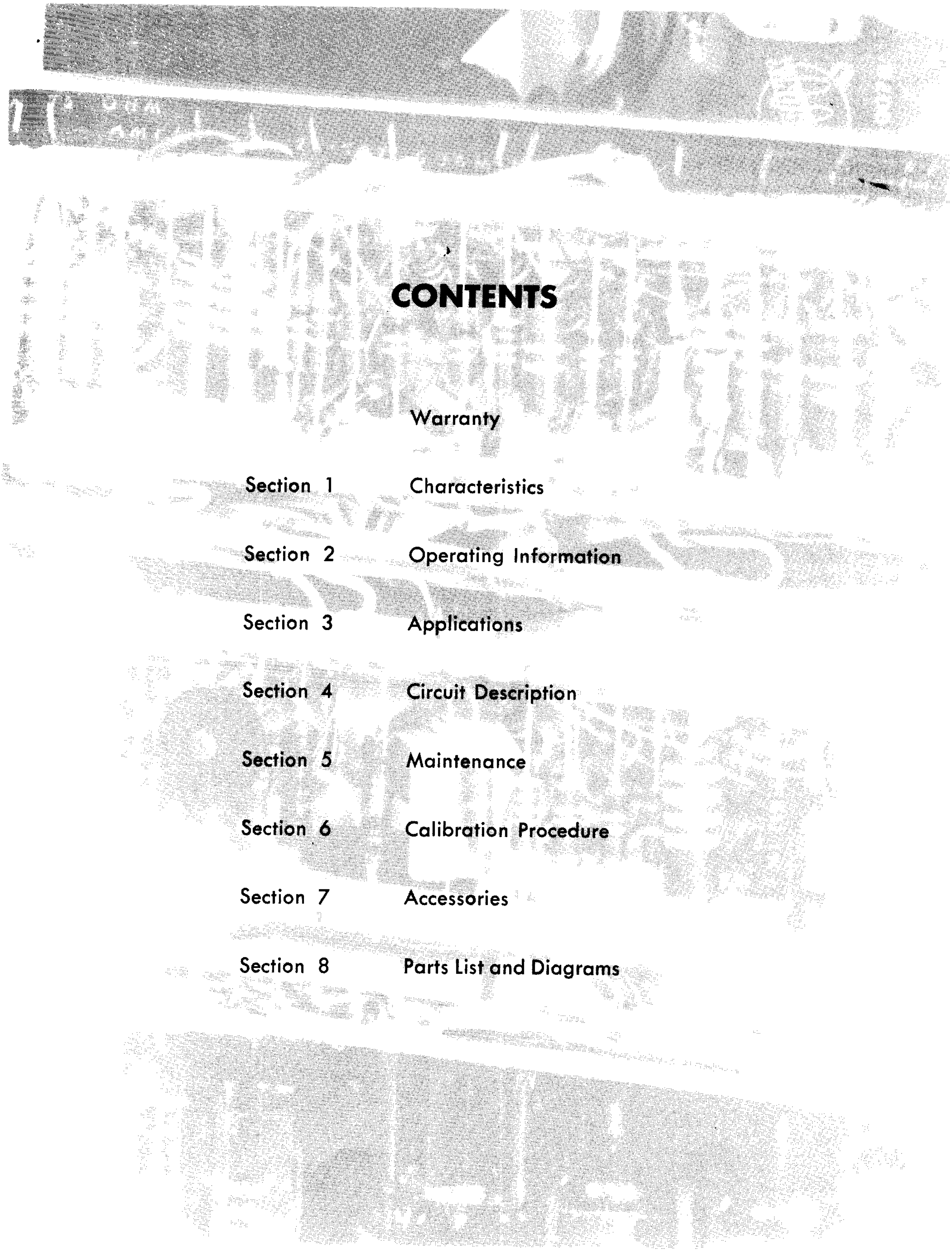
TYPE D, E, H, 122, 1121 and 519

IMPORTANT

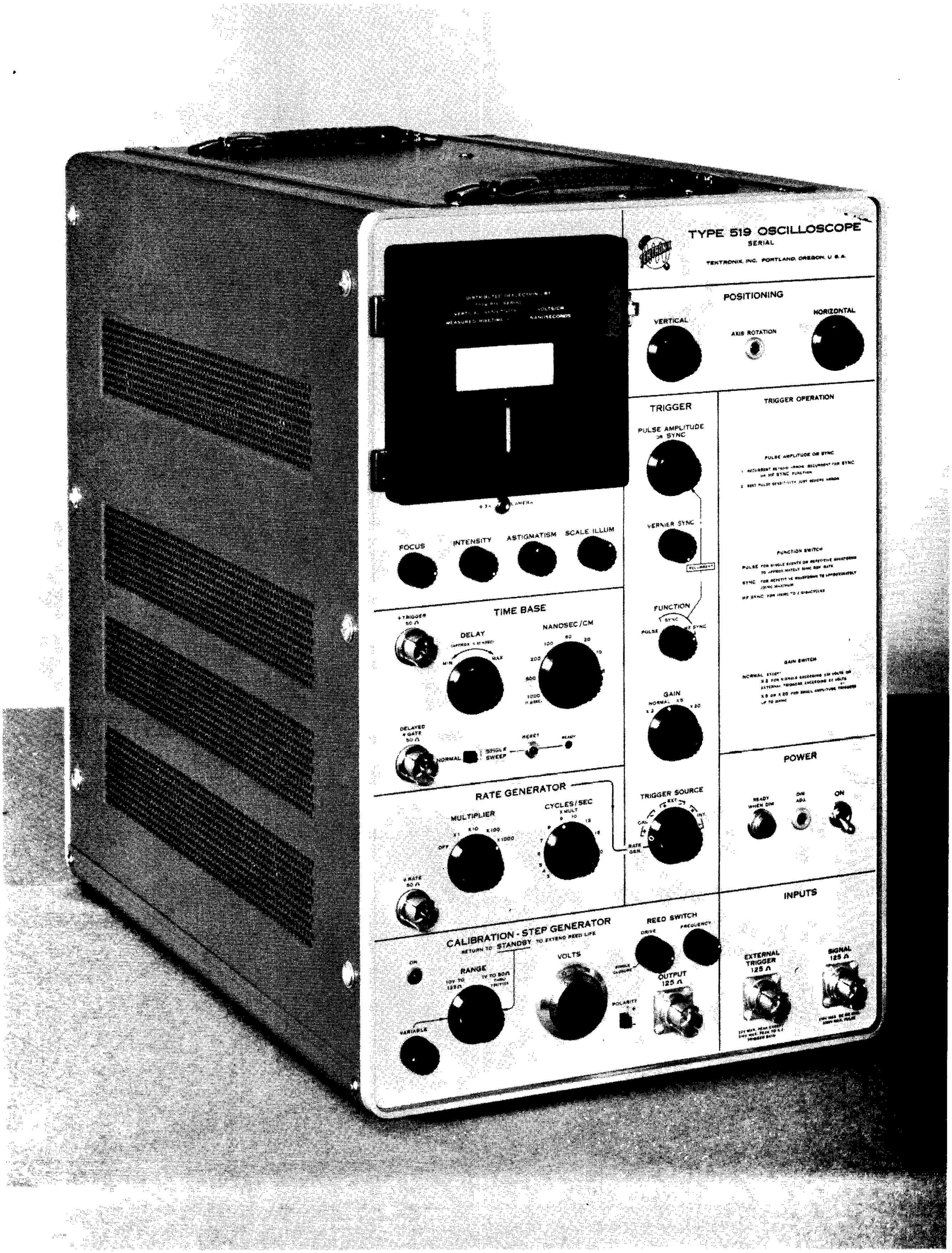
Before operating this instrument, be sure to remove the plastic shipping clamps from the shock mounts of the amplifier chassis. These clamps should be saved and reinstalled as shown in the sketch if the instrument is to be shipped. Be sure the tongue is inserted next to the chassis to prevent damage to the shock mount.

The clamp should be on the same side of the shock mount as the nut.





CONTENTS


TYPE 519 OSCILLOSCOPE
SERIAL
TEKTRONIX, INC. PORTLAND, OREGON, U.S.A.
POSITIONING
VERTICAL
AXIS ROTATION
HORIZONTAL
TRIGGER
PULSE AMPLITUDE OR SYNC
VERNIER SYNC
FUNCTION
PULSE
SYNC
HF SYNC
GAIN
NORMAL
TRIGGER SOURCE
CAL
EXT
INT
RATE GEN.
TRIGGER OPERATION
PULSE AMPLITUDE OR SYNC
FUNCTION SWITCH
GAIN SWITCH
POWER
READY WHEN DIM
DIM ADJ.
ON
INPUTS
EXTERNAL TRIGGER 125 Ω
SIGNAL 125 Ω
CAMERA
FOCUS
INTENSITY
ASTIGMATISM
SCALE ILLUM
TIME BASE
+ TRIGGER 50 Ω
DELAY
MIN
MAX
NANOSEC/CM
DELAYED + GATE 50 Ω
NORMAL
SINGLE SWEEP
RESET
READY
RATE GENERATOR
MULTIPLIER
OFF
X1
X10
X100
X1000
CYCLES/SEC
X MULT
+ RATE 50 Ω
CALIBRATION - STEP GENERATOR
RETURN TO STANDBY TO EXTEND REED LIFE
REED SWITCH
DRIVE
FREQUENCY
ON
RANGE
VOLTS
SINGLE CLOSURE
OUTPUT 125 Ω
POLARITY
VARIABLE

Type 519

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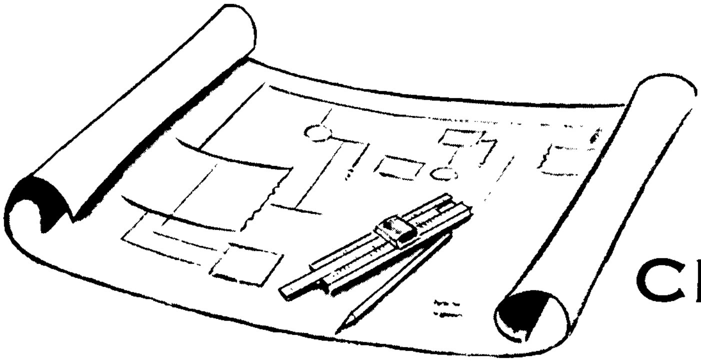

SECTION 1

CHARACTERISTICS

General Information

The Tektronix Type 519 Oscilloscope is a wide-band laboratory instrument designed expressly for the observation and measurement of high-frequency phenomena. Fast linear sweeps, high CRT accelerating potential, excellent triggering sensitivity, wide-band trigger system, and vertical bandwidth well beyond 1000 megacycles permit accurate repetitive and single-shot displays to be observed and photographed from fractional-nanosecond signals. An internal delay line in the vertical channel of the instrument permits display of the leading edge of the signal triggering the oscilloscope. Sweep delay control through 35 nanoseconds permits viewing signals before and after the main signal event.

The Type 519 incorporates two internal waveform generators. An adjustable repetition-rate fast-rise pulse generator and a fast-rise calibration-step generator supply waveforms which can be used to check the calibration of the oscilloscope itself, or to drive external devices. These waveform generators meet most requirements to complete a test setup.

VERTICAL-DEFLECTION SYSTEM

Vertical Deflection Factor

With Type T519P-A CRT, less than 10 volts per cm. Exact CRT deflection factor indicated on CRT face mask of each instrument.

Passband

With Type T519P-A CRT, dc to 1000 megacycles minimum at 3-db down.

Risetime

With Type T519P-A CRT, less than 0.35 nanosecond *

Input Impedance

125 ohms.

Maximum Allowable Input Power to Vertical Channel

1.8 watts, corresponding to ±15 volts dc or rms.

Maximum Allowable Peak Signal Amplitude

±100 volts. Repeated pulses of higher voltage may damage the 125-ohm signal termination resistor.

Internal Signal Delay

Approximately 45 nanoseconds, fixed.

Voltage Standing Wave Ratio

Nominally 1.25:1 to 1000 mc.

TRIGGER

Triggering Signal Sources

Internal from ± applied signals, internal from the Rate Generator, internal from the Calibration-Step Generator, and external from ± trigger inputs.

External Triggering Signal Requirements

Pulse amplitude: 20 millivolts. Duration: 1 nanosecond or longer. Maximum permissible external triggering signal: ±10 volts peak, higher with external attenuators. Repetition rate: to 1000 mc.

Internal Triggering Signal Requirements

Pulse amplitude: sufficient signal to produce a 2 trace-width deflection on the screen (approximately 200 mv). Duration: 1 nanosecond or longer. Repetition rate: to 1000 mc.

Countdown

A sweep is obtained for each trigger signal at trigger signal frequencies below the maximum sweep repetition rate. Triggering circuits countdown for trigger signal frequencies

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* 1 nanosecond $=10^{-9}$ seconds.

higher than the maximum sweep repetition rate. Sine-wave trigger requirements: 1 mc to 1000 mc, 20 mv peak-to-peak external trigger input, or 200 mv peak-to-peak signal to vertical input.

Pulse Amplitude or Sync

Single control adjusts pulse triggering level or high-frequency sync. An additional control provides vernier sync.

Delay

Sweep-start delay over a range of 35 nanoseconds. Permits waveform to be positioned horizontally within the sweep, to display a selected time interval.

TIME BASE

Sweep Rates

Nine Ranges: 2, 5, 10, 20, 50, 100, 200, 500, and 1000 nanoseconds per centimeter.

Accuracy

Typically within 2% of indicated rate on all ranges except the 2-nanosecond range, which is within 3%. These specifications apply to the entire sweep except for the first 2 nanoseconds or 2 mm (whichever is larger).

Single Sweeps

Normal or single sweeps selected by front-panel switch.

+Trigger Output

Greater than 1-volt pulse into 50 ohms upon triggering.

Delayed + Gate

Greater than 1-volt gate into 50 ohms during sweep; delayed with respect to + Trigger Output depending on the setting of the sweep-delay control.

RATE GENERATOR

Risetime

Less than 0.8 nanosecond (0.5 nanosecond typical).

Pulse Repetition Rate

3 cps to 30 kc, continuously variable.

Pulse Duration

10 nanoseconds nominal.

Output Impedance

50 ohms.

Amplitude

Approximately +15 volts.

CALIBRATION-STEP GENERATOR

Risetime

Approximately 0.1 nanosecond.

Repetition Rate

Adjustable from 250 to 1000 step waveforms per second; normally operated near reed-switch resonant frequency at approximately 750 steps per second.

Output Impedance

125 ohms.

Amplitude

Into 125 ohms, 0 to 10 volts. Into 50 ohms through T50/T125 adapter, 0 to 1 volt. Voltages applied to both impedances are continuously variable and calibrated. Uncalibrated voltages up to 50 volts into 125 ohms.

Polarity

The ouput polarity can be selected by a front-panel switch.

CATHODE RAY TUBE

Type

T519P-A

Phosphors

Type P11 phosphor standard (recommended for single-shot photographic recording at fastest sweep rate). Other phosphors available only on special request.

Usable Viewing Area

Two centimeters vertical, six centimeters horizontal.

Accelerating Voltage

24 kv.

Spot Diameter

0.004 inch (approximately 0.1 mm) at normal intensity.

Deflection

Electrostatic. Vertical deflection system is 125-ohm distributed-constant delay line. Conventional horizontal deflection plates.

CONSTRUCTION AND POWER REQUIREMENTS

Construction

Single-unit construction with light-weight aluminum-alloy chassis and four-piece vinyl-finish cabinet. Side panels, top and bottom panels are separately removable.

Ventilation

Filtered forced air with protective thermal cutout insures safe operating temperatures.

Dimensions

Approximately 22¼" high, 14¾" wide, and 25¼" long.

Weight

Approximately 99 pounds.

Power Requirements

105 to 125 or 210 to 250 volts, 50 to 60 cycles, approximately 650 watts.

ACCESSORIES SUPPLIED WITH THE TYPE 519

(Refer to pages 2-10, 2-11, and 2-12 for additional information on the accessories.)

1—125 Ω	Termination †	(017-007)
1	Adaptor T50/T125 †	(017-052)
2—125 Ω	Insertion Units †	(017-013)
1	Adaptor N50/N125 †	(017-053)
1	Adaptor T50/N125 †	(017-055)
1—125 Ω	Coupling Capacitor †	(017-018)
1—125 Ω	1 KMC Timing Standard †	(017-019)
1—125 Ω	1 nsec Delay Cable	(017-507)
1—125 Ω	2 nsec Delay Cable	(017-508)
1—125 Ω	5 nsec Delay Cable	(017-509)
1—125 Ω	10 nsec Delay Cable	(017-510)
1	Delay Line Equalizer †	(017-057)

1—Set of spare miscellaneous cable connector parts consisting of:

1	Double Button Assy. †	(017-032)
1	Panel Adaptor Assy. †	(017-033)
1	125 Ω Cable Connector †	(017-035)

2—Spare Reed Switches †	(260-362)
1—Viewing Hood (includes attached bezel)	(016-025)
1—3-conductor Power Cord	(161-010)
1—Power Cord Adaptor	(103-013)
2—Instruction Manuals	

NOTE

Other accessories are available for the Type 519 Oscilloscope. Information on the optional accessories is contained in Section 7.

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† The following accessories are supplied in a walnut box. (Tek # 202-083) with a foam plastic tray (Tek #436-030).

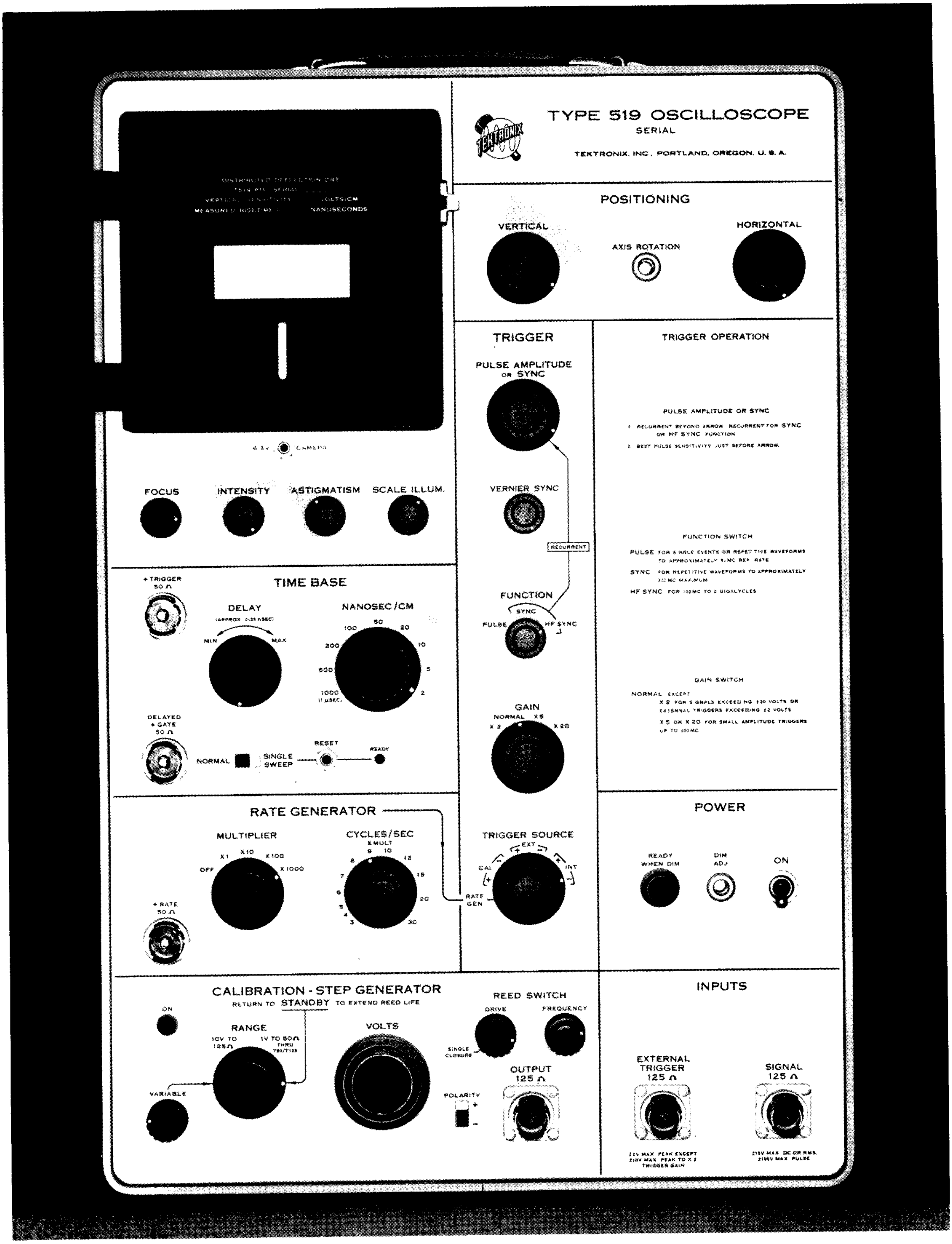
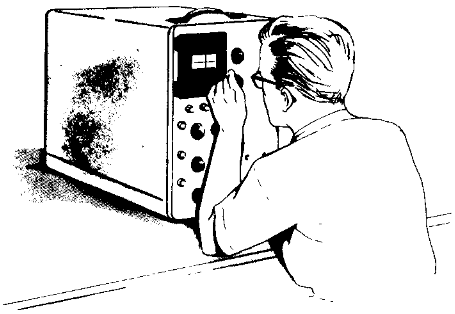


Fig. 2-1. Type 519 Oscilloscope front panel.



SECTION 2

OPERATING INFORMATION

Introduction

The Type 519 Oscilloscope is a high speed laboratory instrument designed for observing, measuring, and photographically recording phenomena in the nanosecond (millimicrosecond) domain. However, before the instrument can be used successfully, it is important for you to have an understanding of the operation of each control. This section of the Instruction Manual is intended to help you acquire this understanding. Much of the familiarity with the controls will come only with actual use of the instrument. A brief description of each of the front-panel controls follows. Front-panel markings are shown in Fig. 2-1.

FUNCTION OF CONTROLS

CRT

FOCUS	Used in conjuction with the ASTIGMATISM control to focus the oscilloscope trace.
INTENSITY	Adjusts the brightness of the trace.
ASTIGMATISM	Used in conjunction with the FOCUS control to obtain a round spot and a sharply focused trace.
SCALE ILLUM.	Adjusts the brightness of the graticule markings.
Graticule Control	A knurled knob located below the center of the graticule permits graticule to be moved down out of the viewing area.

TIME BASE

NANOSEC/CM	Selects the desired time base.
DELAY	Determines the delay of the start of the sweep with respect to the trigger signal input.
NORMAL-SINGLE SWEEP	Selects either normal or single-sweep operation.

RATE GENERATOR

CYCLES/SEC	Used in conjunction with the MULTIPLIER control to set the Rate Generator output frequency.
MULTIPLIER	Multiplier for the CYCLES/SEC control. Should be set to OFF position when Rate Generator is not being used.

CALIBRATION-STEP GENERATOR

RANGE	Selects full-scale amplitude of the calibrated steps, a variable uncalibrated step amplitude, or a standby condition. Should be set to STANDBY when Calibration-Step Generator is not being used.
VARIABLE	Permits the step waveform to be preset to an arbitrary desired amplitude up to about 50 volts into a 125-ohm load.
VOLTS	Sets the output voltage of the calibration-step waveform in the 10 V and 1 V positions of the RANGE switch.
REED SWITCH:	
DRIVE	Adjusts the reed-switch magnetic excitation for proper closures or permits single reed operation.
FREQUENCY	Controls frequency of the reed-switch magnetic excitation to help minimize contact bounce.

TRIGGER

PULSE AMPLITUDE OR SYNC *	Selects triggering signal amplitude required to operate triggering circuits, or adjusts synchronization.
VERNIER SYNC	Used in conjunction with PULSE AMPLITUDE OR SYNC control to synchronize the sweep.
FUNCTION *	Permits choice of triggered or synchronized displays.
GAIN *	Selects proper gain or attenuation for the triggering signal.
TRIGGER SOURCE	Selects the triggering signal source and polarity.

---

* Also see TRIGGER OPERATION section of front-panel, Fig. 2-1.

POSITIONING

VERTICAL	Adjusts the vertical position of the trace.
AXIS ROTATION	Aligns the trace parallel to the horizontal graticule lines.
HORIZONTAL	Adjusts the horizontal position of the trace.

POWER

DIM ADJ.	Used to adjust the brightness of pilot light after 45-second warm-up period.
ON	AC line switch.

PRELIMINARY INSTRUCTIONS

Cooling

A blower maintains safe operating temperature in the Type 519 Oscilloscope by drawing air through a filter and circulating it over the components. Therefore, the instrument must be placed so that the air intake and cabinet ventilating holes are not blocked. The air filter must be kept clean to permit adequate air flow.

A thermal cutout switch disconnects the dc power if the instrument becomes overheated. The pilot lamp will return to full brightness in the event that dc power is lost. If this happens, check immediately for proper airflow into the instrument. The blower continues to cool the interior and reduces the time the thermal switch remains open. DC power will be restored when the temperature drops to a safe value.

Power Requirements

The regulated power supplies in the Type 519 Oscilloscope will operate with line voltages from 105 to 125 volts (117 nominal) or from 210 to 250 volts (234 nominal). The line voltage for which your instrument is wired at the factory is indicated on a metal tag fastened to the rear panel near the power receptacle. Transformer connections may be changed for either 117- or 234-volt operation by using the information given in Fig. 2-2. The power transformer is wound with two 117-volt primaries which are connected in parallel for 117-volt operation and in series for 234-volt operation. Since the blower motor is connected across only one of the transformer primaries, no change in the motor lead connections is required. When the transformer connections are changed, the voltage indicated on the metal tag should be covered with another tag which conforms to the new operating voltage.

For maximum dependability and long life, the line voltage applied to the Type 519 Oscilloscope should be near the voltage indicated on the metal tag located near the power receptacle at the rear of the instrument. If the line voltage exceeds the operating limits, or has a poor waveform (distorted sine waves), unstable power-supply operation may

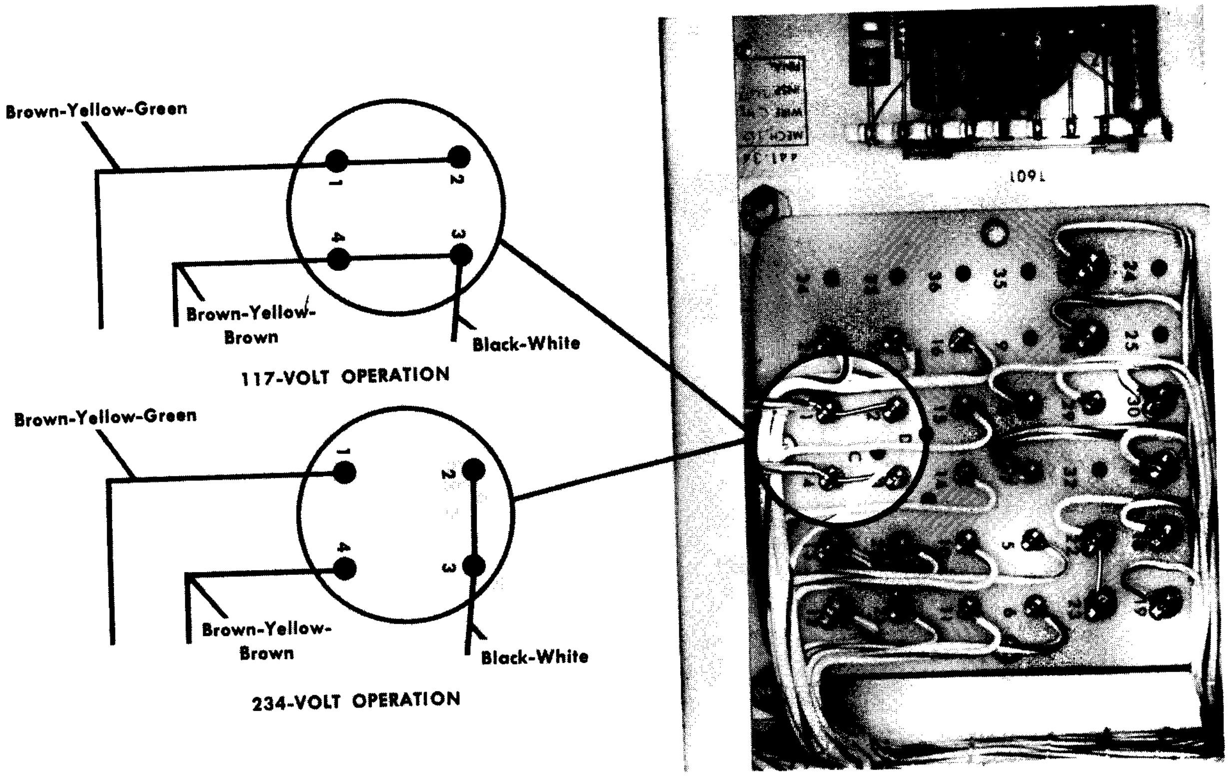


Fig. 2-2. Power transformer connections for operation of the Type 519 Oscilloscope at 117 or 234 volts.

result. Check for proper line voltages and waveform before checking for other causes of unstable operation.

Fuse Requirements

When the Type 519 Oscilloscope is connected for 117-volt operation, use a 7-amp slow-blowing type fuse. When the instrument is connected for 234-volt operation, use a 4-amp slow-blowing type fuse.

Time Delay

A time delay relay used in the Type 519 delays operation of the instrument for approximately 45 seconds after the instrument is switched on. The relay allows a brief tube-warmup period before the dc operating voltages are applied. When the ac-power pilot light dims, the instrument is ready for use.

If the ac-power is interrupted for only an instant, the normal 45-second delay will occur before the instrument returns to full operation.

Dim Adjustment

The DIM ADJ. control is a screwdriver adjustment which controls the brightness of the ac-power pilot light after the 45-second warm-up period. Normally, it is adjusted to a setting which will reduce glare from the pilot light when waveform observations are being made in a darkened room.

Camera Bezel

When one of the Tektronix cameras is used with the Type 519 the bezel supplied on the oscilloscope must be used. The bezel supplied with the camera will not take the graticule assembly properly.

FIRST-TIME OPERATION

To place the Type 519 in operation for the first time, the following procedure is suggested:

1. Set the front-panel controls as follows (controls not mentioned may be placed in any position):

POWER	Off
DIM ADJ.	Centered
INTENSITY	Fully counterclockwise
NORMAL-SINGLE SWEEP	NORMAL
NANOSEC/CM	5
DELAY	Centered
MULTIPLIER	X1000
CYCLES/SEC	10
RANGE	STANDBY
TRIGGER SOURCE	RATE GEN.
GAIN	NORMAL
FUNCTION	PULSE
PULSE AMPLITUDE OR SYNC	Fully counterclockwise
VERTICAL	Centered
HORIZONTAL	Fully clockwise

2. (The line voltage for which the instrument is wired at the factory is indicated near the power cord receptacle.) Connect the power cord to the rear of the instrument and to the source of power.

3. Set the POWER switch to ON.

4. Allow about 45 seconds for the pilot lamp to dim, indicating that dc operating voltages are applied and the instrument is ready for use.

CAUTION

Do not turn the intensity so high that a bright glow surrounds the spot. Excessive brightness of a stationary spot may damage the screen in a few seconds.

5. Advance the INTENSITY control until a visible spot appears near the left center of the screen.

6. Adjust the FOCUS and ASTIGMATISM controls to produce a small round spot.

7. Advance the PULSE AMPLITUDE OR SYNC control fully clockwise to obtain a horizontal sweep across the screen. Readjust the INTENSITY control for suitable trace brightness.

8. Rotate the HORIZONTAL positioning control to position the start of the trace at the left marking of the graticule.

9. Adjust the AXIS ROTATION control until the trace is parallel to the horizontal markings of the graticule.

10. Connect a T50/N125 adapter to the +RATE 50 Ω connector ***making certain that the 50-ohm connectors are mated.*** If the wrong impedance connectors are mated, the signal path remains open and the connections will not seat fully.

11. Connect a 2-nsec 125-ohm cable ***from the 125-ohm end*** of the adapter to the SIGNAL 125 Ω connector.

12. Rotate the PULSE AMPLITUDE OR SYNC control slowly counterclockwise and adjust the DELAY control until a stable display of the Rate Generator pulse is obtained. Locate the waveform vertically using the VERTICAL positioning control.

13. Adjust the FOCUS, INTENSITY, and ASTIGMATISM controls until a sharp trace with adequate intensity is obtained. These controls are slightly interdependent. An external signal and/or trigger may now be applied to the input connectors. If external triggers are used, set the TRIGGER SOURCE switch to + or — EXT. If internal triggering from the input signal is used, set the TRIGGER SOURCE switch to + or — INT.

CRT CONTROLS AND GRATICULE

Intensity

The INTENSITY control is used to adjust the brightness of the oscilloscope display. Compensation can be made for changes in brightness resulting from changes in the triggering rate or time base. The INTENSITY control is rotated clockwise to increase brightness and counterclockwise to decrease brightness. Care must be taken when using the INTENSITY control that the brightness is not turned up to the point where the phosphor on the face of the cathode ray tube (CRT) becomes permanently damaged. The intensity of the beam should never be turned up to the point where a bright halo forms around a stationary spot.

The FOCUS and ASTIGMATISM controls permit a sharp, clearly defined spot or trace to be obtained. Perhaps the best way to adjust the FOCUS and ASTIGMATISM controls is to display a waveform on the oscilloscope and then adjust the FOCUS and ASTIGMATISM controls alternately for the best overall focus of the trace. It may be necessary to make a new adjustment of the controls if the intensity of the trace is changed.

The disappearing graticule used with the Type 519 Oscilloscope is accurately marked with 6 horizontal and 2 vertical 1-centimeter divisions. The minor division markings on the horizontal centerline are 5 millimeters apart; those on the vertical centerline are 2 millimeters apart. The graticule markings allow accurate time and voltage measurements to be made from the oscilloscope screen.

To move the graticule out of the viewing area of the screen, loosen the knurled knob located just below the graticule and slide it downward the full length of the slot. Tighten the knob. To return the graticule to functioning position, reverse the process.

The graticule cover and mask assembly is held securely in place by four slotted graticule nuts and is provided with hinge fittings for mounting the viewing hood. In addition, the hinge fittings allow quick removal of the viewing hood so that a Tektronix Model C-12 or C-19 camera may be mounted. The Model C-19 camera is especially designed to photograph the fast sweeps of the Type 519 Oscilloscope. When the camera is not being used, it can be unlatched and swung away from the CRT screen.

Graticule Illumination

The graticule is illuminated by two lamps located at the top edge of the graticule. The SCALE ILLUM. control, located below the oscilloscope screen, is rotated clockwise to brighten the graticule markings and counterclockwise to dim them.

Camera Jack

A camera jack, marked 6.3V CAMERA, provides a 6.3-volt source for use with a camera. When the camera plug is inserted in the jack, the SCALE ILLUM. control and oscilloscope graticule lights are automatically disconnected.

POSITIONING

Two controls, VERTICAL and HORIZONTAL, are used to position the trace to the desired point on the oscilloscope screen. A third positioning control, AXIS ROTATION, is used to align the trace with the horizontal markings of the graticule.

The VERTICAL position control has sufficient range to allow the trace to be positioned completely off the top or bottom of the screen, or to any intermediate point. The trace moves up when the control is rotated clockwise and down when the control is rotated counterclockwise.

The HORIZONTAL position control causes the trace to move to the right when it is rotated in the clockwise direction and to the left when it is rotated counterclockwise. The total horizontal positioning range of the control is about 2 centimeters.

The AXIS ROTATION control is a screwdriver adjustment located between the VERTICAL and HORIZONTAL controls. This adjustment permits the trace to be rotated about an axis through the center of the screen.

VERTICAL-DEFLECTION SYSTEM

Signal Input Connection

The electrical signal to be observed is applied externally through a 125-ohm coaxial cable to the SIGNAL 125 Ω connector. If the impedance of the signal source is other than 125 ohms, corresponding cables and a suitable adaptor should be used to prevent mismatches and resulting reflections. The signal passes internally first through a trigger takeoff, then through a 45-nsec delay cable to the distributed vertical deflection system of the CRT. The signal causes the spot to be deflected vertically. The spot traces out the signal waveform on the screen as the spot is deflected horizontally by the horizontal sweep circuits. The vertical size of the displayed waveform can be adjusted to a suitable amplitude by inserting external attenuators or an amplifier in series with the signal-carrying cable. Or, if the Calibration-Step Generator is being used as the signal source, the vertical amplitude of the waveform can be adjusted by means of the Calibration-Step Generator front-panel controls.

The vertical sensitivity of the Type 519 Oscilloscope is dependent on the CRT mounted in the instrument and on the adjustment of the high voltage. The risetime and sensitivity of each Type 519 CRT is measured at the factory. These measurements are then recorded on the CRT face mask. The sensitivity measurement can be checked at any time by using the Calibration-Step Generator.

To check the measurement, connect a 125-ohm cable from the OUTPUT 125 Ω connector to the SIGNAL 125 Ω connector. Set the (CALIBRATION-STEP GENERATOR) RANGE switch to 10V TO 125 Ω and rotate the VOLTS control to 10.00. Adjust the oscilloscope front-panel controls for a stable presentation of the step waveform. Adjust the VOLTS control until the portion of the waveform located 2 nsec after the rise is exactly one centimeter high. The vertical sensitivity in volts per centimeter can be read directly from the VOLTS dial.

For example, if the VOLTS dial shows a reading of 8.70, the vertical deflection factor is 8.7 volts per centimeter.

When connecting the oscilloscope to any signal source, the connections should be made directly through 125-ohm cables or through suitable impedance matching devices to the SIGNAL 125 Ω connector. However, when impedance matching devices are used, you must consider possible signal voltage changes produced by the devices. If the signal amplitude is too great, it will be necessary to attenuate the signal to a usable level before applying it to the SIGNAL 125 Ω connector. This can be done by inserting a 125 Ω attenuator (of known attenuation factor) between the signal source and the SIGNAL 125 Ω connector. Attenuators may be used individually or may be "stacked" (connected in series).

If the signal amplitude is too low to produce sufficient vertical deflection, an external amplifier can be inserted between the signal source and the SIGNAL 125 Ω connector. However, if the amplifier does not provide the correct input and output impedance, severe waveform distortion may result. In addition, if the amplifier stages have limited bandwidth, or do not operate linearly, the signal will not be reproduced faithfully on the CRT.

In general, to obtain an accurate waveform display and to prevent unwanted reflection of high-frequency waveforms or of fast-rise pulses, all cables should be terminated in their characteristic impedances. An exception is described under Accessories, part (4) Adaptor N50/N125 (page 2-11).

Delaying the Signal

The Type 519 Oscilloscope contains a fixed 45-nanosecond signal-delay line which allows sufficient time for the trigger circuits to process the trigger signal and start the sweep before the leading edge of the input signal arrives at the CRT. The internal delay cable provides about 10 nanoseconds extra delay after sweep start and before display of the triggering signal. At the slower sweep rates the triggering signal will appear very near the start of the trace. If you wish the signal to appear farther to the right, you may insert additional 125-ohm delay cable, but at the expense of risetime. The extra delay cable must be added after the trigger takeoff point to increase the signal delay. The most common point of insertion is at the CRT end of the fixed delay line.

The DELAY control provides a 35-nanosecond adjustment in sweep starting time with respect to the triggering signal. Within this range of adjustment, the DELAY control can be used to select the display time and thus apparently position the waveform horizontally on the screen with respect to the trace.

For triggered sweep operation with externally-derived trigger signals, the time relationship of the external trigger signal to the input signal must fall within the adjustment range of the DELAY control. If, for example, too much delay is introduced by using long cables to couple the trigger signal to the EXTERNAL TRIGGER 125 Ω connector, the input signal will arrive at the vertical deflection plates before the sweep is triggered. The signal input waveform, having arrived early, will not be displayed on the screen. To offset external delay of this type, shorten the external trigger cable, if possible. If this is not possible, cable can be added into the signal-carrying circuits, but only with loss of bandwidth due to high-frequency attenuation in the cable.

The delay provided by a typical 125-ohm cable such as the RG-63/U cables shipped with the oscilloscope is approximately 1.2 nsec per foot. If any portion of the input waveform is displayed on the screen, the amount of delay which must be added or subtracted to display the waveform properly on the screen can be determined by the sweep rate and the number of divisions that the display must be moved. If the display must be moved to the right, less delay in the trigger cable is required. Fig. 2-3 shows displays resulting from incorrect signal or trigger delays.

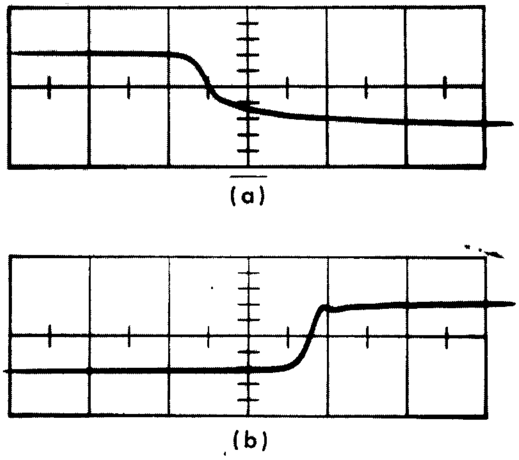


Fig. 2-3. Typical waveforms resulting from incorrect signal or triggering signal delays. Waveform (a) results from either too much triggering delay or too little signal delay. Waveform (b) results either from too little triggering delay or too much signal delay.

When 30-megacycle or higher repetition-rate signals of identical shape and amplitude are being displayed, the DELAY control will always permit display of the complete waveform. If all waveforms are uniform, it is not important which one is displayed. The internal delay line may be bypassed by direct connections to the CRT if desired, at the sacrifice of internal triggering from the signal.

Triggering (or Synchronizing) the Sweep

In most applications it is desirable for a repetitive waveform to appear stationary on the oscilloscope screen so that the characteristics of the waveform can be examined in detail. As a necessary condition for this type of display, the start of each horizontal sweep must be time-related to a characteristic of the input waveform. In the Type 519 Oscilloscope this is accomplished either by triggering or synchronizing the sweep with the displayed waveform or with another waveform bearing a definite time relationship to the displayed waveform. More information about the horizontal sweep is given in the Time Base portion of this section of the manual.

The following paragraphs outline the operation of the various triggering controls in the TRIGGER section of the front panel, in the order normally encountered. Usually, the TRIGGER SOURCE switch would be set first, GAIN switch second, and FUNCTION switch third. Finally, the PULSE AMPLITUDE OR SYNC control is adjusted to obtain a stable display for "triggered" sweep operation. For "synchronized" sweep operation, both the PULSE AMPLITUDE OR SYNC and VERNIER SYNC controls may be adjusted to obtain a stable display.

Selecting the Trigger Source

The sweep can be either triggered or synchronized (depending upon the setting of the FUNCTION switch) from the following sources: (1) displayed waveform, (2) externally-derived waveform, (3) Calibration-Step Generator, or (4) Rate Generator. The trigger source selection is by means of the TRIGGER SOURCE switch. Each trigger source has advantages for certain applications.

(1) Displayed Waveform. Triggering from the displayed waveform is the method most commonly used. Triggering is from the displayed waveform with the TRIGGER SOURCE switch set to either the +INT. or —INT. position. Internal triggering is convenient, since no external triggering signals or connections are required. A displayed waveform that produces at least two trace-widths of vertical deflection with a time duration of one nanosecond or more is sufficient for reliable triggering.

(2) Externally-Derived Signal. To trigger the sweep from an external signal, connect the triggering signal to the EXTERNAL TRIGGER 125 Ω input connector. The external triggering signal must be at least 20 millivolts in amplitude, with a time duration of 1 nanosecond or more. The maximum amplitude should not exceed ±2 volts peak except when the GAIN switch is set to X.2. In the X.2 position the external trigger should not exceed ±10 volts. Larger triggers may be attenuated externally. External triggering signals can be used when the TRIGGER SOURCE switch is set to either +EXT. or —EXT. External triggering signals preferably should be disconnected from the EXTERNAL TRIGGER 125 Ω connector when some other mode of triggering is used to reduce the possibility of stray triggering.

External triggering provides definite advantages over other methods of triggering in certain applications. With external triggering, the triggering signal usually remains constant in amplitude and shape (depending upon the source). Also, time and phase relationships between waveforms at different points in a circuit can be seen. If, for example, the external triggering signal is derived from the waveform at the input to a device under test, it is possible to observe the shaping, jitter, amplification, or delay of the signal through the device without resetting the oscilloscope triggering controls for each observation.

(3) Calibration-Step Generator. In the +CAL. or —CAL. positions of the TRIGGER SOURCE switch, the triggering signal is obtained internally from the Calibration-Step Generator. The signal is derived through the use of a trigger takeoff circuit inserted near the termination of the generator. Therefore, it is necessary to keep in mind that the controls which adjust the output amplitude of the Calibration-Step Generator also affect the amplitude of the triggering signal available at the +CAL. and —CAL. positions of the TRIGGER SOURCE switch. These two positions of the TRIGGER SOURCE switch are used to observe a waveform which is time-related to the output waveform of the Calibration-Step Generator. It is then possible to observe and accurately measure shaping, jitter, amplification, or delay at various points in the device under test. In addition, the internal-trigger requirement for a minimum signal height and duration can be circumvented. When the step generator is not being used, it should be set on STANDBY.

(4) Rate Generator. The RATE GEN. position of the TRIGGER SOURCE switch provides triggering signals which can be varied to cover a continuous repetition-rate range from 3 cps to 30 kc. These signals can then be used to trigger the sweep at a known repetition rate within the above range. To select the Rate Generator trigger, set the TRIGGER SOURCE switch to RATE GEN. Then set the MULTIVIBRATOR switch and CYCLES/SEC control to the desired repetition rate.

Selecting the Trigger Polarity

The horizontal sweep can be triggered on either the rising (+slope) or falling (—slope) portion of the triggering waveform as determined by the position of the TRIGGER SOURCE switch.

In many applications the triggering polarity is important since triggering on the wrong slope will make it impossible to display the portion of the waveform which is of interest. In many other cases, however, such as high-frequency repetitive waveforms, the triggering signal polarity is usually not important.

Selecting the Trigger Gain

A four-position GAIN switch permits incoming trigger signals to be attenuated or amplified as necessary for proper triggering or synchronization. The four gain settings are: X.2, NORMAL, X5, and X20. To aid in determining which GAIN switch setting to use for reliable triggering, Table 2-1 is included. Additional information is given in the PULSE AMPLITUDE OR SYNC control description.

TABLE 2-1

TRIGGER SOURCE Switch Setting	Approximate GAIN Switch Settings			
	X.2	NORMAL	X5†	X20†
RATE GEN.		Always set in this position.		
±CAL. *		8 v to 50 v	1.5 v to 50 v	0.5 v to 50 v
±EXT.	1 v to 10 v (peak)	0.2 v to 2 v (peak)	0.04 v to 2 v	0.01 v to 2 v
±INT. **	10 v (pulse) to 100 v (pulse)	2 v to 20 v (pulse)	0.4 v to 20 v	0.1 v to 20 v

† Used for small amplitude triggers up to 200 mc.

* Calibration-Step Generator output step amplitudes are listed. Approximately 2.5% of the step amplitude is coupled to the +CAL. and —CAL. positions of the TRIGGER SOURCE switch.

** Voltage ranges of signals applied to the SIGNAL 125 Ω connector are given. Approximately 10% of the signal amplitude is picked off and coupled to the +INT. and —INT. positions of the TRIGGER SOURCE switch.

Selecting the Trigger Function

Three functions or modes of operation are provided in the Type 519 Oscilloscope to cover a wide range of triggering conditions. They are: PULSE, SYNC, and HF SYNC.

To determine the best trigger mode for a particular application, it is best to have some understanding of all three before making a selection.

Each of the triggering modes is designed to provide stable triggering from a certain type of waveform. For many applications, however, more than one mode will work well. For such applications, the triggering mode selected is simply a matter of choice.

The PULSE mode permits choice of a free-running sweep or a sweep triggered by signals at random or uniform repetition rates up to 50 mc. The upper repetition-rate limit varies, depending upon the regularity of the pulse period. The PULSE mode, when used in conjunction with the SINGLE SWEEP feature, permits photographs to be made of single events at any setting of the NANOSEC/CM switch.

The SYNC mode permits stable displays of waveforms occurring at a constant repetition rate up to approximately 150 mc. To select this mode, place the FUNCTION switch in the SYNC position.

The HF SYNC mode permits the sweep to be synchronized from high-frequency signals in the range from approximately 100 mc to more than 2 kmc. To use the high-frequency synchronization mode, place the FUNCTION switch in the HF SYNC position.

Triggering or Synchronizing the Sweep

The last controls normally operated in the TRIGGER section of the front panel are the PULSE AMPLITUDE OR SYNC and VERNIER SYNC controls. These controls are used for two functions: pulse amplitude selection and synchronization, depending upon the setting of the FUNCTION switch.

If the FUNCTION switch is set to the PULSE position, the PULSE AMPLITUDE OR SYNC control determines the level a signal must reach to initiate the sweep. All triggers below the set level are rejected. In order for the control to operate properly within its rotational range, sufficiently large triggers must be available as explained earlier under Selecting the Trigger Gain.

Triggering on small signals is best when the control is set just short of the point where the sweep free runs. The sweep normally free runs when the PULSE AMPLITUDE OR SYNC control is rotated clockwise past the RECURRENT arrow.

If the FUNCTION switch is set to either the SYNC or the HF SYNC position, the PULSE AMPLITUDE OR SYNC control is used for making the coarse synchronization adjustment. Final adjustment may be made with the VERNIER SYNC control. The sweep repetition rate will synchronize at the frequency of the triggering signal or at some submultiple frequency.

The VERNIER SYNC control is normally set at midrange until the coarse adjustment is made, then the VERNIER SYNC control is adjusted to obtain a stable display.

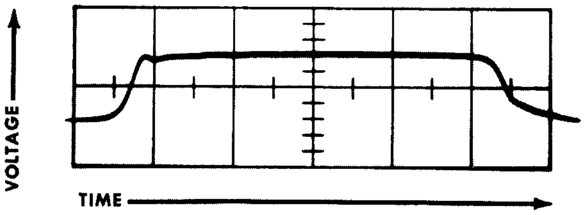


Fig. 2-4. The usual oscilloscope display is a graphical presentation of voltage versus time.

TIME BASE

Horizontal Sweep

The Type 519 Oscilloscope graphically presents instantaneous signal voltage versus time (see Fig. 2-4). The signal voltage produces vertical deflection of the trace; time is represented through horizontal deflection. The horizontal sweep is also known as the time base, since horizontal deflection of the spot bears a definite relationship to time and provides the means for making time measurements from the screen. The NANOSEC/CM switch selects the desired sweep rate from one of nine accurately calibrated rates available. Time base steps range from 2 nanoseconds per centimeter to 1000 nanoseconds (1 μsec) per centimeter. The sweep generator has been designed to provide long-term stability of sweep calibration and linearity.

Single Sweep Operation

The Type 519 Oscilloscope permits a single-sweep presentation to be obtained and eliminates all subsequent sweeps so the signal can be clearly recorded without confusion resulting from multiple traces. The single-sweep feature is selected by placing the NORMAL-SINGLE SWEEP switch in the SINGLE SWEEP position. The RESET button must be actuated to "arm" the time base and permit a single-trigger event.

When the FUNCTION switch is placed in the PULSE position and the PULSE AMPLITUDE OR SYNC control is set fully clockwise (past the RECURRENT arrow or line), a single sweep runs immediately each time the RESET button is depressed.

When the PULSE AMPLITUDE OR SYNC control is set for triggered sweep operation, the single sweep does not necessarily occur immediately after the RESET button is depressed. Instead, the READY lamp lights to indicate that the sweep is armed and ready to be triggered. When a trigger is received, the sweep runs once and the READY light goes out. Each time the RESET button is depressed the procedure is repeated.

When the FUNCTION switch is placed either in the SYNC or HF SYNC position, a single sweep runs immediately each time the RESET button is depressed regardless of the settings of the PULSE AMPLITUDE OR SYNC control.

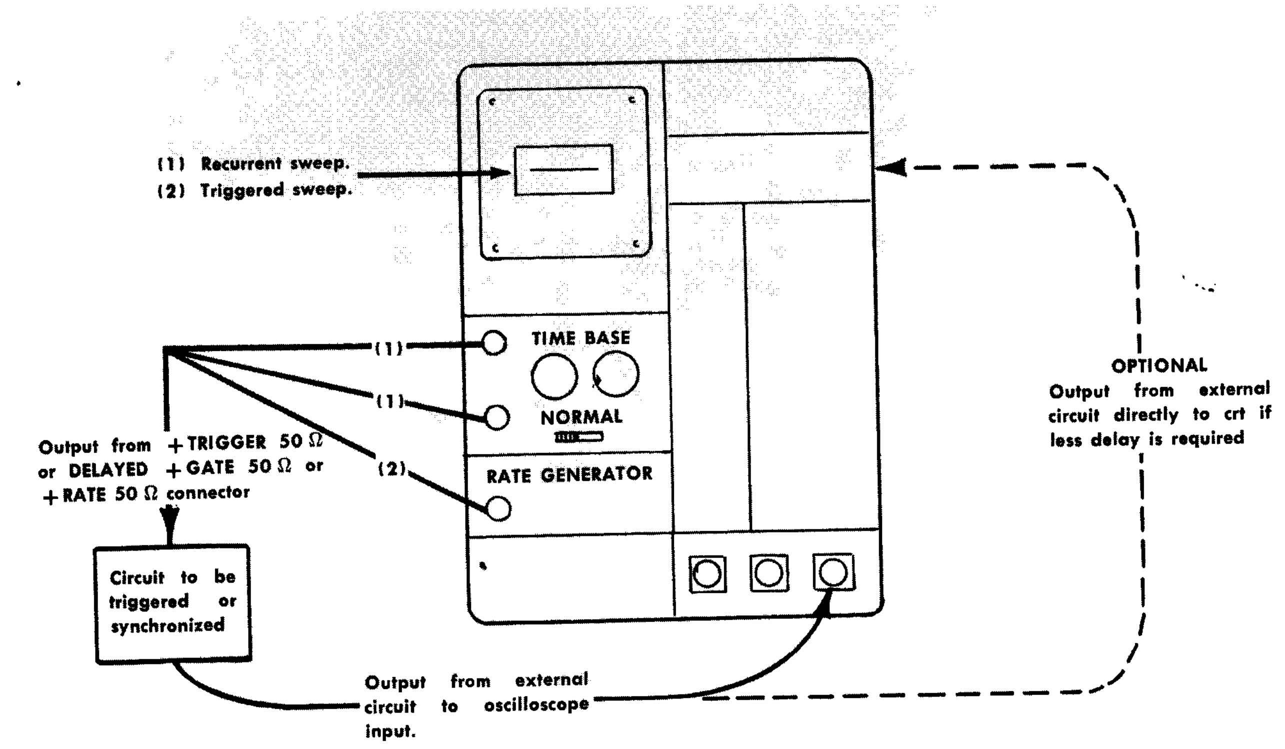


Fig. 2-5. Using the Type 519 Oscilloscope to drive an external circuit. The output of the external circuit is then applied to the input of the oscilloscope for display.

Synchroscope Operation

In the usual oscilloscope application, the sweep is triggered or synchronized by the input waveform. However, in some applications it may be more desirable to reverse the process and drive an external circuit from the oscilloscope. In this "synchroscope" application, the sweep is caused to free run or to be triggered by the Calibration-Step Generator or the Rate Generator. The output signal from the +TRIGGER 50 Ω, the DELAYED +GATE, the +RATE 50 Ω, or the OUTPUT 125 Ω connector is used to initiate the input waveform (see Fig. 2-5).

The sweep can be made to free run in any position of the FUNCTION switch. If the PULSE position of the FUNCTION switch is used, the PULSE AMPLITUDE OR SYNC control must be rotated fully clockwise past the RECURRENT arrow. The sweep free runs at all times when the FUNCTION switch is in either the SYNC or HF SYNC positions. The number of free-running sweeps per second is determined by the settings of the NANOSEC/CM switch (refer to Table 2-2).

A free-running sweep also provides a convenient reference trace on the oscilloscope screen without requiring an input signal. The trace can then be positioned to a desired point on the oscilloscope screen or can be used to establish a zero-voltage reference line.

Delayed Trigger

A delayed triggering pulse is produced at the DELAYED +GATE 50 Ω connector of the oscilloscope at approximately the time of sweep start. The delay of the delayed triggering pulse with respect to the time that the trigger is accepted and a pulse is produced at the +TRIGGER 50 Ω connector can be adjusted over a range of approximately 35 nanoseconds by means of the DELAY control.

TABLE 2-2

NANOSEC/CM Switch Settings	SWEEP REPETITION RATES (Recurrent Rates)
2	Adjusted to 400 kc
5	200 kc nominal
10	100 kc nominal
20	50 kc nominal
50	20 kc nominal
100	10 kc nominal
200	5 kc nominal
500	2 kc nominal
1000	1 kc nominal

RATE GENERATOR

The output pulse from a transistor operating in the avalanche mode is coupled to the RATE GEN. position of the TRIGGER SOURCE switch and to the +RATE 50 Ω connector. The pulse risetime is less than 0.8 nanosecond, amplitude is nominally +15 volts, and duration is approximately 10 nanoseconds. A typical Rate Generator waveform as displayed on the Type 519 is shown in Fig. 2-6. To use the

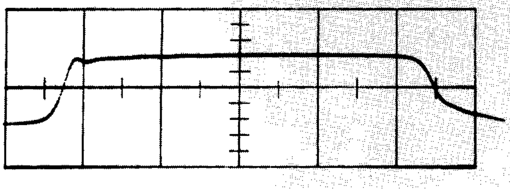


Fig. 2-6. Typical Rate Generator output waveform as displayed on the Type 519 Oscilloscope.

Rate Generator, set the TRIGGER SOURCE switch to RATE GEN. Then adjust the CYCLES/SEC and MULTIPLIER controls for the desired repetition rate. Any frequency between 3 cps and 30 kc can be selected within an accuracy of 10%.

Since the sweep can be triggered at the repetition rate set by the Rate Generator from 3 cps to 30 kc, this feature can be used for applications such as those described previously under the headings "Selecting the Trigger Source", and "Synchroscope Operation". When the Rate Generator is not used, it should be turned off by placing the MULTIPLIER switch to the OFF position to reduce the possibility of stray triggering.

CALIBRATION-STEP GENERATOR

Step Waveform

The step waveform from the Calibration-Step Generator is generated by discharging a charged coaxial line into an external load through a magnetically-operated dry-reed switch. The physical length of the charged line determines the duration of the output step waveform. In the Type 519, with no external charge line added, the duration of the constant-amplitude portion of the step is equal to twice the transit time of the built-in 1.5-nsec charge line. (Transit time of the charge line is the time required for a signal to pass from one end of the line to the other.) For the 1.5-nsec charge line, then, the duration of the output pulse is 3 nsec. To obtain a longer duration step waveform, an additional length of charge line (cable) may be added to the Charge Line Connector located next to the Trigger Takeoff (see Fig. 2-7). When an additional charge line is added, the charging network and the charging voltage must be disconnected. They must then be connected to the open end of the added charge line. A typical display of the Calibration-Step Generator waveform as seen on the Type 519 Oscilloscope appears in Fig. 2-8.

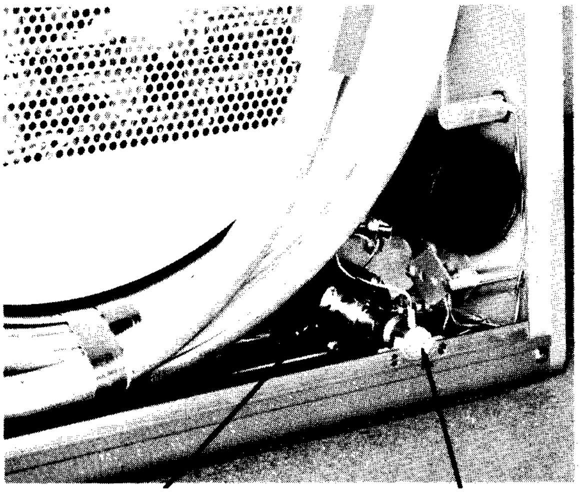


Fig. 2-7. Locations of the Calibration-Step Generator line charging network and trigger takeoff.

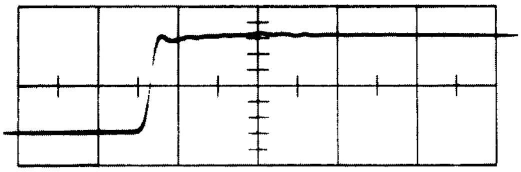


Fig. 2-8. Typical Calibration-Step Generator waveform as displayed on the Type 519 Oscilloscope. It is not always possible to completely eliminate reed switch multiple contact bounce. Extraneous traces, therefore, sometimes will occur in the display.

Polarity

Step polarity is selected by the POLARITY switch. The polarity of the step at the output connector is the same as the polarity of the charge voltage. The setting of the TRIGGER SOURCE switch should agree with the setting of the POLARITY switch for normal triggering.

Amplitude

The step amplitude is dependent upon the amount of charging voltage used. The charge voltage obtained from the charging source at the instant of reed switch closure is 2 times the step voltage present at the OUTPUT 125 Ω connector when driving an external 125-ohm load. The step voltage reading is accurately indicated by the settings of the RANGE and VOLTS controls.

When the VOLTS control is set to 10.00, the RANGE switch permits a choice of two full scale step amplitudes, 10 volts or 1 volt. When the RANGE switch is placed in the 10V TO 125 Ω position, 10 volts is produced across a 125-ohm load. When the RANGE switch is set in the 1V TO 50 Ω position, a T50/T125 adapter must be properly connected to the OUTPUT 125 Ω connector to obtain a 1-volt step into a 50 ohm load.

The scale of the VOLTS control, when used with either of the two above RANGE switch positions, indicates the step amplitude. The VOLTS control is the 0 to 1 multiplier for the two ranges.

When the RANGE switch is set to the VARIABLE position, the step amplitude may be preset by the VARIABLE control to any uncalibrated amplitude from 0 to approximately 50 volts when driving a 125-ohm load. To determine the amplitude of the step for any setting of the VARIABLE control, apply the step waveform from the OUTPUT 125 Ω connector through a 125-ohm cable (and attenuator, if needed) to the SIGNAL 125 Ω connector. Measure the amplitude of the vertical deflection in centimeters and multiply the distance measured by the sensitivity of the oscilloscope (and attenuation if used).

Adjusting the Drive and Frequency

Two front-panel controls, DRIVE and FREQUENCY, control the movement of the dry-reed switch. These controls are adjusted to cause the reed to make-and-break contact with a minimum of contact bounce.

To adjust the two controls, they must first be preset fully counterclockwise. Then advance the DRIVE control until the reed vibrates (makes a buzzing sound). Advance the FREQUENCY control until the reed fails to operate and then rotate the control slightly counterclockwise to start the reed operating again. Slowly rotate the DRIVE control counterclockwise while rotating the FREQUENCY control back and forth to find the resonant frequency of the reed. The resonant frequency is found when the drive is decreased to a point where the reed will vibrate in only one small rotational area of the FREQUENCY control range. For optimum operation the DRIVE and FREQUENCY controls are then adjusted to obtain the most stable waveform near the resonant frequency of the reed. When adjusting the DRIVE control, use enough drive to get solid closures of the reed contacts. The resonant frequency of most reeds is usually within the range of 700 to 800 cps.

NOTE

The reed switches used in the Type 519 are chosen to produce the best possible waveform. The high requirements of these switches frequently result in a short lifetime. To extend the life of the reed switch set the RANGE switch to STANDBY when the Calibration-Step Generator is not being used.

ACCESSORIES

The following information pertains to the accessories which are included with the Type 519 Oscilloscope. Other optional accessories which are available are accompanied by specific application notes. See also Section 7, Accessories.

(1) 125 Ω Termination

The 125 Ω Termination (Fig. 2-9) is supplied as a spare for the T519P-A CRT termination or to terminate any 125-ohm cable.

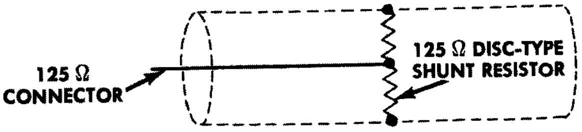


Fig. 2-9. Construction of the 125Ω Termination.

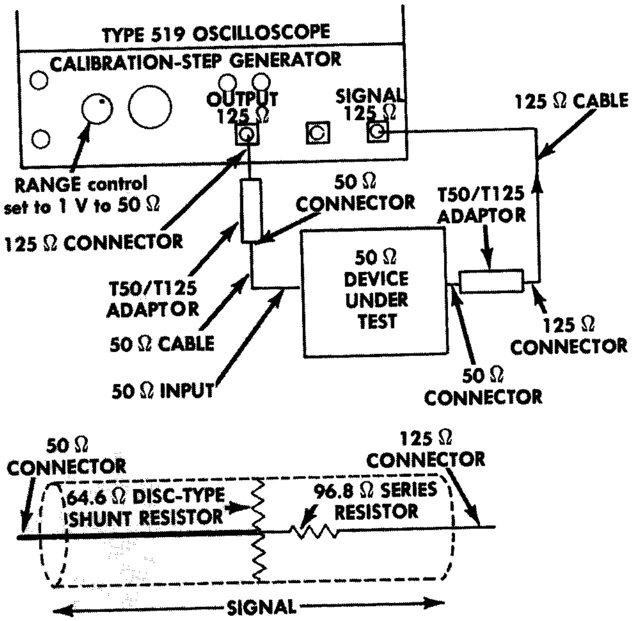


Fig. 2-10. Construction of the T50/T125 Adaptor. Also shown are two typical applications for this adaptor.

(2) Adaptor T50/T125*

This adaptor (Fig. 2-10) is commonly known as a minimum loss matching pad. Designed to match between a 50-ohm line and 125-ohm line, the attenuator presents minimum loss and reflections. It contains a network composed of a shunt and a series resistor. Though the attenuator presents a correct impedance match "in either direction", the signal voltage transmission factor of 0.225 in going from 125 ohms to 50 ohms is less than the N50/N125 adaptor described later. In going from 50 ohms to 125 ohms, the signal voltage transmission factor is approximately 0.564. The primary advantage of the T50/T125 adaptor is that it receives signals into either end without producing reflections.

(3) Adaptor T50/N125

This adaptor is usually called a 50-ohm termination adaptor and the internal circuitry is shown in Fig. 2-11. In actual use the 83.3-ohm resistor is shunted by the 125-ohm input impedance of the load. The combined resistances present a total input impedance of 50-ohms to the signal source.

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* The letter "T" in an adaptor type means "Terminated"; "N" means "Not Terminated".

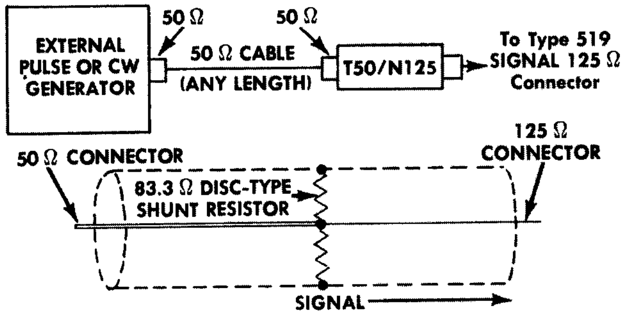


Fig. 2-11. Construction of the T50/N125 Adaptor. A typical application for this adaptor is also shown.

The adaptor is designed to handle pulse or continuous-wave signals originating from a 50-ohm source. It is not generally used to handle a signal traveling in the 125-ohm to 50-ohm direction, since it does not provide a termination for the 125-ohm connector. When a T50/N125 is used to connect a 50-ohm signal to the 519 signal input connector, the signal voltage is unchanged and the signal cable is fully terminated. The vertical deflection system has 50 nsec of delay before it is terminated in 125 ohms. Any reflections from the CRT, its connections, or termination, would return through the delay line and reflect from the nonterminating end of the T50/N125 to reappear at the CRT 90 to 100 nanoseconds after the original signal.

(4) Adaptor N50/N125

Also called an unterminated adaptor, this accessory (Fig. 2-12) is a straight-thru connector which connects a 50-ohm line directly to a 125-ohm line. This unit is used primarily for pulse applications. If a pulse from 50 ohms is applied to the 50-ohm end of the adaptor, the pulse amplitude increases 1.43 times at the 125-ohm end due to the reflection at the end of the 50-ohm system. In going from 125 to 50 ohms, approximately a 0.572 transmission factor results. This is more than for any of the other adaptors. Since it is a nonterminating unit, it will produce a high VSWR when used with high-frequency sine waves.

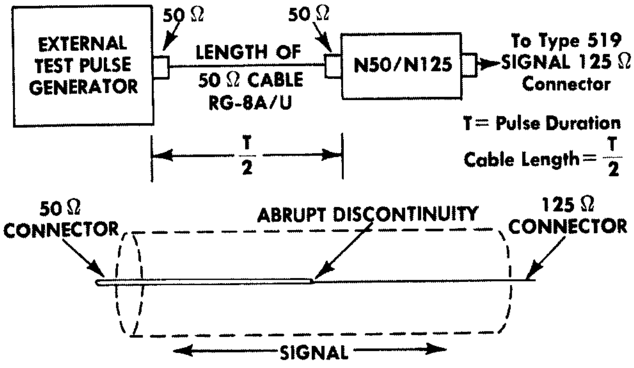


Fig. 2-12. Construction of the N50/N125 Adaptor. Also shown is a typical application for the adaptor.

When the adaptor is used for pulses, the abrupt discontinuity inherent in the unit causes a reflection to occur which may interfere with the displayed waveform unless certain precautionary measures are taken. To prevent a reflection from occurring on the displayed waveform, make the electrical length of the cable supplying the adaptor equal to or more than T/2, where T is the length of the pulse to be observed. The reflection will then appear after the displayed waveform.

TABLE 2-3

SIGNAL VOLTAGE TRANSMISSION FACTORS		
SIGNAL DIRECTION 50 Ω to 125 Ω	ADAPTOR TYPE	SIGNAL DIRECTION 125 Ω to 50 Ω
.564	T50/T125	.225
1.000	T50/N125	Not Used
Not Used	N50/T125	.400
1.43	N50/N125	.572
1.58	Theoretical Maximum Power Transfer	.633

(5) 125 Ω Insertion Unit

This unit is a hollow tube with 125-ohm connectors on each end and access holes located on each side to permit small components to be mounted inside. A snap-on sleeve cover permits adequate shielding of components and provides minimum discontinuity in the line. The unit facilitates 125-ohm (or 50-ohm, if desired) connections for pulse testing components such as diodes or transistors. It can also be used for testing or design of networks such as filters, attenuators, impedance-matching circuits, etc., and measurements on amplifiers and many other devices. The device makes it unnecessary to use a chassis with long leads and poor impedance matching. Instead, the components or circuit can be mounted in the small insertion unit and used as part of the 125-ohm system.

For series tests, the effective impedance of the test circuit is $2Z_0$. For shunt tests, the effective test circuit impedance is $Z_0/2$. Thus, for tests using 125-ohm cable, a series measurement is with 250 ohms equivalent series resistance while a test from center conductor to ground is with a 62.5-ohm equivalent source resistance. The above conditions assume proper termination impedances in both directions from the test point.

(6) 125 Ω Coupling Capacitor

The 125 Ω Coupling Capacitor connector contains a silvered-ceramic, wafer-type capacitor connected in series with the inner conductor. A slight amount of compensating inductance is supplied by the conductors butt-soldered to the capacitor. (See Fig. 2-13).

This unit is normally used for ac-coupling high-frequency signals to the Type 519 Oscilloscope with minimum reflections. Low-frequency signals and dc are blocked. Its characteristics are:

Coupling Capacitance:	0.01 μf ±20%, 0.0082 μf GMV.

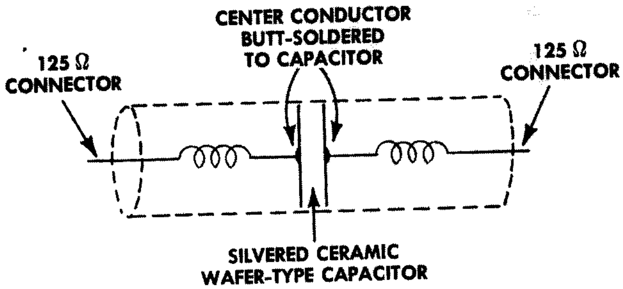


Fig. 2-13. Construction of the 125Ω Coupling Capacitor.

Voltage Rating:	400 volts.
Reflections:	Negligible.
Low-Frequency Cutoff in 125 Ω:	Approximately 65 kc.

(7) 125 Ω 1 KMC Timing Standard

The 125 Ω 1 KMC Timing Standard is a Sweep Calibrator which can be used to make periodic sweep calibration checks of the 2- and 5-nanosecond/cm rates. Refer to the Calibration Procedure section of this manual.

(8) 125 Ω Delay Cables

Different length cables are supplied for use in coupling the signal and/or trigger to the appropriate input connectors on the front panel of the Type 519 Oscilloscope. The loss per foot of RG-63/U cable is 0.06 db at 1 kmc. The delay time marked on each cable is the time required for a signal to travel from one end of the cable to the other.

(9) 125 Ω Cable Connector Parts

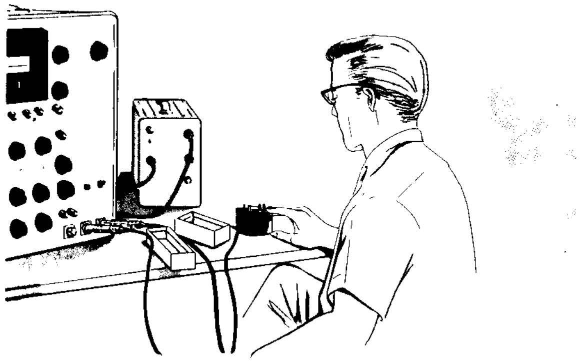
(a) Double Button Assembly. Used for replacing a damaged or worn insert in any of the 125-ohm front-panel connectors or cable connectors.

(b) Panel Adaptor Assembly. Replacement for any of the front-panel 125-ohm connectors.

(c) 125 Ω Cable Connector. Replacement for any of the cable connectors.

(10) Reed Switch

Two spare reed switches are included as replacements for the reed switch used in the Calibration-Step Generator. To replace the reed switch refer to the Maintenance section of this manual.



SECTION 3

APPLICATIONS

Introduction

Information presented in this section of the manual has been selected to show typical applications for the Type 519 Oscilloscope. Among these applications are the measurements of voltage, time, and frequency. In addition, other applications are described and illustrated to point out the various features designed into the instrument. Since the number of applications for the Type 519 is large, it is beyond the scope of this manual to cover more than a few of the most general applications.

Voltage Measurements

Vertical displacements on the CRT screen are related to the applied signal voltage by means of the vertical deflection factor indicated on the CRT face mask. By means of the indicated deflection factor it is possible to make accurate voltage measurements from the oscilloscope screen. The accuracy of the voltage measurements made with the Type 519 depends to a large extent on how accurately vertical measurements are made on the oscilloscope display. It is important to obtain sufficient vertical deflection, if possible, for accurate measurements to be made. Also, care must be used so that the width of the trace is not included in the measurements. All measurements should be consistently made from the same point on the trace; for example the top, center or bottom. If the center of the trace is used for one reading, it should be used for all successive readings.

To make a voltage measurement on a waveform, the following method can be used (see Fig. 3-1).

1. By using the graticule, measure the vertical deflection in centimeters between the appropriate two points on the waveform.

2. Multiply the vertical distance by the vertical deflection factor and by the attenuation factor; divide the result obtained by the amplification factor (if either attenuation or amplifiers are used). The figure obtained is the voltage difference between the two points on the displayed waveform.

As an example, assume that using a 5X attenuator, you measure a vertical distance of 1.2 centimeters between two points on the waveform. Also assume that the vertical deflection factor is 8.7 volts per centimeter. In this case then, 1.2 centimeters multiplied by a deflection factor of 8.7 volts per centimeter gives a product of 10.44 volts. This figure multiplied by the attenuation factor of 5 gives the actual voltage difference of 52.2 volts.

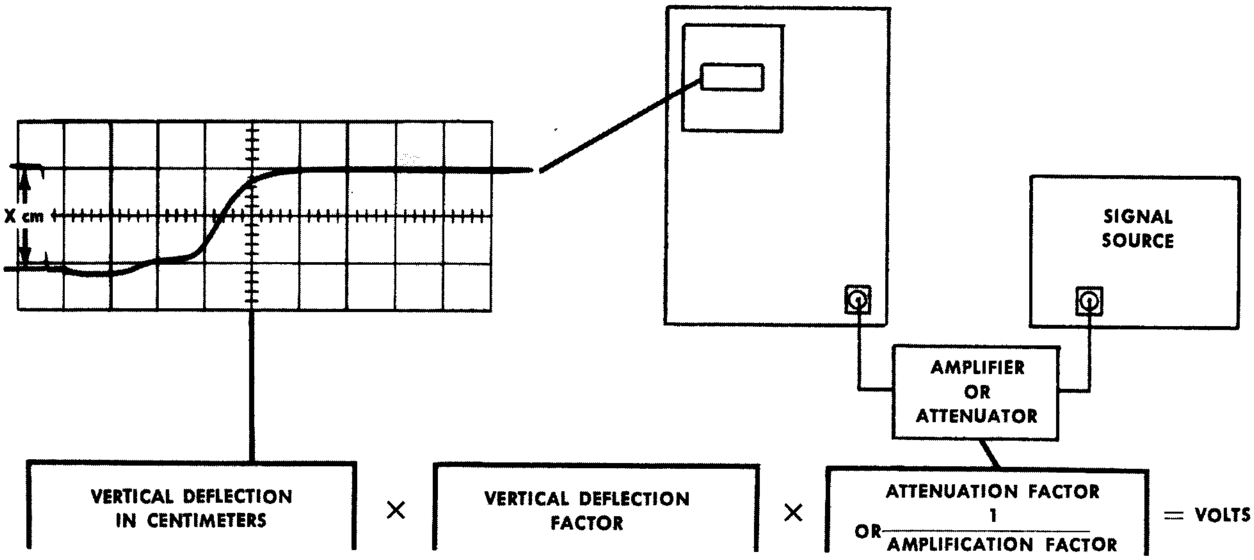


Fig. 3-1. Measuring voltages from the oscilloscope display.

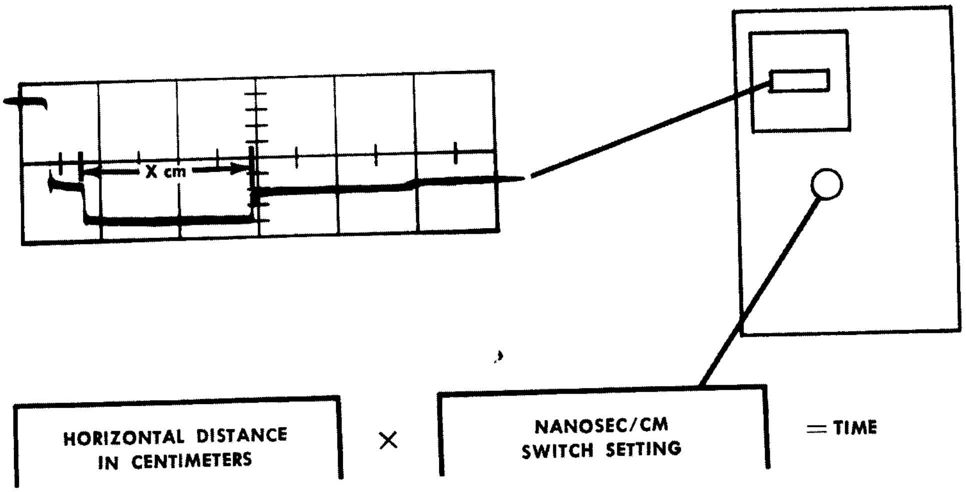


Fig. 3-2. Measuring the time between two events on the oscilloscope display.

Time Measurements

Due to the calibrated linear sweep rates of the Type 519 Oscilloscope, any horizontal distance on the screen represents a definite known interval of time. Using this feature the time between two displayed events can be accurately measured directly from the oscilloscope screen. Time measurements can be made as follows (see Fig. 3-2):

1. Using the graticule, measure the horizontal distance in centimeters between the two displayed events whose time interval you wish to find.
2. Multiply the distance measured by the setting of the NANOSEC/CM switch to obtain the actual time interval.

For example, assume that the NANOSEC/CM switch setting is 10 and that you measure a horizontal distance of 4 centimeters between the two desired points. The time interval is then 4 centimeters multiplied by 10 nanoseconds per centimeter or 40 nanoseconds.

Frequency Measurements

By using the method described for measuring time intervals, the period (time required for one cycle) of a recurrent waveform can be measured. The frequency of the waveform can then be easily calculated since frequency is the reciprocal of the period. Frequencies which may be measured with the 519 using this method range from approximately 200 kc to over 1000 mc. For example, if the period of a recurrent waveform is accurately measured and found to be 5 nanoseconds, the frequency is the reciprocal of 5 nanoseconds, or 200 mc.

Another method which is frequently preferable is described as follows: At any given oscilloscope sweep rate, the number of cycles of the input waveform that are displayed in *5 centimeters* of the screen is dependent on the frequency of the input waveform. At a sweep rate of 10 nanoseconds per centimeter, for example, 3 cycles are displayed with a 60-mc input signal, 2½ cycles with a

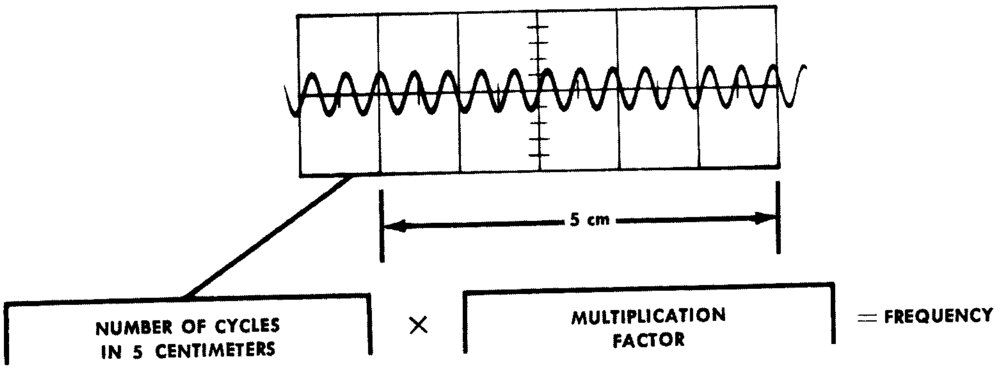


Fig. 3-3. Measuring the frequency of a repetitive signal by counting the number of cycles which are displayed in 5 centimeters. This example shows 12 cycles in 5 centimeters.

50-mc signal, and 2 cycles with a 40-mc input signal. By utilizing the pattern of these observations the frequency of a waveform can be measured by counting the number of cycles in 5 centimeters on the screen, and multiplying this by the factor given in Table 3-1 for that sweep rate (see Fig. 3-3). Since each sweep rate has a fixed multiplication factor, frequencies can easily be determined by this method once the multiplication factors for the various sweep rates are known. The appropriate multipliers are found by taking the reciprocal of the time required for the sweep to move 5 centimeters. The method can be summarized as follows:

1. Place the NANOSEC/CM switch at a setting which permits several cycles of the input waveform to be displayed.
2. Count the number of cycles of the waveform that are displayed in 5 centimeters.
3. Multiply the number of cycles by the multiplication factor for the sweep rate being used.

As an example, assume that with a sweep rate of 5 nanoseconds per centimeter, 3.2 cycles are displayed in 5 centimeters. The multiplication factor for a sweep rate of 5 nanoseconds is the reciprocal of 25 nanoseconds (5 times 5 nanoseconds), or 40 megacycles. The frequency is 3.2 multiplied by 40 megacycles, or 128 megacycles.

TABLE 3-1

FREQUENCY MULTIPLICATION FACTORS FOR 5 CM INTERVAL

NANOSEC/CM Switch Setting	Multiplication Factor (megacycles)
2	100
5	40
10	20
20	10
50	4
100	2
200	1
500	.4
1000	.2

Measuring Diode Switching Characteristics

Dynamic test measurements in the nanosecond region can be made with the Type 519 Oscilloscope to study switching and storage times in semiconductor diodes. In addition, diodes can be selected and compared for particular response characteristics. Two basic diode test circuits are illustrated here to demonstrate how the oscilloscope may be used as a pulse generator and indicator unit.

The first test circuit for diodes is shown in Fig. 3-4. This circuit can be used to measure diode reverse recovery time. In this circuit, the Calibration-Step Generator is used to abruptly shut off the forward current passing through the diode. The oscilloscope displays the current through the diode as a function of time. The current values are then found from the display by dividing the waveform voltage by 125 ohms. From the displayed waveform on the CRT the recovery time of the diode can be measured.

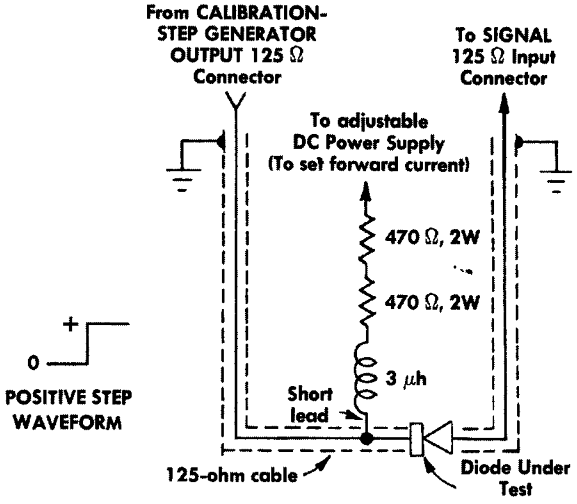


Fig. 3-4. 250-ohm test circuit for measuring diode reverse recovery time. If desired, the diode and pulse polarity may be reversed to obtain an inverted display.

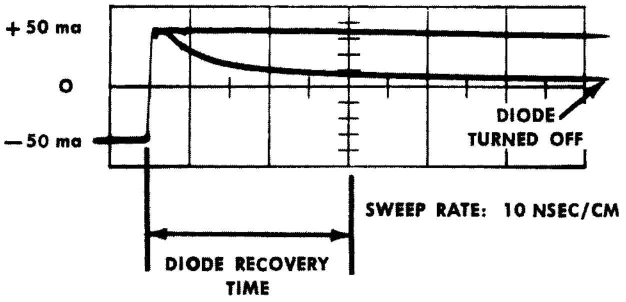


Fig. 3-5. Typical reverse recovery transient for a T12G diode. The upper trace shows only the Calibration-Step Generator waveform which is used to establish the initial reverse current. The lower trace shows the recovery waveform.

The resistors used in the circuit set the forward current through the diode. These resistors and the 125-ohm input impedance of the oscilloscope set the forward current at 47 ma when used with a +50-volt power supply; total power dissipated is 2.35 watts. A convenient amount of vertical deflection is obtained with a forward current of at least 30 ma. The shortest possible leads *must* be used to construct the system.

A variable dc supply may be used to supply multiples of 5 or 10 ma of forward current. Keep in mind that the maximum forward current must not only be within the test diode rating, but also within resistor dissipation ratings, including the 1.8 watt rating of the 125-ohm termination resistor connected at the neck of the CRT. Steady current flow through the CRT termination resistor should never exceed 120 ma.

A typical reverse recovery waveform is shown in Fig. 3-5. The trace was obtained when a positive-going pulse was applied from the Calibration-Step Generator to a T12G

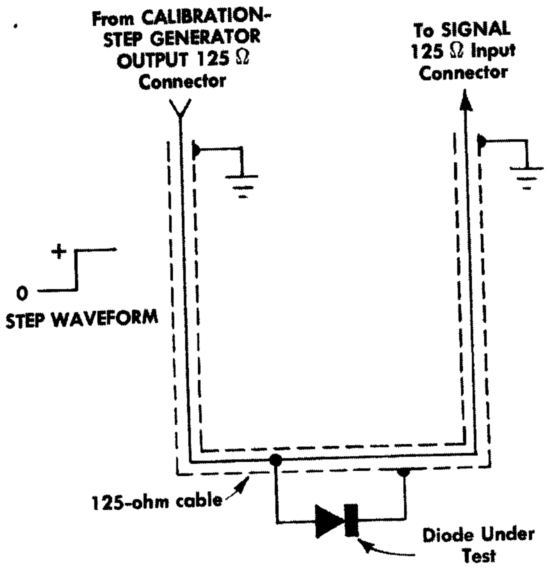


Fig. 3-6. Test circuit for measuring the turn-on time of a diode. If desired, the diode and pulse polarity may be reversed to obtain an inverted display.

test diode. A dc supply voltage of approximately −50 volts is connected to the diode through 940 ohms to establish a forward reference current of −50 ma. The lower trace shows the diode recovery while the upper trace indicates the reverse current caused by the positive-going step waveform when the diode is shorted out temporarily. With the diode shorted out, the step waveform is adjusted for the desired initial turn-off current during diode recovery (+50 ma in the example). The time required from the application of the switching pulse until the current through the diode reaches essentially zero or a predetermined value of current is the reverse recovery time for that diode.

The second diode test circuit, shown in Fig. 3-6, is used to turn the diode on so the turn-on time can be measured. To turn on the diode, a positive-going step is applied from the Calibration-Step Generator to the diode when it is connected directly across the 125-ohm coaxial cable.

A typical resultant waveform obtained when the T12G diode is being turned on is shown by the lower waveform in Fig. 3-7 (a). The upper waveform is the step pulse generated by the Calibration-Step Generator with the diode disconnected. The fact that the voltage across the diode does not drop to zero is due to the forward drop across the impedance of the diode. The dynamic diode impedance as a function of time can be determined from the oscilloscope display by means of the following equation:

$$Z = \frac{125A}{2(1-A)}$$

where $A = V_2/V_1$ as shown in Fig. 3-7. V_1 is almost constant while V_2 varies considerably with time. A plot of the diode impedance as a function of time obtained using the recovery waveform and the above equation is shown in Fig. 3-7 (b). Turn-on curves for other diodes are shown in Fig. 3-8.

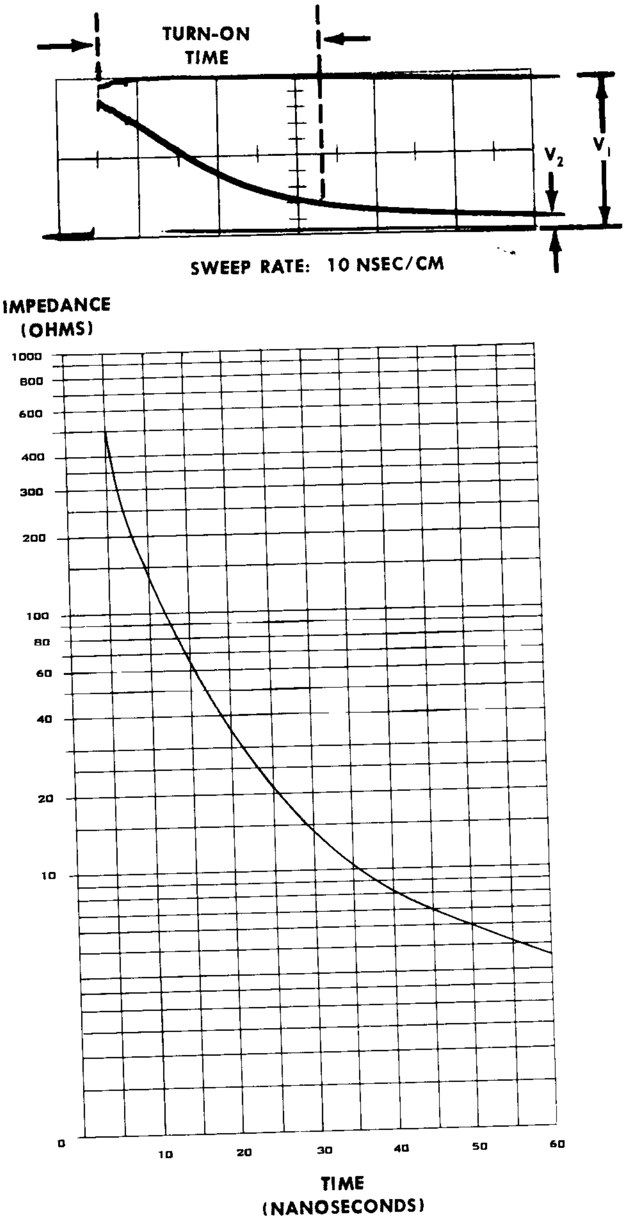


Fig. 3-7. (a) Typical turn-on curve for a T12G diode on the lower trace. The upper trace shows the Calibration-Step Generator waveform. (b) A plot of impedance versus time constructed from the turn-on curve shown in (a).

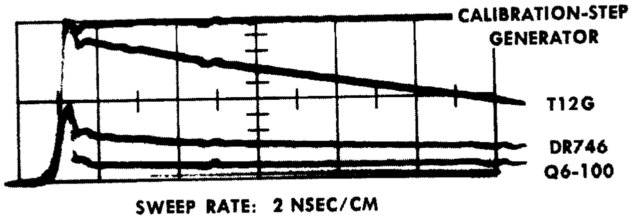


Fig. 3-8. Typical turn-on curves for various types of diodes.

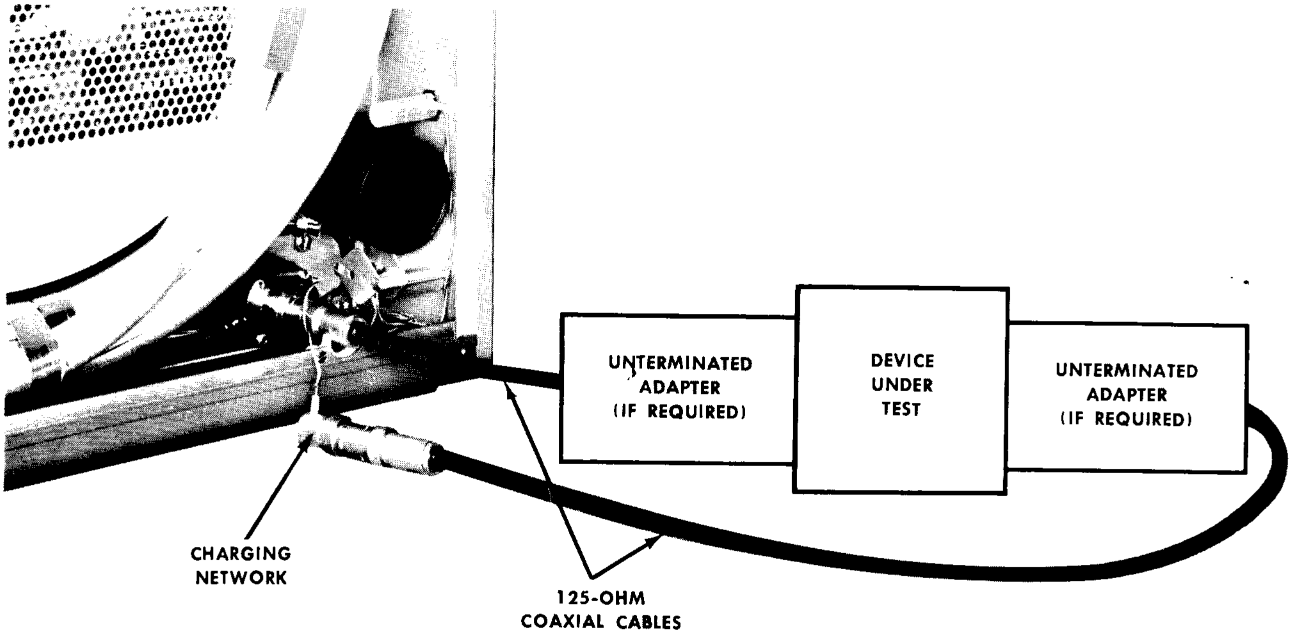


Fig. 3-9. Connection of a test device into the charge line of the Calibration-Step Generator.

Impedance Measurement by Reflection

A clear picture of transmission-line characteristics is made possible by the use of the Type 519 Oscilloscope. The presence of discontinuities along a transmission line can be determined while the line is under study by means of the oscilloscope display.

The Calibration-Step Generator of the Type 519 provides an excellent means for measuring the impedances of certain devices and cables. In an application of this sort, the device is connected as part of the charge line for the Calibration-Step Generator while the output of the step generator is applied to the oscilloscope input. If the impedance of the inserted device is exactly 125 ohms, it will merely increase the time that the amplitude of the Calibration-Step Generator waveform remains constant. However, if the inserted device is not exactly 125 ohms or does not have a constant impedance, then irregularities can be used to determine the impedance of the inserted device and to determine whether this impedance is constant. The displayed waveform will also indicate double the delay time for the inserted device.

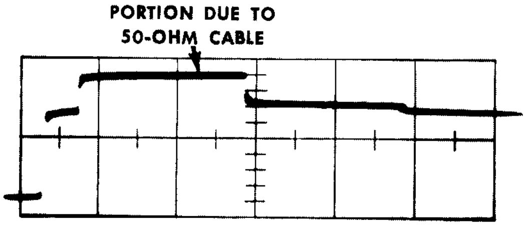


Fig. 3-10. Waveform obtained when a section of 50-ohm cable is connected as part of the charge line for the Calibration-Step Generator.

The test device, such as a piece of coaxial cable, a connector assembly, or a delay line, can be connected into the charge line of the Calibration-Step Generator in the manner shown in Fig. 3-9. In Fig. 3-10 the Calibration-Step Generator waveform is shown when a length of 50-ohm cable is connected into the charge line in series with two lengths of 125-ohm cable. The portion of the waveform due to the 50-ohm section is nearly 1½ times as high as the portions of the waveform due to the 125-ohm cables. The duration of the Calibration-Step Generator waveform due to the 50-ohm cable is twice the delay time of the cable so it is evident from the picture that the true delay time of the 50-ohm cable used is approximately 12 nsec.

In Fig. 3-10 the relative amplitude of the portions of the waveform bear a definite relationship to the impedance of the device that generated that portion. The impedance of an unknown device can thus be measured by comparing the amplitude of the portion of the Calibration-Step Generator waveform produced by it against the amplitude of the initial portion due to the 125-ohm system. The method is generally limited to the first reflection, unless the deviations are small, due to multiple reflections and reflection losses.

If we call the amplitude produced by the 125-ohm system V_O and the amplitude produced by the inserted device V_X, then the impedance of the inserted device is given by the formula:

$$Z = 125\,(2\frac{V_O}{V_X} - 1)$$

In Fig. 3-10 the ratio of V_O to V_X is approximately 0.7. Using this in the above formula gives the correct impedance of 50 ohms used to produce the waveform.

It is essential in applications of the type described here that no shorts, terminations, terminated adaptors, or attenuators having low shunt resistance to ground are used in the charge line of the Calibration-Step Generator. If devices such as these are used, they will prevent the charge line from charging to the correct voltage and will thereby prevent the Calibration-Step Generator from producing an output waveform. Where it is necessary to match one type of connector to another, unterminated adaptors should be used. While a series coupling capacitor (125 Ω connectors) may be used to allow the step generator to function, experience will show that the capacitor cannot retain its initial charge indefinitely, so voltage sag across its terminals will show in the observations. Further, the coupling capacitor is already quite large to be charged between operations of the reed switch at 750 cycles per second. External charging voltage connected through a 5000-ohm resistor by a short lead to the center conductor of an insertion unit will permit better operation with the coupling capacitor. The insertion unit must appear on the reed-switch side of the capacitor and the short-circuit or shunt resistance must be connected beyond the series capacitor.

Obtaining Information from Small Deflections

The vertical deflection factor of the Type 519 Oscilloscope is approximately 10 volts per centimeter. Consequently, very small deflections in the oscilloscope display may be important. Careful analysis and proper techniques will allow you to obtain a great deal of information from these small signals. The triggering circuits of the Type 519 are sufficiently sensitive that signals which produce only a few trace widths of deflection will provide a stable display.

One of the more obvious means of recovering information from small deflections involves the use of photographic enlargement. Here, the oscilloscope display is photographed using a high quality system and the photograph is then enlarged to a convenient size. Measurements may then be made from the enlarged photograph. The distance between graticule lines on the enlarged photograph can be used to determine the exact enlargement factors so that distances on the enlarged photograph can be readily converted into measurements of voltage and time. The primary difficulty with this method is the delay involved in obtaining enlarged prints.

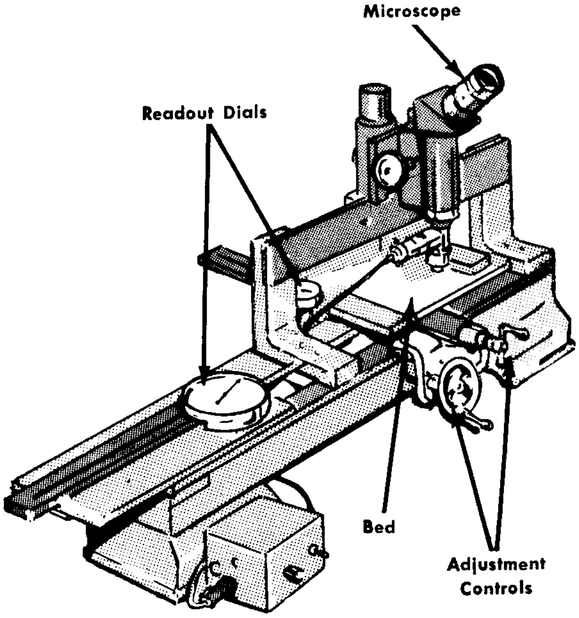


Fig. 3-11. A typical cross-feed manipulator and microscope which can be used to obtain information from small deflections by the trace-splitting technique.

A second method for obtaining information almost immediately from small deflection involves the use of a device such as a cross-feed manipulator, as shown in Fig. 3-11. A Polaroid® photograph is taken and mounted on the table of the cross-feed manipulator under a microscope containing cross hairs. The table is then adjusted until the center of the trace at one point of measurement lies directly under the cross hairs. The calibrated dials are then set to zero. The manipulator is then adjusted until the second point of measurement lies under the cross hairs and a second reading on the calibrated dials is made. This distance multiplied by the appropriate deflection factor gives the actual time or voltage between the two points.

In both methods described, a line is imagined to run through the exact center of the oscilloscope trace. This line splits the trace into two halves and consequently the technique of measurement involving this imaginary line is sometimes referred to as "trace splitting". All measurements are made with respect to the center of the trace and thus to the line passing through the center of the trace. Measurements made with respect to the trace-splitting line are much more accurate than those obtained from, say, one side of the trace.

How well the position of the trace-splitting line can be determined will depend to a large extent on the care with which the measurements are made and upon how sharply the trace is focused. Obviously, the better the trace is focused the easier it is to determine exactly where the center of the trace is located. Care should be taken to obtain the best possible trace and camera focus. It is not necessary to actually draw in the trace-splitting line. In most cases this would be very difficult, if not impossible. It is only necessary for you to make all measurements under the microscope (or from an enlarged photograph) from the exact center of the trace.

Substitution Method of Frequency Measurement

Occasionally you may want to measure the average repetition frequency of a random input signal. One means of doing this involves the use of the Rate Generator in the Type 519, or some external signal generator with calibrated frequencies. In this application, the random signal is first used to trigger the oscilloscope. The output from the DELAYED +GATE connector is then used to charge a capacitor. The circuit is shown in Fig. 3-12. The voltage to which the capacitor charges will depend on the average repetition rate of the signal and on the setting of the NANOSEC/CM switch. If then the oscilloscope is triggered from the Rate Generator output or from the external signal generator, the frequency can be adjusted to give the same voltage across the capacitor.

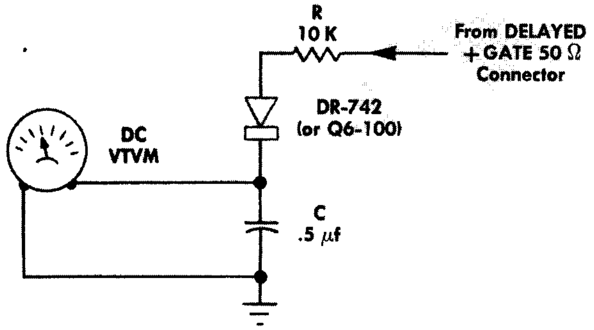


Fig. 3-12. Circuit used to measure the average repetition rate of a random signal using the substitution method. The circuit and technique can also be used to measure the frequency of periodic signals with frequencies too low to be measured directly from the oscilloscope screen.

When the same voltage is obtained, the repetition rate of the Rate Generator or external signal generator is the same as the average repetition rate of the random signal. The repetition rate can be read from the Rate Generator or external signal generator controls. A VTVM is used to measure the voltage across the capacitor in both cases. The average repetition rate of the random signal cannot exceed the highest repetition rate of the Rate Generator (approximately 30 kc) if the Rate Generator is used for the frequency comparison. Care must be taken to insure that the oscilloscope is triggered once for each random input signal. The value of the capacitor used in the application must be chosen to give a substantial voltage reading so that reasonably accurate comparisons can be made.

The settings of the NANOSEC/CM control must be made as a compromise between two factors. Since the width of the gate obtained from the DELAYED +GATE connector depends on the setting of the NANOSEC/CM switch, the switch must be set to produce a substantial charge on the capacitor. The maximum charge is obtained with the widest gate and thus the slowest sweep. However, in order to measure fairly high frequency signals (up to 400 kc) the NANOSEC/CM switch should be set to allow the highest possible sweep repetition rate. The maximum possible sweep repetition rate is obtained when the NANOSEC/CM switch is set for the fastest sweep. A typical value for the capacitance is 0.5 μf. The resistance is 10 k. If the voltage reading on the meter drops below 1 volt, short out the 10-k resistor. This method should permit you to cover the complete range of 3 cps to 400 kc.

An example of the use of the substitution method is shown in Fig. 3-13. In this application a random repetition-rate signal is being generated by a high-voltage corona discharge between a metal plate and a discharge rod. The metal plate is connected to a +20-kv voltage source. The discharge rod is mounted 4½ inches from, and perpendicular to, the metal plate. The corona signal is applied to the SIGNAL 125 Ω connector of the Type 519 through a 125-ohm coaxial cable.

The average repetition rate of the corona discharge in this example was measured and found to be 2300 pps.

Use of the Instrument in Rapid-Changing High Fields

The Type 519 Oscilloscope is a well shielded instrument. However, shielding provides only attenuation and not complete exclusion of extraneous fields. Therefore, in the presence of very large fields such as those set up by large surge generators, erratic triggering may result as the triggering circuits operate from energy obtained from the external fields. It is important to recognize that the presence of a strong external field can adversely affect the operation of the instrument unless adequate precautions are taken.

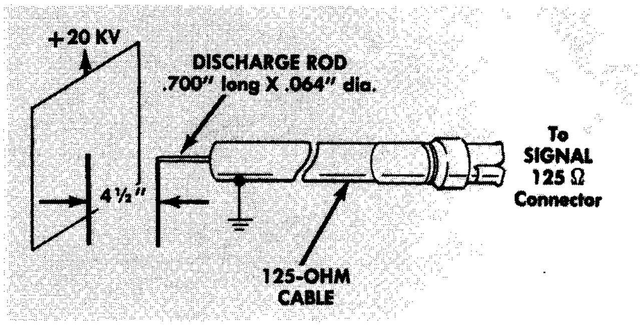


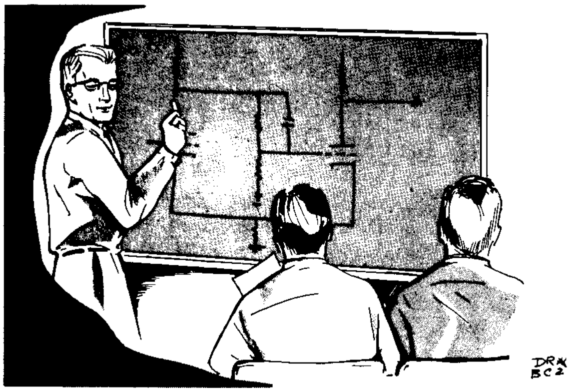
Fig. 3-13. Using the substitution method for determining the average repetition rate of a corona discharge signal.

Extremely large fields may produce false signals on the oscilloscope screen. If difficulties in triggering or false waveforms result from external fields, it will be necessary to further shield either the instrument or the generator, or to move the instrument to a point farther away from the source of the stray field.

Use of Ferrite Cores

In many applications for the Type 519, large ground currents are present. These ground currents enter the Type 519 either from the power line or signal cables, and may cause stray triggering or enter into the oscilloscope display. Stray signals generally enter the signal circuit through leaky coaxial cables or poor grounding. Solid cable is better than braided cable because it has lower outer conductor impedances and no electrostatic leakage. Care must be taken not to include transient voltage drops in inductive ground connections into the signal-input circuit.

Large transient ground currents can frequently be attenuated by passing either the power cord or signal coaxial cables through a ferrite torroid. The impedance to ground current is related to the square of the number of times the lead passes through the core. The power or signal is not affected by the core. Ferrites should be placed as near as possible to the connections to equipment under test.



SECTION 4

CIRCUIT DESCRIPTION

BLOCK DIAGRAM

A simplified block diagram of the Type 519 Oscilloscope is shown in Fig. 4-1. This diagram can be used to gain a general understanding of the operation of the instrument after which the schematic diagrams at the rear of the manual can be used for more detailed information. The information which follows describes briefly the function and purpose of each of the blocks shown in the block diagram. This is followed by a detailed circuit description of the instrument.

Input signals to the Type 519 are applied to the SIGNAL 125 Ω connector on the front panel of the instrument. The signal is then applied through a trigger takeoff and a 45-nsec delay line to the terminated 125-ohm vertical deflection system of the CRT. The delay permits the horizontal sweep to be started before the vertical signal arrives at the CRT. The trigger takeoff obtains a sample of the input signal which is then applied to the Trigger Channel as a triggering signal.

A TRIGGER SOURCE switch in the Trigger Channel selects the triggering signal used to initiate or synchronize the hori-

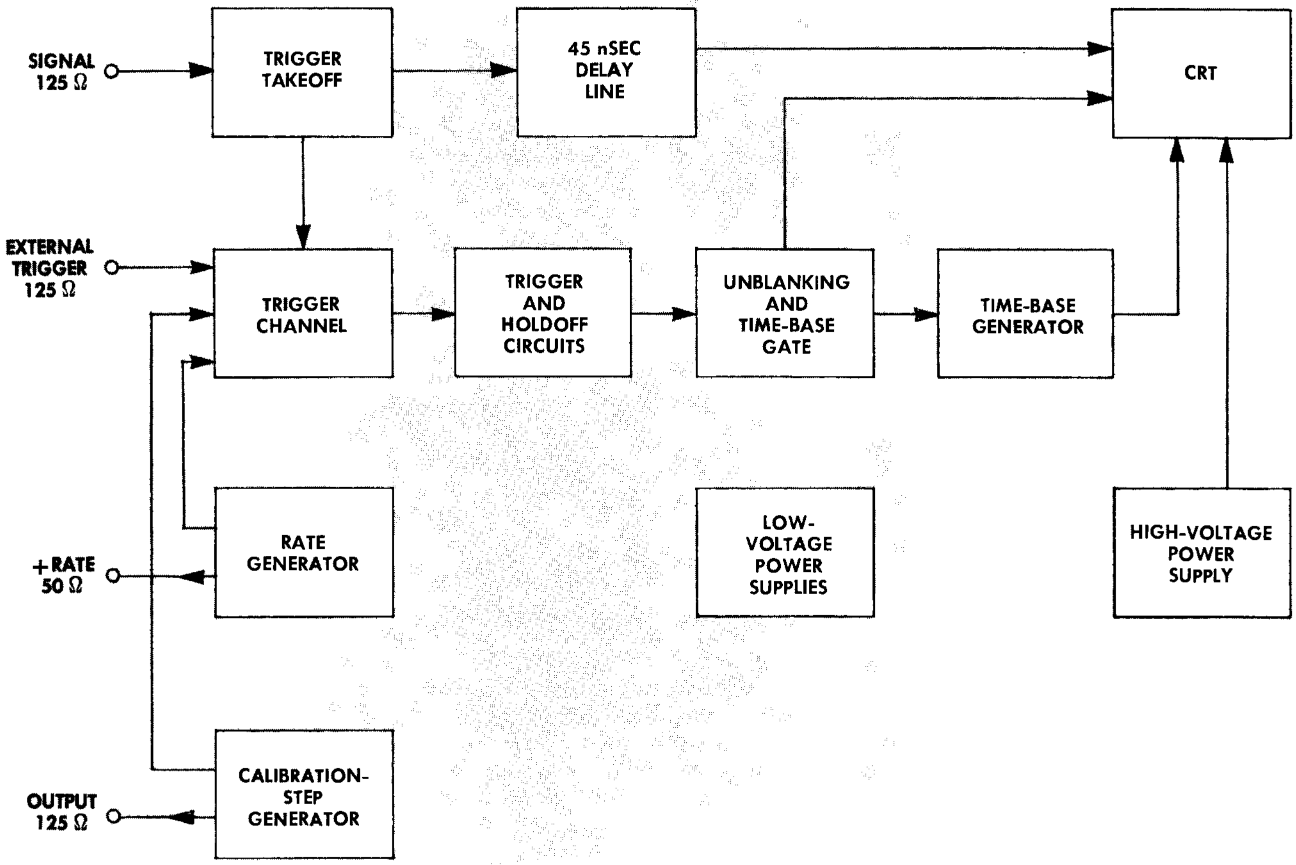


Fig. 4-1. Type 519 Oscilloscope simplified block diagram.

zontal sweep. Possible triggering signal sources are the vertical signal, external trigger inputs, the Rate Generator, and the Calibration-Step Generator. The selected trigger signals are amplified, or attenuated, to the required level in the Trigger Channel and then applied to the Trigger and Holdoff Circuit. When very high frequency signals are used, a special countdown circuit in the Trigger Channel reduces the signal frequency applied to the trigger circuits. The countdown circuit operates from input frequencies to 2 kmc.

The triggering signal obtained from the Trigger Channel is used to initiate or synchronize the operation of the First Regenerator Blocking Oscillator. The blocking oscillator produces an output waveform with constant amplitude and shape regardless of the shape or amplitude of the triggering signal. A holdoff circuit prevents the blocking oscillator from being triggered again before it and the sweep circuits have had a chance to reset after a sweep. The holdoff circuit also permits single sweeps to be generated by the instrument. Because of the holdoff circuit, the maximum repetition rate of the blocking oscillator (and the sweep), at 2 nanoseconds per centimeter, is approximately 400 kc. The blocking oscillator is capable of counting down from frequencies up to approximately 50 mc.

The output from the First Regenerator Blocking Oscillator operates a delay circuit which then operates the Second Regenerator Blocking Oscillator after a variable delay time. Since the sweep can thus be delayed through 35 nanoseconds with respect to the trigger signal, this ultimately permits the vertical signal to be positioned horizontally within the oscilloscope trace. The output from the Second Regenerator Blocking Oscillator is amplified and applied to the Unblanking and Time-Base Gate circuits.

When triggered by the output of the Second Regenerator Blocking Oscillator, the Unblanking Circuit applies a gate to the cathode of the CRT to unblank the beam for the duration of the horizontal sweep. The time-base gate which is produced by the gate timer circuit is applied to the Time-Base Generator where it is used to gate on the sweep. The duration of the gate is dependent on the setting of the NANOSEC/CM control.

The Time-Base Generator in the Type 519 consists essentially of a clamp tube, timing resistors, the capacitance in the plate circuit of the clamp tube, and a bootstrap circuit. When the clamp tube is gated off by the output of the Time-Base Gate Generator, the plate capacitance of the clamp tube charges, producing the sweep sawtooth. A special bootstrap circuit is used to apply the sawtooth to the positive end of the timing resistor, thereby producing a linear sawtooth by maintaining the charging current for the capacitance relatively constant.

The plate voltage of the clamp tube is regulated by a feedback loop which operates on the grid of the clamp tube. Regulation of the clamp tube plate voltage results in a constant starting voltage for the sweep sawtooth waveform. In addition, a separate regulator circuit automatically adjusts the screen voltage to maintain the control grid of the clamp tube at −3.2 volts regardless of the setting of the NANOSEC/CM switch. This maintains the correct operating point for the clamp tube.

The sawtooth waveform which is generated is applied to a paraphase amplifier and then to the horizontal deflection plates of the CRT to produce the horizontal sweep.

The high accelerating potentials required for operation of the CRT are supplied by the regulated High-Voltage Power Supply. Other operating potentials used by the Type 519 are obtained from the Low-Voltage Power Supplies.

Two signal generators are contained in the Type 519. The Calibration-Step Generator produces output steps which are continuously variable in amplitude and accurately calibrated. The repetition rate of the output steps is approximately 750 steps per second and the risetime is approximately 0.1 nanosecond. The Rate Generator produces output pulses which are fixed in amplitude but variable in repetition rate. Repetition rate is variable between 3 cps and 30 kc. The risetime of the Rate Generator waveform is nominally 0.5 nanosecond.

VERTICAL SIGNAL CHANNEL

Trigger Takeoff

Input signals applied at the SIGNAL 125 Ω connector are passed through a trigger takeoff before being applied to the input of the 45-nanosecond delay line. The purpose of the trigger takeoff is to obtain a sample of the input signal which can then be applied to the oscilloscope triggering circuits.

A drawing of the trigger takeoff is shown in Fig. 4-2. A gap is made in the outer conductor of the 125 Ω coaxial cable while the inner conductor is not disturbed. Between two metal rings at the gap in the outer conductor of the coaxial cable are connected eight short jumpers. Each jumper is connected through a small ferrite core. An output lead is connected through each of the eight cores in series. The eight cores and leads form eight small 1:1 transformers.

The output load on the trigger takeoff is 125 ohms. Consequently, due to the series arrangement, the impedance reflected back into the primaries of each of the small transformers is approximately 16 ohms. Core impedances reduce this primary impedance. The eight small transformers connected in parallel across the gap in the outer conductor of the coaxial cable actually present a total impedance of approximately 1.5 ohms with a decay time constant of 30 nanoseconds. The slight series impedance results in less than 1% reflection. Over 99% of the input signal is transmitted through the trigger takeoff into the 45-nanosecond delay line.

The voltage developed across the gap in the coaxial cable due to the trigger takeoff is approximately 1.3% of the input voltage. This voltage appears across each of the eight 1:1 transformers connected across the gap. Since the takeoff loop is connected in series through all eight transformers, the voltages of each of the transformers are additive. The net result is that the total output of the trigger takeoff is 8 times 1.3% or approximately 10% of the input signal voltage. This triggering signal is obtained at the expense of approximately 0.7% attenuation of the signal applied to the oscilloscope.

Since the gap is short-circuited by the cover, the only thing preventing the gap from being shorted out is a small amount of inductance in the outer conductor inside the cover. At low frequencies the inductance in the outer con-

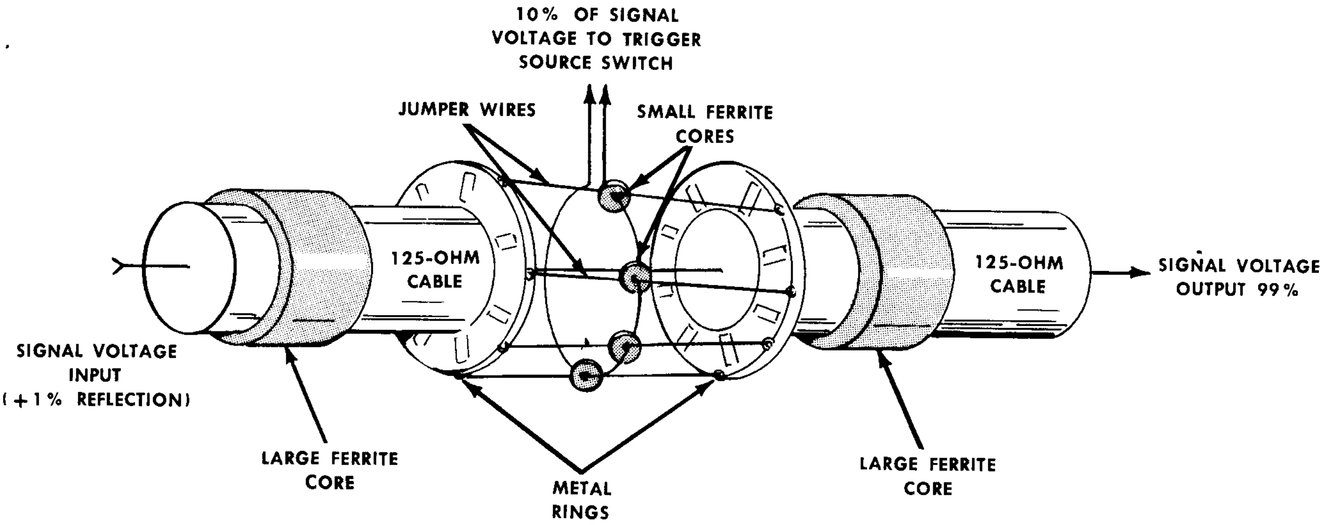


Fig. 4-2. Construction details of the trigger takeoff. The center portion is expanded to show details of the wiring. Only four of the eight jumper wires and small cores are shown for simplicity.

ductor would be insufficient to prevent the gap from being shorted out and consequently no voltage would be developed across the gap. The net result is that no output could be obtained from the trigger takeoff. To extend the low-frequency response of the takeoff, large ferrite cores are placed around the cable on both sides of the gap inside the cover. The cores increase the inductance of the outer conductor and thus permits the trigger takeoff to operate at much lower frequencies. These cores do not affect the input signal.

Delay Line

Signals transmitted through the trigger takeoff are applied through the 45-nanosecond delay line to the vertical deflection system of the CRT. The delay line is a high-quality, low-loss coaxial line which is especially selected for minimum deterioration of input signal waveshape. In addition, special care is taken in the design of the sweep circuit to insure that the sweep is started as soon as possible after a triggering signal is applied. This permits a minimum length of delay cable to allow display of the leading edge of the signal which produces the trigger.

Cathode-Ray Tube

A distributed deflection system is used in the CRT of the Type 519. The upper vertical deflection plate is, in effect, a large number of very small deflection plates. The signal is applied only to this upper deflection system. The lower deflection plate is internally bypassed to ground and is used only to apply the vertical positioning voltage.

The distributed deflection system is so designed that the velocity of propagation of the signal toward the screen is the same as the velocity of the beam electrons in the deflection system. The overall effects of the large number of effective vertical deflection plates is that their individual deflections are additive. By this means the sensitivity of the CRT is kept relatively high while transit time effects and capacitance in the plates are minimized.

Since the deflection system of the CRT is part of the 125-ohm vertical deflection system, it is important that the deflection system also present a constant impedance of 125 ohms. Any deviation from this impedance would cause reflections from the deflection system and would result in distortion of the displayed waveform. To insure that the deflection system in each CRT is exactly 125 ohms, each is tuned by means of 27 trimmers for least reflected energy. This is done before the deflection system is sealed into the envelope of the CRT and is again quality-checked after final processing of the CRT.

After the signal has passed through the deflection system of the CRT it is terminated by a 125-ohm resistor connected to the side of the CRT. Thus the signal energy traveling through the deflection system is absored rather than being reflected back into the deflection system.

TRIGGER CHANNEL

Trigger Source Switch

Triggering signals obtained from the Rate Generator, Calibration-Step Generator, EXTERNAL TRIGGER 125 Ω connector, and from the vertical input signal are applied to the TRIGGER SOURCE switch. The TRIGGER SOURCE switch determines which triggering signal is applied into the Trigger Channel.

When triggering signals obtained from the vertical input signal, the EXTERNAL TRIGGER 125 Ω connector or the Calibration-Step Generator are not used, the triggering signals are terminated by 120 ohms. A termination is not necessary when the Rate Generator triggers are not used.

Since the Calibration-Step Generator is capable of producing very large steps, an attenuator is placed in the trigger signal lead running to the TRIGGER SOURCE switch. The attenuator, composed of R6 and R7, prevents the triggering signal applied into the Trigger Channel from exceeding about 2 volts. Larger signals could conceivably cause damage in the Trigger Channel in GAIN switch positions other than X.2.

Resistors R8, R9, and R15 are added in series with the triggering signal leads to damp unwanted resonances in unused sections of the TRIGGER SOURCE switch.

In addition to its primary function of selecting the triggering signal, the TRIGGER SOURCE switch also selects the triggering signal slope which produces triggering. In the + positions the positive or rising slope is selected, while in the — positions the negative or falling slope is selected. Positive-slope triggers are required to actually trigger the blocking oscillators in the Trigger Channel. Consequently, when a negative slope is selected, the signal must be inverted to convert the negative slope to a positive slope.

Inversion of the triggering signal is accomplished in the 125-ohm transmission line between the TRIGGER SOURCE and GAIN switches. One conductor of the transmission line is grounded, while the other conductor is connected to the GAIN switch. Triggering signals may be applied to either of the two transmission line leads depending on the position of the TRIGGER SOURCE switch. When the triggering signal is connected to the ungrounded conductor of the transmission line, the signal is passed through the line without inversion. However, when the signal is connected to the grounded conductor, the signal applied to the GAIN switch is inverted. When the triggering signal is connected to the grounded transmission line conductor, the small end-to-end inductance of the line prevents ac signals from being shorted out. The transmission line is passed four times through a small ferrite core to increase the inductance of the lead and thus extend the low frequency performance of the inverting network.

Gain Switch

Since triggering signals selected by the TRIGGER SOURCE switch may have a large range of amplitudes, some means must be provided for altering these signal amplitudes to satisfy the requirements of the triggering circuits. Amplifiers and attenuators switched in by the GAIN switch perform this function.

Four positions are provided in the GAIN switch. Amplifier and attenuator connections for each of these positions are as follows:

GAIN Switch Setting	
X.2	X5 Attenuator
NORMAL	Signal Unchanged
X5	X4 Attenuator and X20 Amplifier
X20	X20 Amplifier

The various positions of the GAIN switch allow triggering signals arriving at the switch with between 20 mv and 10 volts of amplitude to trigger the oscilloscope.

X20 Amplifiers

Two identical wideband trigger amplifiers are arranged to permit stable triggering from small input signals. The amplifiers are arranged on plug-in boards and are interchangeable. Each offers approximately 20 times gain with an upper 3-db point beyond 100 megacycles. The high frequency input impedance of each amplifier is 125 ohms, matching the trigger system transmission line impedance. The amplifiers employ feedback, degeneration, and frequency-sensitive networks to maintain good transient response, bandwidth, and input impedance. Excellent gain stability and dc-voltage stability results.

The input impedance of 125 ohms is closely maintained at various frequencies by frequency-sensitive networks L30, R30, R32, and C32. At the highest frequencies, the signal is applied through C32 directly to the base of Q34 while L30 and R30 supply additional termination for slower input signals which are not easily passed by C32. Feedback through R45 also contributes to the termination of slower trigger signals.

Signals applied at the base of Q34 appear amplified at the collector and are directly coupled to the base of Q44, where they are further amplified. The output of the amplifier is coupled through C46. Each amplifier stage causes a phase reversal but since two stages are used, the output signal has the same polarity as the input signal.

DC operating voltages are stabilized by emitter-circuit degeneration in both Q34 and Q44. At low frequencies R43 produces a slight amount of degeneration in the emitter circuit of Q44. At high frequencies, R43 is bypassed by C43 and the reduced degeneration helps to compensate for the high-frequency loss in gain in transistors Q34 and Q44. R32 and C32 also tend to compensate for this loss of gain in the transistors. L37 adds high-frequency peaking at the collector of Q34.

A dc potential of —0.4 volt appears at the input of each amplifier. This voltage is necessary for proper action of the pulse-amplitude-selecting diodes, D68 and D69, which precede the Second X20 Amplifier. Diode D69 must be forward biased to permit trigger signals to be applied to the second amplifier.

A voltage divider consisting of R47, R37, and R36 supplies the collector voltage for Q34. The values for the resistors are chosen to provide the correct voltage for the base of Q44.

Function Switch

Signals from the output of the GAIN switch and the optional First X20 Amplifier are applied through a 125-ohm transmission line to the FUNCTION switch. In the PULSE and SYNC positions of the FUNCTION switch the triggering signals are applied to the Second X20 Amplifier through the pulse-amplitude-selecting diodes. Front panel selection of trigger level by R66A changes the current through R64 and R63, thereby selecting the trigger height required to send a signal through diode D69 into the Second X20 Amplifier. In the SYNC position, pulse-amplitude-selecting diode D69 is forward biased by R63 to pass very small triggers. In the HF SYNC position, triggering signals are connected directly to the Countdown Oscillator. The output of the Countdown Oscillator is then applied through D69 to the Second X20 Amplifier. When the Countdown Oscillator is used, it free-runs at approximately 30 mc but is synchronized by the trigger signal. The countdown operation assures that the output of the Second X20 Amplifier does not exceed 30 mc.

In the PULSE position of the FUNCTION switch, resistors R63, R64, and R66A form a voltage divider between +225 and —26.5 volts. The divider sets the voltage at the junction of D68 and D69. Varying the setting of R66A changes the bias applied to the two diodes. When the junction of D68 and D69 is negative with respect to ground D68 conducts, shunting any small incoming signals through R68 to ground. However, if the positive trigger signal is large enough, it will cut off D68. A signal at the junction of the two diodes which is more positive than approximately —0.2 volt will cause D69 to conduct, thereby passing the positive portion of the signal on to the Second X20 Amplifier.

By varying the setting of R66A it is possible to determine the signal amplitude required to cause D68 to cutoff and D69 to conduct. The circuit can be set to pass a certain signal amplitude while rejecting all signals with less amplitude. This amplitude-level-selection feature is necessary to permit stable triggering from a wide range of signal amplitudes. When maximum triggering sensitivity is required, R66A is set to the grounded end. This places a slightly positive potential at the junction of D68 and D69, thereby allowing all positive trigger signals to pass to the X20 Amplifier without significant amplitude reduction.

In addition to the operations already described, the FUNCTION switch also performs several other operations. These other operations will be described in conjunction with the circuit most nearly related to the operation.

Countdown Oscillator

The Countdown Oscillator (D50) circuit is connected into the trigger channel only in the HF SYNC position of the FUNCTION switch. Voltage is applied through R56 and L53 to the cathode of the tunnel diode, D50. The circuit configuration causes the Countdown Oscillator to free run at approximately 30 mc. The Countdown Oscillator can be synchronized by trigger signals with frequencies up to approximately 2 kmc. The PULSE AMPLITUDE OR SYNC and VERNIER SYNC controls vary the basic frequency of the Countdown Oscillator slightly to permit steady synchronization to be obtained.

Fig. 4-3 shows a simplified diagram of the Countdown Oscillator. The 5.5-ohm load is produced by R54 and R55 in parallel. Approximately 0.2 volt is obtained from a voltage divider, consisting of R56 and the parallel combination of R54 and R55, from —26.5 volts. The PULSE AMPLITUDE OR SYNC control, R66A, and the VERNIER SYNC control, R67, also exert some influence on the voltage applied to the tunnel diode, allowing the frequency of the oscillator to be varied as required for stable synchronization by the incoming trigger signal.

Inductor L53 plays an extremely important part in the operation of the tunnel diode oscillator. As power is first applied to the circuit, the voltage across the tunnel diode builds up until the voltage passes over the peak of the diode characteristic curve, shown in Fig. 4-4. This places the diode in its negative resistance region. Any further increase in voltage would cause the current through the diode to decrease. However, as the diode current starts to decrease, the current through L53 is maintained as its flux starts to collapse and opposes a change in current. The current through L53 not taken by D50 flows into stray capacitance and charges the circuit to the voltage at point B where all the current through L53 is again required by the diode.

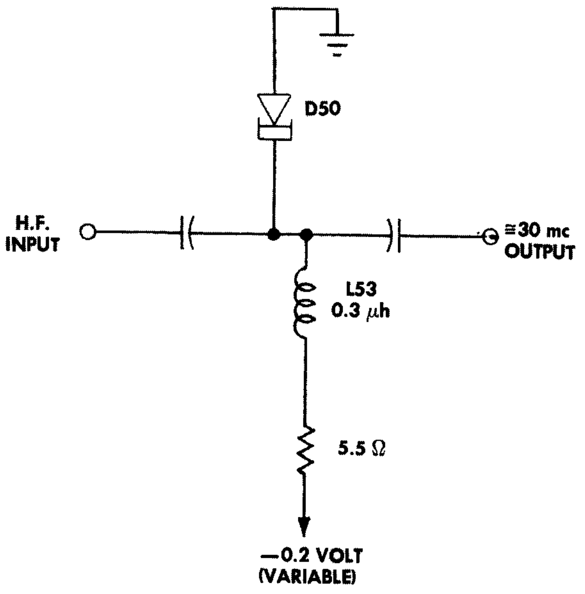


Fig. 4-3. Simplified circuit diagram of the Countdown Oscillator.

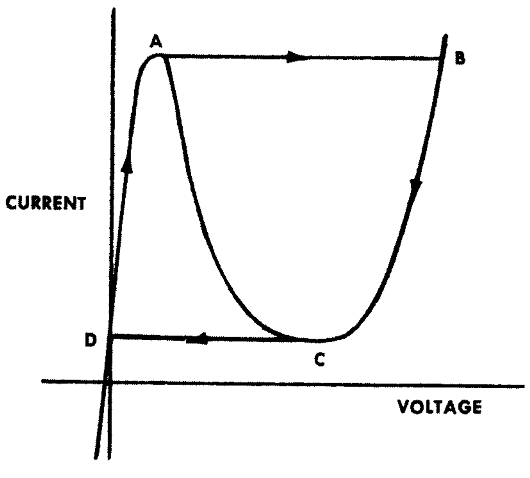


Fig. 4-4. Operating cycle of the Countdown Oscillator. The diagram shows the voltage-current curve for the tunnel diode with the operating cycle indicated.

As current through L53 decays, the voltage across the diode decreases until point C on the diode characteristic curve is reached. At this time, the voltage again forces the diode into its negative resistance region. Any further decrease in voltage would then cause an increase in diode current. Because L53 does not permit a rapid change in current, the excess diode current discharges circuit capacitances to the voltage at point D in the diagram. When the voltage and current reach point D, the diode voltage and current again slowly build up until the voltage again goes over the peak at A into the negative resistance region. At this point the cycle of operation starts over. The result of the foregoing operation is a continuous oscillation of the output of L53 about the cycle shown in Fig. 4-4. The output signals from the oscillator are approximately 0.5 volt in amplitude.

Varying the voltage applied to the tunnel diode oscillator by means of R66A and R67 selectively changes the time required for the transition from D to A and from B to C, thereby changing the frequency of oscillation. By changing the frequency of oscillation, the oscillator can be brought within the range where it can be synchronized by the applied trigger frequency.

Trigger signals to the Countdown Oscillator are connected from a 125-ohm transmission line through a high-pass filter and R51 to the cathode of D50. The filter consists of C51 and L50, and is used to isolate the Countdown Oscillator output from the trigger input circuits. Resistors R50 and R51 are used to terminate the transmission line to the Countdown Oscillator. Inductor L52 isolates the Countdown Oscillator from the output transmission line.

In operation, the input triggering signals are added to the voltages appearing across the tunnel diode. The triggering signals can thus cause the tunnel diode to switch slightly ahead of the time that it normally would. The frequency of the Countdown Oscillator can be adjusted to give stable synchronization.

Second X20 Amplifier

The input to the Second X20 Amplifier is obtained from either the input triggering signals or from the Countdown Oscillator, depending on the setting of the FUNCTION switch. The selected signal is amplified and applied to the First Regenerator Blocking Oscillator. The operation of the Second X20 Amplifier is the same as the First X20 Amplifier.

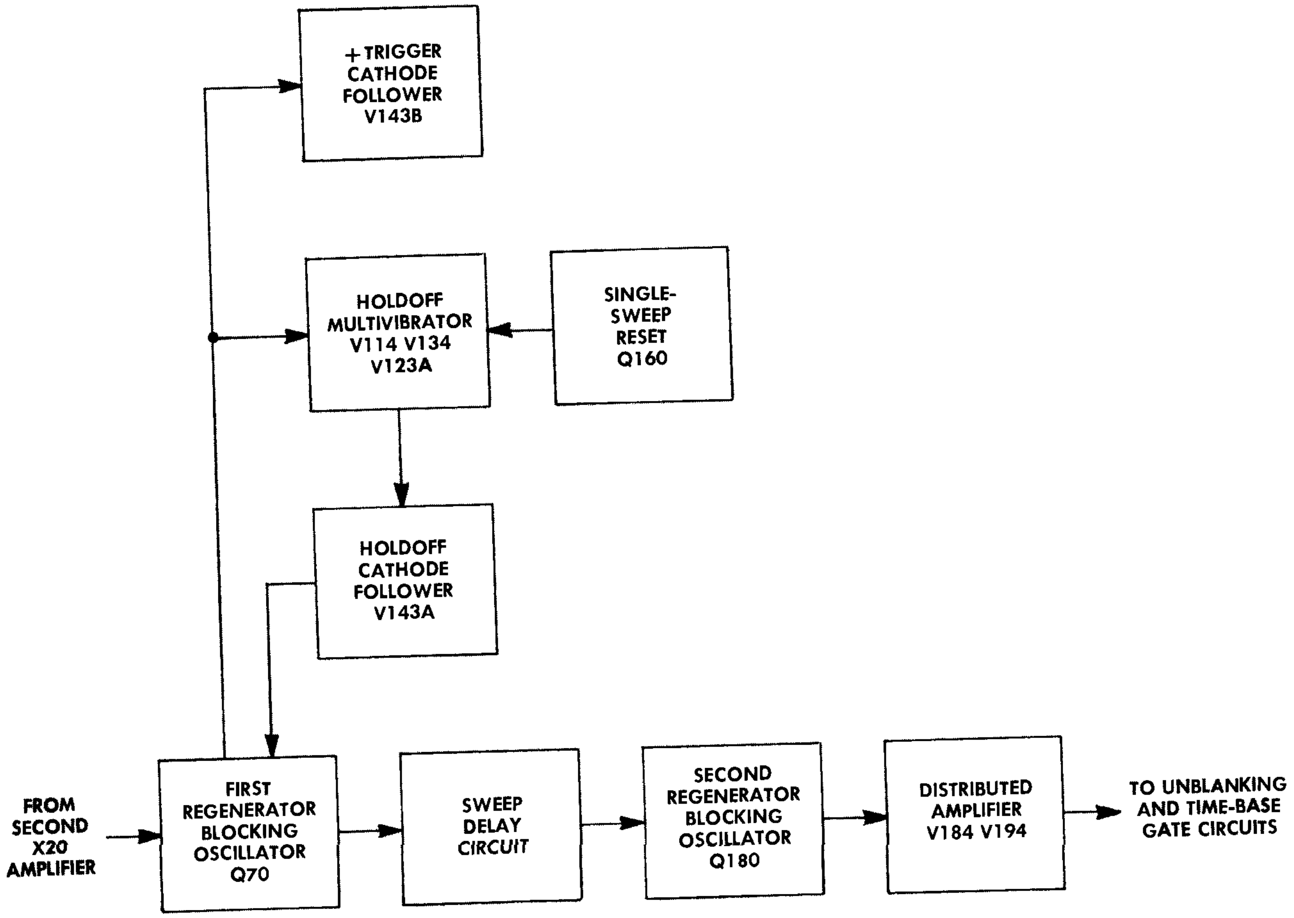


Fig. 4-5. Trigger Circuit block diagram.

TRIGGER AND HOLDOFF CIRCUITS

First Regenerator Blocking Oscillator

Fig. 4-5 shows a block diagram of the Trigger and Holdoff circuits. Trigger signals from the output of the Second X20 Amplifier are applied through C70 to a trigger amplitude limiting circuit. Low amplitude positive triggering signals are passed through diodes D70 and D71 to one of the windings of T70. Large positive signals cause the junction of D70 and D71 to go more positive, thereby causing D71 to turn off. This prevents the large amplitude signals from passing through D71 into T70. Diode D70 cuts off to prevent large amplitude negative signals from being passed.

Only positive signals are effective in initiating the operation of Q70. When a positive triggering signal is applied, current from R71 and D71 which normally flows through T70 and R72 to ground is interrupted. Field collapse in T70 then induces a negative voltage at the base of Q70. This causes Q70 to conduct, thereby permitting current to flow through the collector winding to T70. This induces a still greater negative voltage at the base causing the transistor to conduct more heavily. The regenerative action continues until Q70 saturates. The heavy conduction by Q70 starts to discharge C77. As C77 discharges, the output voltage from T70 is decreased. This causes the drive to the base of Q70 to be reduced, and the blocking oscillator is thereby reset. The cycle of operation is then completed and C77 recharges.

In order to prevent a large backswing in the output due to collapse of the field about T70, diode D72 is placed directly across one of the transformer windings. On the backswing, the diode conducts, effectively shorting out the voltage.

At the completion of each cycle of operation, the First Regenerator Blocking Oscillator is prevented from operating again for a certain time interval by the Holdoff Circuit. The purpose of the Holdoff Circuit is to insure that the operating frequency of Q70 does not exceed the limits of the circuits which follow. The maximum repetition rate permitted by the Holdoff Circuit at a sweep rate of 2 nsec/cm is approximately 400 kc. If triggering signals are applied with frequencies higher than 400 kc, the circuit counts down.

The bias on the base of Q70 is controlled by a voltage divider network between ground and +225 volts and by the output of the Holdoff Circuit. In the PULSE position of the FUNCTION switch, the setting of R66B influences the bias on Q70. By raising or lowering the base voltage on Q70, R66B determines how much amplitude the triggering signal must have in order to trigger Q70. When R66B is set for minimum resistance, the voltage at the base of Q70 is insufficient to keep the transistor turned off and the circuit free runs at a rate determined by the Holdoff Circuit.

In the SYNC position of the FUNCTION switch, the junction of R155 and R156 is grounded, allowing Q70 to free run. The rate that the circuit free runs is again determined by the Holdoff Circuit. The length of holdoff can be varied by R66A and R67 through R60 and R61, respectively, to permit the circuit to be synchronized by incoming trigger signals.

Resistors R155 and R156 determine the triggering level when the HF SYNC position of the FUNCTION switch is used. The level selected gives correct triggering for amplified signals from the Countdown Oscillator.

Two blocking oscillator outputs are obtained from separate windings of T70. One output is applied to the Holdoff Multivibrator and + Trigger Cathode Follower while the other output operates the Sweep Delay Circuit.

+ Trigger Cathode Follower

A positive output from the First Regenerator Blocking Oscillator is applied through R75 and R145 to the grid of V143B. The output signal from the cathode is applied through a length of 50-ohm cable to the +TRIGGER 50 Ω connector on the front panel. The output impedance of the cathode follower is approximately 50 ohms during the time the tube is conducting.

Holdoff Multivibrator

A simplified diagram of the Holdoff Multivibrator Circuit is shown in Fig. 4-6. In the normal static state, V114 is cut off and V134 is conducting. A common cathode resistor, R116, insures that both tubes do not conduct simultaneously. The grid of V114 is held approximately 4 volts negative by a voltage divider between —26.5 volts and ground consisting of R71, D71, and R72. The grid of V134 is clamped at ground potential by the grid-to-cathode portion of V123B which operates as a diode. Since the grid of V134 is more positive than the grid of V114, V134 conducts. This causes the common cathode of V114 and V134 to be at approximately ground potential, holding V114 in cutoff.

With V114 cut off, the grid of V123A is at approximately +100 volts, thereby setting the cathode of V123A also at approximately +100 volts. With the control grid of V134 clamped at ground, and the cathode of V123A at +100 volts, capacitors C126 and C123 are charged to approximately 100 volts.

When Q70 operates, a positive pulse of approximately 8 volts is applied thorugh R75 to the control grid of V114. The amplitude of this pulse is sufficient to bring V114 out of cutoff. As V114 conducts its plate voltage drops, causing the cathode voltage of V123A to also drop. The drop in voltage at the cathode of V123A cuts off V134 and causes capacitors C126 and C123 to start discharging through R126 and R125. As the capacitors discharge, the voltage at the grid of V134 rises slowly, eventually permitting V134 to again conduct, thereby cutting off V114 once more. The length of time required for C126 and C123 to discharge sufficiently to permit V134 to conduct is determined by the values of R124, R125, R126, C123, and C126, and by the voltage at R124.

The values of R126 and C126 are selected by the setting of the NANOSEC/CM switch. The length of time that V134 remains cut off is therefore also determined by the setting of the NANOSEC/CM switch. Voltages applied from the VERNIER SYNC control, R67, and the PULSE AMPLITUDE OR SYNC control, R66A, are applied to the

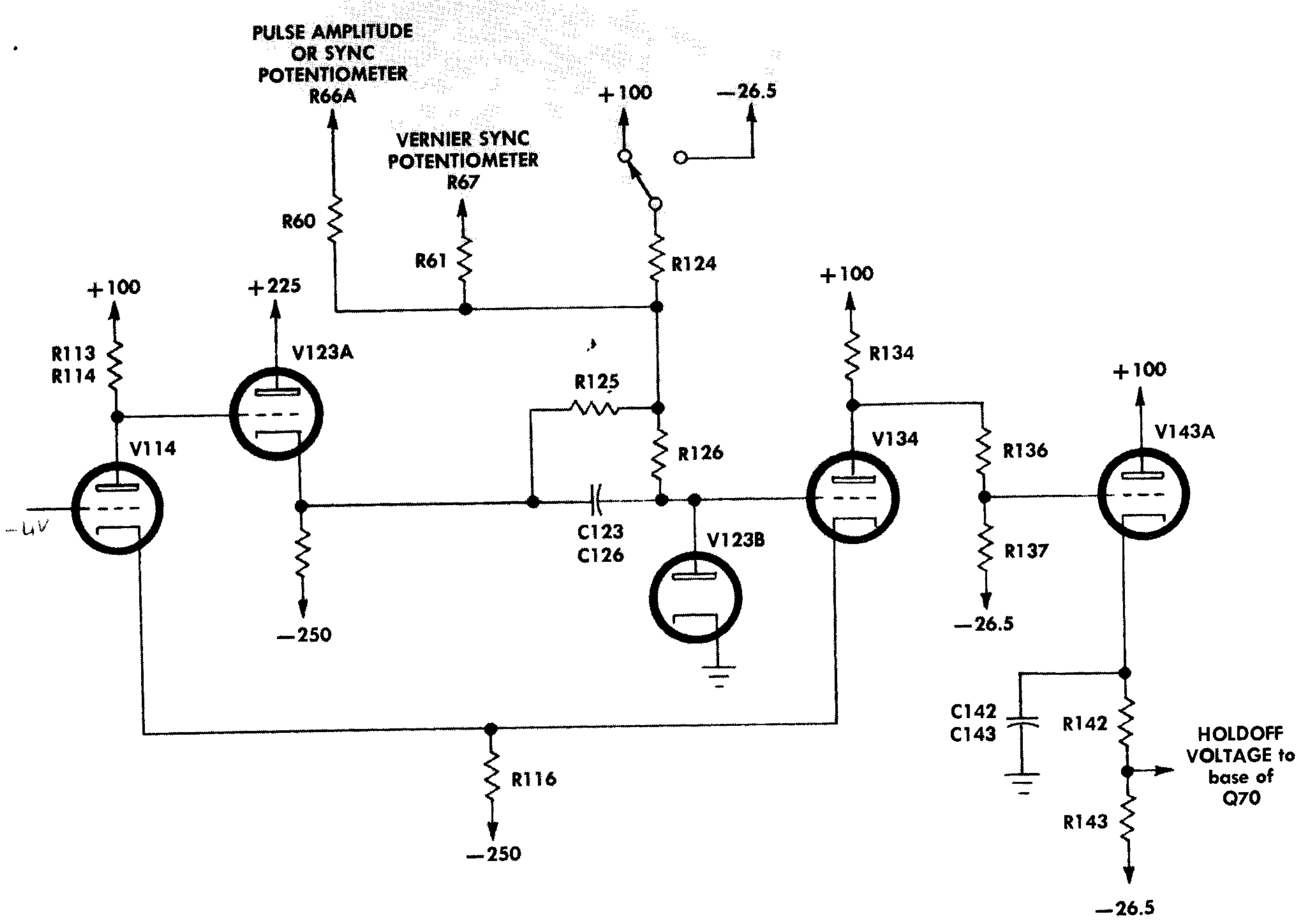


Fig. 4-6. Holdoff Circuit simplified circuit diagram.

junction of R126 and R125. Both of these controls influence the voltage at this point and thus the time that V134 remains cut off. By modifying the holdoff time provided by the Holdoff Multivibrator, the VERNIER SYNC and PULSE AMPLITUDE OR SYNC controls can be used to slightly control the repetition rate of the First Regenerator Blocking Oscillator, Q70, in order to obtain stable synchronization.

Tube V123A is used in the circuit to provide a low impedance charge path for C123 and C126. This allows the two capacitors to rapidly charge to the full 100 volts when V134 conducts. It is important that the capacitors regain their full charge rapidly in order for the multivibrator to be prepared for the next pulse from Q70. Capacitor C113 acts as a bootstrap capacitor for V114 and is used to speed the rise of the pulse at the plate of V114.

As previously mentioned, the grid and cathode of V123B are used as a diode which clamps the grid of V134 at ground potential when V134 is conducting. In addition, the plate circuit of V123B is used to light the READY lamp on the front panel of the instrument. The lamp lights when V134 is conducting to indicate that the holdoff period has elapsed and that the Holdoff Multivibrator has been reset.

Holdoff Cathode Follower

When the Holdoff Multivibrator is triggered by the output of Q70, the rise in plate voltage of V134 is applied to the grid of Holdoff Cathode Follower, V143A. The resulting positive rise in voltage at the cathode of V143A is then applied to the base of Q70 holding the transistor cut off.

As the cathode voltage of V143A rises, capacitors C143 and C142 are charged rapidly through the cathode follower to the cathode voltage. Later, as the Holdoff Multivibrator resets, the grid voltage of V143A drops to its original level. Because of capacitors C142 and C143, however, the cathode of V143A is unable to follow, and the cathode follower cuts off. Capacitors C142 and C143 then slowly discharge through the cathode resistors, gradually permitting the base voltage of Q70 to approach the point where it can again be triggered. The effect of the capacitors in the cathode circuit of V143A is to add an additional holdoff time to the holdoff time provided by the action of the Holdoff Multivibrator. The purpose of this additional holdoff time is to permit the Holdoff Multivibrator to become reset and C123 and C126 to become fully charged before Q70 is permitted to operate on the next cycle.

The value of C143 is determined by the setting of the NANOSEC/CM switch. The extension of the holdoff time provided by the Holdoff Cathode Follower is, therefore, selected by the setting of the NANOSEC/CM switch to provide the necessary charging time for C123 and C126.

Single-Sweep Reset

When the NORMAL—SINGLE SWEEP switch is placed at SINGLE SWEEP, R124 is disconnected from +100 volts and reconnected to —26.5 volts. The resulting decrease in the voltage at the grid of V134 causes V134 to normally cut off and V114 to normally conduct. With V134 cut off, the positive voltage at the cathode of V143A prevents Q70 from being triggered, thereby preventing sweeps from being generated.

In the SINGLE SWEEP position, the NORMAL—SINGLE SWEEP switch also applies power to Q160. Since Q160 is normally not conducting, C164 and C168 both charge to 26.5 volts. The base of Q160 is held at ground by the connection through R163. When the RESET switch is closed, C168 discharges through R168. As C168 discharges, the voltage at the base of Q160 goes negative, bringing the transistor into conduction. When Q160 conducts, the increase in current through T160 induces a more negative voltage at the base of Q160 causing the transistor to conduct more heavily. This then induces a still greater negative voltage at the base. As C164 discharges into the T160, the output voltage and regeneration base drive decrease. This decrease in the base drive causes the transistor to start to turn off. This induces a positive voltage at the base of Q160 which cuts off the transistor. When the transistor reaches cutoff, the cycle is completed.

If, after a switching cycle, the RESET button is still depressed, Q160 goes back into conduction. However, C164 was discharged by the switching cycle and is therefore unable to support another cycle until sufficient time has elapsed for the capacitor to recharge. Transistor Q160 continues to conduct as long as the RESET button is depressed. The voltage drop across R164 prevents C164 from charging back to —26.5 volts again until the switch is released. The lack of charge on C164 prevents Q160 from performing its switching operation more than once each time the RESET button is pressed.

An output pulse from T160 is applied to reset the Holdoff Multivibrator. A voltage divider consisting of R160 and R161 between ground and —12.6 volts biases the junction of diodes D160 and D161 at about —9 volts. Diode D161 clamps the amplitude of the pulse at ground level. D160 resets the circuit only if the cathode voltage level is below ground.

When V134 is conducting, the common cathodes of V114 and V134 are at approximately ground potential. When V114 is conducting the common cathode is about 3 volts negative. Diode D160 is thus held cut off at all times except when it receives the reset pulses from T160. Diode D161 shunts positive signals larger than approximately 9 volts to ground.

When the RESET button is pressed, the positive output from T160 is applied to the common cathode circuit causing V114 to cut off. The rise in plate voltage of V114 causes the cathode voltage of V123A to go to about +100 volts. Resistors R124 and R125 form a voltage divider between —26.5 volts and the +100 volts on the cathode of V123A. The voltage divider places a positive voltage on the grids of V134 and V123B causing them to conduct. This in turn lights the READY lamp and permits Q70 to be triggered on the next triggering signal. When Q70 is triggered, the sweep runs and the positive output from T70 again causes V114 to go back into conduction, cutting off V134. The Holdoff Multivibrator remains in this condition until the RESET button is again pressed to reset the multivibrator.

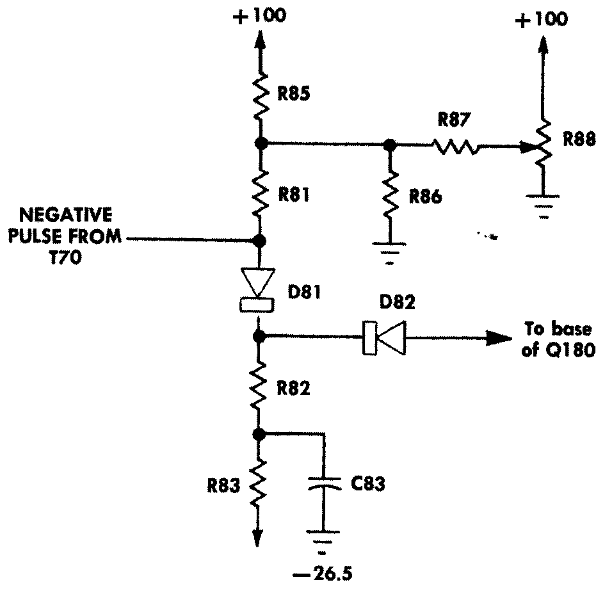


Fig. 4-7. Sweep Delay Circuit simplified circuit diagram.

Sweep Delay Circuit

A simplified diagram of the Sweep Delay Circuit is shown in Fig. 4-7. A voltage divider between +100 volts and —26.5 volts initially sets the voltage at the junction of D81 and D82. The voltage at this point in the circuit can be varied by means of the DELAY control, R88. The voltage varies from ground potential to several volts positive. When Q70 goes through its blocking oscillator cycle, a negative pulse at the junction of D80 and D81 causes D81 to cut off, thereby interrupting the voltage divider network. The sudden drop in current through R82 produces a small negative voltage step at the cathode of D82. This is followed by a negative ramp as C83 charges through R83. When the voltage at the cathode of D82 becomes negative the diode conducts, producing a negative voltage at the base of Q180. When the voltage at the base of Q180 goes sufficiently negative to allow the transistor to conduct, a blocking oscillator cycle is started.

The time duration between the operation of Q70 and the triggering of Q180 is largely determined by the initial charge on C83. The charge on C83, however, is determined by the setting of the DELAY control, R88. By changing the setting of R88, the starting point of the ramp-shaped waveform applied to the cathode of D82 can be changed. Thus, the delay in the operation of Q180 can also be varied. The small resistor, R82, provides a small step at the start of the ramp-shaped waveform which overcomes the bias on D82 and allows Q180 to be triggered with minimum delay when R88 is at the ground end.

Second Regenerator Blocking Oscillator

Operation of Q180 is similar to the operation of Q70 and Q160 and will therefore not be described in detail. The purpose of the Second Regenerator Blocking Oscillator is to produce a constant output-amplitude pulse after a variable time-delay, each time that the oscilloscope is triggered. The output of the Second Regenerator is applied from T180 to a distributed amplifier stage through R185.

Distributed Amplifier Stage

The output of approximately +10 volts from T180 is applied to the grid line of V184 and V194. Bias for the tubes is obtained from the junction of R187 and R188 and is applied through R185 to the grid line.

The positive signal at the grids of V184 and V194 produces a negative signal at the plates. The negative signal is applied through C190 and C196 to the plate line of the Distributed Amplifier. The main purpose of the amplifier is to develop the large amount of power required to drive the Time-Base Gate and Unblanking circuits. The distributed amplifier circuit is used to minimize the deterioration of the risetime of the output from the Second Regenerator Blocking Oscillator.

When the positive pulse from T180 is applied, the tubes are brought into very heavy conduction, with a total peak current of approximately 0.5 ampere. The peak current, however, is only demanded for approximately 25 nanoseconds out of each 2.5 microseconds or more, resulting in an average current of approximately 5 ma. The large amount of peak current develops approximately a 40-volt pulse across the 100-ohm load at the output (R199) and the 220-ohm reverse termination (R190).

The pulse developed in the plate line of V184 and V194 is negative. However, the Time-Base Generator and Unblanking circuits require a positive drive pulse. Transformer T198 is used to produce the voltage inversion. The transformer uses a twin lead transmission line passed seven times through a ferrite core. Energy is coupled into one of the twin leads at the input side and taken from the other lead at the output side with the opposite polarity. The ferrite core is used to extend the low-frequency response of the transformer. This transformer is similar to the one described previously which inverts triggering signals at the TRIGGER SOURCE switch.

The output from T198 is a positive pulse of approximately 40 volts. The pulse is passed through D197 and D198 into a length of coaxial cable, where it is transmitted into the Unblanking and Time-Base Gate Generator circuits. After a certain period determined by the setting of the NANOSEC/CM switch (and for only the three fastest sweeps) the pulse is reflected back to the junction of D197, D198, and D199, but in the opposite polarity. The negative reflected pulse causes D199 to conduct allowing the reflected pulse to be terminated and absorbed by R199. This prevents unwanted multiple reflections.

UNBLANKING AND TIME-BASE GATE

Clipping Line

As shown in the block diagram of Fig. 4-8, the positive pulse from T198 is applied through a lumped-constant delay line into the clipping line. The clipping line is used to determine the length of the time-base gate in the 2, 5, and 10 positions of the NANOSEC/CM switch and is composed of 3 sections of coaxial cable. In these positions, the positive pulse travels down the clipping line until it reaches the short provided by a switch contact. The shorted output causes a 100% reflection of the pulse and a polarity reversal. The reflected pulse then turns off the positive gate appearing at the grid of V244. The duration of the positive pulse appearing at the grid of V244 depends on the time required for the pulse to travel to the end of the clipping line, reflect from the shorted end, and return to the grid of V244. This is twice the transit time of the length of cable used. The NANOSEC/CM switch changes the length of coaxial cable used to produce the reflection and thus determines the length of the gate produced.

The maximum gate length which can be produced by means of the clipping line is limited by two primary factors. The first limitation is that the gate cannot last longer than the duration of the positive pulse obtained from T198. The second limitation is imposed by the physical need for additional lengths of cable for the clipping lines as the length of the gate is increased. The long cables required for long gates would make this means of setting the gate lengths impractical.

In all positions of the NANOSEC/CM control except 2, 5, and 10, R250 terminates the clipping line and thereby prevents reflections. In all of these slower sweep-rate positions, the Gate Extender Multivibrator determines the final length of the time-base gate.

Gate Extender

In the 2, 5, and 10 positions of the NANOSEC/CM switch, plate voltage is disconnected from V264, V393B, and V283, thereby disabling the Gate Extender Circuit. In these positions, the length of the gate is determined solely by the clipping line length. In all other positions of the NANOSEC/CM switch, plate voltage is applied to the tubes. Fig. 4-9 is a simplified diagram of the Gate Extender Circuit.

A voltage divider between —250 volts and ground consisting of R257, R256, and R250 holds V264 in cut off by maintaining the grid a few volts negative. With V264 cut off, R262 and R263 set the plate voltage at approximately +100 volts. Tube V274 is normally conducting heavily. Grid current keeps the grid at approximately ground potential. Capacitor C262 is therefore charged to approximately 100 volts.

When a positive pulse is applied to the grid of V264, the tube conducts, causing the plate voltage to drop. The

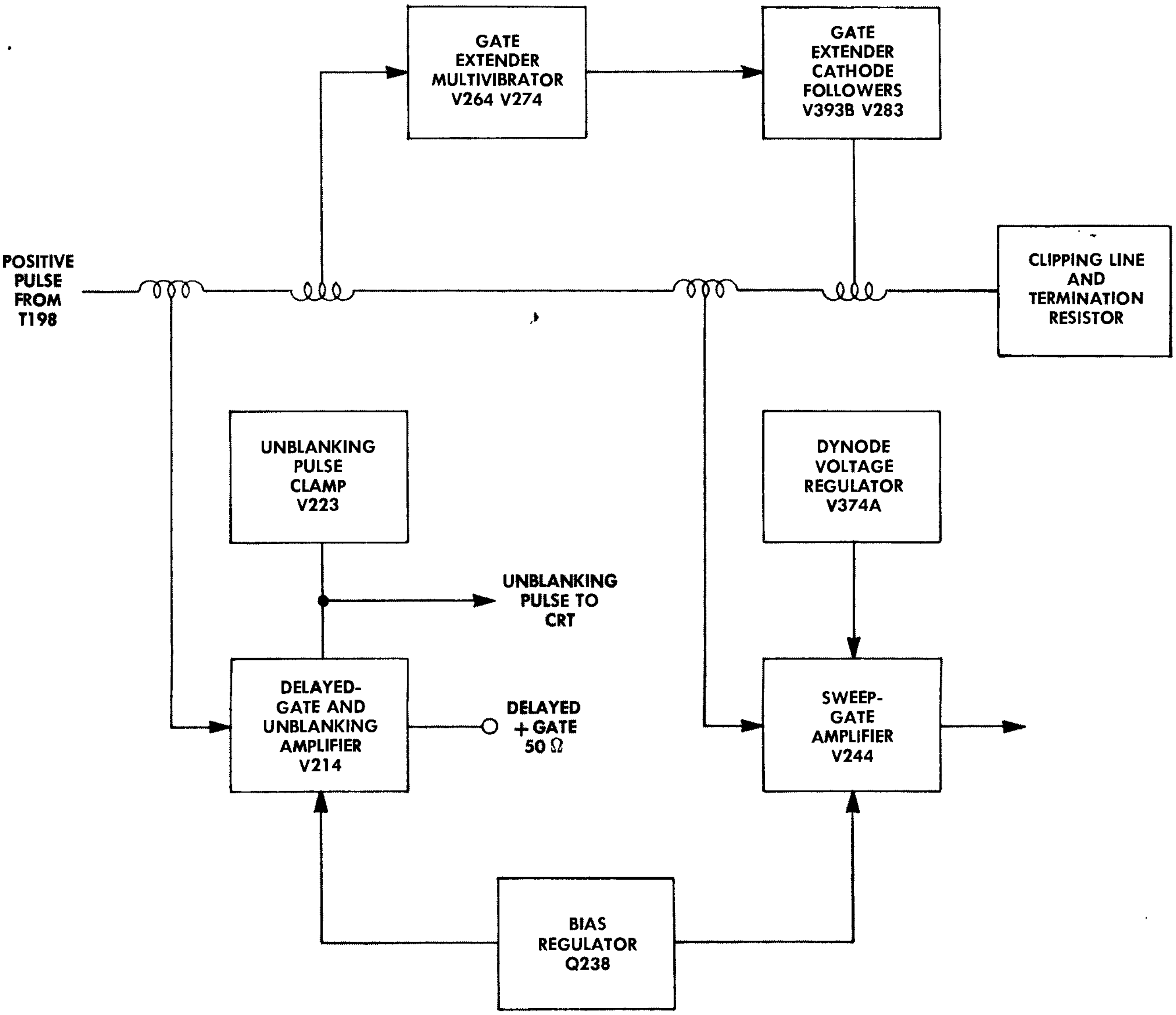


Fig. 4-8. Unblanking and Time-Base Gate Circuit block diagram.

drop in plate voltage causes V274 to cut off. When C262 has discharged through R271 and R270, V274 again conducts and ends the time-base gate. The time that V274 remains cut off is controlled by the setting of C262 and by the value of R270 selected by the NANOSEC/CM switch. At the 1000 setting of the NANOSEC/CM switch the duration of the gate is approximately 9 microseconds.

During the time that V274 is cut off, its plate voltage is near +100 volts. The positive rise in voltage is divided across R280 and R281 and applied to the grid of V393B. The purpose of the divider is to obtain the correct dc level for the grid of V393B. The output from cathode follower V393B is then applied to the grids of both sections of V283. The resultant rise of approximately 20 to 30 volts at the cathodes of V283 causes the grid of V244 to go positive by a similar amount. The voltage obtained from V283 extends the pulse obtained from T198 for the time interval required for a particular sweep duration. During the time that the pulse from T198 is present, the positive voltage at the cathodes of V283 holds V283 in cutoff.

The resulting positive gate is applied to the Sweep-Gate Amplifier, V244, to V264, and to the Delayed-Gate and Unblanking Amplifier, V214. The positive signal at V264 regenerates the input signal after expiration of the drive pulse and causes the Gate Extender to operate as a one-shot multivibrator.

Gate Amplifier

V244 is a secondary emission tube which is used to obtain the high current necessary to drive the Time-Base Generator. Both the cathode and dynode voltages are regulated. The cathode voltage of both V214 and V244 is set at approximately +3.7 volts by emitter follower Q238. The positive voltage on the cathodes holds both V214 and

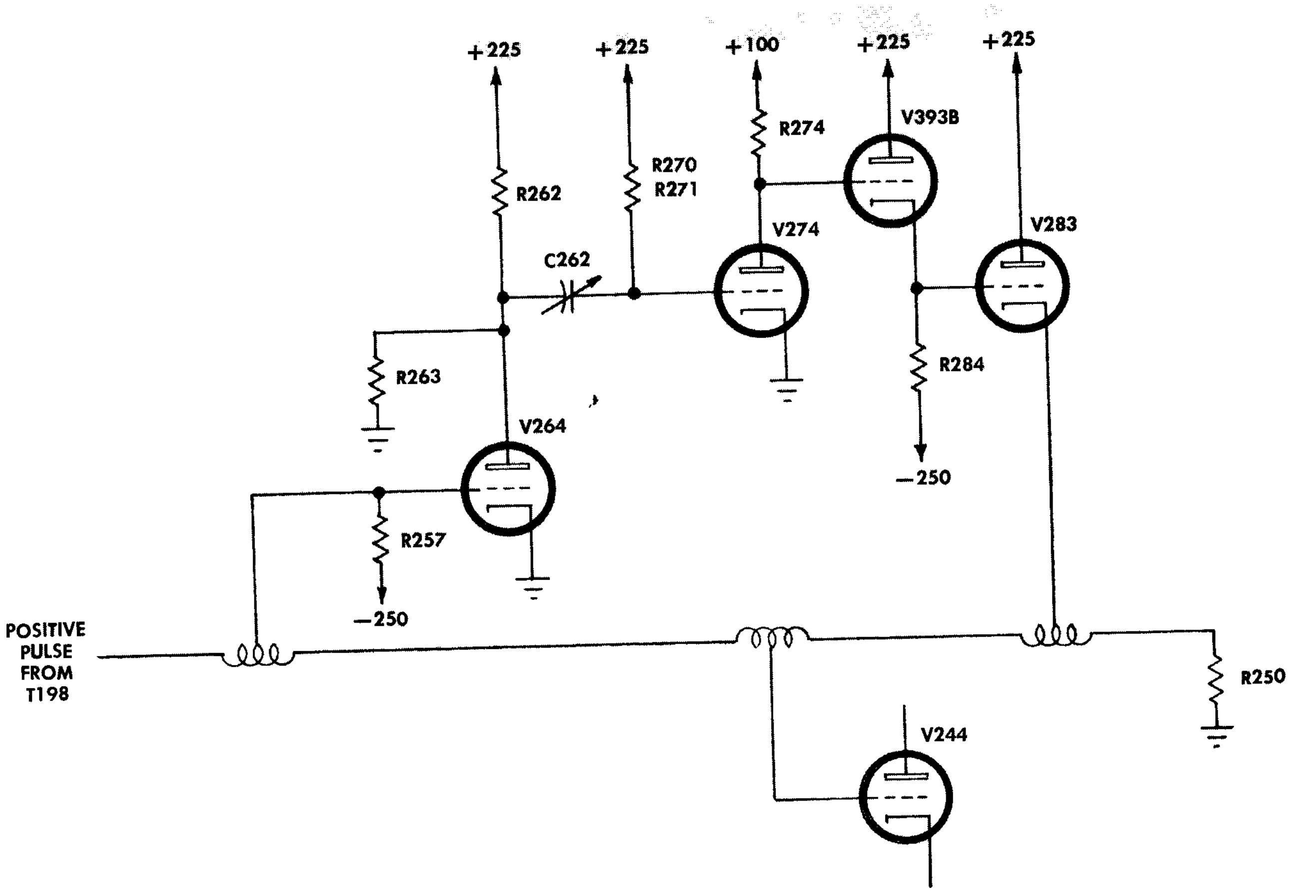


Fig. 4-9. Gate Extender Circuit simplified circuit diagram.

V244 in cutoff while permitting the grids to be near ground potential. The dynode voltage of V244 is maintained at a constant level by shunt regulator V374A.

When a positive pulse is applied to the control grid, V244 conducts heavily causing the plate voltage to drop. The resulting negative pulse at the plate is applied to the Time-Base Generator where it is used to gate on the sweep.

Delayed-Gate and Unblanking Amplifier

With no positive gate applied to the grid of V214, the tube is biased beyond cutoff by Q238, and the plate voltage is approximately +650 volts. The high cathode voltage holds V223 in cut off. When the positive gate is applied to the grid of V214, the tube conducts heavily and the plate voltage drops. Tube V223 limits the amount that the plate voltage of V214 can drop. The control grids of V223 are set at approximately +540 volts by Zener diode D220. Thus, when the cathode voltage of V223 drops to approximately +540 volts, the tube conducts, preventing a further decrease in voltage. The limiting action of V223 permits the plate voltage of V214 to decrease by only about 110 volts.

The drop in plate voltage of V214 is applied through C228 and other components to the cathode of the CRT. The negative pulse at the cathode unblanks the CRT for the duration of the time-base positive gate at the grid of V214.

In addition to the high current feature of the secondary emission tubes, such as V214, it is possible to obtain both positive and negative outputs simultaneously from the tubes. This feature is utilized in V214 where a positive signal is obtained from the dynode and applied to the DELAYED +GATE 50 Ω connector on the front panel of the instrument. Since the dynode emits secondary electrons when struck by the electrons from the cathode, the dynode goes more positive when the tube conducts. A positive pulse is thereby obtained at the front panel connector when V214 is driven into conduction by the positive gate at the control grid.

TIME-BASE GENERATOR

Block Diagram

A block diagram of the Time-Base Generator is shown in Fig. 4-10. Two conditions are automatically maintained between sweeps in order for the generator to function properly. The first condition is that the plate voltage of V331 is maintained at +155 volts to insure that the sweep sawtooth waveform starts from the same voltage for each

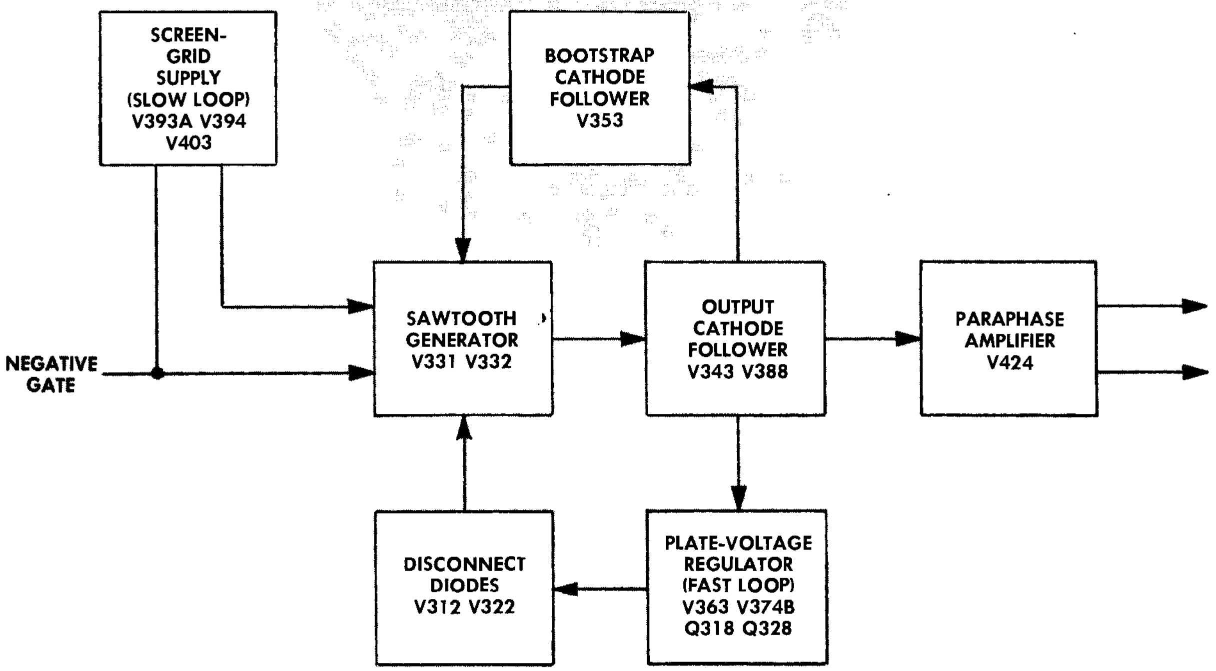


Fig. 4-10. Time-Base Generator block diagram.

sweep. The second condition is that the control grid voltage of V331 is maintained at approximately —3.2 volts. Two feedback loops are used to provide these starting conditions. The two loops are shown on the block diagram.

The first feedback loop operates if the plate voltage of V331 deviates from +155 volts between sweeps. When this occurs, an error signal is generated in the Plate-Voltage Regulator Circuit (fast loop) which is amplified and fed through the Disconnect Diodes to the control grid of V331. The error signal causes V331 to change its operating point to bring the plate voltage back to +155 volts. However, the signal at the grid of V331 disturbs the condition that the grid voltage remain at —3.2 volts and thus causes the second feedback circuit (slow loop) to operate. The Screen-Grid Supply compares the grid voltage of V331 against a reference. If the control grid voltage is not at —3.2 volts, the Screen-Grid Supply adjusts the screen-grid voltage of V331 in such a manner as to cause the fast loop to move the control grid to —3.2 volts.

When a negative gate is applied to the Sweep Generator, both feedback loops are temporarily disabled and V331 is cut off. The sawtooth waveform is then generated in the plate circuit of V331 and applied through the Output Cathode Follower and the Paraphase Amplifier to the deflection plates of the CRT. The sawtooth waveform at the CRT moves the electron beam horizontally across the screen to form the sweep. A bootstrap cathode-follower circuit is used to improve the linearity of the basic sweep generator by driving the more-positive end of the timing resistors.

Plate-Voltage Regulator

After each sweep is produced, the plate voltage of V331 is returned to +155 volts by the fast regulator loop. Any tendency for this voltage to shift between sweeps would result in a horizontal movement of the start of the sweep on the screen.

The plate voltage of V331 is applied directly to the grids of output cathode follower V343. The level of the voltage at the cathodes of V343 is reduced approximately 250 volts by Zener diodes D344 and D345 and applied through R344 to the control grids of V363. The cathode voltage of V363 is in turn applied through R375 and L375 to the cathode of V374B where it is compared with the voltage on the control grid obtained from R374. If the plate voltage of V331 is higher than normal, for example, the cathode voltage of V374B will be more positive than normal. This reduces conduction through V374B, causing the plate current to decrease at R373. The resulting rise in voltage is applied to the base of Q318 causing the current through Q318 and Q328 to decrease.

The current through disconnect diodes V312 and V322 is set by transistors Q328 and Q318. Therefore, as the current through the transistors is reduced, so also is the current through the disconnect diodes. The voltage drop across R380 is therefore reduced, allowing the control grid of V331 to move in the positive direction. This permits V331 to conduct more heavily, lowering the plate voltage to the proper level.

A decrease in the plate voltage of V331 is compensated for similarly. The grid voltage of V331 would be forced more negative by the feedback loop to decrease conduction and thereby allow the plate voltage to rise to the proper level.

Screen-Grid Supply

As a result of action by the Plate-Voltage Regulator loop, the control grid of V331 may tend to not be at the normal —3.2 volts. This is corrected by the slow loop as follows: The voltage at the grid of V331 is also applied to the grid of V393A, where it is compared with the voltage at the grid of V394. If the grid voltage of V331 is more negative, for example, than normal, the negative voltage at the grid of V393A produces an increase in conduction through V394. This produces a drop in the plate voltage of V394. The voltage drop is applied through a divider to the grid of V403 causing a decrease in the screen-grid voltage of V331.

When the screen-grid voltage of V331 is decreased, conduction through V331 also decreases, causing the plate voltage to rise. The Plate-Voltage Regulator loop makes the control grid of V331 more positive to increase the current and return the plate voltage to normal. Thus, the change in screen-grid voltage produced by the Screen-Grid Supply causes the Plate-Voltage Regulator loop to return the control grid to —3.2 volts. The reference voltage which the control-grid voltage of V331 is compared against can be adjusted by means of R396 to obtain the correct regulated control-grid voltage.

Capacitor C333C in the cathode of V403 prevents the Screen-Grid Supply from operating as fast as the Plate-Voltage Regulator loop. The main function of the Screen-Grid Supply is to readjust screen voltage as the Sweep Range switch is operated and as V331 eventually ages or is replaced.

Sawtooth Generator

When a negative gate is produced by the Time-Base Gate circuits, the amplified gate is applied through Zener diodes D305, D306, D307 and D308 and developed across R380. This negative gate is approximately 45 volts in amplitude. The four Zener diodes decrease the dc level of the gate without affecting its amplitude. The negative gate cuts off V312 and V322 and drives V393A toward cutoff, thereby disabling the feedback loops. The negative gate also cuts off V331 to initiate the generation of the sawtooth waveform. A simplified diagram of the Time-Base Generator is contained in Fig. 4-11.

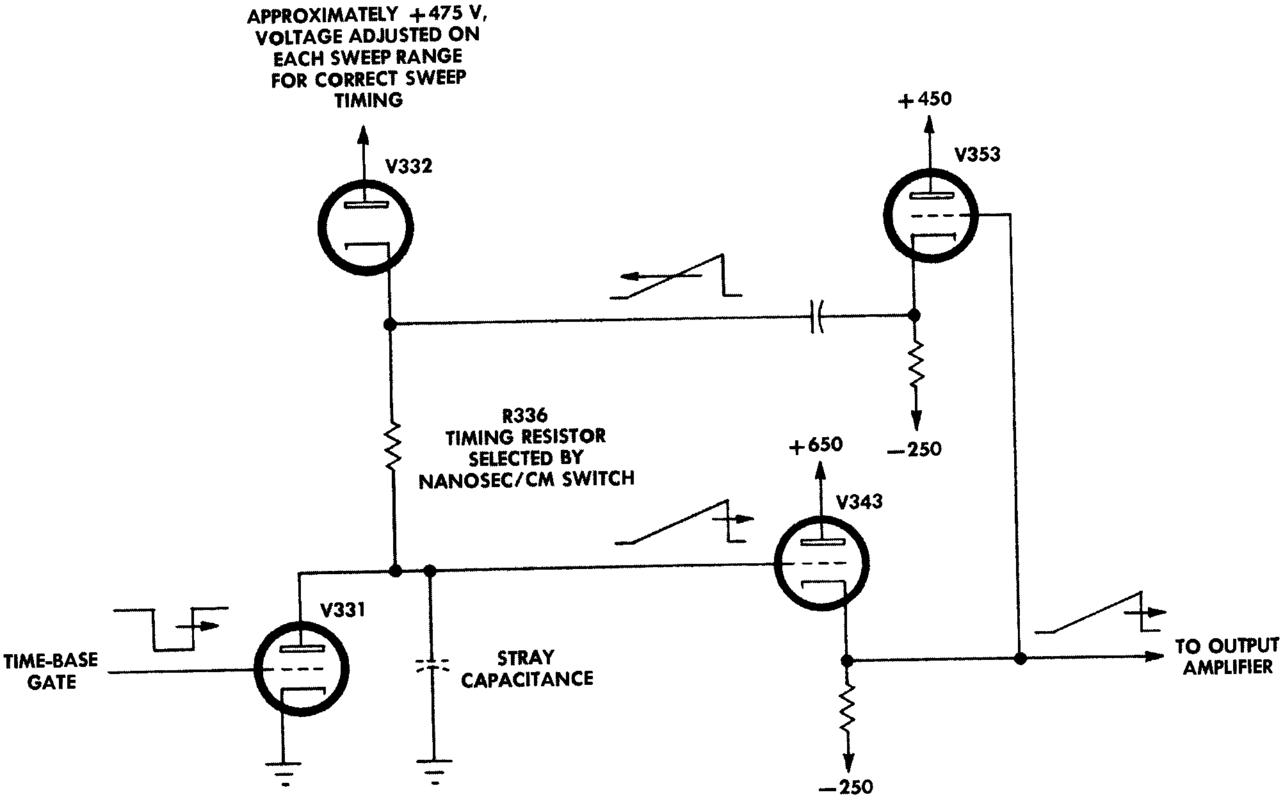


Fig. 4-11. Time-Base Generator simplified circuit diagram.

Approximately 16 pf total capacitance to ground appears in the plate circuit of V331. When the tube cuts off, the capacitance starts to charge toward approximately +475 volts through R336. The rate at which the stray capacitance charges is determined by the particular value of R336 selected by the NANOSEC/CM switch and by the exact voltage obtained from the +475-volt supply. The rate at which the stray capacitance charges determines the rate of rise of the sawtooth waveform produced across the stray capacitance and ultimately the sweep rate. The voltage obtained from the +475 volt supply is adjustable by means of a separate potentiometer for each range of the NANOSEC/CM switch. The potentiometers are adjusted to provide the necessary voltage to obtain correct sweep timing on their respective sweep ranges (refer to the Power Supply Diagram.)

The sawtooth waveform produced by the charging of the stray capacitance is applied to the grids of the Output Cathode Follower, V343. At the cathode of V343 the dc level of the sawtooth waveform is decreased by about 250 volts by diodes D344 and D345 while the amplitude of the sawtooth is unchanged. The sawtooth waveform is then applied to the grids of V353, the Bootstrap Cathode Follower. The sawtooth waveform appearing at the cathodes of V353 is applied through C356 and C357 to the cathode of V332, thereby cutting V332 off. Since the voltage at the cathode of V332 rises at approximately the same rate as the voltage at the plate of V331, the voltage across the timing resistor, R336, remains approximately constant. With the voltage across the timing resistor constant, the current charging the stray capacitance is also constant. The Bootstrap Cathode Follower thus causes the capacitance to charge linearly rather than in the normal exponential manner. The linear charging of the capacitance produces a linear output sawtooth waveform. The output sawtooth waveform is applied from the junction of D345 and R344 to the grids of V424.

Tube V388 is used to rapidly discharge the capacitance in the cathode circuit of V343 after each sweep. This is important in order to return the grids of V353 to normal as rapidly as possible to allow C356 and C357 to discharge in time to be ready for the next sweep. Normally V388 is cut off by the bias voltage obtained from the junction of R381 and R383. When the negative gate is applied to start the sweep, the signal passing through C380 is clamped by D384, charging C380.

At the end of the sweep gate, the positive rise in voltage is coupled to the grid of V388 through C380. This causes V388 to go into conduction to supply the current necessary to discharge the capacitance in the cathode circuit of V343. The current available to discharge the capacitance causes the cathode voltage of V343 to fall rapidly, as is required.

Paraphase Amplifier

The output sawtooth waveform is applied to the grids of the Paraphase Amplifier, V424. A positive-going sawtooth is obtained from the cathode and a negative-going sawtooth is obtained from the plate. The amplitude of both sawtooths is 150 volts or more. Zener diodes D430 and D431 are used to decrease the dc level of the sawtooth waveform obtained from the plate to the same average voltage as the sawtooth obtained from the cathode. The negative going waveform is applied to the left hand deflection plate of the CRT while the positive going waveform is applied to the right hand deflection plate. Positioning voltages are applied to the deflection plates from R441 through isolation resistors R440 and R442.

The Paraphase Amplifier is designed to reset somewhat slowly. If it were to reset rapidly, the sweep retrace would be visible on the screen unless the CRT is very rapidly blanked. In order to produce this rapid blanking, complex blanking circuitry would be required. Therefore to keep the blanking circuitry as simple as possible, the beam is held at the right side of the screen by V424 until the blanking circuit has a chance to blank the beam. V424 then slowly resets. Even on the fastest sweeps V424 has much more than sufficient time for reset.

HIGH-VOLTAGE POWER SUPPLY AND CRT CIRCUITS

High-Voltage Power Supply

The High-Voltage Oscillator, V800, operates at approximately 20 kc due to the resonant circuit of C808 and the high-voltage transformer. The primary voltage of T801 is stepped up at the secondary and applied to the high voltage rectifiers. A voltage tripler circuit made up of V802, V812, and V822 produces approximately +20 kv which is applied to the post-accelerating terminal of the CRT. The cathode of V832 is connected to a tap on the secondary of T801. The rectified voltage at the plate of V832 is approximately —4.2 kv.

A sample of the voltage obtained from the plate of V832 is applied from a voltage divider network to the grid of V814B. If the supply voltage changes from the preset level, a voltage change appears at the grid of V814B. The voltage change is amplified by V814B and V814A and causes a change in the screen voltage of V800 which adjusts the amplitude of the oscillations to compensate for the change in high voltage. The high voltage is set by adjusting R841, which controls the voltage at the grid of V814B.

CRT Circuits

A voltage divider between the plate of V832 and ground is used to obtain operating potentials for the cathode, control grid, and focus grid of the CRT. Four neon bulbs, B853, B854, B855, and B856, are used to regulate the cathode, control grid, and focus grid voltages to prevent changes in cathode current from affecting the operating voltages of the CRT.

The control grid voltage for the CRT is obtained from R856 which is at a more negative point than the point where the cathode voltage is obtained. The negative voltage on the grid normally holds the CRT cut off until the unblanking pulse is applied to the cathode from the unblanking circuit. The INTENSITY control, however, has sufficient range to overcome the cut off bias in the absence of an unblanking pulse.

Vertical positioning voltages are obtained from R865 and applied through R867 to R868 and the bypassed lower vertical deflection plate of the CRT. Other operating voltages for the CRT are also obtained from simple voltage divider networks.

LOW-VOLTAGE POWER SUPPLIES

Primary Power

Line voltage is applied through F601 and SW601 to the primary windings of T601. Two primary windings are used. The two windings are connected in parallel for 117-volt operation and in series for 234-volt operation. The blower is connected across one of the primary windings and operates whenever the POWER switch is closed.

Voltage applied at the primary winding of T601 energizes the secondary windings of the transformer. Voltage obtained from terminals 18, 19, 22 and 23 is rectified by D650 and D651 and applied to energize the regulated heater supply. Negative 26.5 volts from the regulated heater supply is applied to the time delay relay K601. After approximately a 45-second delay, the contacts of K601 close, thereby energizing K602. The contacts of K602 then energize K603. The purpose of the time delay relay is to delay application of power supply voltages to oscilloscope circuits until the tube filaments have had a chance to heat. Relays K602 and K603 control the application of the power supply voltages to the other circuits of the oscilloscope and to all Power-Supply regulator circuits except the —250-volt and —26.5-volt regulators. If the temperature inside the instrument becomes excessively high, the contacts of the thermal cutout, TK602, open to de-energize relays K602 and K603 and thereby remove power from the oscilloscope circuits.

—250-Volt Power Supply

Voltage obtained from terminals 6 and 11 of T601 is applied through a full-wave bridge rectifier circuit and filter to the regulator circuit of the —250-Volt Power Supply. By varying the drop in voltage across V627A, the negative output voltage from the power supply can be controlled. The greater the voltage dropped across V627A, the less the output voltage of the power supply.

A voltage divider consisting of R646, R647, and R648 is used to set the voltage on one of the grids of V646. The voltage on the other grid is determined by voltage regulator tube V639 and R633. The voltage across V639 holds constant at about 85 volts by gas-tube regulator action. This places pin 7 of V646 normally at —165 volts. The voltage on pin 2 of V646 is set by R647 for —250 volts out of the power supply.

When the output voltage has been set, any change in that voltage produces a voltage change at the grids of V646 which constitutes an error signal. If the output voltage of the power supply becomes less negative than normal, as for additional load, the grid voltages of V646 also start to rise. Due to the constant voltage drop across V639 the change in voltage at pin 7 is approximately 3 times greater than the change at pin 2. Consequently the net change in the voltage between the grids of V646 is approximately 2/3 the change in the output voltage of the power supply. The larger change at pin 7 causes that section to conduct more heavily. The amplified signal at pin 6 is then applied to the grid of V624 as a negative-going signal. This causes V624 to conduct less and the further amplified error signal at the plate of V624 is applied to the grid of V627A as a positive-going signal. The positive signal on the grid of V627A causes the tube to conduct more heavily, thereby reducing the voltage-drop across the tube and increasing the output voltage of the power supply to the normal level.

A tendency for the power supply output to increase is eliminated in the same manner except that the polarity of all the signals is reversed from the previous example. Thus the regulator compensates for either an increase or a decrease in the output of the power supply to insure that the voltage remains at the normal level.

The —250-Volt Regulator operates at all times, and is not dependent on the operation of K601, K602, and K603.

Regulated Heater Supply

Voltage for the Regulated Heater Supply is obtained from terminals 18, 19, 22, and 23 of T601. Negative 35 volts is obtained from D650 and D651 and applied to the collector of the series regulator, Q777. A voltage divider between —250 volts and ground sets the reference voltage on the base of Q766A. The voltage on the base of Q766B is set by a voltage divider between —26.5 volts and ground. Because of the common emitter resistor for Q766A and Q766B, the voltage at the base of Q766B is compared against the voltage at the base of Q766A. If the —26.5 volts changes, an error signal is produced at the base of Q766B. This error signal is amplified by Q766B and applied through Q773 to the base of Q777 in the direction which returns the output voltage to normal.

A voltage divider between —26.5 volts and ground sets the base of Q767 at approximately —13 volts. The emitter of Q767 stabilizes the —12.6 volt output from the supply.

Other Regulator Circuits

The other regulator circuits are similar in operation to the —250-Volt Regulator and the —26.5-Volt Regulator (Regulated Heater Supply). Each of the regulators uses the —250-Volt Supply as part of its reference. Voltages obtained from the output of each supply are compared to a reference voltage. An error signal is produced when the output voltage deviates from its normal value. The error signal is then amplified and used to control the operation of a series regulator tube. The polarity of the error signal applied to the series regulator is always such as to bring the output voltage back to normal.

The +475-Volt Supply is somewhat different from the other circuits in that several potentiometers are used to adjust the output of the supply. A separate potentiometer is provided for each position of the NANOSEC/CM switch. The voltage at the grid of V724 can be adjusted by means of the particular R732 selected by the NANOSEC/CM switch. By setting the output-voltage divider ratio, R732 determines the output voltage of the power supply. The output voltage is adjusted on each setting of the NANOSEC/CM control by means of the respective R732 for correct sweep timing on that range.

CALIBRATION-STEP GENERATOR

Reed Switch and Charge Line

A mechanical dry-reed switch and associated charge line are used to produce the output steps from the Calibration-Step Generator. The charge line is a polystyrene-foam insulated, rigid coaxial line with a characteristic impedance of 125 ohms and a one-way transit time of 1.5 nanoseconds. The reed switch is located inside the charge line and forms part of the 125-ohm system.

Charging voltage for the charge line is obtained from voltage divider networks and applied through a special charging network to the charge line. The POLARITY switch determines the polarity of the charging voltage and the RANGE switch determines the magnitude of the voltage applied to the VOLTS control, R879. In the 1 V and 10 V positions of the RANGE switch, the charging voltage obtained from R879 is applied through R882 and R883 to the charge line. In the VARIABLE position of the RANGE switch the charging voltage is obtained from the VARIABLE potentiometer, R875. The amplitude of the output steps from the Calibration-Step Generator into a 125-ohm load is exactly half of the charging voltage.

As the dry metal reed switch starts to close, the capacitance of its contacts increases considerably. The added capacitance at the contacts draws charge out of the charge line. This would have a tendency to affect the amplitude of the output pulse unless some provision is made to reduce this effect. Capacitor C883 prevents the charge drawn from the line from affecting the amplitude by any significant amount.

When the switch contacts close, the charge line acts as a 125-ohm source supplying energy to a 125-ohm load. As a result only half of the charging voltage appears across the output 125-ohm load. At the same time that the contacts close, a backwave is propagated down the charge line toward the charging network. Resistor R883 is used to terminate the backwave and thus eliminate a reflection from the charging network. The output step amplitude remains relatively constant for twice the transit time of the charge line, after which the output amplitude decays as C883 discharges. When the switch contacts again open, the charge line and C883 are slowly recharged through the charging network to the initial voltage before the contacts close again.

The charging network can be disconnected from a fixed charge line in the instrument. This permits additional lengths of charge line and other devices to be added to the internal charge line. The charging network is then connected to the end of the additional charge line.

A 125-ohm trigger takeoff is used in the charge line to obtain a triggering signal for the oscilloscope sweep. The trigger takeoff is identical in function to the trigger takeoff at the vertical input of the oscilloscope. The takeoff obtains a suitable triggering signal from the backwave propagated down the charge line.

The dry metal reed is used in the Calibration-Step Generator because of the relative ease of making the switch appear to be part of a 125-ohm transmission line. It is important that the switch be part of the 125-ohm system in order to prevent reflections and mismatches occuring at the switch. Use of a mercury switch would further complicate the design of the transmission system. The dry reed is selected because of its excellent waveform. The lifetime of the switch is frequently quite short because of the severe requirements of the application.

Oscillator

An oscillator is used to drive the reed switch and thereby produce the output steps. The oscillator is composed of tubes V885 and V895A.

The basic circuit is that of a Wien-Bridge Oscillator, as can be seen from the simplified diagram in Fig. 4-12. Two stages of triode amplification provide gain necessary to maintain oscillations. The amplitude of the oscillations is very high, resulting in highly clipped waveforms. Adjustment of the FREQUENCY control simultaneously varies the settings of R892A and R892B. This shifts the frequency at which the peak positive feedback occurs and thus changes the frequency of the oscillator.

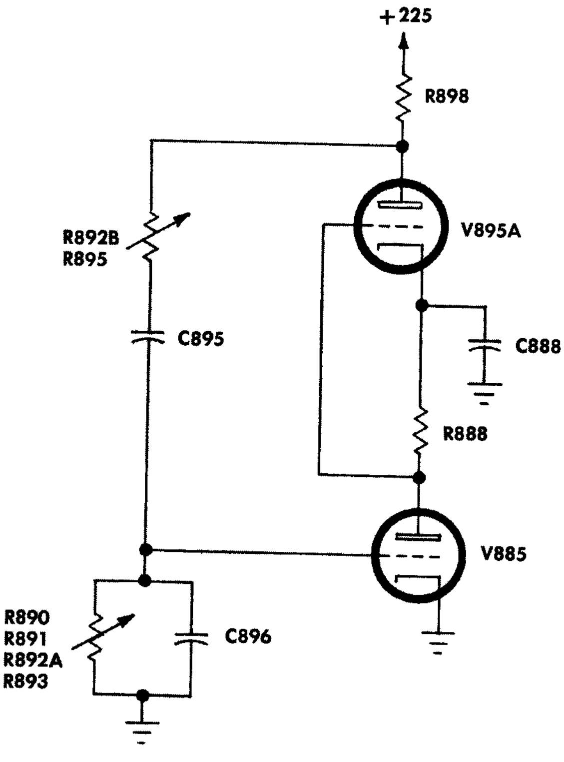


Fig. 4-12. Simplified circuit diagram of the Calibration-Step Generator oscillator.

The output of the oscillator is taken from the plate of pentode V885. Plate current is divided through R885 and L885. The amount of current passing through L885 is determined by the setting of R885. The field set up by L885 actuates the reed at the frequency of the oscillator.

In normal operation, the frequency of the oscillator is adjusted near the mechanical resonant frequency of the reed switch (approximately 700 to 800 cycles). Operation near the natural resonant frequency of the reed switch reduces the tendency for the contacts to bounce and reduces the amount of drive which must be provided by L885.

When the DRIVE control is rotated fully counterclockwise to the SINGLE CLOSURE position, SW885 closes sending current from R886 through L885. The current through the coil causes the reed to close once.

RATE GENERATOR

Multivibrator

Tubes V915 and V895B form a free-running multivibrator circuit which is used to control the repetition rate of the Rate Generator. For the purpose of explaining the operation of this circuit, we will assume that V915A conducts as power is applied to the circuit and that the MULTIPLIER switch is set to X1. This connects C920A between the cathode of V915B and the grid of V895B and connects C920B between the plate of V895B and the grid of V915A. As V915A conducts, its plate voltage drops causing a decrease in voltage at the cathode of V915B. The drop in voltage is coupled through C920A to the grid of V895B, cutting the tube off. The resulting increase in the plate voltage at V895B is coupled to the grid of V915A through C920B driving V915A farther into conduction. Capacitor C920A then discharges through R925 and R923 permitting the grid of V895B to slowly rise. When the charge on C920A becomes insufficient to hold V895B cut off, V895B goes into conduction. The time that V895B remains cut off is determined by the values of C920A, R925, and R923 and by the voltages obtained from R923.

When V895B conducts, the drop in its plate voltage is coupled to the grid of V915A, causing V915A to cut off. This causes the plate of V915A and the cathode of V915B to rise, coupling a positive signal to the grid of V895B to drive V895B farther into conduction. The time that V915A is held cut off is determined by the time required for C920B to discharge through R928, R929 and R911. As C920B discharges, the grid of V915A rises and eventually permits the tube to come back into conduction. When V915A conducts again, another cycle of operation is initiated.

The frequency of the multivibrator operation is determined by the values of C920 selected by the MULTIPLIER switch and by the setting of the CYCLES/SEC control. The values of C920 affect the period of time that both V915A and V895B remain cut off. The setting of R923 affects the time that V895B remains cut off and controls the output swing of V915B, reducing the amplitude of drive to the grid of V895B at the clockwise end of the CYCLES/SEC control.

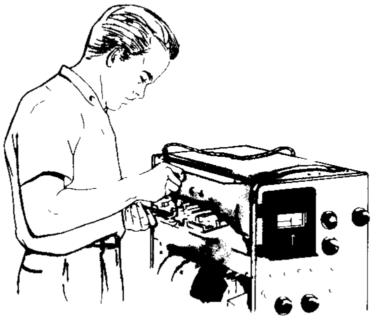
Cathode follower V915B also serves to couple the output of the multivibrator to the avalanche circuit through C930.

Avalanche Circuit

The output pulses from the multivibrator circuit are applied through C930 to the collector circuit of Q934. The AVALANCHE SET control R931 adjusts the collector voltage of Q934 to the point where the transistor is just short of avalanching. When a positive pulse is applied from the multivibrator as V915A cuts off, the additional voltage is enough to cause Q934 to avalanche, thereby discharging the fixed charge line in the collector circuit. The duration of the output pulse is twice the transit time of the charge line, or approximately 10 nanoseconds for the charge line used with the instrument.

The output from Q934 is taken from the emitter circuit. The components added to the emitter circuit are used to fully terminate the discharge of the charge line and to shape the output waveform. The circuit can be used to drive a 50-ohm load directly from the +RATE 50 Ω connector on the front panel.

A sample of the output pulse is developed through R939 and applied to the triggering circuit of the oscilloscope. This permits the oscilloscope to be triggered easily from the rate generator without any external patching of the signals.



SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Air Filter

The Type 519 Oscilloscope is cooled by air drawn through a washable filter located at the rear of the instrument. The filter is constructed of adhesive-coated aluminum wool. If the filter becomes excessively dirty, it will restrict the flow of air into the instrument and may cause overheating. High internal temperatures will not only reduce the lifetime of the instrument components but may also cause the thermal cutout to open at a crucial point in an experiment. Any time that the thermal cutout opens, the filter should be checked immediately.

The filter should be visually checked every few weeks. It should be cleaned at least every three or four months, more often if required. To clean the filter, first remove the loose dirt by tapping the filter gently on a hard surface. Then wash the filter by running hot soapy water through it until it is clean. After rinsing and allowing it to dry, coat the filter with an adhesive such as "Handi-Koter" or "Filter-coat" (products of the Research Products Corporation). These products are generally available from air-conditioner suppliers.

Cleaning the Exterior

Loose dust accumulating on the outside of the Type 519 can be removed with a lint-free cloth or a small paint brush. The paint brush is particularly useful for dislodging dust on and around the front-panel controls. A soft cloth dampened with water and a small amount of liquid detergent can be used to remove the harder coating of dirt. Abrasive cleansers should not be used.

To clean the graticule and the face of the CRT, first remove the four slotted graticule nuts and remove the cover and mask assembly. Then unscrew the knurled knob used to position the graticule and remove the graticule from the mask assembly. Clean the graticule and the face of the CRT with a soft, lint-free cloth dampened with denatured alcohol.

The graticule cover and mask assembly are remounted by reversing the order of their removal.

Removal of Panels

The side, top, and bottom panels of the Type 519 can be removed separately for maintenance work. The side panels are held in place by small screwhead fasteners. To remove the side panels, use a screwdriver or coin to rotate the fasteners approximately two turns counterclockwise. Then pull the upper portion of the panels outward from the carrying handles. Top and bottom panels are held in place by small screws. After first removing the screws, the top and bottom panels can be lifted off.

Cleaning the Interior

Although air entering the Type 519 is filtered, some dust may penetrate into the interior of the instrument. This dust should be removed occasionally to prevent instrument failures due to the conductivity of the dust under high humidity conditions. Perhaps the best way to keep the interior of the instrument clean is to blow dust off using compressed air. A very high velocity air stream should be avoided, however, to prevent damage to some of the components. Persistent dirt can be removed using a damp cloth or a small paint brush.

Special attention should be given to the high-voltage circuits, including parts inside the high voltage box. Since most of the high-voltage parts are enclosed in a transparent plastic box, very little dust should accumulate on these parts. If dust does accumulate it should be removed, since excessive dust combined with high humidity can produce arcing and possible high-voltage failures. Presence of arcing will normally cause false triggering of the instrument, particularly for X20 trigger gain.

A cloth dampened in denatured alcohol may be used to clean dirt and dust off the high voltage anode lead and around the anode of the CRT. A cotton-tipped applicator can be used for cleaning in narrow spaces and for cleaning ceramic strips.

Visual Inspection

Many potential and existant troubles can be detected by a visual inspection of the instrument. For this reason, you should perform a complete visual check every time the instrument is calibrated or repaired. Visual checks should also be made during other routine maintenance work.

Defects which may be detected visually include such things as loose or broken connections, loose set screws in the knobs or shaft couplers, loose or damaged coaxial connectors, improperly seated tubes or transistors, scorched or burned parts, and broken terminal strips. The remedy for most of these troubles is apparent. However, particular care must be taken when heat-damaged components are detected. Overheating of parts is often the result of other, less apparent, defects in the circuit. It is essential that you determine the cause of overheating before replacing heat-damaged parts in order to prevent further damage.

Blower Motor

The blower motor bearings are factory lubricated and sealed. No additional lubrication is required for the life of the instrument.

Tube Checks

Periodic tube checks on the tubes used in the Type 519 Oscilloscope are not recommended. Tube testers in many cases indicate a tube to be defective when that tube is operating quite satisfactory in a circuit, and fail to indicate tube defects which affect the performance of the circuits. The ultimate criterion of the usability of a tube is whether or not the tube works properly in the circuit. If it does not, then it should be replaced. If it is working correctly, it should not be replaced. Unnecessary replacement of tubes is not only expensive but may also result in needless recalibration of the instrument.

Recalibration

The Type 519 Oscilloscope is a stable instrument that will provide many hours of trouble-free operation. However, to insure the reliability of measurements we suggest that you recalibrate the instrument after each 500 hours of operation (or every six months if used intermittently). A complete step-by-step calibration procedure is given in the Calibration Procedure section of this manual.

REMOVAL AND REPLACEMENT OF PARTS

General Information

Most parts in the Type 519 Oscilloscope can be replaced without detailed instructions. Other parts, however, can best be removed if a definite procedure is followed. Instructtions for the removal of some of these parts are contained in the following paragraphs. Because of the nature of the instrument, replacement of certain parts will require that you recalibrate portions of the oscilloscope to insure proper operation. Refer to the Calibration Procedure portion of this manual for the applicable calibration steps.

Removal of Cathode-Ray Tube

If it becomes necessary to replace the CRT, the CRT and shield should be removed as a single unit. To remove the unit, first disconnect all leads to the CRT. Disconnect the input coaxial cable and termination from the mounting board. Disconnect the CRT socket from the CRT base by pressing back on the plastic flanges attached to each side of the socket. The sockets can be worked loose by pressing first on one flange and then the other until the socket is free of the CRT. Remove the four slotted graticule nuts which hold the graticule cover and mask assembly in place. Remove the graticule cover and mask. Disconnect the rear supports of the CRT shield and gently remove the complete CRT assembly through the front-panel opening of the oscilloscope, taking extreme care of exposed hardware. The CRT can then be removed from the shield only if absolutely necessary. Separation from the shield is usually undesirable due to (1) cost of the tube and (2) possibility of damage to exposed tube pins and resultant loss of vacuum. CRT's are shipped from the factory with a shield already installed.

Installation of CRT

With the CRT and shield reinserted and the shield bolted into the instrument, small leads can be reconnected by following the color code information printed on the shield. Then connect the anode lead, coaxial cable, and termination. Replace the mask in the graticule cover assembly making certain the serial numbers of the CRT and mask agree. After replacing the CRT and mask, recheck the vertical sensitivity to determine if this measurement agrees with the figure on the mask. A slight adjustment in high voltage may be necessary to correct the deflection factor; however, any future adjustment of either the —250-volt supply or high-voltage supply will affect the vertical sensitivity. Adjust the AXIS ROTATION control to align the trace with the horizontal graticule markings and check the calibration of the sweeps with the 1 KMC Timing Standard. Detailed instructions for completing these steps can be found in the Calibration Procedure section of this manual.

Replacement of Switches

Methods for removal of defective switches are, for the most part, obvious, and only a normal amount of care is required. Single wafers are normally not replaced in the switches used in the Type 519. If one wafer is defective, the entire switch should be replaced. Switches can be ordered from Tektronix, either wired or unwired, as desired.

Because of the complexity of the NANOSEC/CM switch, some special care is required to remove this switch. First loosen the shaft coupling just in front of the forward support for the switch. Then slide the coupling down the shaft. Disconnect the two metal supports for the switch from the chassis. Unsolder all leads coming to the switch while making a careful drawing of the lead connections. Remove the lock nut which holds the switch in the front support, and slide the switch out of the support. It should then be possible to remove the switch from the instrument.

The NANOSEC/CM switch should be replaced by reversing the order of the steps required for removal. The wiring diagram made during removal can be used to wire in the new switch.

Tube Replacements

Care should be taken both in preventive and corrective maintenance that tubes are not replaced unless they are actually causing trouble. Many times during routine maintenance it will be necessary for you to remove tubes from their sockets. It is important that these tubes be returned to the same sockets unless they are actually defective. Unnecessary replacement or switching of tubes will often necessitate recalibration of the instrument. If tubes do require replacement, it is recommended that they be replaced by previously checked high-quality tubes.

To replace V331, first loosen the screws which hold the anode strap of the tube in place. Then rotate the anode strap out of the way. The tube can then be pulled from the socket.

Replacing the Reed Switch

The reed switch in the Calibration-Step Generator can be replaced as follows:

Remove the four mounting screws which hold the OUTPUT 125 Ω connector to the front panel. Grasp the connector and pull straight out from the front panel to extract the attached coax assembly. The complete assembly is about 18" long and contains the reed switch (see Fig. 5-1). Disassemble the OUTPUT 125 Ω connector to expose the reed switch. Grip the metal end of the reed switch with long-nosed pliers and pull the reed switch out.

To install the replacement reed switch, remove the 125-ohm connector double button assembly from the connector sleeve. Insert one end of the reed switch into the button assembly and use the button assembly as a holder. Plug the other end of the reed switch into the center conductor located inside the tube. Look through the small hole in the side of the tube to see that the switch and conductor are properly connected. Align the slots in the connector parts and reassemble the connector. Insert the coax tube assembly through the front panel while holding the OUTPUT 125 Ω connector so that the flanges are in the same position as the EXTERNAL TRIGGER 125 Ω connector. This insures that the connector at the rear of the coax tube assembly will mate properly with the connector at the rear of the instrument. Mount the OUTPUT 125 Ω connector securely to the front panel with the four screws.

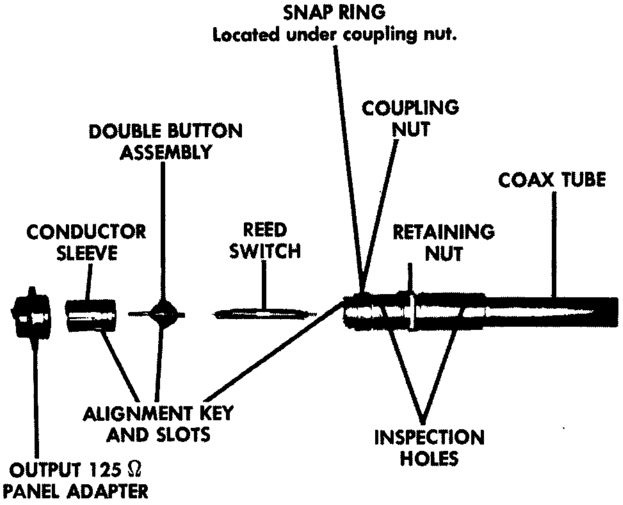


Fig. 5-1. Exploded view of the coax tube assembly. The Snap Ring, Coupling Nut, and Retaining Nut need not be removed from the tube when the reed switch is replaced.

Soldering Precautions

In the production of Tektronix instruments a special 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, or by excessive heating of the terminal strip with a soldering iron. Occasional use of ordinary 50-50 solder will not break the bond unless excessive heat is applied.

If you frequently perform work on Tektronix instruments, it is advisable that you have a stock of solder containing about 3% silver. This type of solder is used quite often in printed circuitry and is generally available locally. It may also be purchased directly from Tektronix in one-pound rolls; order by part number 251-514.

Because of the shape of the terminals of the ceramic terminal strips, you may wish to use a wedge-shaped tip on your soldering iron. These tips allow you to apply heat directly to the solder in the terminals and reduces the amount of heat required. It is important to use as little heat as possible while producing a full-flow joint.

Due to the high-frequency requirements of the Type 519, many of the components are soldered in place with very short leads. This is necessary to reduce the lead inductance. When these components are replaced, the leads should again be made as short as possible. The proper technique for soldering and unsoldering short-lead components requires: (1) the use of long-nose pliers to hold the lead securely between the component and the point where the heat is applied, allowing the pliers to serve as a heat sink; (2) the use of a hot iron for a short time; and (3) careful manipulation of the leads to prevent lead breakage.

Ceramic Terminal Strips

Damaged ceramic terminal strips are most easily removed by unsoldering all connections, then using a plastic or hard rubber mallet to knock the yokes out of the chassis. This can be done by using the mallet to hit the ends of the yokes protruding through the chassis. The strip with the two yokes can then be removed as a unit. The spacers will probably come out with the yokes. If not, the spacers can be pulled out separately afterwards.

Another way of removing the terminal strip is to use diagonal cutters to cut off the side of the yoke holding the strip. This method permits the strip to be removed from a difficult area where the mallet cannot be used effectively. The remainder of the yokes and the spacers can be pulled out separately after the removal of the strip. Since a replacement strip is supplied with yokes already attached, the old yokes need not be salvaged. However, the old spacers can be used at least twice before new ones need be ordered.

When the damaged strip and yoke assembly has been removed, place the spacers into the holes in the chassis. Then set the ends of the yoke pins into the spacers. Then press or tap lightly directly above the yokes to drive the yoke pins down through the spacers. Be certain that the yoke pins are driven completely through the spacers. Using a pair of diagonal cutters, cut off the portion of the yoke pin protruding through the spacers. Fig. 5-2 shows how the ceramic strip parts fit together.

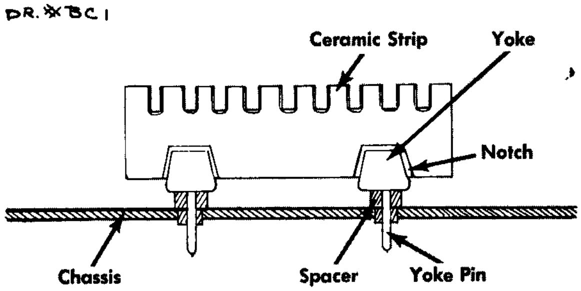


Fig. 5-2. Installation of ceramic terminal strips.

TROUBLESHOOTING

General Troubleshooting Information

This portion of the Instruction Manual includes information that will enable you to more efficiently troubleshoot the Type 519 in the event that a trouble develops. During troubleshooting work, you should correlate information contained in this section with information obtained from other parts of the manual.

When a trouble occurs in the instrument, you should first recheck the settings of *all* controls to see that they are set properly. Then operate the front panel controls to see what effect, if any, they have on the trouble. The normal or abnormal operation of each control will allow you to firmly establish the trouble symptoms in your mind. (The location of a trouble which occurs only in certain positions of a control can usually be determined immediately from the trouble symptoms.)

After the trouble symptoms are clearly established, look first for the obvious causes of the trouble. Check to see that the pilot light is on; feel for irregularities in the operation of the controls; listen for any unusual sound; see that the tube filaments are lit; visually check the entire instrument. The type of trouble will indicate the checks to make.

In general, a troubleshooting procedure can be thought of as consisting of two parts; circuit isolation and circuit troubleshooting. In many cases, the general procedure outlined will enable you to accomplish the first part of the procedure. You have then only to find the exact cause of the trouble in the isolated circuit. If the above procedure does not enable you to isolate the defective circuit, then additional checks will be required. After the defective circuit has been determined, detailed checks within the circuit will allow you to determine the exact cause of the trouble.

Tables 5-2 and 5-3 can be used to troubleshoot the Type 519. Table 5-2 is used first to isolate certain troubles to a particular circuit or stage. Table 5-3 is then used to locate the trouble in the isolated circuit or stage. References in Table 5-2 direct you to the appropriate step or steps in Table 5-3. It is clearly not practical to include every possible trouble in the troubleshooting tables, and therefore only those troubles most likely to occur are included. Troubles not found in the tables must be located using the general method of first isolating the defective stage and then determining the cause of the trouble within the stage.

Table 5-3 can also be used independently of Table 5-2. The steps in Table 5-3 are arranged so that they can be used to perform a quick check on the operation of each circuit. The table is subdivided into separate sections for the major circuits contained in the instrument so that if you are able to immediately isolate trouble to a circuit, you can proceed directly to the appropriate section of Table 5-3 without first using Table 5-2.

Although the Type 519 is a stable instrument, it is possible for circuits to get out of calibration thereby producing an apparent trouble. Before proceeding with any detailed trouble analysis be sure that the trouble cannot be corrected by means of some adjustment. If there is any doubt, recalibrate the entire suspected circuit using the information in Section 6.

Unusual troubles may occur due to a failure in one of the power supplies. Also, the circuit configurations used in the Type 519 make it possible for an incorrect power-supply voltage to affect one circuit more than others. Consequently, a power supply trouble should be considered as a possibility in virtually any type of failure which may occur in the instrument. If there is any doubt as to whether a power supply may be causing the trouble, the power-supply regulated voltages and ripple should be checked before proceeding with the troubleshooting procedure. If the output and ripple voltages of the regulated power supplies are correct, the power supplies can be assumed to be operating correctly.

When trouble has been isolated to a circuit, perform a complete visual check of that circuit. Many troubles can be found most easily by visual means. If a visual check fails to detect the cause of the trouble, check the tubes used in the circuit by substitution. Approximately 90% of the troubles which occur in Tektronix instruments result from tube failures. Be sure to return any tubes found to be good to their original sockets.

Transistor defects usually take the form of the transistor either opening or shorting. In the case of the trigger amplifiers, signal-tracing around the suspected transistors should first be done. The plug-in trigger amplifiers may also be interchanged. A transistor-curve display instrument, such as the Tektronix Type 575, can also be of help in finding abnormal transistor difficulties. However, in power supply circuits such as the —26.5-volt supply, most failures can be located with an ohmmeter. A check for open or shorted transistors can be made using an ohmmeter. Use of the R × 1 scale of the ohmmeter should be avoided, however, because the low resistance in series with the transistor and the voltage source could conceivably cause damage to a good transistor. Checks should be made with the ohmmeter leads connected both ways across the transistor so that the effects of the polarity reversal of the voltage across the transistor can be observed. If there is doubt about whether a transistor is good or not, substitute another transistor for it in the circuit. Be sure first, however, that the voltages and loads on the transistor are normal before making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

Separate circuit diagrams for each circuit are contained in the back of this manual. In addition, a block diagram provides an overall picture of instrument operation. The reference designation of each electronic component in the instrument is shown on the circuit diagrams as well as important voltages and waveforms. The following is a list of the reference designations associated with each circuit.

Numbers less than 100	Trigger Processing Channel
100 numbers	Triggering Circuits
200 numbers	Time-Base Gate and Unblanking
300 and 400 numbers	Time-Base Generator
600 and 700 numbers	Low-Voltage Power Supplies
800 numbers	CRT Circuit and Calibration-Step Generator
900 numbers	Rate Generator

Switch wafers shown on the circuit diagrams are coded to indicate the position of the wafer on the actual switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the front of the switch to the rear. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function.

All wiring in the Type 519 is color coded to facilitate circuit tracing. The power-supply buses are identified by the following code; the widest stripe identifies the first color in the code.

+650 v	Blue-green-brown on white
+475 v	Yellow-violet-brown on white
+450 v	Yellow-green-brown on white
+225 v	Red-red-brown on white
+100 v	Brown-black-brown on white
—250 v	Red-green-brown on dark background
—26.5 v	Red-blue on dark background
—14 v	Black-yellow on white
—12.6 v	Black-orange on white

In the troubleshooting tables that follow, reference is made in several places to the use of an oscilloscope to check the waveform at some point in the circuit. Because of the extremely short times involved in many of the waveforms throughout the instrument, it is necessary that you use a wide-band oscilloscope for these checks. A 30-mc instrument such as the Tektronix 540-series oscilloscopes is a minimum. If possible, a 100-mc oscilloscope should be used, such as the Tektronix Type 580-series instruments.

TABLE 5-1. V331 SCREEN VOLTAGE

SWEEP RATE	AVERAGE	NORMAL UPPER LIMIT	NORMAL LOWER LIMIT
2 NSEC/CM	115	135	95
5 NSEC/CM	65	80	50
10 NSEC/CM	50	60	40
20 NSEC/CM	35	45	25
50 NSEC/CM	25	35	15
100 NSEC/CM	22	30	14
200 NSEC/CM	18	25	10
500 NSEC/CM	15	25	5
1000 NSEC/CM	13	25	5

TABLE 5-2, CIRCUIT ISOLATION

TROUBLE	PROBABLE CAUSES OF TROUBLE	CHECK	IF NORMAL	IF ABNORMAL
1. Pilot light and tube filaments do not light.	Line power not applied. Fuse F601. Power switch SW601. Power Transformer T601.	Check to see that oscilloscope is properly connected to power source. Then check for correct line voltage between terminals 1 and 4 of T601.	T601 is probably defective.	F601 or SW601 probably defective.
2. Pilot light does not dim after normal time delay. No dc power.	—250-Volt Power Supply. —26.5-Volt Power Supply. K601, K602, K603, TK602.	1. Check for —26.5 volts at output of the —26.5-Volt Power Supply.	Check power supply relays.	Proceed to check no. 2.
		2. Check for —250 volts at output of —250-Volt Power Supply.	Trouble is in —26.5-Volt Power Supply. Proceed to step 18 of Table 5-3.	Trouble is in —250-Volt Power Supply. Proceed to step 4 of Table 5-3.
3. No spot or trace on screen of oscilloscope.	Beam positioned off screen. Beam deflected off screen. CRT circuit. Unblanking circuit. Time-Base Generator. High-Voltage Power Supply. Loose CRT Socket.	1. Set PULSE AMPLITUDE OR SYNC control fully clockwise to free run the sweep. Turn up intensity. A trace should appear.	Adjust the INTENSITY control for normal brightness, then stop the sweep by setting the FUNCTION switch to PULSE and the PULSE AMPLITUDE OR SYNC control fully counterclockwise. The spot and trace should disappear. If so, instrument is operating normally. If not, unblanking circuit is defective; proceed to step 54 of Table 5-3.	Proceed to check no. 2.
		2. Disconnect any input signals. Set HORIZONTAL control fully clockwise. Ground vertical positioning plate at neck pin of CRT. A spot or trace should appear.	The vertical positioning circuit is defective. Check R865, R867, and R868.	Proceed to check no. 3.
		3. Set VERTICAL control to midrange. Stop the sweep, and short between the horizontal deflection plates. A spot should appear on the screen.	Trouble is in Time-Base Generator. Proceed to step 56 of Table 5-3.	Trouble is in CRT circuit. Proceed to step 19 of Table 5-3.
4. Trace not focused properly.	ASTIGMATISM or FOCUS controls not set correctly. CRT Circuit.	Adjust FOCUS and ASTIGMATISM controls as described in Operating Instructions. Trace should focus properly.	Instrument is operating correctly.	Trouble is in CRT Circuit. Proceed to step 27 in Table 5-3.
5. Incorrect trace geometry.	GEOMETRY control misadjusted. CRT Circuit.	Set GEOMETRY control as described in CALIBRATION procedure. Adjustment should correct trouble.	Instrument is operating correctly.	Trouble is in CRT Circuit. Proceed to step 27 in Table 5-3.

Table 5-2, *(continued)*

TROUBLE	PROBABLE CAUSES OF TROUBLE	CHECK	IF NORMAL	IF ABNORMAL
6. Sweep inoperative.	Trigger and Holdoff Circuit. Time-Base Gate. Time-Base Generator. Single-Sweep Switch.	1. Set PULSE AMPLITUDE OR SYNC control fully clockwise and check for approximately a +30-volt gate at junction of D198 and D199.	Proceed to check no. 2.	Trouble is in Trigger and Holdoff Circuit. Proceed to step 34 of Table 5-3.
		2. Check for negative gate at the plate of V244; should be approximately 40 volts or more.	Trouble is in Time-Base Generator. Proceed to step 56 of Table 5-3.	Trouble is in the Time-Base Gate Generator. Proceed to step 46 of Table 5-3.
7. Sweep operates but cannot be triggered or synchronized.	X20 Amplifiers. TRIGGER SOURCE switch SW10. GAIN switch SW20. Trigger Takeoff. Corona in High-Voltage Power Supply. Large external fields. Extraneous signals due to ground loops.	1. Attempt to trigger oscilloscope by applying a signal to the EXTERNAL TRIGGER 125 Ω connector. The oscilloscope should trigger properly.	Check the trigger takeoff and SW10.	Check that trigger amplifiers are correctly installed. Set GAIN at NORMAL. If proper triggering is still not obtained interchange the two amplifiers. Then proceed to check no. 2.
		2. Place FUNCTION switch at PULSE. Using a test oscilloscope, trace the triggering signal through triggering channel to Q70. The signal should not disappear at any point.	The triggering channel is normal.	The point where the triggering signal disappears will isolate the trouble.
8. Sweep cannot be synchronized in HF SYNC position of FUNCTION switch.	Countdown Oscillator D50. FUNCTION switch SW50.	With the FUNCTION switch at H.F. SYNC and no triggering signal applied, check that countdown oscillator D50 is operating at a frequency of approximately 10-30 mc.	Check FUNCTION switch.	Trouble is in the Countdown Oscillator. Proceed to step 37 of Table 5-3.
9. Short sweep length.	Time-Base Gate. Time-Base Generator. CRT horizontal deflection lead disconnected.	Check width of gate at plate of V244. Width of the gate should be at least 7 times the sweep time per centimeter.	Trouble is in the Time-Base Generator. Check value of timing resistor and adjustment of +475-Volt Power Supply.	Trouble is in the Time-Base Gate. Proceed to step 46 in Table 5-3.
10. Start of sweep shifts horizontally on screen.	Holdoff Circuit. Time-Base Generator.	Disconnect triggering signals and free run the sweep. Maximum repetition rate of the triggering circuit at various sweep rates should be approximately as shown in Table 2-2.	Trouble is in Time-Base Generator. Proceed to step 56 in Table 5-3.	Trouble is in Holdoff Circuit. Proceed to step 38 in Table 5-3.
11. Incorrect sweep timing.	Incorrect Timing Adjustment. Time-Base Generator. +475-Volt Power Supply.	1. Check timing adjustment. Adjustment should correct difficulty.	Instrument is operating correctly.	Proceed to check no. 2.

TROUBLE	PROBABLE CAUSES OF TROUBLE	CHECK	IF NORMAL	IF ABNORMAL
		2. Check output voltage of +475-Volt Power Supply. Output should be variable between approximately +360 and approximately +550 volts.	Trouble is in the Time-Base Generator Check value of timing resistor R336.	Trouble is in +475-Volt Power Supply. Proceed to step 17 in Table 5-3.
12. Nonlinear sweeps.	Time-Base Generator.	Proceed to step 63 in Table 5-3.		
13. No single sweeps obtainable.	Holdoff Circuit.	Proceed to step 43 of Table 5-3.		
14. No vertical deflection.	Improper triggering delay. Loose input connection. Faulty external attenuator. Faulty signal source.	1. Check delay line connections to CRT. Check for 125 ohms as measured at SIGNAL 125 Ω connector. Adjust oscilloscope for internal triggering from the applied waveform. The oscilloscope should trigger and the sweep should run.	Adjust the DELAY control to move waveform on screen. If it appears, the instrument is operating correctly. If not, the trouble is in the sweep delay circuit. Check R82, C83, R83, D81, R81, R85, R86, R87, and R88.	Proceed to check no. 2.
		2. Check input connections. Substitute external attenuators. Waveform should appear.	Trouble has been corrected.	Check for open or shorted input cables. Check signal source. Substitute known input waveform.
15. Waveform distortion.	Loose input connectors. Improper impedance matching of external cables and signal sources. CRT termination missing. Excess external cabling. Faulty signal source.	Check for distortion using Calibration-Step Generator. Check for loose input connectors, proper impedance matching, and that the termination for the CRT is in place. Proper waveform should appear.	Trouble has been corrected.	Check external cable lengths to determine if excess cabling is causing a loss of performance. Check the signal source.
16. Calibration-Step Generator does not operate properly.	Calibration-Step Generator.	Proceed to step 68 of Table 5-3.		
17. Rate Generator does not operate properly.	Rate Generator.	Proceed to step 74 of Table 5-3.		

TABLE 5-3, CIRCUIT TROUBLESHOOTING

STEP	IF NORMAL	IF ABNORMAL
—250-Volt Power Supply		
1. Check for —250 volts at the output of —250-Volt Power Supply.	Proceed to step 2.	Proceed to step 4.
2. Stop the sweep and check ripple voltage at output of —250-Volt Power Supply. Should be approximately 5 mv or less.	Proceed to step 3.	Check C613, C646, and C647.
3. Connect the oscilloscope to a variable autotransformer and check that the power supply remains in regulation when the line voltage is varied between 105 and 125 volts.	Power supply is operating correctly.	Check power-line waveform for extreme flat-top or peaking. Check D610, D611, D612 and D613. Check V627, R627 and K602-4.
4. Check voltage across C613.	If power supply output voltage is within approximately 25 volts of —250 volts, proceed to step 7. If more negative than —275 volts, proceed to step 8. If less negative than —225 proceed to step 9.	Proceed to step 6.
5. Check voltage drop across R610.	Proceed to step 6.	If voltage is abnormally high, check R610. If R610 is normal, there is an unusually high load on the power supply. Check for cause of extra loading. If voltage is low, proceed to step 6.
6. Check voltage between terminals 6 and 11 of T601.	Check D610, D611, D612, and D613. Proceed to step 7.	Check T601.
7. Use the —250V control to set the output voltage. It should be possible to adjust the control for exactly —250 volts output.	Trouble is apparently corrected. Check vertical deflection factor and sweep timing.	If output voltage varies but cannot be set to correct value, check V639, R646, R647, and R648. Recheck step 5. If the output voltage does not vary, check V646, V639, V624, and V627.
8. Check for the following tube conditions: V627A shorted, V624 open (open filament or low emission) V639 open, or V646 shorted. Use voltage and resistance checks if necessary.		
9. Check for the following tube conditions: V627A open (open filament or low emission), V624 shorted, V639 shorted, or V646 open. Use voltage and resistance checks if necessary.		
+225-Volt Power Supply		
10. Check for +225 ±5 volts at the output of the +225-Volt Power Supply.	Proceed to step 11.	Be certain —250-Volt Power Supply is adjusted and regulating. Then proceed to step 13.
11. Stop the sweep and check ripple at output of the +225-Volt Power Supply. Should be approximately 3 mv or less.	Proceed to step 12.	Check C661, C662, C663, and C668.
12. Connect the oscilloscope to a variable autotransformer and check that power supply remains in regulation when line voltage is varied between 105 and 125 volts.	Power supply is operating normally.	Check power line waveform for extreme flat-top or peaking. Check V627, R677, D660, D661, D662, and D663.

STEP	IF NORMAL	IF ABNORMAL
13. Check voltage across C661, C662, and C663.	If output voltage of the power supply is near normal, check R688 and R689. If output voltage is considerably higher than normal, proceed to step 15. If the output voltage is much lower than normal proceed to step 16.	Proceed to step 14.
14. Check voltage drop across R660 and R661.	Check D660, D661, D662, D663, and T601.	If voltage is abnormally high, check R660 and R661. If the resistors are normal, there is an unusually high load on the power supply. Check for cause of extra loading. If voltage is low, check D660, D661, D662, D663, and T601.
15. Check for the following tube conditions: V627B shorted, V674 open (open filament or low emission), or V686 shorted. Use voltage and resistance checks if necessary.		
16. Check for the following tube conditions: V627B open (open filament or low emission), V674 shorted, or V686 open. Use voltage and resistance checks if necessary.		
+475-Volt Power Supply		
17. Use the same general troubleshooting procedure as for the —250-Volt Power Supply.		
Other Low-Voltage Power Supplies		
18. Use the same general troubleshooting procedure as for the +225-Volt Power Supply. Always check supplies in this order: (1) —250, (2) —26.5, (3) +225, (4) +100, +450, +475, or +650.		
CRT Circuit		
19. Check for —4 kv at the junction of R854 and R855 (HIGH VOLTAGE TEST POINT) being careful to avoid contact with the circuit. Switch off power while making connections.	Proceed to step 20.	If the voltage is near zero, proceed to step 22. If the voltage is not near zero, proceed to step 25.
20. Vary setting of the INTENSITY control, and vary line voltage between 105 and 125 volts while checking voltage at junction of R854 and R855. The voltage should remain in regulation.	Proceed to step 21.	Proceed to step 26.
21. Use a high-voltage probe and a great deal of care to measure the voltage at the ungrounded side of C835. The voltage should be approximately 20 kv.	The high voltage power supply is operating normally. The trouble is probably a defective CRT.	Check V802, V812, V822, and their associated components.
22. Check Fuse F801 and R801.	Proceed to step 23.	Replace F801 or R801.
23. Check to see if oscillator, V800, is operating by seeing if the filaments of V802, V812, V822, and V832 are lit. This should be apparent without removing the metal shield.	Proceed to step 24.	Check for 20-kc oscillator waveform at pin 5, V800. Check V800 or T801.

Table 5-3, *(continued)*

STEP	IF NORMAL	IF ABNORMAL
24. Check voltage at plate of V832. This voltage should be more than —4 kv.	Check R856, R855, B853, B854, B855, and B856.	Check T801, V832, C832, and C833.
25. Use R841 to adjust voltage at junction of R854 and R855 to —4 kv. The adjustment should be possible.	The trouble has been corrected.	If voltage varies with setting of R841, check resistance of R844, R843, R842, R841, and R840. If voltage does not vary, check V814A and V814B and their associated components.
26. Check that neon bulbs B853, B854, B855, and B856 are lit at all settings of the INTENSITY control.	Check V814, V800 and associated components.	Check R855, R856 and the neon bulbs. The drop across each neon bulb should be from 55 to 70 volts.
27. Perform step 19.	Proceed to step 28.	Follow information given for steps 19 and 21.
28. Check voltages obtained from FOCUS, GEOMETRY, and ASTIGMATISM controls.	Check CRT tube socket connection. Check the CRT.	Check the circuit of the appropriate control.
Time-Base Trigger and Holdoff Circuit		
29. Set the FUNCTION switch to H.F. SYNC and use test oscilloscope to check (at junction of R63 and D69) whether the Countdown Oscillator is running. Approximately a 10- to 30-mc signal should be present.	Proceed to step 30.	Proceed to step 37.
30. Set the FUNCTION switch to PULSE and PULSE AMPLITUDE OR SYNC control just short of the free-running position. Connect a triggering signal to the EXTERNAL TRIGGER 125 Ω connector and set TRIGGER SOURCE switch to either +EXT. or —EXT. The triggering signal should appear at the junction of R63 and D69.	Proceed to step 31.	Trace the triggering signal through the triggering channel to point where signal is lost. The point where signal disappears will isolate the trouble.
31. Check that the triggering signal appears at input to Second X20 Amplifier.	Proceed to step 32.	Check D68, D69, R63, R64, and R66A.
32. Check that the triggering signal appears at output of Second X20 Amplifier.	Proceed to step 33.	Trouble is in X20 Amplifier. Verify by interchanging amplifiers. Trace signal through amplifier to detect cause.
33. Check that the triggering signal appears at junction of D71 and D72.	Proceed to step 34.	Check components between the output of Second X20 Amplifier and T70.
34. Determine whether Q70 is being triggered by observing the waveform at the collector of Q70. If the transistor is triggering, a large positive-going swing should appear at the collector.	Proceed to step 35.	Check the READY lamp on the front panel. If the lamp is lit, check Q70 and T70. If the lamp is not lit, proceed to step 38.
35. Using a test oscilloscope, check to see whether Q180 is being triggered by observing the waveform at the collector. If Q180 is triggering, a positive-going swing should be apparent at the collector.	Proceed to step 36.	Try all settings of the DELAY control. If any setting of R88 causes Q180 to trigger, the trouble is probably in the delay circuit. Resistance checks can be used to locate the cause of the trouble. If Q180 does not trigger at any setting of R88, check Q180, D82, T70, and T180.

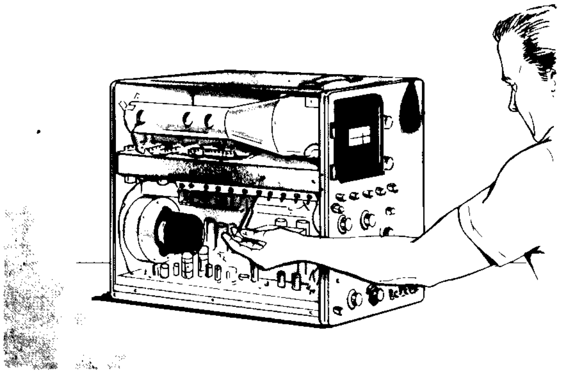
STEP	IF NORMAL	IF ABNORMAL
36. Check for a positive gate approximately 30 volts in amplitude at the junction of D198 and D199.	The Time-Base Trigger Circuit is operating correctly.	Check V184, V194, and their associated components.
37. Set the FUNCTION switch to H.F. SYNC. Check for about —0.2 volt at the cathode of D50.	Check D50 and L52.	Check R56, R54, and R55 and the —26.5-Volt Power Supply.
38. Set the FUNCTION switch to PULSE and the PULSE AMPLITUDE OR SYNC control fully counterclockwise. Set the NORMAL-SINGLE SWEEP switch to NORMAL. Check that V114 is cut off and V134 is conducting. This can be determined by measuring the drop across the plate resistors of the two tubes.	Check V123B. Proceed to step 39 if necessary.	Check V114, V134, and the grid resistors for the two tubes.
39. Rotate the PULSE AMPLITUDE OR SYNC control fully clockwise. Check for a series of positive 7- to 10-volt pulses at pin 2 of V114.	Proceed to step 40.	Check for —0.3 v at cathode of D144. Also check Q70, R78, R77 and T70.
40. Check that V114 conducts each time a positive pulse is applied to the grid. The plate voltage should drop from +100 volts.	Proceed to step 41.	Check V114 and its plate resistors. Check the grid-to-cathode voltage to be sure that positive pulses applied to the grid cause the tube to conduct.
41. Check that V134 cuts off each time that V114 conducts, and that V134 remains cut off for a period which varies with the setting of the NANOSEC/CM switch. When V134 cuts off, its plate voltage should rise to approximately +75 volts.	Proceed to step 42.	Check V123A and its associated components.
42. Check the voltage at the base of Q70. The base of Q70 should go positive each time that Q70 completes a cycle and remain there for a period of time that depends on the setting of the NANOSEC/CM switch. After a definite interval, the voltage should drop exponentially.	The holdoff circuit apparently is operating correctly.	Check V143A and its cathode circuit.
43. Place the NORMAL-SINGLE SWEEP switch at SINGLE SWEEP. Set the FUNCTION switch at PULSE and the PULSE AMPLITUDE OR SYNC control fully counterclockwise. Press the RESET buttons. The READY lamp should light.	The reset circuit is operating normally.	Proceed to step 44.
44. Connect a test oscilloscope at the junction of D160 and D161 and check that a positive pulse occurs at this point each time the RESET button is pressed.	Check D160.	Proceed to step 45.
45. Check the collector voltage of Q160. It should normally be approximately —26.5 volts.	Check Q160 and the base circuit.	Check Q160, C164, R164, SW160, SW168.
Time-Base Gate and Unblanking Circuit		
46. Check for approximately +3.7 volts at pin 1 of V244.	Proceed to step 47.	Check Q238, R230, and R231.

STEP	IF NORMAL	IF ABNORMAL
47. Set the PULSE AMPLITUDE OR SYNC control fully clockwise and set the NORMAL-SINGLE SWEEP switch to NORMAL. Set the NANOSEC/CM switch to 10. Check the duration of the gate appearing at pin 2 of V244. The duration of the gate should be 70 nanoseconds.	Proceed to step 48.	Check the NANOSEC/CM switch and the coaxial cables used for gate timing. See that Q180, V184, V194, D197, and D198 are functioning properly.
48. Set the NANOSEC/CM switch to 1000 and check the length of the gate appearing at pin 2 of V244. The gate duration should be approximately 9 μsec.	Proceed to step 49.	Proceed to step 50.
49. Check the waveform at pin 8 of V244. The waveform should be a negative gate of more than 40 volts with a duration of approximately 9 μsec.	The Time-Base Gate Generator is operating correctly.	Check V244 and the associated circuitry.
50. Set the NANOSEC/CM switch to 20 and check that a series of positive pulses or gates appear at pin 1 of V264.	Proceed to step 51.	Check R256 and R260.
51. Check for a series of negative-going pulses (near 160 volts amplitude) at pin 5 of V264.	Proceed to step 52.	Check V264 and the associated components.
52. Check waveform at pin 8 of V274. The waveform should be a series of positive-going gates with a duration of approximately 180 nsec.	Proceed to step 53.	If the gates do not appear, check C262 and V274. If the duration of the gates is incorrect, check the setting of C262 using the Calibration Procedure. Then check R270 and R271.
53. Check for a series of 180-nsec positive gates at pin 8 of V393B.	Check V283 and the associated components.	Check V393B and R280, R281, and R282.
54. Adjust the oscilloscope for a free-running sweep, and set the NANOSEC/CM switch to 1000. Check for positive gates at pin 2 of V214. The gate duration should be approximately 9 μsec.	Proceed to step 55.	Check L250.
55. Check the waveform at pin 8 of V214. This should be a series of negative gates approximately 9 μsec in duration and approximately 110 volts in amplitude.	The unblanking circuit is operating normally.	If no gate is present, check V214. If the gate is abnormally large, check V223 and D220.
Time-Base Generator **CAUTION** Certain failures in the Time-Base Generator may cause damage to the screen grid of V331. Consequently, when troubles are traced to the Time-Base Generator, the screen-grid and control-grid voltages of V331 should be checked immediately. If the screen-grid voltage is more than 140 volts, and the control-grid voltage is within 1 volt of ground, the instrument should not be left on for more than 30 seconds at a time (measured from the end of the time delay period). Voltage readings must be made within the 30-second periods.		
56. Observe CAUTION above. Check for +155 volts at the plate of V331 with the NANOSEC/CM switch at 2.	Proceed to step 57.	If plate voltage is zero, check V332, R336, and R334. If the plate is near +475 volts first check the setting of R374, then check V331. If the plate is near +155 volts try to adjust to correct value with R374. If trouble is not corrected, proceed to step 59.

STEP	IF NORMAL	IF ABNORMAL
57. Check for —3.2 volts at the control grid of V331 with the NANOSEC/CM switch at 2.	Proceed to step 58.	Use R396 to adjust voltage to correct level. If trouble cannot be corrected, proceed to step 60.
58. Check that screen-grid voltage of V331 is less than +140 volts.	Circuit is operating correctly.	Replace V331.
59. Check the control-grid voltage of V331. If the plate voltage of V331 is high, the control-grid voltage should be less than —3.2 volts. If the plate voltage of V331 is low, the control-grid voltage should be more than —3.2 volts.	The Plate-Voltage Regulator is operating. Proceed to step 61.	Check V312, V322, Q318, Q328, V374, V363 and V343. Check voltages in Plate-Voltage Regulator against those indicated on the schematic diagram.
60. Check the screen-grid voltage of V331 against the values in Table 5-1.	Circuit should be operating correctly. Recheck the setting of R396.	Proceed to step 61.
61. Check plate voltage of V394. The voltage should be higher than normal if the control-grid voltage of V331 is less than —3.2 volts. The voltage should be less than normal if the control-grid voltage of V331 is more than —3.2 volts.	Check V403.	Check V393A and V394.
62. Free-run the sweep and check the amplitude of the gate at the grid of V331. The gate should drive the grid of V331 negative by at least 40 volts.	Proceed to step 63.	Check D305, D306, D307 and D308, and C312.
63. Set the NANOSEC/CM switch to 1000 and free run the sweep. Check for a sawtooth waveform of approximately 150 volts or more at pin 3 of V343. Use a 10X probe on the test oscilloscope.	Proceed to step 64.	Check V343, V332, and R336.
64. Check for approximately a 150-volt or more sawtooth waveform at pin 2 of V424.	Proceed to step 65.	Check D344, D345, and C344.
65. Check for approximately a 150-volt or more sawtooth waveform at pins 3 and 8 of V353.	Proceed to step 66.	Check V353.
66. Check for a linear sawtooth of approximately 150 volts at pins 3 and 6 of V424. Pin 6 negative waveform may have low amplitude due to capacitance of test probe.	Proceed to step 67.	Check V424. See that deflection plate leads are connected properly.
67. Check for linear sawtooth waveform of approximately 150 volts or more at the junction of R440 and R445, and at the junction of R442 and R446.	Time-Base Generator is operating correctly.	Check D430, D431, R433, R435, C435, C433, and C430.
Calibration-Step Generator		
68. Set the RANGE switch to 10V TO 125 Ω. You should hear the reed switch operating.	Proceed to step 70.	Adjust the FREQUENCY and DRIVE controls to see if the reed will vibrate. If it does, proceed to step 70. If not, proceed to step 69.
69. Check that the oscillator is operating by observing the waveform at pin 5 of V885. The normal waveform should be present.	Check L885 and R885.	Check V885 and V895A.

Table 5-3, *(continued)*

STEP	IF NORMAL	IF ABNORMAL
70. Check the frequency of oscillator operation while varying the setting of the FREQUENCY control. The frequency should vary between approximately 250 and 1100 cycles per second.	Proceed to step 71.	Check the network in the plate circuit of V895A and the grid circuit of V885.
71. Display the output waveform of the Calibration-Step Generator on the Type 519. It should be possible to obtain triggering.	Proceed to step 72.	If the sweep cannot be triggered properly, check the charging network, charging voltage attenuators, and the reed switch. Be sure Calibration-Step Generator has a dc load (no series capacitor).
72. Check the waveform displayed on the Type 519. There should be no appreciable time or amplitude jitter.	Proceed to step 73.	Check the reed switch.
73. Check the amplitude of the displayed step waveform on the Type 519 against the settings of the POLARITY, RANGE and VOLTS controls.	Calibration-Step Generator is apparently operating correctly.	Check the charging voltage attenuators for proper values.
Rate Generator		
74. Set the MULTIPLIER switch to X1000 and the CYCLES/SEC control to 30. Check for approximately a 30-kc switching waveform at pin 3 of V915B.	Proceed to step 75.	If the multivibrator is not operating, check to see if other settings of the MULTIPLIER and CYCLES/SEC controls will cause the multivibrator to run. If so, check the components used only in the inoperative positions. If not, check V915 and V895, and components common to all settings of the controls. If the frequency of operation is incorrect check R923, R924, and the appropriate C920 values.
75. Connect the output waveform from the +RATE 50 Ω connector to the input of the Type 519 through a T50/T125 adapter. Check the appearance of the waveform. It should be approximately 7-10 volts in amplitude, as displayed on the screen, and approximately 10 nsec in duration.	Proceed to step 76.	If no pulses are present, adjust the AVALANCHE SET control as described in the Calibration Procedure. If the trouble cannot be corrected, check Q934 and its emitter and collector circuits. If the pulse amplitude is incorrect or if the waveform is severely distorted, check Q934 and the emitter circuit.
76. Set the MULTIPLIER switch to OFF and check to see that the waveform disappears from the screen of the Type 519.	The Rate Generator is operating correctly.	The Avalanche stage is free running. Adjust the AVALANCHE SET control to the point where the generator just stops free running. If the adjustment cannot be made, check R933, R932, R931 and Q934.



SECTION 6

CALIBRATION PROCEDURE

INTRODUCTION

The following paragraphs outline the procedure used to calibrate the Type 519 Oscilloscope. The instrument should not require frequent recalibration, but occasional adjustments will be necessary when tubes and other components are changed. Also, a periodic recalibration is desirable from the standpoint of preventive maintenance.

Apparent troubles in the instrument are occasionally the result of improper calibration of one or more circuits. Consequently, calibration checks should be an integral part of any troubleshooting procedure. Abnormal indications occuring during calibration checks will often aid in isolating troubles to a definite circuit or stage.

In the instructions that follow, the steps are arranged in the proper sequence for a complete calibration of the instrument. Each numbered step contains the information required to make one check or adjustment or a series of related checks or adjustments. The steps are arranged to avoid unnecessary repetition of checks or adjustments.

EQUIPMENT REQUIRED

The following equipment or its equivalent is required to perform a complete calibration of the Type 519 Oscilloscope.

1. An accurate dc voltmeter with a sensitivity of 20,000 ohms per volt or more.
2. A nonloading dc voltmeter such as John Fluke 800, if available.
3. An accurate ac voltmeter capable of reading voltages from 105 to 125 or from 210 to 250 volts.
4. An ohmmeter.
5. An autotransformer with output voltage variable between 105 and 125 or 210 and 250 volts. Minimum rating of 1 kva.
6. A test oscilloscope with a bandpass to at least 30 mc and a maximum sensitivity of at least 50 millivolts per centimeter. Must also have a sensitivity of at least 5 millivolts per centimeter at reduced bandpass. Oscilloscope such as a Tektronix Type 540-Series and Type L Plug-In Unit is suitable.
7. Time-mark generator capable of generating 1 μsec markers and 5, 10, and 50 mc sine waves, such as the Tektronix Type 180A.
8. A 125 Ω, 1 KMC Timing Standard, such as Tektronix Part No. 017-019, or accurate source of sine waves with frequency to 1000 mc.
9. Miscellaneous adapters and cables.
10. Miscellaneous alignment tools and other hand tools.

PRELIMINARY PROCEDURE

Make a complete visual check of the instrument. Then use an ohmmeter to make a check on the resistance at the regulated bus of each power-supply lead to ground at the test points shown in Fig. 6-1. The values of resistance should be approximately as follows:

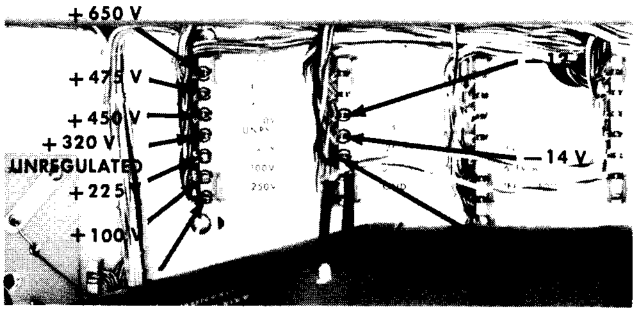


Fig. 6-1. Locations of low-voltage power supply test points on the top of the instrument near the CRT.

TABLE 6-1

POWER SUPPLY LEAD	RESISTANCE TO GROUND
—250 volts	12 k
—26.5 volts	2 Ω
—14 volts	2 Ω
+100 volts	3 k
+225 volts	4 k
+320 volts (unregulated)	4 k
+450 volts	50 k
+475 volts	30 k
+650 volts	40 k or higher

Set the INTENSITY control fully counterclockwise and connect the power cord and ac voltmeter to the output of the variable autotransformer. Set the POWER switch to ON and adjust the autotransformer for an output of 117 volts (or other voltage for which the instrument is wired). Allow the instrument to warm up for several minutes before proceeding with the calibration steps.

ADJUSTMENT PROCEDURE

1. Adjust —250-Volt Power Supply

Connect the dc voltmeter to the —250-volt test point shown in Fig. 6-1. Set the —250V control for exactly —250 volts.

2. Check the Low-Voltage Power Supplies

Stop the sweep by setting the FUNCTION switch to PULSE and the PULSE AMPLITUDE OR SYNC control fully counterclockwise. Use the dc voltmeter to check the output of each of the low-voltage power supplies. Vary the output of the autotransformer between 105 and 125 (or 210 and 250) volts while checking that the power supplies regulate over the entire range. Check for proper regulation at 125 volts with the NANOSEC/CM switch set at 1000, and at 105 volts with the NANOSEC/CM switch set at 2. Using the high gain plug-in unit for the test oscilloscope, check the ripple voltage of each power supply. Voltages and ripple voltages should be approximately as follows:

TABLE 6-2

POWER SUPPLY	OUTPUT VOLTAGE	RIPPLE VOLTAGE (peak-to-peak typical)
—250 volts	—250 volts	3 mv
—26.5 volts	—26.5 ±0.5 volts	5 mv
—14 volts	—14 ±0.5 volts	3 mv
+100 volts	+100 ±3 volts	3 mv
+225 volts	+225 ±5 volts	2 mv
+450 volts	450 ±10 volts	10 mv
+475 volts	+400 to 550*	15 mv
+650 volts	+650 ± 25 volts	50 mv

* Depends on setting of NANOSEC/CM switch.

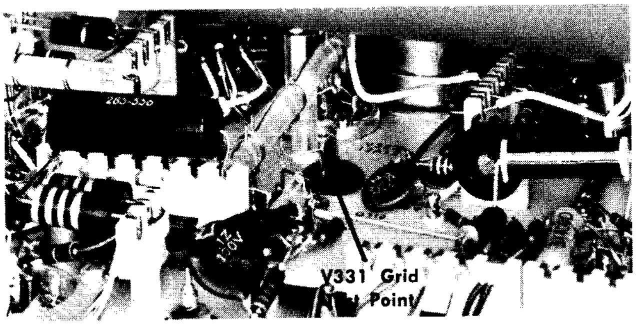


Fig. 6-2. Location of the V331 control-grid test point.

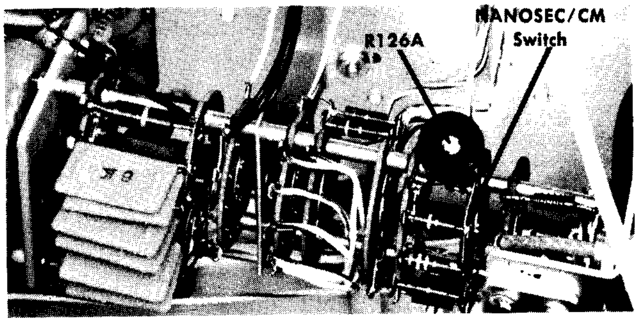


Fig. 6-3. Location of the 400 KC REP. RATE adjustment, R126A.

3. Set Sweep Repetition Rate

Set the PULSE AMPLITUDE OR SYNC control fully clockwise and the NANOSEC/CM switch to 2. Connect the probe of the test oscilloscope to the grid line of V331 at the point shown in Fig. 6-2. Adjust R126A (see Fig. 6-3) for 2.5 μsec between the gates displayed on the test oscilloscope. Check the repetition rates of other ranges using the following data:

TABLE 6-3

NANOSEC/CM SETTING	APPROXIMATE TIME BETWEEN GATES
5	5.5 μsec
10	11 μsec
20	24 μsec
50	60 μsec
100	100 μsec
200	200 μsec
500	500 μsec
1000	1 ms

4. Set Position of Pulse Amplitude or Sync Knob

Turn the PULSE AMPLITUDE OR SYNC control slowly counterclockwise until the sweep just stops running. The dot on the knob should be just above the RECURRENT line on the front panel. If not, loosen the knob on the shaft and rotate it to the proper position. Retighten the knob. The sweep should now free run any time that the knob is positioned clockwise past the line.

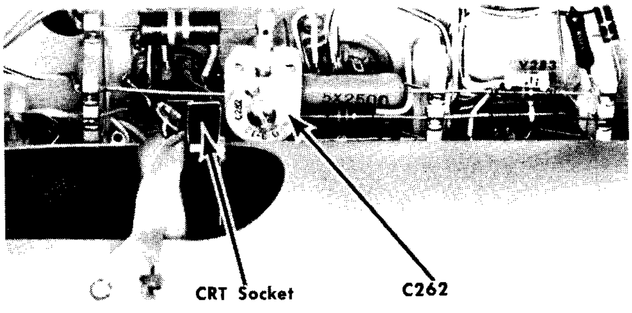


Fig. 6-4. Location of the SWEEP GATE LENGTH adjustment, C262.

5. Set Time-Base Gate Duration

Set the PULSE AMPLITUDE OR SYNC control fully clockwise and connect the test oscilloscope to the grid line of V331, at the test point shown in Fig. 6-2. Set the NANOSEC/CM switch to 1000 and adjust C262 (see Fig. 6-4) for 9-μsec gates displayed on the test oscilloscope. Measure the duration of the gate at the 50% voltage level. Check the duration of the gates at the other sweep rates according to the following table:

TABLE 6-4

NANOSEC/CM SETTING	GATE DURATION (at 50% voltage level) 30-Megacycle Oscilloscope
500	4.5 μsec minimum
200	1.8 μsec minimum
100	900 nsec minimum
50	450 nsec minimum
20	180 nsec minimum
10	70 nsec approximately
5	35 nsec approximately
2	14 nsec approximately

6. Check Gate and Unblanking Amplitudes

Set the NANOSEC/CM switch to 10 and free run the sweep. Check for the following gate amplitudes:

TABLE 6-5

LOCATION	AMPLITUDE
Pin 2 of V244	+20 volts minimum
Pin 3 of V223	Approximately —110 volts
Grid line of V331	—35 volts minimum

7. Check +Trigger Pulse

Free run the sweep and connect the probe of the test oscilloscope to the +TRIGGER 50 Ω connector on the front panel of the Type 519. The pulses displayed on the test oscilloscope should be approximately 50 nsec in duration as measured at the 50% voltage level, and should have a peak amplitude of approximately 4 volts when unterminated.

8. Check the Delayed +Gate

Set the NANOSEC/CM switch to 1000 and free run the sweep. Check the amplitude of the waveform at the DELAYED +GATE 50 Ω connector by connecting the probe of the test oscilloscope directly to the connector. The gates displayed on the test oscilloscope should have a peak amplitude of approximately 9 to 10 volts when unterminated, falling off to approximately 50% of this at the end of the gate (see Fig. 6-5.)

Connect the output of the +TRIGGER 50 Ω connector to the external triggering connector of the test oscilloscope and trigger the oscilloscope from this signal. Set the NANOSEC/CM switch to 10. Observe the output of the DELAYED +GATE 50 Ω connector while rotating the DELAY control. It should be possible to move the delayed +gate approximately 35 nsec in time by means of the DELAY control.

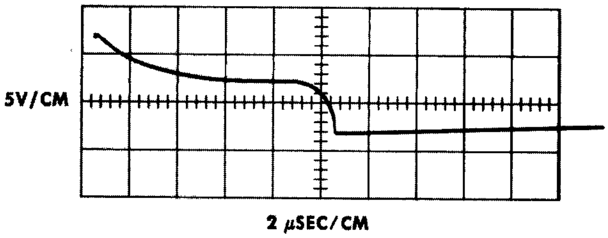


Fig. 6-5. Typical Delayed +Gate as displayed on a 30 mc test oscilloscope.

9. Check Single-Sweep Operation

Set the NORMAL-SINGLE SWEEP switch to SINGLE SWEEP and the PULSE AMPLITUDE OR SYNC control fully clockwise. Set the NANOSEC/CM switch to 1000. The sweep should run once each time the RESET button is pressed.

Set the PULSE AMPLITUDE OR SYNC control fully counterclockwise. The READY lamp should light when the RESET button is pressed, but the sweep should not run.

10. Check Zener Diode Strings

Stop the sweep and check the voltage drop across the Zener diode strings in the Time-Base Generator. The voltage drop across D305, D306, D307 and D308 should be 500 to 550 volts. The drop across D344 and D345 should be 250 ± 5 volts. The drop across D430 and D431 should be 340 ±6 volts.

11. Set Grid Voltage of V331

Set the NANOSEC/CM switch to 2 and stop the sweep. Connect the dc voltmeter to the grid test point of V331 and adjust the 4CX250F GRID —3.2 VOLTS control for exactly —3.2 volts.

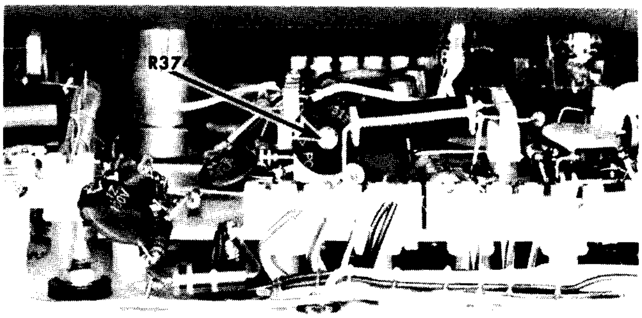


Fig. 6-6. Location of the V331 PLATE +155 V adjustment, R374.

12. Set Plate Voltage of V331

Connect the dc voltmeter to the plate of V331 at the plate strap of the tube. Adjust R374 (see Fig. 6-6) for exactly +155 volts at the plate.

13. Adjust High Voltage

Turn off the oscilloscope power. Connect the dc voltmeter to the HV TEST POINT on the right side of the instrument (be sure the voltmeter is capable of indicating at least 4 kv). Turn on the oscilloscope and allow the normal warmup period to pass. Then adjust the HIGH VOLTAGE control for —4 kv. Check to see that the high voltage power supply regulates by first positioning the trace or spot off the screen and then adjusting the intensity up and down. Then adjust the output voltage from the variable autotransformer between 105 and 125 (or 210 and 250) volts and again check that the high voltage power supply remains in regulation. Switch off the oscilloscope power and disconnect the meter. Then turn on the oscilloscope.

The final adjustment of the high voltage should be made after step 15 by setting the vertical deflection factor into exact agreement with the figure on the CRT facemask. Only then proceed to step 16.

14. Adjust Axis Rotation

Free run the sweep and position the trace near the center horizontal graticule line. Set the NANOSEC/CM switch to 1000. Adjust the AXIS ROTATION control so that the trace runs parallel to the horizontal graticule line.

15. Adjust Geometry

Position the trace to the top of the screen and adjust the GEOMETRY control to minimize bowing of the trace. Position the trace to the bottom of the screen and recheck the setting of the control. Make the final setting of the GEOMETRY control so that the best overall geometry is obtained.

NOTE

Make final setting of high voltage to produce correct vertical deflection factor before proceeding with sweep timing adjustments.

16. Set Sweep Timing

Set the NANOSEC/CM switch to 50 and apply 50-mc sine waves from the time-mark generator to the input of the Type 519. Obtain a stable display of the sine waves on the screen of the oscilloscope. Adjust the 50 nSEC control to obtain 2½ cycles per centimeter over the righthand 5 centimeters of the display. Adjust C425 for optimum linearity while the 50 nSEC control is being set.

Set other sweep rates as indicated in Table 6-6.

TABLE 6-6

SWEEP RATE	INPUT SIGNAL	CONTROL	ADJUST FOR
1000 nsec/cm	1-μsec time markers	1 μSEC	1 marker/cm
500 nsec/cm	5-mc sine waves	500 nSEC	2½ cycles/cm
200 nsec/cm	5-mc sine waves	200 nSEC	1 cycle/cm
100 nsec/cm	10-mc sine waves	100 nSEC	1 cycle/cm
20 nsec/cm	50-mc sine waves	20 nSEC	1 cycle/cm
10 nsec/cm	50-mc sine waves	10 nSEC	1 cycle/2 cm

Connect the 1 KMC Timing Standard to the SIGNAL 125 Ω connector on the front panel of the Type 519. Connect a 125-ohm cable from the OUTPUT 125 Ω connector to the 1 KMC Timing Standard. Set the VARIABLE control fully clockwise, the TRIGGER SOURCE switch to +CAL., and the POLARITY switch to +. Be sure that the trigger takeoff for the Calibration-Step Generator is installed in the instrument. Set the RANGE switch to VARIABLE. Adjust the DRIVE and FREQUENCY controls for stable operation of the reed switch and adjust the triggering controls for a stable display of the timing waveform on the screen of the oscilloscope. Use the DELAY control to position the start of the waveform so that it starts about 1 centimeter from the start of the sweep when the NANOSEC/CM switch is set to 5.

With the timing waveform displayed and the NANOSEC/CM switch set to 5, adjust the 5 nSEC control for 5 cycles per centimeter over the middle 4 centimeters of the display. Set the NANOSEC/CM switch to 2, position the trace to start approximately 1 centimeter to the left of the graticule marks and readjust the DELAY control so the first graticule mark is lined up with the first peak of the timing waveform. Adjust the 2 nSEC control for 2 cycles per centimeter over 6 centimeters.

17. Check Calibration-Step Generator Charging Voltage

Set the VOLTS control to 10 and the RANGE switch to 10V TO 125 Ω. Measure the dc voltage at the input to the charging network. The voltage should be approximately 20.2 volts, using a nonloading voltmeter. Set the RANGE switch to 1V TO 50 Ω and again check the voltage at the input to the charging network. The voltage should now be approximately 8.8 volts, using a nonloading voltmeter. Set the RANGE switch to STANDBY.

18. Set Rate Generator Frequency

Connect the 10X attenuator probe of the test oscilloscope

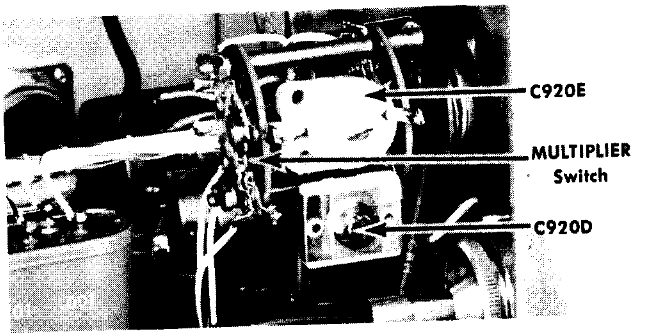


Fig. 6-7. Location of the Rate Generator frequency adjustments, C920D and C920E.

to pin 3 of V915B. Set the MULTIPLIER control to X10 and the CYCLES/SEC control to 3. Adjust the FREQUENCY RANGE control for a multivibrator frequency of 30 cps (33.3 msec between waveforms).

Set the MULTIPLIER switch to X1000 and the CYCLES/SEC control to 3. Set C920D (see Fig. 6-7) for 3 kc (333 μsec between multivibrator waveforms).

Set the CYCLES/SEC control to 30. Adjust C920E (see Fig. 6-7) for 30 kc (33.3 μsec between multivibrator waveforms).

19. Adjust the Avalanche Generator

Set the CYCLES/SEC control to 30 and the MULTIPLIER switch to X1000. Display the output of the rate generator on the Type 519 by connecting the 50-ohm end of a T50/T125 adaptor into the +RATE 50 Ω connector and then connecting from the T50/T125 adaptor to the SIGNAL 125 Ω connector. Set the NANOSEC/CM switch to 100. Set the AVALANCHE SET control fully clockwise and then turn the control slowly counterclockwise until the avalanche generator just stops free running (as indicated by a sudden decrease in the number of pulses displayed on the screen).

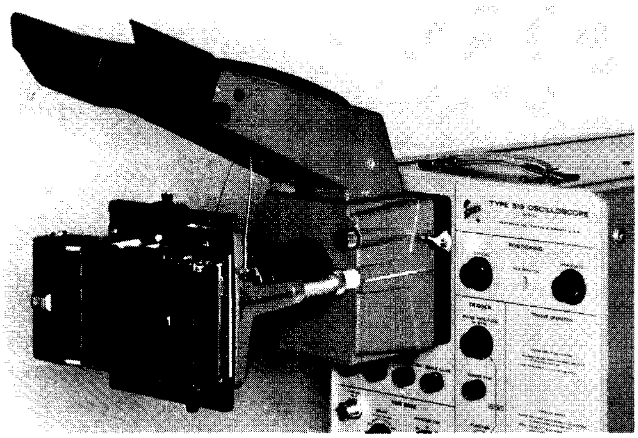
ACCESSORIES

The Tektronix Type 519 Oscilloscope will fit many measurement applications and systems through use of various accessories listed in this section. Operational accessories are described on page 2-10.

Accessories should be ordered by type or part number through your local Tektronix Field Office or Representative. Complete, up-to-date price information is also available from your local Field Office or Representative.

TYPE C-19 OSCILLOSCOPE CAMERA

The Tektronix C-19 Camera satisfies a need for making permanent recordings of crt displays on Tektronix 5-inch fast-transient oscilloscopes such as the Types 519, 581 and 585. High-speed pulse recordings of fast waveforms, where a a very fast writing rate is important, are easy with a C-19 Camera.



Viewing

The C-19 Camera viewing system uses two first-surface mirrors in the viewing hood. With this viewing system the operator's eyes and the camera lens receive nearly equal amounts of light. The viewing hood prevents room light interference and allows comfortable viewing with or without glasses.

Lens

The standard lens for the C-19 Camera is a Simpson f/1.5, with an object-to-image ratio of 1:0.5. The shutter is an Alphax No. 4 providing six speeds from 1 second to 1/50 second and Time and Bulb settings.

The crt image is passed directly to the camera lens without image reversal. To assure maximum light transmission to the film, the C-19 has been designed without a beam-splitting mirror between crt and lens.

Film Backs

The C-19 accepts several different type backs. A Polaroid® back for quick-develop recording and a standard focusing 4" x 5" Graflok back are furnished with the camera. Once focused, all backs are accepted without refocusing. The C-19 also accepts other readily available Graflok accessories, such as film pack adaptors, roll film holders, glass-plate holders, cut-film holders, and 35 mm adaptors. All film backs rotate through 90-degree increments and can be moved horizontally or vertically, with respect to the lens.

The long axis of the film can be oriented horizontally or vertically, independently of the horizontal or vertical orientation of the sliding back.

® Registered trademark of the Polaroid Corp.

Film

Some popular types of film used by the Type C-19 Camera are:

Polaroid type 410 Pola Scope—used for especially high writing rate single trace oscillography. Produces a 3¼" x 4¼" print.

Polaroid Type 47—used especially for high writing rate, produces a 3¼" x 4¼" print.

Polaroid Type 46L—produces a 3¼" x 4¼" transparency, and can be enlarged easily by conventional methods.

Polaroid Type 44—ideal for a majority of trace recordings.

Polaroid Type 42—primarily used with stationary traces, most economical of the Polaroid films.

Eastman cut films such as Royal-X Pan, Royal Pan, Royal Ortho, and Tri-X Pan. 35 mm still camera film. Cut-film sizes are 2¼" x 3¼", 3¼" x 4¼", and 4" x 5".

Mounting

Attaching the camera to the oscilloscope is easy. A hinged mounting adaptor is firmly attached to the oscilloscope with coin-slotted graticule nuts. The camera fits snugly into the hinge fittings, yet can be lifted out with ease or swung completely away from the crt to allow full visibility of the screen. A quarter-turn Camera Mounting Latch secures the camera body to the mounting adaptor.

Controls

A chrome-plated focusing knob on the camera body positions the lens with respect to the display.

Shutter speed is adjustable by rotating a knurled ring located on the lens mount.

Shutter release may be cable operated and controlled from the right side of the camera, or it may be operated by a small chrome-plated lever located on the left side of the lens mount.

The f-stop lever on the lens mount selects the desired aperture from f/1.5 to f/16.

A clockwise twist of the viewing door knob allows you to look through the viewing hood at the display even when taking pictures.

Construction

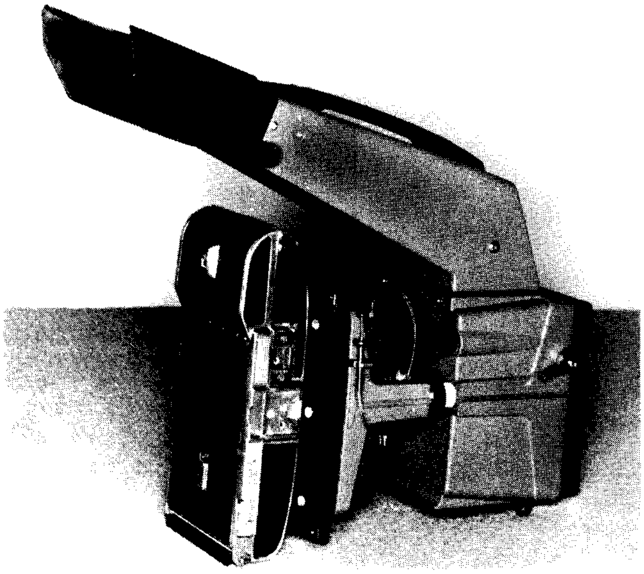
Die-cast aluminum construction of the camera body, adaptor, and lens mount makes the Type C-19 Camera a rugged instrument, capable of withstanding long and constant use. Weight is approximately 17 lbs. with Polaroid Land back.

Camera Accessories

Polaroid two-minute timer—adjustable from 5 seconds to 2 minutes. Can be mounted on side of viewing hood.

To be released in the near future:

Solenoid—for remote tripping of a single camera or a bank of cameras simultaneously, such as by programed electrical impulses.



TYPE C-12 OSCILLOSCOPE CAMERA

Essentially the same as the Type C-19 Camera except there is a beam-splitting mirror between the crt display and the camera lens.

Interchangeable Lens

Lens easily changed by loosening two adustable locknuts. Lenses available are f/1.5, f/1.9 and f/4.5. The Oscillo-Raptar f/1.9 lens with an object-to-image ratio of 1:0.9 is the standard lens for the C-12 Camera.

Binocular Viewing

Orthogonal and undistorted view over 8 x 10 centimeter graticule and crt display. Viewing hood allows comfortable operator viewing with or without glasses.

Interchangeable Backs

The Type C-12 Camera can be used with the same film backs as the C-19 Camera. Once the camera is focused, all backs are accepted without refocusing.

Rotating and Sliding Backs

All backs can be rotated through 90° increments. The backs may be moved horizontally or vertically to any of five positions in either direction.

Hinge Mounting

The camera can be swung away from the crt screen for full screen visibility. It also lifts easily out of the hinge fittings for storage.

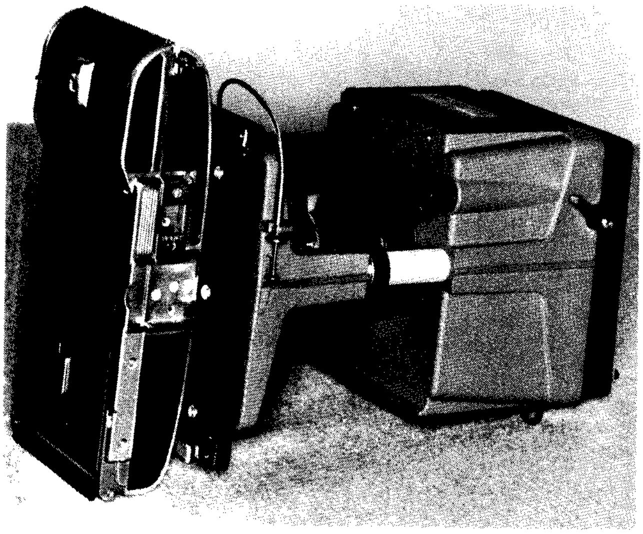
Ordering

The Type C-12 Camera is shipped with a Graflok 4 x 5 focusing back and a Polaroid Land Roll Film back. Many applications can be solved by several other lens combinations and backs that are available. Consult your Field Engineer or Field Office for details.

TYPE C-13 OSCILLOSCOPE CAMERA

The C-13 is similar to the two cameras just described, but does not have a viewing hood. The camera must be swung away from the crt display during set-up.

Lens supplied with the C-13 is a f/4.5 Amaton with object-to-image ratio of 1:0.7. Other Tektronix camera lens systems fit the C-13.



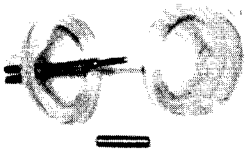
CABLE CONNECTORS AND ADAPTORS

The Type 519 125 Ω signal input connector is a Tektronix (TEK) modification of the General Radio (GR) 50 Ω Type 874-PB flange-mounted panel connector. The center conductor and plastic spacer have been modified to make the connector surge impedance 125 Ω.

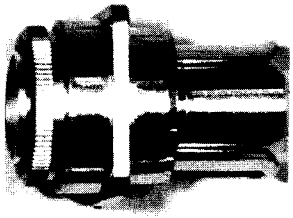
If a GR Type 874 50 Ω connector is accidentally forced into a 125 Ω connector, it is possible to break the 125 Ω connector's plastic center conductor spacer. Therefore, plastic double-button and center conductor king-connector replacements are available.

VSWR of either GR 50 Ω or GR-TEK 125 Ω connectors, paired and properly terminated, is less than 1.02 to beyond 1000 megacycles.

When assembling the 125 Ω cable connector (part number 017-035) on your own RG-63B/U cable, do not tighten with a wrench. Excessive tightening will compress the cable causing a change in surge impedance at the connector, with resultant signal reflections.



017-032



017-033

017-035

TABLE 7-1
GR-TEK 125Ω CABLE CONNECTORS AND PARTS

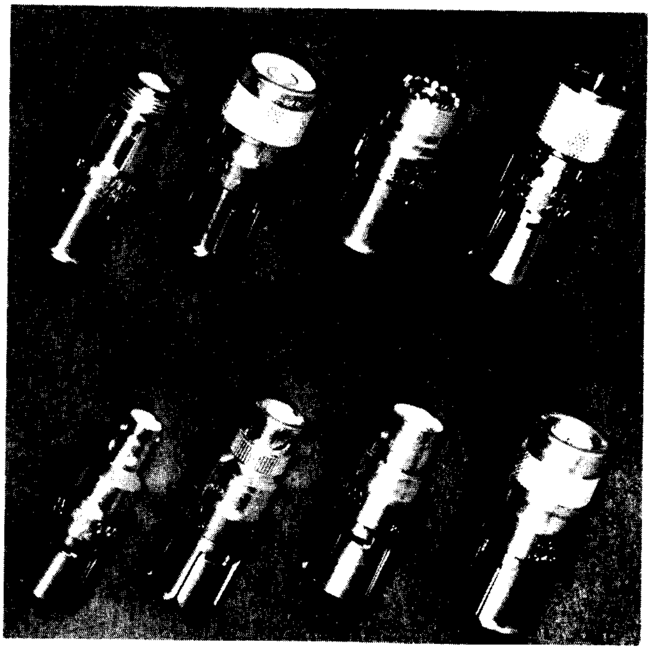
Description	Part Number
125 Ω plastic double-button assembly with center conductor king-connectors.	017-032
125 Ω connector panel adaptor assembly, as used for Type 519 SIGNAL input.	017-033
125 Ω cable connector for RG-63B/U.	017-035
125 Ω elbow connector.	017-043

TABLE 7-2
50Ω GR TYPE 874-Q ADAPTORS

Description	Part Number
Type 874 Connector and Type N Jack (GR Type 874-QNJ). Fits Type N Plug.	017-020
Type 874 Connector and Type N Plug (GR Type 874-QNP). Fits Type N Jack.	017-021
Type 874 Connector and Type UHF Jack (GR Type 874-QUJ). Fits Type UHF Plug.	017-022
Type 874 Connector and Type UHF Plug (GR Type 874-QUP). Fits Type UHF Jack.	017-023
Type 874 Connector and Type BNC Jack (GR Type 874-QBJ). Fits Type BNC Plug.	017-024
Type 874 Connector and Type BNC Plug (GR Type 874-QBP). Fits Type BNC Jack.	017-025
Type 874 Connector and Type C Jack (GR Type 874-QCJ). Fits Type C Plug.	017-026
Type 874 Connector and Type C Plug (GR Type 874-QCP). Fits Type C Jack.	017-027

50 Ω Connector Adaptors

GR Type 874-Q Adaptors connect between the GR Type 874 50 Ω Coaxial Connectors and other commonly used



50 Ω types. By plugging together the GR 50 Ω ends of two appropriate adaptors, you can also interconnect other systems.

With the exception of the UHF adaptor, typical VSWR up to 2000 megacycles for adaptors listed in Table 7-2 is less than 1.03 when properly terminated.

Coaxial System Impedance Adaptors

With the adaptors listed in Table 7-3 plus the Connector Adaptors of Table 7-2, you can connect nearly any 50 Ω system to the Type 519 125 Ω input.

The T50/T125* Attenuator correctly matches a 50 Ω line to the Type 519 125 Ω input with a VSWR of less than 1.1 up to 1500 Mc.

The unterminated adator N50/N125* has no resistance elements and changes from a 50 Ω surge impedance to a 125 Ω surge impedance abruptly. It will produce high VSWR when used with high-frequency sine waves. When the adaptor is used for pulses, the abrupt discontinuity inherent in the unit causes a reflection to occur which may interfere with the displayed waveform unless certain precautions are taken. To prevent reflections from occurring on the displayed waveform, either drive from a correctly matched generator, or make the electrical length of the cable supplying the adaptor equal to or more than T/2, where T is the length of the pulse being observed. The reflection will then appear after the displayed waveform.

Two other 50 Ω adaptors are listed, one terminated at the 50 Ω end, and the other terminated at the 125 Ω end. Both are capable of handling sine waves when working in a properly terminated system. If proper terminations are not available, care must be exercised to avoid reflections such as described for the N50/N125 Adaptor.

The last item of Table 7-3, the T200/N125 Adaptor, permits you to drive the Type 519 from a 200 Ω output impedance system. The adaptor is not correctly terminated at the 125 Ω end, and is intended to accept signals at the 200 Ω end only.

Power ratings of the adaptors listed in Table 7-3 do not permit dc full scale deflection at the Type 519 vertical sensitivity. However, this does not limit full scale deflection for pulse work when the pulses have a duty cycle sufficiently low that the effective power dissipated within the adaptor is within the rating stated. For example, the T50/T125 Attenuator has a 50-ohm input rating of 1.5 watts, corresponding to 9.4 volts in a 50-ohm resistor. 9.4 volts X 0.564 transmission factor will produce about ½ cm of deflection on the Type 519 crt. Two full centimeters of deflection can be attained by using pulses with 6% or less duty cycle. This same principle applies to each of the adaptors, providing the individual adaptor power and voltage transmission factor rating are observed.

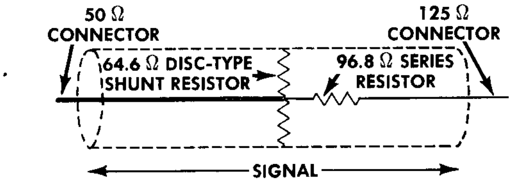
In case resistance elements are damaged by excessive power, order replacement parts by part number as indicated in Table 7-3. The adaptors are designed for easy resistance element replacement.

*** T indicates Terminating; N indicates Nonterminating.**

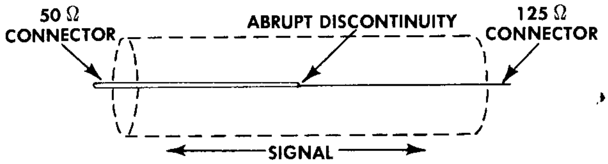
TABLE 7-3

COAXIAL SYSTEM ATTENUATOR AND IMPEDANCE ADAPTORS WITH GR-TEK 125 Ω CONNECTORS

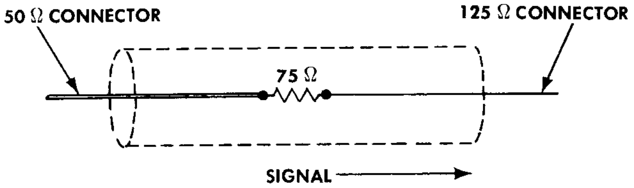
Description	Part Number	Resistance Element Part Number
T50/125 Attenuator. Correctly matches 50 Ω to 125 Ω or 125 Ω to 50 Ω. 1.5 w feeding 50 Ω, 0.5 w feeding 125 Ω. Voltage Transmission Factors: 0.564, 50 Ω to 125 Ω 0.225, 125 Ω to 50 Ω	017-052 Replaces 017-008	~~307-075~~ 214-0267-00
N50/N125 Adaptor. Intended for pulse work. No resistance elements. Voltage Transmission Factors: 1.43, 50 Ω to 125 Ω 0.572, 125 Ω to 50 Ω	017-053 Replaces 017-015	No resistance element
N50/T125 Adaptor. 125 Ω to 50 Ω, 0.85 w. Voltage Transmission Factor: 0.4	017-054 Replaces 017-016	309-169
T50/N125 Adaptor. 50 Ω to 125 Ω, 2 w. Voltage Transmission Factor: 1.0	017-055 Replaces 017-017	~~307-076~~ 214-0268-00
T200/N125 Adaptor. 200 Ω to 125 Ω, 1.33 w. Voltage Transmission Factor: 0.625	017-038	309-169



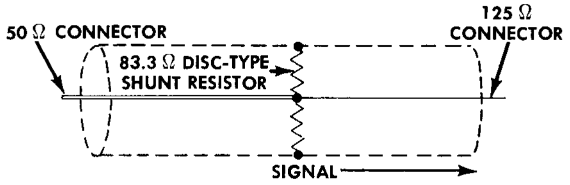
T50/T125 **017-052**
Resistance element **307-075**



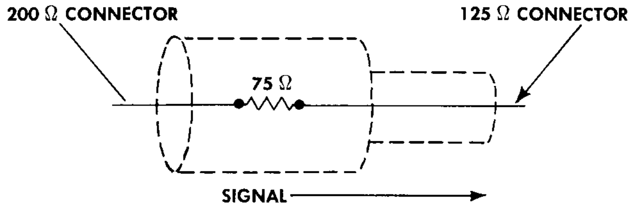
N50/N125 **017-053**
No resistance element



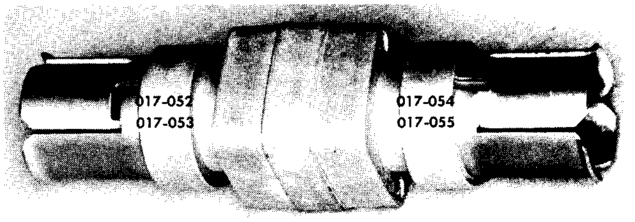
N50/T125 ADAPTOR **017-054**
Resistance element **309-169**



T50/N125 **017-055**
Resistance element **307-076**



T200/N125 ADAPTOR **017-038**
Resistance element **309-169**



125 Ω TERMINATIONS AND ATTENUATORS

The Type 519 crt requires the special 125 Ω terminating resistor listed at the top of Table 7-4. It is fitted with a GR-TEK 125 Ω connector.

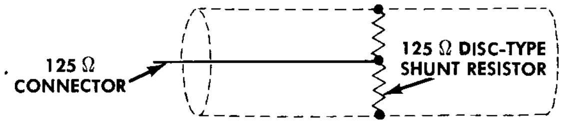
125 Ω system T Attenuators provide attenuation of the signal within your 125 Ω system. Each of the T Attenuators in Table 7-4 exhibits a VSWR of less than 1.1 up to 1500 megacycles when properly terminated.

The power rating of the T Attenuators apply only when properly terminated. Since the power ratings are low, the T Attenuators are best for pulse work with a duty cycle low enough to avoid overheating the resistive elements. Order replacement resistance elements by part number as indicated in Table 7-4.

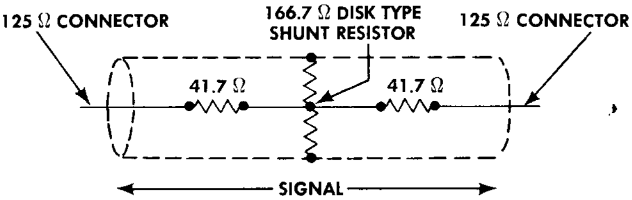
TABLE 7-4
125 Ω TERMINATION AND ATTENUATORS

(Connectors are GR-TEK 125 Ω)

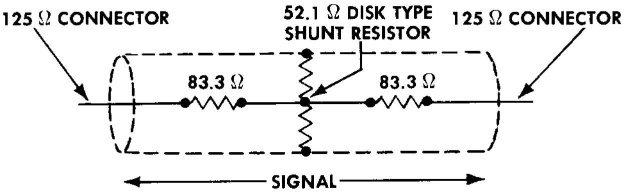
Description	Part Number	Resistance Element Part Number
125 Ω Termination. 1.8 watts. Corresponding to a max dc or rms signal of 15 volts.	017-007	Not replaceable
125 Ω 2:1 T Attenuator. 1.0 watt.	017-048 Replaces 017-004	307-074
125 Ω 5:1 T Attenuator. 0.75 watt.	017-049 Replaces 017-005	307-073
125 Ω 10:1 T Attenuator. 0.5 watt.	017-050 Replaces 017-006	307-072



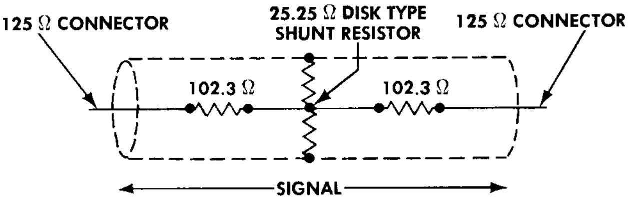
125 Ω Termination



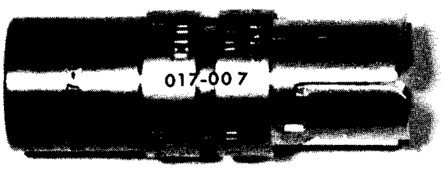
2:1 T ATTENUATOR	**017-048**
Resistance element	**307-074**

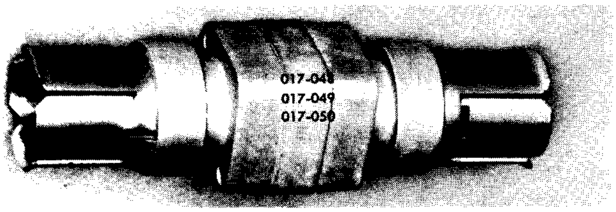


5:1 T ATTENUATOR	**017-049**
Resistance element	**307-073**



10:1 T ATTENUATOR	**017-050**
Resistance element	**307-072**



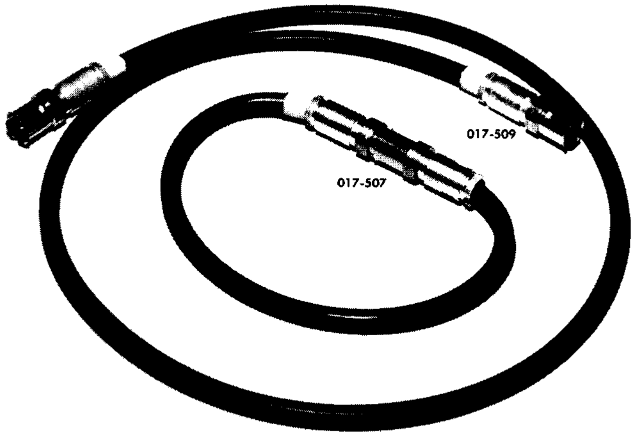


125 Ω CABLES

Each of the cables listed in Table 7-5 is fitted with GR-TEK 125 Ω connectors.

TABLE 7-5
125 Ω CABLES WITH GR-TEK 125 Ω CONNECTORS

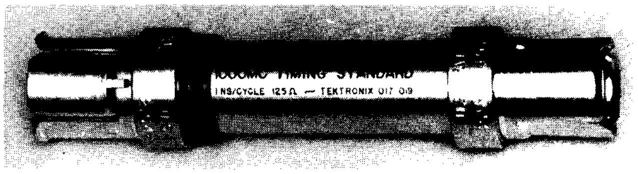
Description	Part Number
125 Ω RG-63B/U, 1 nsec delay, 9¾″	017-507
125 Ω RG-63B/U, 2 nsec delay, 19½″	017-508
125 Ω RG-63B/U, 5 nsec delay, 49″	017-509
125 Ω RG-63B/U, 10 nsec delay, 98″	017-510
125 Ω RG-63B/U, 20 nsec delay, 195″	017-511



TIMING STANDARD

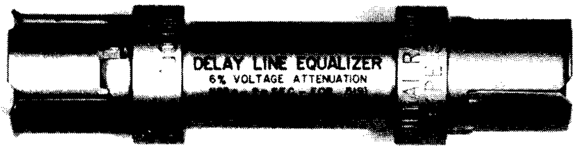
The accuracy of the fastest sweep rate of the Type 519 can be easily checked by using the 125 Ω kilomegacycle timing standard. Refer to the calibration procedure in this manual for directions for its use.

125 Ω 1 Kmc Timing Standard. Accuracy ±0.5%. Part Number 017-019.



DELAY LINE EQUALIZER

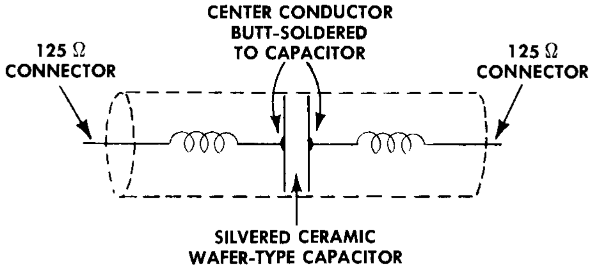
The vertical system response of the Type 519 is slightly greater for low frequencies than for very high frequencies, due to normal bandpass limitations of the coaxial delay line. To make the crt presentation essentially flat for all frequencies of the Type 519 bandpass, a 2-nsecond time constant, 6% voltage attenuation, 125 Ω equalizer is available. To be inserted between the internal delay line and the crt input terminals, the DELAY LINE EQUALIZER corrects for normal coaxial cable frequency response aberrations. 125 Ω Delay Line Equalizer. Part Number 017-057.

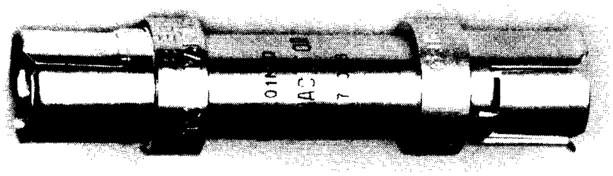


125 Ω COUPLING CAPACITOR

A coupling capacitor may be required when the signal to your Type 519 Oscilloscope has a dc component. If the dc level of the signal would exceed the power limits of the 125 Ω crt termination, adaptors, or attenuators, the coupling capacitor can be used to protect these devices.

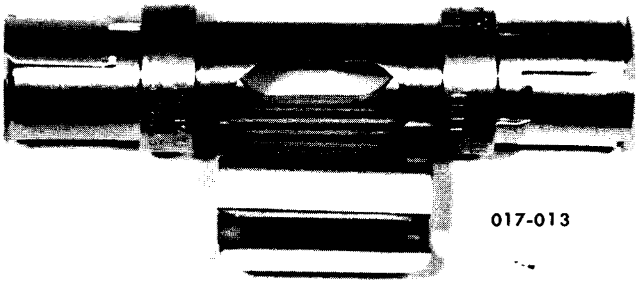
Coupling Capacitor, 125 Ω environment: 0.01 μf ±20%; GMV 0.0082 μf at 200 volts peak. Will withstand 400 volts dc without damage, but voltage coefficient will change value outside the GMV. The capacitor time constant will exceed 205 milliseconds in a 125 Ω system. Part Number 017-018.





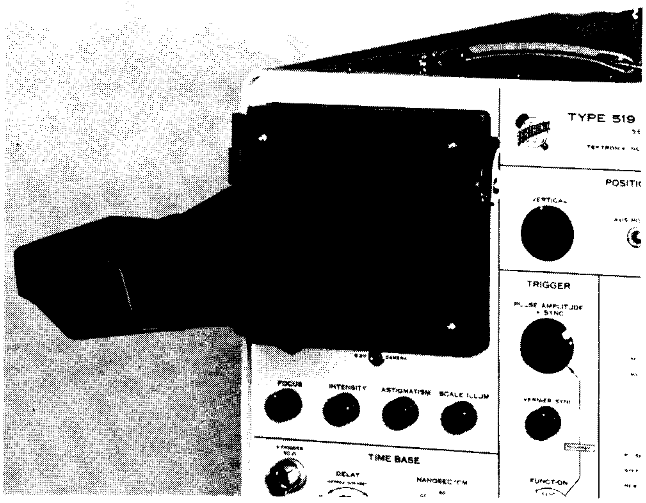
COMPONENT INSERTION UNIT

The wide bandpass and excellent transient response of the Type 519 Oscilloscope permit measurements of pulse characteristics of diodes, transistors, capacitors, and other small components. The GR-TEK Component Insertion Unit allows small components to be placed directly in a 125 Ω system with shortest leads and least disturbance of the 125 Ω line. Or, the unit shield can be opened just enough to allow coupling out a small part of a signal without greatly disturbing the 125 Ω line. 125 Ω Component Insertion Unit. Part Number 017-013.



TYPE 519 CRT VIEWING HOOD

Special light-tight crt viewing hood that is still light-tight even when operator is wearing glasses; makes viewing of dim traces easy when the room cannot be darkened. Part Number 016-025



MISCELLANEOUS ACCESSORIES

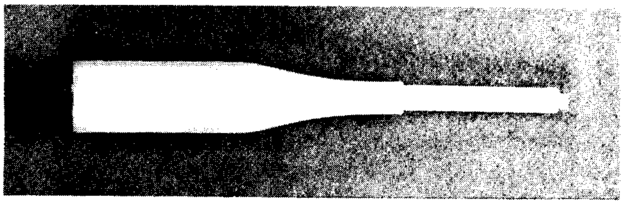
TABLE 7-6

Description	Part Number
Three wire power cord. No. 16 wire.	161-010
Adaptor, 3 wire power cord to 2 wire receptacle.	103-013
Ferrite core, 0.930" ID x 1.570" OD x 0.590".	276-518
Ferrite core, 0.50" ID x 1.0" OD x 0.25".	276-519

RECALIBRATION TOOL

The Type 519 requires an insulated screwdriver for adjustments of small variable capacitors and potentiometers.

The Jaco No. 125 insulated screwdriver, ideal for this purpose, is generally available locally, or it may be purchased from Tektronix. Part Number 003-000.



PARTS LIST

Values are fixed unless marked variable.

Bulbs

Ckt. No.	S/N Range	Description		Tektronix Part Number
B128		Neon, NE-23	Ready	use 150-027
B601		Incandescent #47	Pilot Light	150-001
B606		Incandescent #47	Graticule Light	150-001
B607		Incandescent #47	Graticule Light	150-001
B853		Neon, NE-23		use 150-027
B854		Neon, NE-23		use 150-027
B855		Neon, NE-23		use 150-027
B856		Neon, NE-23		use 150-027
B857	X470-up	Neon, NE-23		150-027
B870		Incandescent #12	ON	150-018

Capacitors

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

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

C29		.1 μf	Discap		200 v		use 283-057
C32†		15 pf	Cer.		500 v	10%	281-509
C33†		.2 μf	Discap		25 v		283-026
C43†		.2 μf	Discap		25 v		283-026
C44†		47 pf	Cer.		500 v		281-518
C46†		.1 μf	Discap		30 v		283-024
C47†		.05 μf	Discap		50 v		283-010
C51		2.2 pf	Cer.		500 v	±.5 pf	281-500
C69		.1 μf	Discap		200 v		use 283-057
C70		.0022 μf	Discap		50 v		283-028
C72		.2 μf	Discap		25 v		283-026
C77		1000 pf	Cer.		500 v	10%	281-536
C83		56 pf	Cer.		500 v	10%	281-521
C84	X138-up	3-12 pf	Cer.	Var.			281-036
C86		150 pf	Cer.		500 v		281-524
C100A,B,C		3 x 20 μf	EMC		350 v		290-115
C113		8 pf	Cer.		500 v	±.5 pf	281-503
C123		39 pf	Cer.		500 v	10%	281-517
C126		330 pf	Cer.		500 v	10%	281-546
C128		.02 μf	Discap		150 v		283-004
C131		.02 μf	Discap		600 v		283-006
C141	X303-up	470 pf	Cer.		500 v		281-525
C142		330 pf	Mica		500 v	10%	283-518
C143		1000 pf	Mica		500 v	10%	281-536
C144		270 pf	Mica		500 v	10%	281-543
C146		100 pf	Mica		350 v		281-523
C151		100 pf	Mica		350 v		281-523
C160		.001 μf	Discap		500 v		283-000
C164		.001 μf	Discap		500 v		283-000
C166		.01 μf	Discap		250 v		283-005
C168		.1 μf	Discap		30 v		283-024
C170	X403-up	.01 μf	Discap		250 v		283-005
C172	X403-up	.1 μf	Discap		30 v		283-024
C183		.0022 μf	Discap		50 v		283-028

† There are two parts of this description in your instrument.

Capacitors *(continued)*

						Tektronix Part Number
C187	.1 μf	Discap		30 v		283-024
C190	.01 μf	Discap		500 v		283-002
C196	.01 μf	Discap		500 v		283-002
C200A,B,C	3 x 20 μf	EMC		350 v		290-115
C211	.02 μf	Discap		600 v		283-006
C214	275 μf	EMT		6 v		290-020
C217	.02 μf	Discap		600 v		283-006
C221	.01 μf	Discap		1000 v		283-013
C222	.01 μf	Discap		1000 v		283-013
C225	.22 μf	PTM		1000 v		285-590
C226	.22 μf	PTM		1000 v		285-590
C228	.0025 μf	Discap		6000 v		283-036
C229	22 pf	Cer.		500 v		281-510
C240A,B,C	3 x 20 μf	EMC		350 v		290-115
C241	.02 μf	Cer.		600 v		283-006
C244	275 μf	EMT		6 v		290-020
C246	.02 μf	Discap		600 v		283-006
C256	10 pf	Cer.		500 v	10%	281-504
C262	3-12 pf	Cer.	Var.			281-007
C280	47 pf	Cer.		500 v		281-518
C312	.1 μf	PTM		600 v		*285-556
C318	.1 μf	Discap		200 v		use 283-057
C320	.1 μf	Discap		200 v		use 283-057
C332†	3 x 20 μf	EMC		350 v		290-089
C333A,B,C	3 x 20 μf	EMC		350 v		290-115
C334A	.02 μf	Discap		600 v		283-006
C334B	.02 μf	Discap		600 v		283-006
C336	.001 μf	Discap		500 v		283-000
C342A	.01 μf	Discap		1000 v		283-013
C342B	.01 μf	Discap		1000 v		283-013
C344	.02 μf	Discap		600 v		283-006
C346	1.5 pf	Cer.		500 v	±.25 pf	281-529
C352A,B	2 x .02 μf	Discap		600 v		283-006
C356	.02 μf	Cer.		1400 v		Use 283-022
C357	.02 μf	Cer.		1400 v		Use 283-022
C370	.01 μf	Discap		500 v		283-002
C380	18 pf	Cer.		500 v	10%	281-542
C382	.02 μf	Discap		600 v		283-006
C385	.02 μf	Discap		600 v		283-006
C399	.02 μf	Discap		150 v		283-004
C422	.02 μf	Discap		600 v		283-006
C425	3-12 pf	Cer.	Var.			281-007
C430	.02 μf	Discap		600 v		283-006
C433	.02 μf	Discap		600 v		283-006
C435	.02 μf	Discap		600 v		283-006
C601	.0015 μf	Cer.		500 v		281-559
C602	.0015 μf	Cer.		500 v		281-559
C613	125 μf	EMC		450 v		290-095
C634	.022 μf	PTM		400 v		285-515
C646	.022 μf	PTM		400 v		285-515

† Note: Cover not included, for cover order Tek. No. 200-257

Capacitors *(continued)*

							Tektronix Part Number
C647		2 x 15 μf	EMC		350 v		290-056
C650		4000 μf	EMT		50 v		290-142
C655A,B †		2 x 1000 μf	EMC		15 v		290-022
C661		125 μf	EMC		450 v		290-045
C662		125 μf	EMC		450 v		290-045
C663		125 μf	EMC		450 v		290-045
C680		.01 μf	PTM		600 v		285-511
C688		.01 μf	PTM		400 v		285-510
C698		.01 μf	PTM		400 v		285-510
C702		2 x 100 μf	EMC		350 v		290-081
C703		2 x 100 μf	EMC		350 v		290-081
C718		.022 μf	PTM		400 v		285-515
C728		.01 μf	PTM		600 v		285-511
C743		2 x 20 μf	EMC		450 v		290-036
C758		.022 μf	PTM		400 v		285-515
C760		50 μf	EMT		50 v		290-117
C767		.1 μf	Discap		30 v		283-024
C771		.1 μf	Discap		200 v		Use 283-057
C801		8 μf	EMT		450 v		290-002
C802		500 pf	Cer.		10,000 v		281-556
C803		.001 μf	Discap		500 v		283-000
C807		.01 μf	PTM		600 v		285-511
C808		.001 μf	PTM		1000 v		285-502
C812		500 pf	Cer.		20,000 v		Use 283-096
C822		500 pf	Cer.		20,000 v		Use 283-096
C832	101-589	Replacement Kit			5000 v		Use *050-223
C832	590-up	.0068 μf	Cer.		5000 v		283-071
C833	101-589	Replacement Kit			5000 v		Use *050-223
C833	590-up	.0068 μf	Cer.		5000 v		283-071
C835		500 pf	Discap		30,000 v		283-037
C841		.01 μf	Discap		1000 v		Use 283-013
C842		.0068 μf	Cer.		5000 v		Use 283-071
C857		.001 μf	Discap		6000 v		283-033
C858		.001 μf	Discap		5000 v		283-021
C862		.001 μf	Discap		6000 v		283-033
C883 ††		.001 μf	Discap		500 v		
C888		.1 μf	PTM		400 v		285-526
C895		180 pf	Mica		500 v	10%	283-509
C896		180 pf	Mica		500 v	10%	283-509
C916		20 μf	EMC		500 v		290-147
C919	X482-up	68 pf	Cer.		500 v	10%	281-549
C920A,B,C		.1 x .01 x .001 μf	Mylar	Timing Series			*291-031
C920D		9-180 pf	Mica	Var.			281-023
C920E		7-45 pf	Cer.	Var.			281-012
C930	101-481	22 pf	Cer.		500 v		281-510
C930	482-up	12 pf	Cer.		500 v	5%	281-508
C938	101-481X	150 pf	Cer.		500 v		281-524

Fuses

F601		7 Amp	3 AG	Slo-Blo 117 V oper. 50 & 60 cycle	159-036
F601		4 Amp	3 AG	Slo-Blo 234 V oper. 50 & 60 cycle	159-028
F606	X323-up	1 Amp	3 AG	Slo-Blo	159-019
F650	X403-up	5 Amp	3 AG	Fast-Blo	159-014
F651	X522-up	15 Amp	3 AG	Fast-Blo	159-038
F801		.25 Amp	3 AG	Fast-Blo	159-027

† Note: Cover not included, for cover order Tek. No. 200-293.
†† If replacement is necessary, order Tektronix part number 132-055.

Diodes

Even though the diodes may be different in physical size they are direct electrical replacements for the diodes in your instrument.

							Tektronix Part Number
D50	101-589	37181 Tunnel 20 MA 4 pf					Use 152-159
D50	590-up	Tunnel 10 MA 2 pf					152-177
D68		Q6100					152-026
D69		Q6100					152-026
D70		DR746					152-007
D71		DR746					152-007
D72		DR746					152-007
D80		Q6100					152-026
D81		Q6100					152-026
D82		Q6100					152-026
D144		Q6100					152-026
D160		T12G					152-008
D161		T12G					152-008
D197	X105-up	1N634					152-025
D198		1N634					152-025
D199		1N634					152-025
D220	101-249	Zener	1.5 w		110 v		152-039
D220	250-up	Zener	1.5 w	Selected			*153-009
D305	101-234	Zener	1.5 w		200 v		152-037
D305	235-249	Zener	1.5 w		140 v		152-038
D305†	250-up	Zener	1.5 w	Selected			*153-010
D306	101-249	Zener	1.5 w		140 v		152-038
D306†	250-up	Zener	1.5 w	Selected			*153-010
D307	101-234	Zener	1.5 w		200 v		152-037
D307	235-249	Zener	1.5 w		140 v		152-038
D307†	250-up	Zener	1.5 w	Selected			*153-010
D308	X235-249	Zener	1.5 w		110 v		152-039
D308†	250-up	Zener	1.5 w	Selected			*153-010
D318		DR746					152-007
D344		Zener	1.5 w		140 v	Selected pair	*153-005
D345		Zener	1.5 w		110 v		
D384		T13G					152-005
D430		Zener	1.5 w		200 v	Selected pair	*153-004
D431		Zener	1.5 w		140 v		
D610		1N2615					152-040
D611		1N2615					152-040
D612		1N2615					152-040
D613		1N2615					152-040
D650	101-476	1N1582C					152-036
D650	477-up	Silicon 1N3209					152-088
D651	101-476	1N1582C					152-036
D651	477-up	Silicon 1N3209					152-088
D655		Silicon 1N2862 (or equal)					152-047
D656		Silicon 1N2862 (or equal)					152-047
D660		1N2615					152-040
D661		1N2615					152-040
D662		1N2615					152-040
D663		1N2615					152-040
D700		Silicon 1N2862 (or equal)					152-047
D701		Silicon 1N2862 (or equal)					152-047
D702		Silicon 1N2862 (or equal)					152-047
D703		Silicon 1N2862 (or equal)					152-047
D740		Silicon 1N2862 (or equal)					152-047
D741		Silicon 1N2862 (or equal)					152-047

† Furnished as a unit. Selected for total voltage drop of 500 to 550 v.

Inductors

			Tektronix Part Number
L30†		.5 µh	*108-170
L37†		1.1 µh	*108-215
L50		Formed from the leads of R50	315-121
L52		.3 µh	*108-182
L53		.3 µh	*108-182
L184		4 Section Grid Line	*108-216
L192		18 µh	*108-129
L193		18 µh	*108-129
L194		2 Section Plate Line	*108-217
L250		5 Section Grid Line	*108-218
L251	X105-161X	.05 µh	*108-235
L312		3 Section Plate Line	*108-219
L336	X162-up	.75 mh, 3 section	108-225
L375		88 µh	*108-022
L885		Reed Drive	*108-222
LR936	101-481	.06 µh	*108-223
	482-up	4 turns on 27 Ω Resistor	*108-266
		125 Ω Delay Line	*119-011

Jacks

J170	X430-up	3 conductor phone jack	131-267

Relays

K601	Thermal, Time Delay 26NO45T	148-006
K602	32 v	148-005
K603	32 v	Use 148-020

Resistors

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

R6	68 Ω	½ w		Use 302-680
R7	100 Ω	½ w		Use 302-101
R8	22 Ω	½ w		302-220
R9	22 Ω	½ w		302-220
R10	240 Ω	½ w	5%	301-241
R11	240 Ω	½ w	5%	301-241
R13	240 Ω	½ w	5%	301-241
R14	240 Ω	½ w	5%	301-241
R15	10 Ω	½ w		302-100
R16	240 Ω	½ w	5%	301-241
R17	240 Ω	½ w	5%	301-241
R18	240 Ω	½ w	5%	301-241
R19	240 Ω	½ w	5%	301-241
R21	82 Ω	1 w		304-820
R22	51 Ω	½ w	5%	301-510
R23	82 Ω	¼ w		316-820
R26	75 Ω	½ w	5%	301-750
R27	68 Ω	½ w	5%	301-680
R28	75 Ω	¼ w	5%	315-750
R30†	180 Ω	¼ w	5%	315-181
R32†	270 Ω	¼ w	5%	315-271
R33†	82 Ω	¼ w	5%	315-820

† There are two parts of this description in your instrument.

Resistors *(continued)*

						Tektronix Part Number
R36†		1.2 k	¼ w		5%	315-122
R37†		1.2 k	¼ w		5%	315-122
R43†		2.4 k	½ w		5%	301-242
R44†		27 Ω	¼ w		5%	315-270
R45†		2.7 k	¼ w		5%	315 272
R46†		2.2 k	½ w		5%	301-222
R47†		47 Ω	¼ w		5%	315-470
R50		120 Ω	¼ w		5%	315-121
R51	101-589	120 Ω	¼ w		5%	315-121
R51	590-up	180 Ω	¼ w		5%	315-181
R53		Selected Value				
R54		11 Ω	¼ w		5%	315-110
R55		11 Ω	¼ w		5%	315-110
R56		750 Ω	5 w	WW	5%	308-067
R57		2.2 k	¼ w			316-222
R58		22 k	¼ w			316-223
R60		2.7 meg	½ w			302-275
R61		6.8 meg	½ w			302-685
R63		220 k	½ w		5%	301-224
R64		1.8 k	½ w		5%	301-182
R66A		500 k		Var.	PULSE AMPLITUDE OR SYNC	311-215
R66B		1 k				
R67		20 k		Var.	VERNIER SYNC	311-018
R68		120 Ω	½ w		5%	301-121
R70		240 Ω	½ w		5%	301-241
R71		3.3 k	½ w		5%	301-332
R72		560 Ω	½ w		5%	301-561
R75		470 Ω	½ w			302-471
R77		1 k	½ w		5%	301-102
R78		680 Ω	½ w		5%	301-681
R81		220 Ω	½ w			302-221
R82		82 Ω	¼ w			316-820
R83		5 k	½ w	Prec.	1%	309-159
R84	X138-up	27 Ω	¼ w		10%	316-270
R85		15 k	1 w	Prec.	1%	310-115
R86		866 Ω	½ w	Prec.	1%	309-273
R87		19.6 k	1 w	Prec.	1%	310-132
R88		30 k		Var.	DELAY	311-021
R100		100 Ω	½ w			302-101
R101		100 Ω	½ w			302-101
R102		100 Ω	½ w			302-101
R113		3 k	½ w		5%	301-302
[illegible]		2.7 k	½ w		5%	301-272
R116		15 k	8 w	WW	5%	308-178
R120		47 Ω	½ w			302-470
R122		100 k	2 w		5%	305-104
R124		91 k	½ w		5%	301-913
R125		300 k	½ w		5%	301-304
R126A		50 k		Var.	400 KC Rep Rate	311-078
R126B		150 k	½ w		5%	301-154
R126C		390 k	½ w		5%	301-394
R126D		1 meg	½ w		5%	301-105
R126E		2.7 meg	½ w		5%	301-275

† There are two parts of this description in your instrument.

Resistors *(continued)*

						Tektronix Part Number
R126F		5.6 meg.	½ w		5%	301-565
R128		33 k	½ w			302-333
R130		6.2 k	2 w		5%	305-622
R131		8.2 k	½ w			302-822
R132		100 Ω	½ w			302-101
R134		6.8 k	2 w		5%	305-682
R136		18 k	½ w	Prec.	1%	309-036
R137		12.5 k	½ w	Prec.	1%	309-228
R142		1 k	½ w		5%	301-102
R143		5.6 k	½ w		5%	301-562
R144		220 Ω	½ w		5%	301-221
R145		470 Ω	½ w			302-471
R146		15 k	½ w			302-153
R147		15 k	½ w			302-153
R149		180 Ω	½ w		5%	301-181
R151		220 Ω	½ w		5%	301-221
R154		4.7 k	½ w		5%	301-472
R155		68 k	1 w			304-683
R156		2.4 k	½ w		5%	301-242
R160		150 k	½ w			302-154
R161		47 k	½ w		5%	301-473
R163		820 Ω	½ w			302-821
R164		330 k	½ w			302-334
R166		10 k	½ k			302-103
R167		15 k	½ w			302-153
R168		470 Ω	½ w			302-471
R169	X403-up	10 k	½ w			302-103
R170	X403-up	15 k	½ w			302-153
R172	X403-up	470 Ω	2 w			306-471
R181		270 Ω	½ w		5%	301-271
R182		3.9 Ω	½ w		5%	307-055
R183		680 Ω	½ w		5%	301-681
R184		330 Ω	2 w			306-331
R185		33 Ω	½ w			302-330
R187		100 Ω	2 w		5%	305-101
R188		47 Ω	½ w		5%	301-470
R190		220 Ω	½ w			302-221
R192		220 Ω	½ w		5%	301-221
R194		220 Ω	½ w		5%	301-221
R199		100 Ω	½ w		5%	301-101
R210		100 Ω	½ w			302-101
R211		10 Ω	½ w			302-100
R214		10 Ω	½ w			302-100
R216		1 k	½ w			302-102
R217		27 Ω	½ w			302-270
R218		22 Ω	½ w			302-220
R220		47 k	½ w			302-473
R221		15 Ω	¼ w			316-150
R222		15 Ω	¼ w			316-150
R223		10 Ω	½ w			302-100
R224		10 Ω	½ w			302-100
R225		470 Ω	½ w			302-471
R226		100 Ω	½ w			302-101

Resistors *(continued)*

						Tektronix Part Number
R227		1 k	½ w			302-102
R228		100 Ω	½ w			302-101
R229		47 Ω	¼ w			316-470
R230		56 k	2 w		5%	305-563
R231		910 Ω	½ w		5%	301-911
R234		120 k	1 w			304-124
R236		150 k	1 w			304-154
R237		1 meg	½ w	Prec.	1%	309-014
R238	101-229	1.5 meg	½ w	Prec.	1%	Use 309-015
	230-up	1.11 meg	½ w	Prec.	1%	309-015
R242	X105-up	33 k	2 w			306-333
R241		10 Ω	½ w			302-100
R243	101-104	15 k	2 w		5%	305-153
R243	105-up	27 k	2 w			306-273
R246		10 Ω	½ w			302-100
R247		100 Ω	½ w			302-101
R250		100 Ω	½ w		5%	301-101
R256		2.2 k	½ w		5%	301-222
R257		120 k	1 w			304-124
R260		22 Ω	½ w			302-220
R262		56 k	½ w		5%	301-563
R263		43 k	½ w		5%	301-433
R265		100 Ω	½ w			302-101
R270A		200 k	½ w		5%	301-204
R270C		390 k	½ w		5%	301-394
R270E		620 k	½ w		5%	301-624
R270G		1.6 meg	½ w		5%	301-165
R270J		2.4 meg	½ w		5%	301-245
R271		100 k	2 w			306-104
R272		47 Ω	¼ w			316-470
R274		2.5 k	5 w	WW	5%	308-127
R275		2 k	5 w	WW	5%	308-091
R280		20 k	½ w		5%	301-203
R281		120 k	½ w	Prec.	1%	309-091
R282		47 Ω	½ w			302-470
R284	101-239	220 k	½ w		5%	Use 306-473
R284	240-up	47 k	2 w			306-473
R285		47 Ω	¼ w			316-470
R286		47 Ω	¼ w			316-470
R287		2.2 k	1 w			304-222
R320		680 Ω	½ w		5%	301-681
R321		1.6 k	1 w		5%	303-162
R331		10 Ω	½ w			302-100
R332		30 k	8 w	WW	5%	308-105
R333		5.6 k	1 w			304-562
R334		4.7 Ω	½ w			307-023
R336A	101-161	10 Ω	1 w			304-100
R336A	162-277	1.8 k	25 w	WW		*308-193
R336A	278-up	1.6 k	25 w	WW		*308-214
R336C	101-161	6 k	3 w	Mica Pl.	1%	*310-579
R336C	162-277	5 k	20 w	WW		*308-194
R336C	278-up	4.5 k	20 w	WW		*308-215
R336D	101-161X	6 k	3 w	Mica Pl.	1%	*310-579
R336E	101-161	16 k	3 w	Mica Pl.	1%	*310-580
R336E	162-277	20 k	3 w	Mica Pl.	1%	*310-585
R336E	278-up	18 k	4 w	Mica Pl.	1%	*310-590

Resistors *(continued)*

							Tektronix Part Number
R336F	101-161	16 k	3 w		Mica Pl.	1%	*310-580
R336F	162-277	20 k	3 w		Mica Pl.	1%	*310-585
R336F	278-up	18 k	4 w		Mica Pl.	1%	*310-590
R336G	101-161	17 k	3 w		Mica Pl.	1%	*310-578
R336G	162-277	20 k	3 w		Mica Pl.	1%	*310-585
R336G	278-up	18 k	4 w		Mica Pl.	1%	*310-590
R336J	101-277	46 k	3 w		Mica Pl.	1%	*310-581
R336J	278-up	43 k	4 w		Mica Pl.	1%	*310-589
R336L	101-277	182 k	1 w		Prec.	1%	310-122
R336L	278-up	172 k	1 w		Prec.	1%	310-142
R336M	101-277	182 k	1 w		Prec.	1%	310-122
R336M	278-up	172 k	1 w		Prec.	1%	310-142
R336N	101-278-up	182 k	1 w		Prec.	1%	310-122
R336N	278-up	172 k	1 w		Prec.	1%	310-142
R336Q	101-277	453 k	1 w		Prec.	1%	310-123
R336Q	278-up	432 k	1 w		Prec.	1%	310-143
R336S	101-277	900 k	1 w		Prec.	1%	310-097
R336S	278-up	866 k	1 w		Prec.	1%	310-144
R337	101-161X	2 k	25 w		WW	5%	308-065
R338	101-161X	15 k	5 w		WW		308-108
R340		100 Ω	½ w			5%	301-101
R341		100 Ω	½ w			5%	301-101
R342		100 Ω	½ w				302-101
R344		40 k	½ w		Prec.	1%	309-155
R347		40 k	½ w		Prec.	1%	309-155
R350		560 Ω	¼ w				316-561
R351		560 Ω	¼ w				316-561
R352	101-277	15 k	1 w				304-153
R352	278-up	10 k	1 w				304-103
R356	101-277	56 k	1 w				304-563
R356	278-up	51 k	1 w			5%	303-513
R357	101-277	56 k	1 w				304-563
R357	278-up	51 k	1 w			5%	303-513
R360		100 Ω	¼ w				316-101
R361		100 Ω	¼ w				316-101
R364		4 k	5 w		WW	5%	308-051
R370	101-104	390 k	½ w		Prec.	1%	309-056
R370	105-up	390 k	½ w			5%	301-394
R371	101-104	220 k	½ w		Prec.	1%	309-052
R371	105-239	220 k	½ w			5%	Use 301-204
R371	240-up	200 k	½ w			5%	301-204
R372		100 Ω	¼ w				316-101
R373		560 Ω	½ w			5%	301-561
R374	X105-up	50 k	.1 w	Var.			311-078
R375		270 Ω	½ w				302-271
R380		91 Ω	½ w				301-910
R381		20 k	½ w			5%	301-203
R383		470 k	½ w			5%	301-474
R384		6.8 k	¼ w			5%	315-682
R385		100 Ω	½ w				302-101
R390		1 k	½ w				302-102
R393		56 k	2 w				306-563
R395		1 meg	1 w				304-105
R396		500 Ω		Var.		4CX250F Grid-3.2 Volts	311-005
R397		560 Ω	½ w			5%	301-561

Resistors *(continued)*

								Tektronix Part Number
R398		5.6 k	½ w				5%	301-562
R399		100 Ω	½ w					302-101
R400		1 meg	½ w					302-105
R401		6.8 meg	½ w					302-685
R406		33 k	2 w					306-333
R420		100 Ω	¼ w					316-101
R421		100 Ω	¼ w					316-101
R422		15 k	2 w				5%	305-153
R425		22 k	1 w					304-223
R426	101-104	39 k	1 w				5%	Use 305-393
R426	105-up	39 k	2 w				5%	305-393
R432		330 k	½ w					302-334
R433		1 meg	½ w				5%	301-105
R435		1 meg	½ w				5%	301-105
R440	101-136	22 meg	½ w					302-226
	137-up	15 meg	½ w					302-156
R441		2 x 500 k		Var.		HORIZONTAL POSITIONING		311-152
R442	101-136	22 meg	½ w					302-226
	137-up	15 meg	½ w					302-156
R445		100 Ω	½ w					302-101
R446		100 Ω	½ w					302-101
R602		18 Ω	2 w					306-180
R603		50 Ω		Var.	WW	DIM ADJ.		311-055
R606		50 Ω		Var.	WW	SCALE ILLUM.		311-055
R610		10 Ω	1 w					304-100
R613		30 k	10 w		WW		5%	308-027
R620		100 k	2 w					306-104
R621		200 k	½ w				5%	301-204
R623		1 meg	½ w					302-105
R624		1 k	½ w					302-102
R625		10 k	1 w					304-103
R626		22 k	2 w					306-223
R627		2 k	10 w		WW			308-017
R628	X611-up	100 Ω	2 w					306-101
R633		33 k	2 w					306-333
R634		220 k	½ w					302-224
R641		220 k	½ w					302-224
R642		82 k	1 w					304-823
R644		1 k	½ w					302-102
R645		220 k	½ w					302-224
R646		100 k	½ w		Prec.		1%	309-045
R647		10 k		Var.	WW	—250 Volts		311-015
R648		50 k	½ w		Prec.		1%	309-090
R650		.5 Ω	20 w		WW		5%	308-171
R651	X403-up	.5 Ω	5 w		WW		5%	308-165
R655		5 Ω	5 w		WW		5%	308-179
R660		10 Ω	2 w					306-100
R661		10 Ω	2 w					306-100
R662		30 k	10 w		WW		5%	308-027
R670		220 k	½ w					302-224
R671		27 k	½ w					302-273
R672		180 k	2 w					306-184
R673		1 meg	½ w					302-105
R674		1 k	½ w					302-102
R677		2 k	10 w		WW		5%	308-017
R680		1 meg	½ w					302-105
R681		3.9 meg	½ w					302-395

Resistors *(continued)*

								Tektronix Part Number
R682		100 k	½ w					302-104
R683		82 k	½ w					302-823
R684		270 k	½ w					302-274
R685		1 k	½ w					302-102
R688		300 k	½ w		Prec.	1%		309-261
R689		330 k	½ w		Prec.	1%		309-101
R693		470 k	½ w					302-474
R694		1 k	½ w					302-102
R695		1 k	½ w					302-102
R697		4.5 k	20 w		WW	5%		308-033
R698		111 k	½ w		Prec.	1%		309-046
R699		267 k	½ w		Prec.	1%		309-276
R700		10 Ω	2 w					306-100
R701		10 Ω	2 w					306-100
R702		30 k	10 w		WW	5%		308-027
R704		60 Ω	5 w		WW	5%		308-162
R710		180 k	½ w					302-184
R711		27 k	½ w					302-273
R712		330 k	2 w					306-334
R713		1 meg	½ w					302-105
R714		1 k	½ w					302-102
R715		1 k	½ w					302-102
R717		12 k	8 w		WW	5%		308-093
R718		429 k	½ w		Prec.	1%		309-170
R719		900 k	1 w		Prec.	1%		310-097
R720		330 k	2 w					306-334
R721		68 k	½ w					302-683
R722		360 k	½ w			5%		301-364
R723		470 k	½ w					302-474
R724		47 Ω	½ w					302-470
R725		1 k	½ w					302-102
R726	X575-up	150 Ω	1 w					304-151
R727	X575-up	150 Ω	1 w					304-151
R728		500 k	1 w		Prec.	1%		310-064
R729		332 k	1 w		Prec.	1%		310-119
R730		680 k	½ w					302-684
R731	X575-up	150 Ω	1 w					304-151
R732A-J		1 meg		Var.		2 nsec-1 μsec.	(9)	311-039
R734		47 Ω	½ w					302-470
R735		47 Ω	½ w					302-470
R740		220 k	½ w					302-224
R741		220 k	½ w					302-224
R742		10 Ω	½ w					302-100
R743		120 k	2 w					306-124
R751		39 k	½ w					302-393
R752		150 k	1 w					304-154
R753		1 meg	½ w					302-105
R754		1 k	½ w					302-102
R755		1 k	½ w					302-102
R758		287 k	½ w		Prec.	1%	Use	309-328
R759		1 meg	1 w		Prec.	1%	Use	310-100
R760		11.76 k	½ w		Prec.	¼%		309-200
R761	101-186	100 k	½ w		WW	1%	Use	309-334
R761	187-up	100 k	½ w		Prec.	1%		309-334
R763		6.8 k	½ w					302-682
R764		3.3 k	½ w					302-332

Resistors *(continued)*

							Tektronix Part Number
R765		100 Ω	½ w			5%	301-101
R766		150 k	½ w				302-154
R767		1 Ω	4 w		Prec.	½%	*310-535
R768		100 Ω	3 w		WW		308-075
R769		100 Ω	3 w		WW		308-075
R770	X403-up	.25 Ω	5 w		WW		308-242
R771		100 k	1 w				304-104
R773		1 k	2 w				306-102
R777		7.5 k	25 w		WW		308-184
R778		60 Ω	5 w		WW	5%	308-162
R780		150 k	½ w				302-154
R781		100 k	½ w				302-104
R783		100 k	½ w				302-104
R785		100 k	½ w				302-104
R801		390 Ω	1 w				304-391
R803	101-383	120 k	2 w				306-124
R803	384-up	100 k	2 w				306-104
R804	101-383	120 k	2 w				306-124
R804	384-up	100 k	2 w				306-104
R806		100 k	½ w				302-104
R807		1.5 k	½ w				302-152
R815		1 meg	½ w				302-105
R834		470 k	½ w				302-474
R835		470 k	½ w				302-474
R840		1.8 meg	1 w				304-185
R841		1 meg		Var.		HIGH VOLTAGE	311-039
R842	101-521	4.7 meg	2 w				306-475
R842	522-up	2.7 meg	2 w				306-275
R843	101-521	4.7 meg	2 w				306-475
R843	522-up	2.7 meg	2 w				306-275
R844	101-521	4.7 meg	2 w				306-475
R844	522-up	2.2 meg	2 w				306-275
R845	X522-up	2.2 meg	2 w				306-225
R846	X522-up	2.2 meg	2 w				306-225
R847	X522-up	2.2 meg	2 w				306-225
R849	X158-up	15 meg	2 w				306-156
R850	101-157	2.7 meg	2 w				306-275
R850	158-up	2.2 meg	2 w				306-225
R851	101-157	2.7 meg	2 w				306-275
R851	158-up	2.2 meg	2 w				306-225
R852	101-157	2.2 meg	2 w				306-225
R852	158-up	1.5 meg	2 w				306-155
R853		5 meg		Var.		FOCUS	311-121
R854	101-157	1.5 meg	2 w				306-155
R854	158-up	1 meg	2 w				306-105
R855	101-383	270 k	½ w				302-274
R855	384-up	1 meg	½ w	Var.		MAX. INTENS.	311-126
R856		1 meg		Var.		INTENSITY	311-041
R857		270 k	¼ w				316-274
R858		1 meg	¼ w				316-105
R859		22 k	¼ w				316-223
R860		2 k		Var.	WW	AXIS ROTATION	311-141
R861		250 k		Var.		GEOMETRY	311-032
R862		1 k	½ w				302-102
R863		1 k	½ w				302-102
R864		250 k		Var.		ASTIGMATISM	311-032
R865		250 k		Var.		VERTICAL POSITIONING	311-032
R866		1 k	½ w				302-102
R867		120 k	1 w				304-124

							Tektronix Part No.
R868	101-224	15 k	½ w			5%	Use 301-183
R868	225-up	18 k	½ w			5%	301-183
R869		10 k	½ w				302-103
R870		2.87 meg	½ w		Prec.	1%	309-329
R871		319 k	½ w		Prec.	1%	309-330
R872		287 k	½ w		Prec.	1%	309-328
R875		250 k		Var.		VARIABLE	311-032
R876		20.2 k	½ w			1%	309-331
R878		Selected w/R879 to 28 k furnished as a unit.				VOLTS	*312-016
R879		30 k		Var.			
R882		47 k	¼ w				316-473
R883		125 Ω	¼ w			1%	319-034
R885†		10 k		Var.	WW	DRIVE	311-237
R886		4.5 k	5 w		WW		308-092
R888		4.7 k	½ w				302-472
R890		1.5 k	½ w				302-152
R891		270 k	½ w				302-274
R892A,B		2 x 2 meg		Var.		FREQUENCY	311-216
R893		470 k	½ w				302-474
R895		470 k	½ w				302-474
R898		56 k	½ w				302-563
R910		47 Ω	½ w				302-470
R911		2.2 meg	½ w			5%	301-225
R913		25 k	8 w		Mica Pl.	1%	*310-503
R915		47 Ω	½ w				302-470
R916		1 k	½ w				302-102
R918	101-481	560 k	½ w				302-564
R918	482-up	120 k	2 w				306-124
R919	101-481	270 k	2 w				306-274
R919	482-up	47 k	½ w				301-473
R921	101-481	47 k	2 w				306-473
R921	482-up	330 k	1 w				304-334
R923	101-481	50 k		Var.	WW	CYCLES/SEC	311-218
R923	482-up	1 meg		Var.			311-039
R924	101-481	20 k		Var.	WW	Frequency Range	311-159
R924	482-565	50 k		Var.			311-329
	566-up	10 k		Var.			311-326
R925	101-481	1 meg	½ w		Prec.	1%	309-014
R925	482-565	1.5 meg	½ w		Prec.	1%	309-017
R925	566-up	1.23 meg	½ w		Prec.	1%	309-016
R926		47 Ω	½ w				302-470
R928		22 k	½ w				302-223
R929		47 k	2 w			5%	305-473
R930	X482-up	3.3 k	¼				316-332
R931	101-481	20 k		Var.		Avalanche Set	311-159
R931	482-up	50 k		Var.			311-329
R932	101-482	10 k	½ w				302-103
R932	482-up	4.7 k	½ w				302-472
R933		5.6 k	½ w				302-562
R934	X482-up	27 k	2 w			5%	305-273
R937	101-482	120 k	¼ w			5%	315-121
R937	482-up	27 Ω	¼ w	Nominal Value		5%	315-270
R938	101-482X	120 k	¼ w			5%	315-121
R939		10 k	¼ w			5%	315-103

† Furnished as a unit with SW885.

Switches

				Tektronix Part Number Wired	Tektronix Part Number Unwired
SW10		Rotary	TRIGGER SOURCE	*262-378	*260-359
SW20		Rotary	GAIN	*262-377	*260-358
SW50		Rotary	FUNCTION	*262-376	*260-357
SW160		Slide	SWEEP DIODE	Use	*260-447
SW168		Push Button	RESET		*260-247
SW336	101-161	Rotary	NANOSEC/CM	*050-058	*260-356
	162-302	Rotary	NANOSEC/CM	*050-058	*260-385
	303-up	Rotary	NANOSEC/CM	Use *262-500	*260-385
SW601	101-402	Toggle	POWER ON	Use	*050-194
SW601	403-up	Toggle			260-506
SW606		Tini-Jax	6.3 V CAMERA		136-094
SW870	101-549	Rotary	RANGE	Use *262-611	*260-361
SW870	550-up	Rotary	RANGE	*262-611	*260-578
SW871		Slide	POLARITY	Use	260-449
SW885†		SPDT			311-237
SW886		Reed	SINGLE CLOSURE		*260-362
SW920		Rotary	MULTIPLIER	*262-379	*260-360
TK602			THERMAL CUTOUT 150°	Use	260-336

Transformers

T4		Trigger Takeoff Assy., Short body (Ferrite Core 276-517)	*660-403
T20		Toroid Core	276-519
T70		Toroid TD28	*120-195
T160		Toroid TD18	*120-178
T180		Toroid TD27	*120-194
T198		Toroid TD26	*120-193
T601		L.V. Power	*120-186
T602		AC Line Filter Toroid, TD30	*120-200
T801		High Voltage	*120-188
T885		Trigger Takeoff Assy., long body (Ferrite Core 276-517)	*660-402
T930	X482-up	Toroid 5T TD109	*120-325

Transistors

Q34††		2N700	151-027
Q44††		2N700	151-027
Q70		2N695/SM04	151-032
Q160		OC170	151-015
Q180		2N695/SM04	151-032
Q238		2N301	151-001
Q318		2N705	151-044
Q328		2N301	151-001
Q766A		2N270	151-007
Q766B		2N270	151-007
Q767		2N277	151-002
Q773		2N301	151-001
Q777	101-402	2N277	151-002
Q777	403-up	MP504	151-102
Q934	101-481	Replacement Kit	Use *050-140
	482-up	Tek Spec, Checked	*153-523

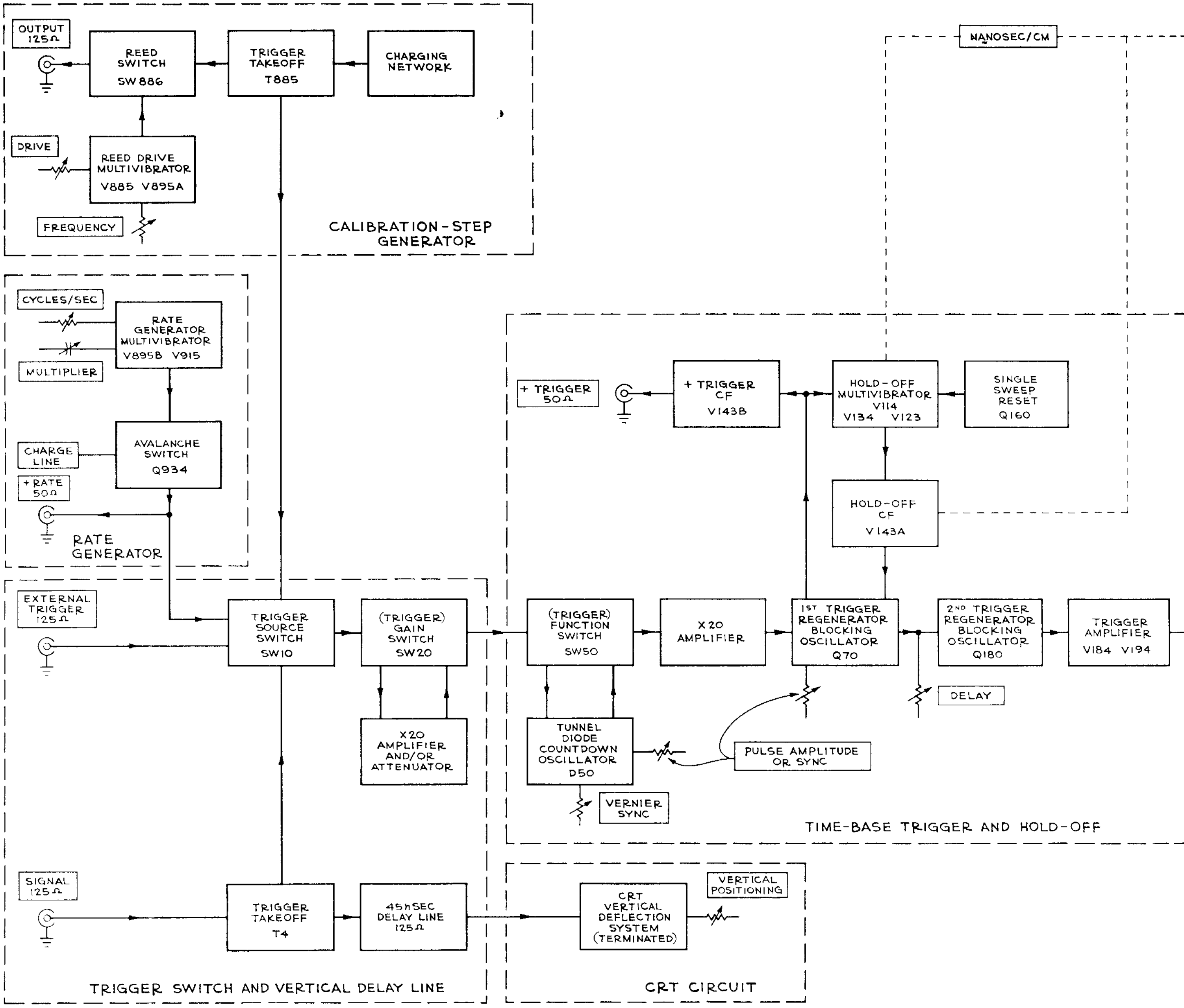
† Furnished as a unit with R885.

†† There are two parts of this description in your instrument.

Electron Tubes

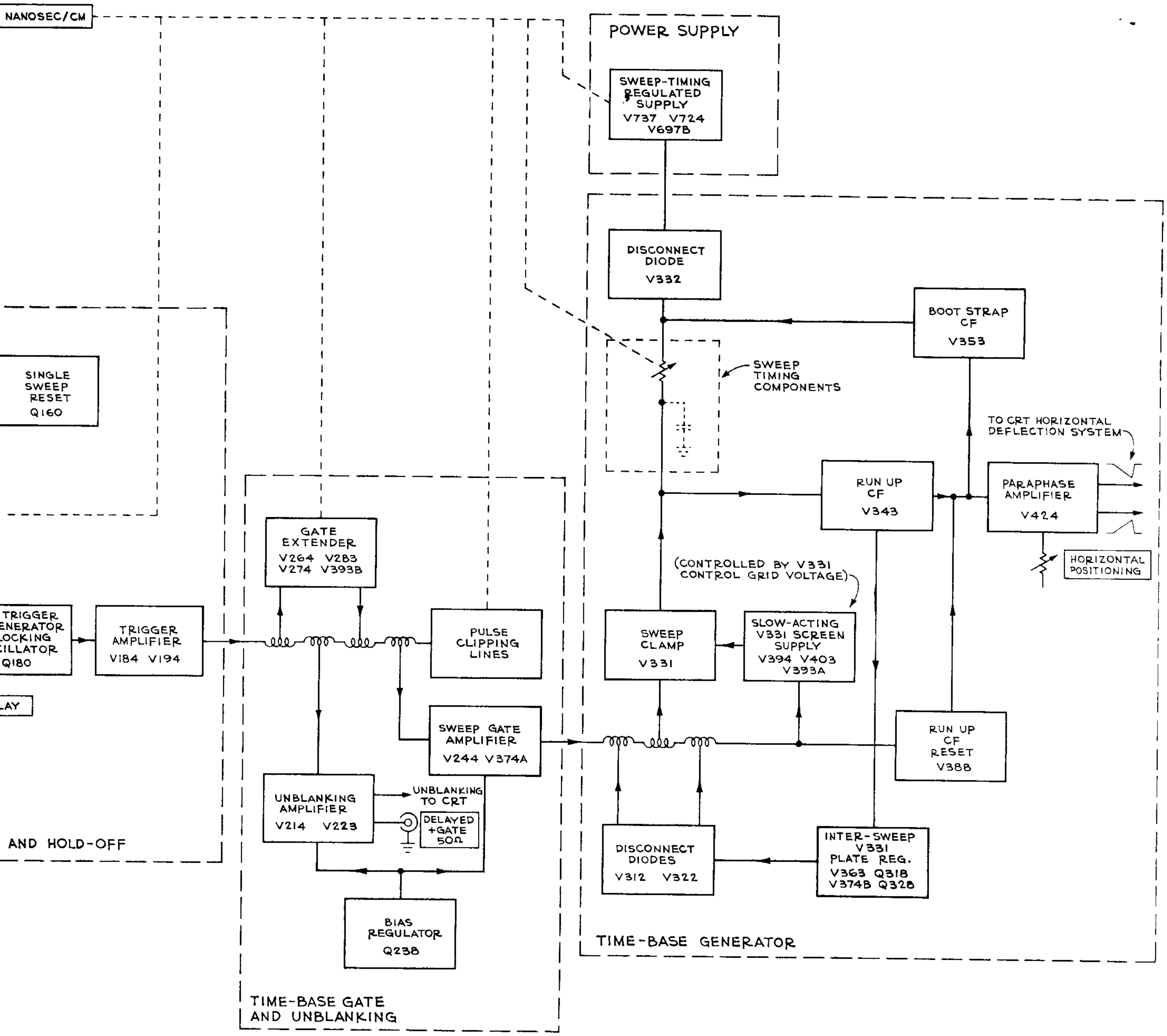
		Tektronix Part Number
V114	6688	154-215
V123	6DJ8	154-187
V134	6688	154-215
V143	6DJ8	154-187
V184	6922 Selected	*157-060
V194	6922 Selected	*157-060
V214	7548	154-310
V223	6DJ8	154-187
V244	7548	154-310
V264	6AU6	154-022
V274	6CW5/EL86	154-202
V283	6DJ8	154-187
V312	12AL5	154-038
V322	12AL5	154-038
V331	4CX25OF	154-300
V332	6AF3	154-301
V343	6DJ8	154-187
V353	6DJ8	154-187
V363	6DJ8	154-187
V374	6DJ8	154-187
V388	12BY7	154-047
V393	6DJ8	154-187
V394	12AU6	154-040
V403	12BY7	154-047
V424	6DJ8	154-187
V624	6AU6	154-022
V627	6080	154-056
V639	0G3/85A2	154-291
V646	12AX7	154-043
V674	12AU6	154-040
V686	12AX7	154-043
V694	12AU6	154-040
V697	6080	154-056
V717	6GE8/7734	154-260
V724	12AU6	154-040
V737	6080	154-056
V757	6GE8/7734	154-260
V800	6AU5	154-021
V802	1X2	154-005B
V812	1X2	154-005B
V814	12AU7	154-041
V822	1X2	154-005B
V832	5642	154-051
V859†	T5191-11 CRT with shield	*154-308
V885	6AQ5	154-017
V895	6DJ8	154-187
V915	6DJ8	154-187

† When ordering a replacement CRT be sure to check the serial number of the CRT in your instrument which is located on the bezel cover over the front of the CRT. If the CRT serial number is 1016 or below, order replacement by part number 154-356. If it is 1017 or above, order part number 154-308.



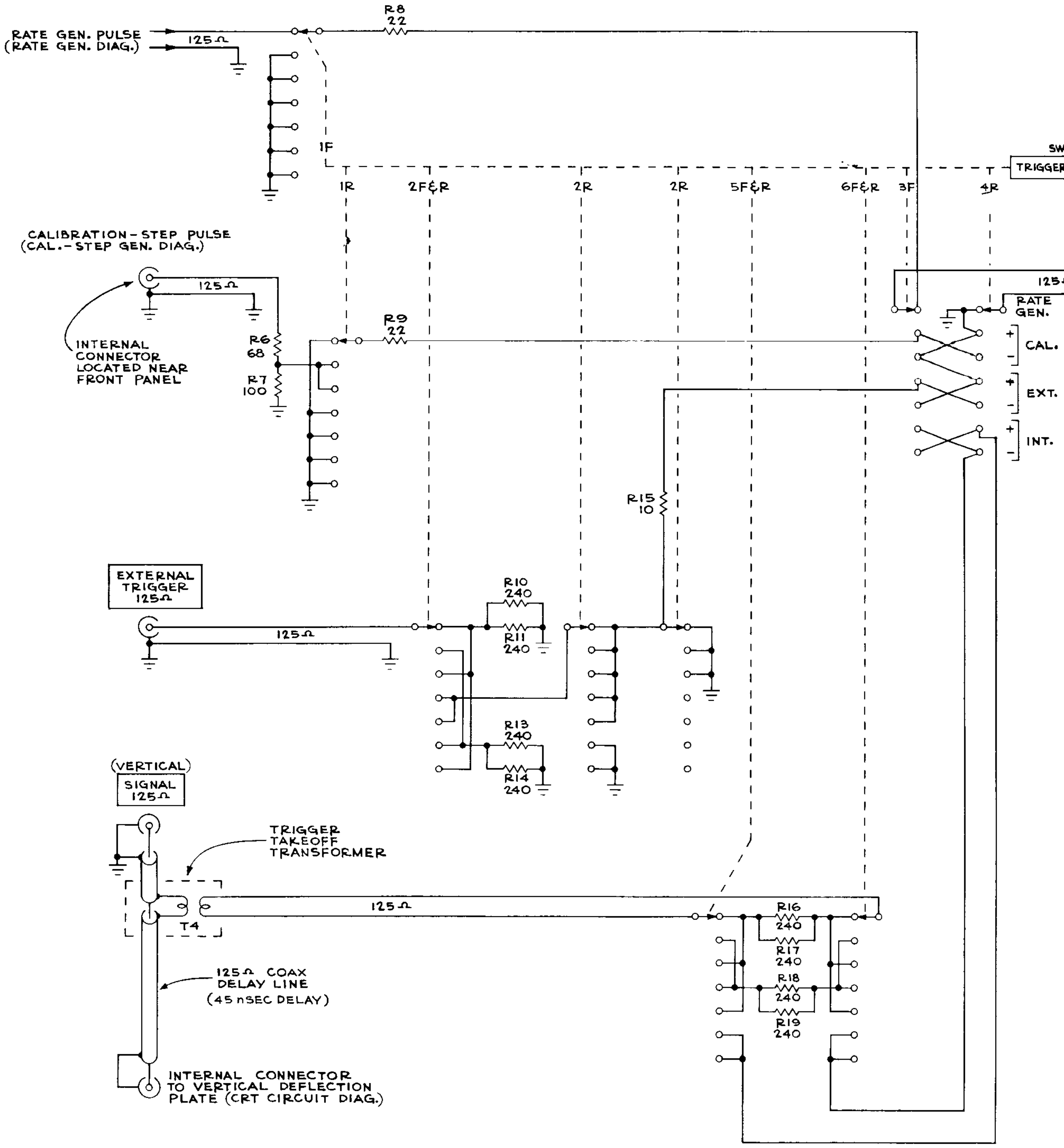
TYPE 519 OSCILLOSCOPE

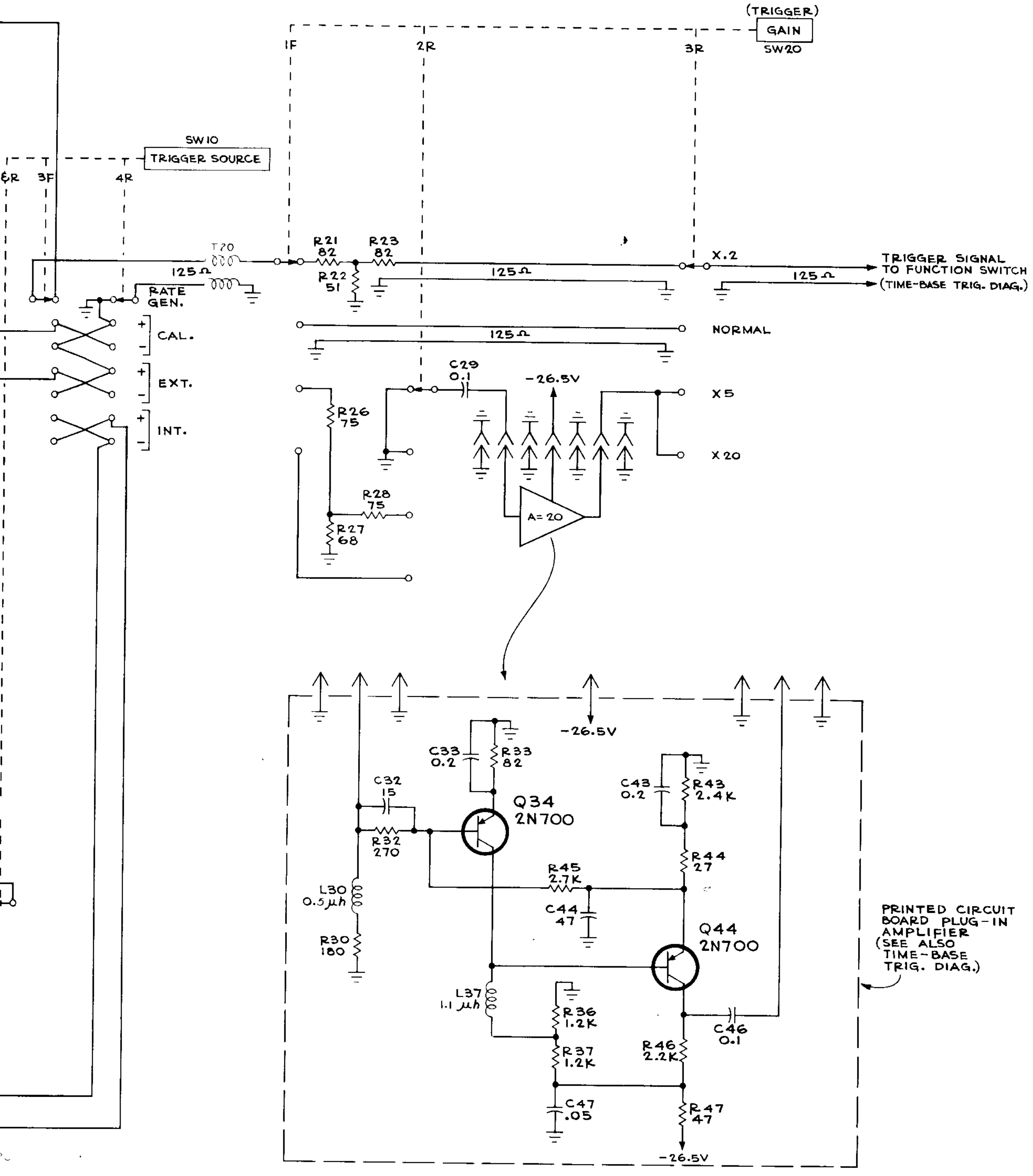
A



BLOCK DIAGRAM

GAB
2-3-61


RATE GEN. PULSE
(RATE GEN. DIAG.)
125Ω
R8
22
1F
1R
2F&R
2R
2R
5F&R
6F&R
3F
4R
SW
TRIGGER
CALIBRATION-STEP PULSE
(CAL.-STEP GEN. DIAG.)
125Ω
INTERNAL
CONNECTOR
LOCATED NEAR
FRONT PANEL
R6
68
R7
100
R9
22
125
RATE
GEN.
+
CAL.
-
+
EXT.
-
+
INT.
-
R15
10
EXTERNAL
TRIGGER
125Ω
125Ω
R10
240
R11
240
R13
240
R14
240
(VERTICAL)
SIGNAL
125Ω
TRIGGER
TAKEOFF
TRANSFORMER
T4
125Ω
R16
240
R17
240
R18
240
R19
240
125Ω COAX
DELAY LINE
(45 nSEC DELAY)
INTERNAL CONNECTOR
TO VERTICAL DEFLECTION
PLATE (CRT CIRCUIT DIAG.)

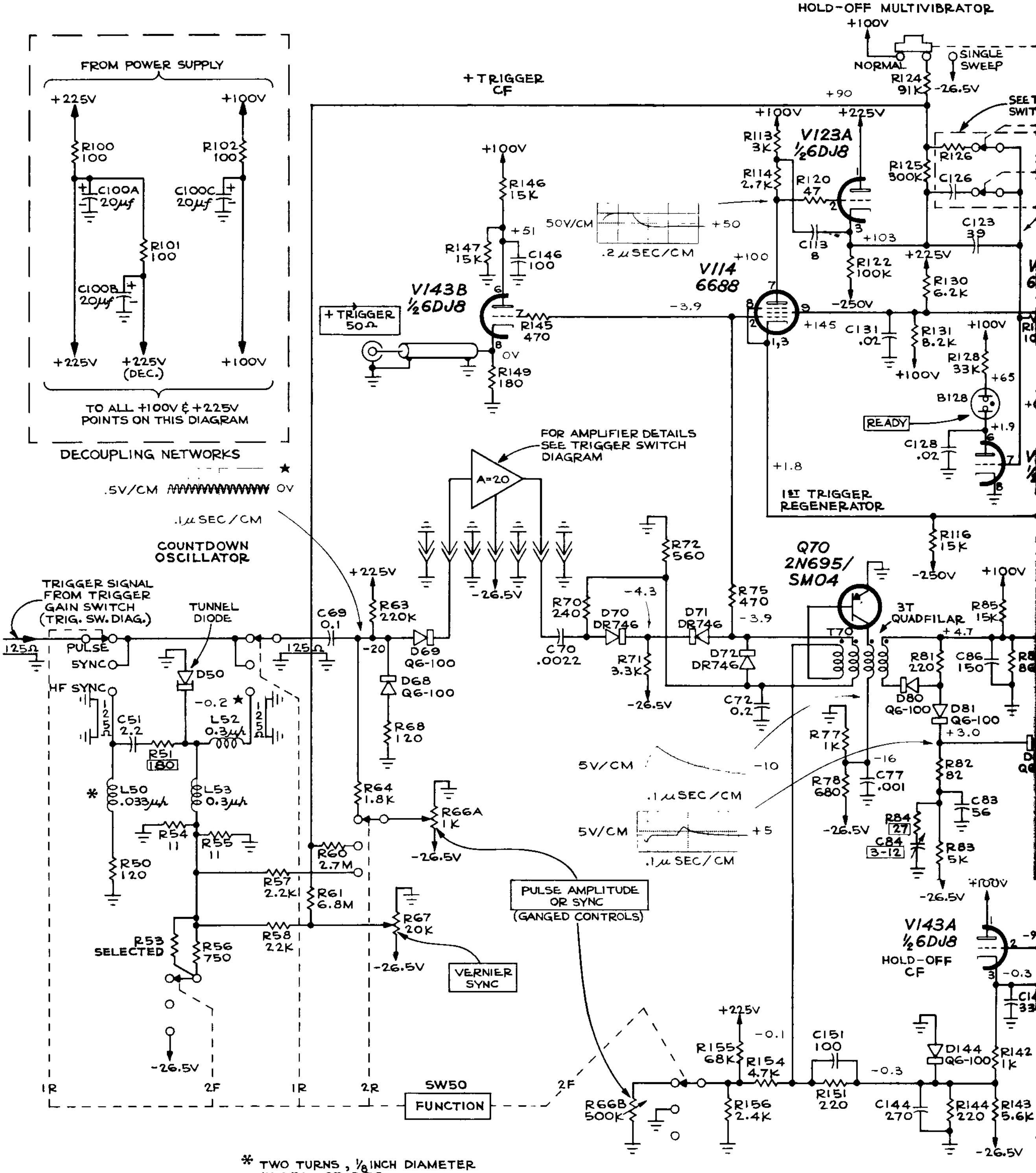


GAB
1263

TRIGGER SWITCH & VERTICAL DELAY LINE

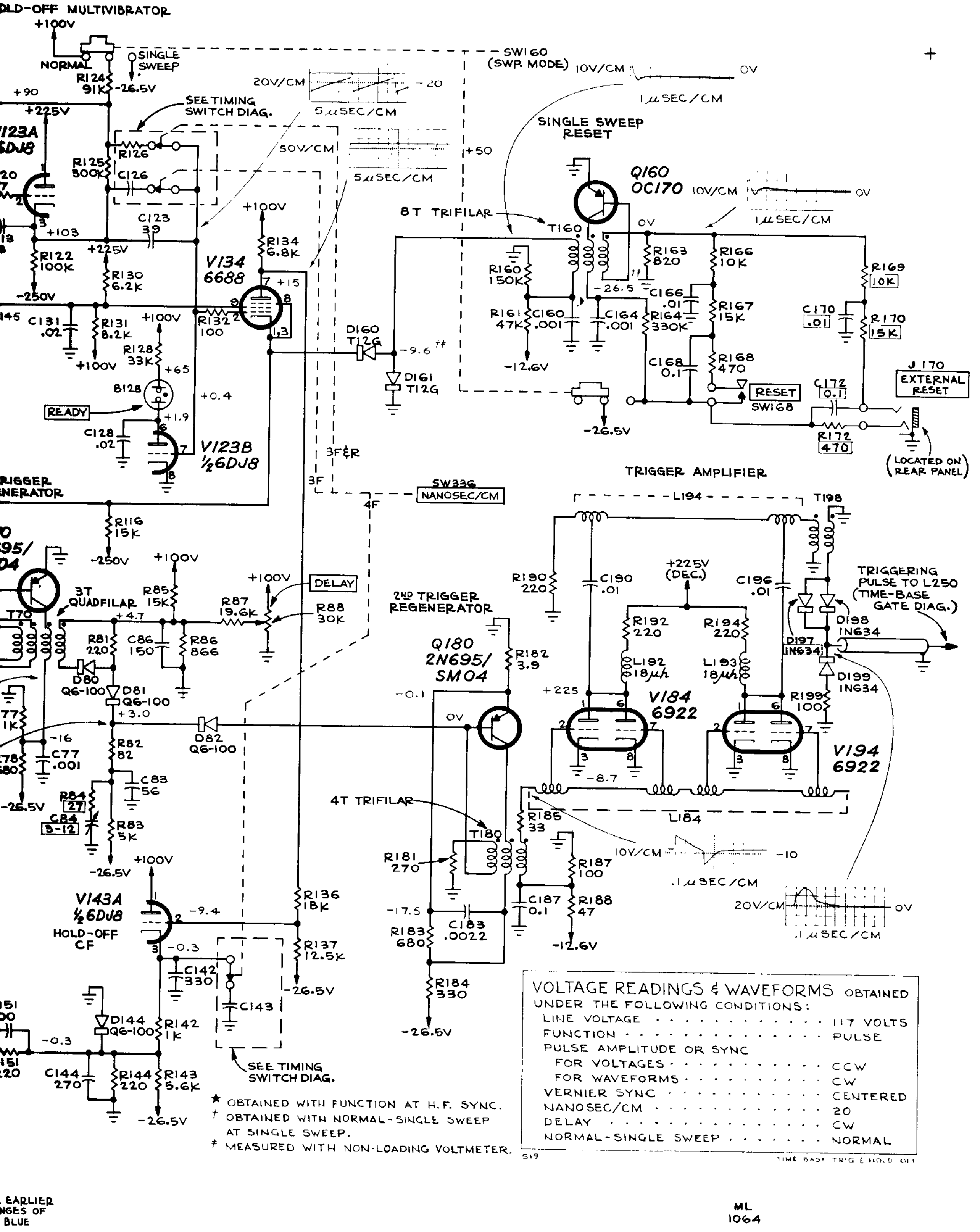
CIRCUIT NUMBERS
4 THRU 40

TRIG. SWITCH & DELAY LINE
4 THRU 47



* TWO TURNS, ⅛ INCH DIAMETER IN LEAD OF R50.
SPACING BETWEEN TURNS NOT CRITICAL.

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



VOLTAGE READINGS & WAVEFORMS OBTAINED UNDER THE FOLLOWING CONDITIONS:

LINE VOLTAGE	117 VOLTS
FUNCTION	PULSE
PULSE AMPLITUDE OR SYNC	
FOR VOLTAGES	CCW
FOR WAVEFORMS	CW
VERNIER SYNC	CENTERED
NANOSEC/CM	20
DELAY	CW
NORMAL-SINGLE SWEEP	NORMAL

519

TIME BASE TRIG & HOLD OFF

★ OBTAINED WITH FUNCTION AT H.F. SYNC.

† OBTAINED WITH NORMAL-SINGLE SWEEP AT SINGLE SWEEP.

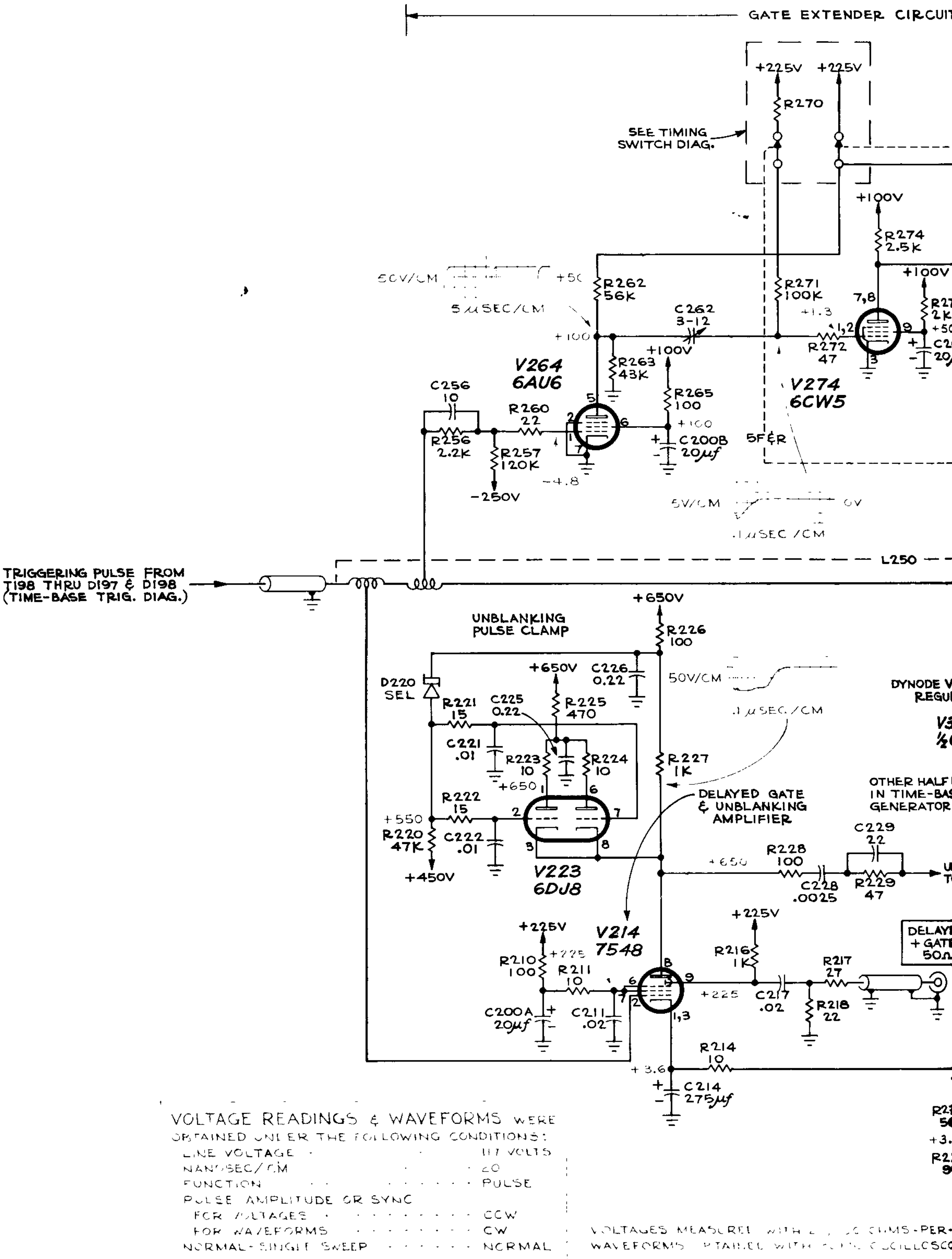
‡ MEASURED WITH NON-LOADING VOLTMETER.

ML 1064

D

TIME-BASE TRIGGER & HOLD-OFF

CIRCUIT NUMBERS
50 THRU 199



VOLTAGE READINGS & WAVEFORMS WERE OBTAINED UNDER THE FOLLOWING CONDITIONS:

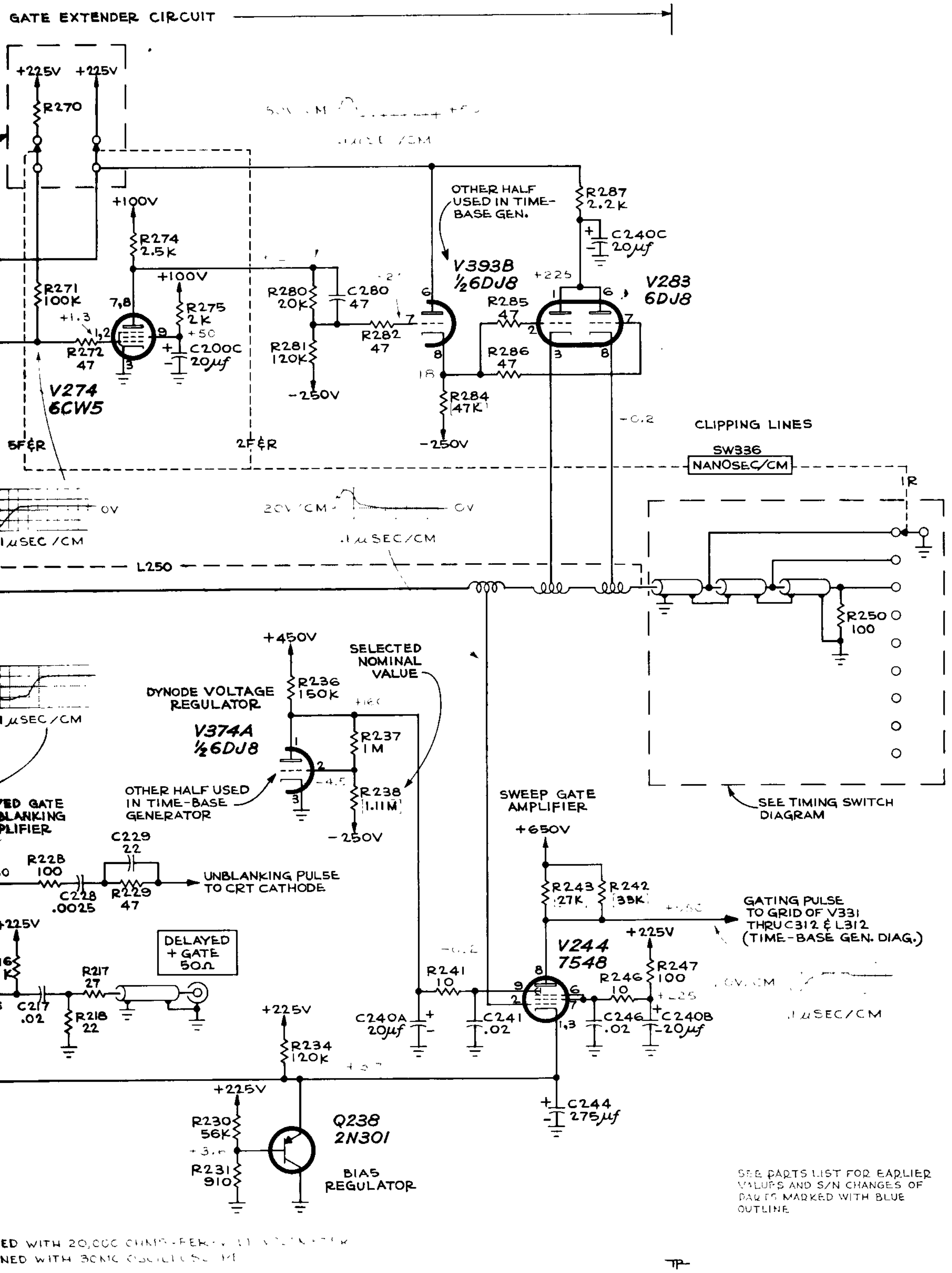
LINE VOLTAGE	117 VOLTS
NANOSEC/CM	20
FUNCTION	PULSE
PULSE AMPLITUDE OR SYNC	
FOR VOLTAGES	CCW
FOR WAVEFORMS	CW
NORMAL-SINGLE SWEEP	NORMAL

TIME BASE GATE & BLANK NG

VOLTAGES MEASURED WITH [illegible] OHMS-PER-

WAVEFORMS OBTAINED WITH [illegible] OSCILLOSCO

TYPE 519 OSCILLOSCOPE



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

ED WITH 20,000 OHMS-PER-VOLT VOLTMETER

NED WITH 30MC OSCILLOSCOPE

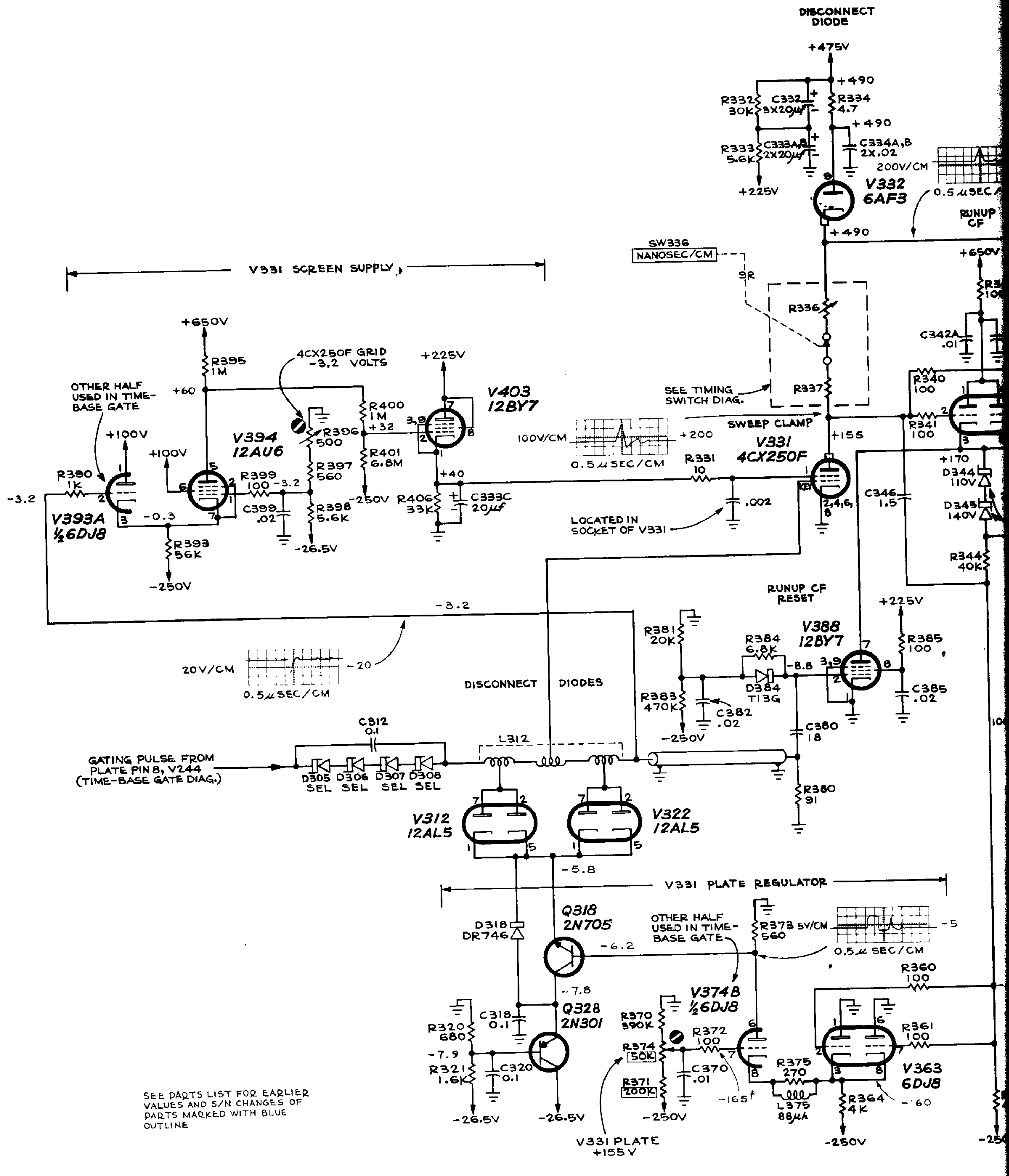
TP
1263

A₃

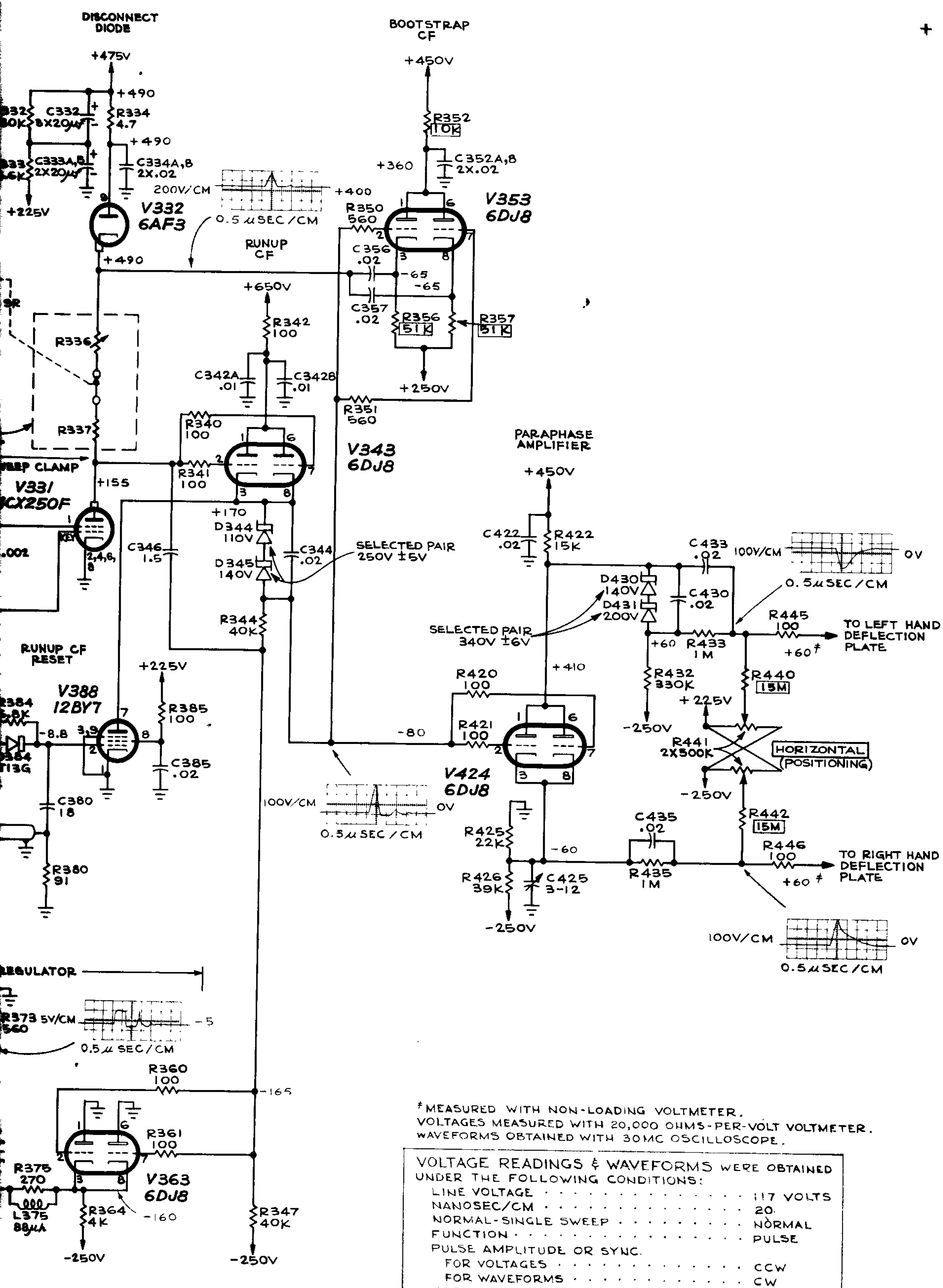
TIME-BASE GATE & UNBLANKING

CIRCUIT NUMBERS
200 THRU 287
ALSO V374A & V393B

TIME-BASE GATE & UNBLANKING
200 THRU 287
ALSO V374A & V393B



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



‡MEASURED WITH NON-LOADING VOLTMETER.
VOLTAGES MEASURED WITH 20,000 OHMS-PER-VOLT VOLTMETER.
WAVEFORMS OBTAINED WITH 30MC OSCILLOSCOPE.

VOLTAGE READINGS & WAVEFORMS WERE OBTAINED UNDER THE FOLLOWING CONDITIONS:

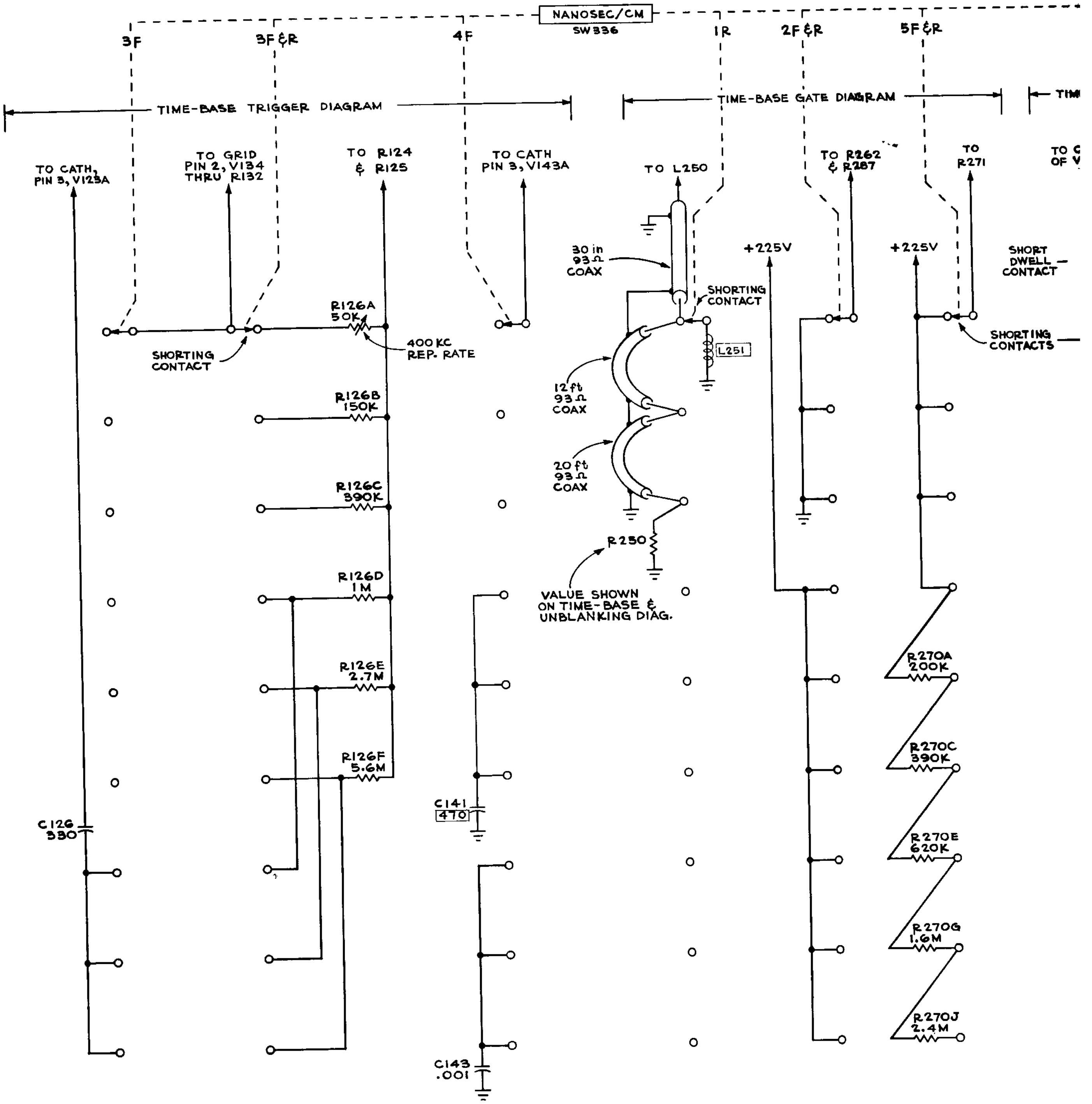
LINE VOLTAGE	117 VOLTS
NANOSEC/CM	20
NORMAL-SINGLE SWEEP	NORMAL
FUNCTION	PULSE
PULSE AMPLITUDE OR SYNC.	
FOR VOLTAGES	CCW
FOR WAVEFORMS	CW
HORIZONTAL	CENTERED

519 TIME-BASE GEN

1263
TP

TIME-BASE GENERATOR

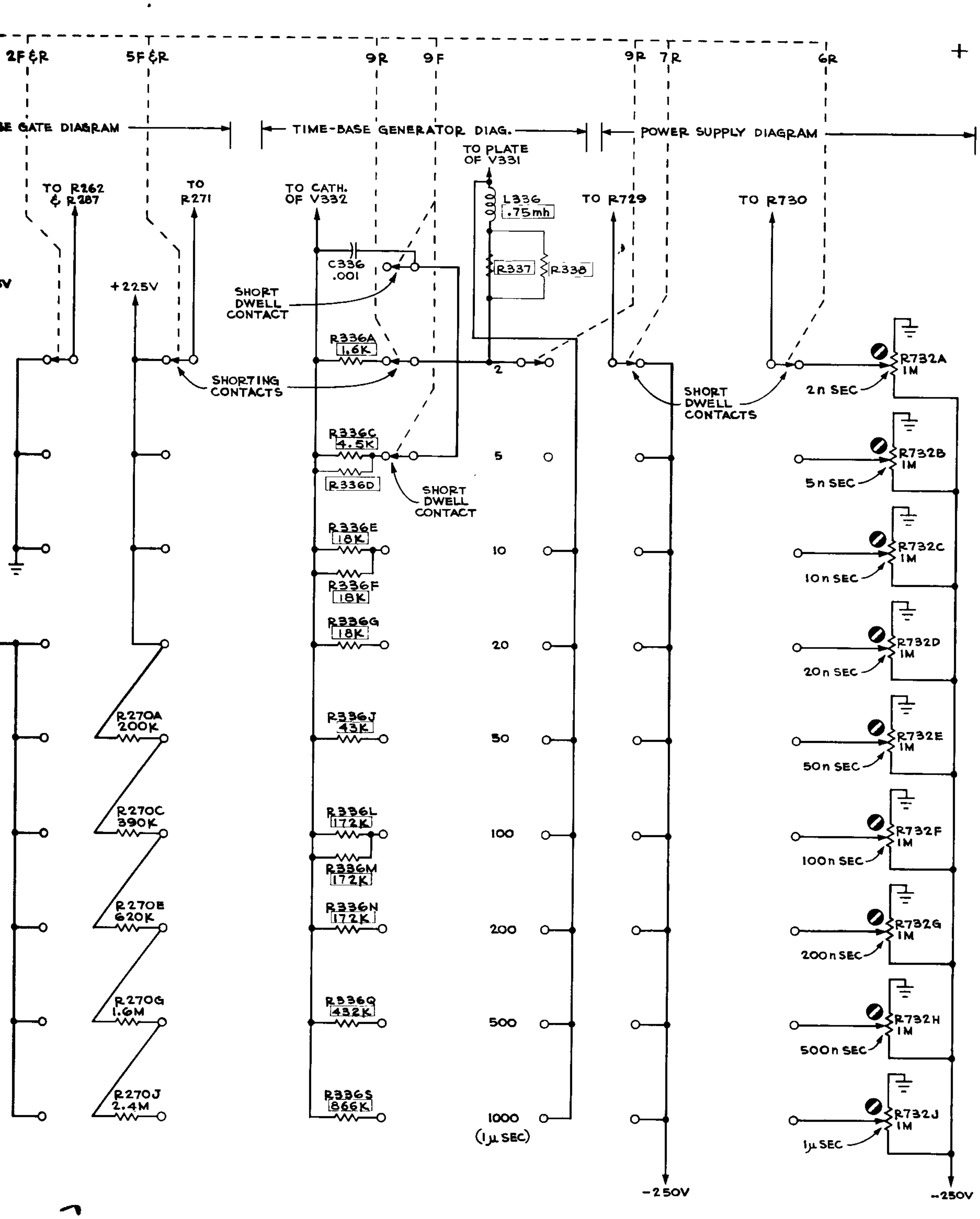
CIRCUIT NUMBERS
305 THRU 446



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

TYPE 519 OSCILLOSCOPE

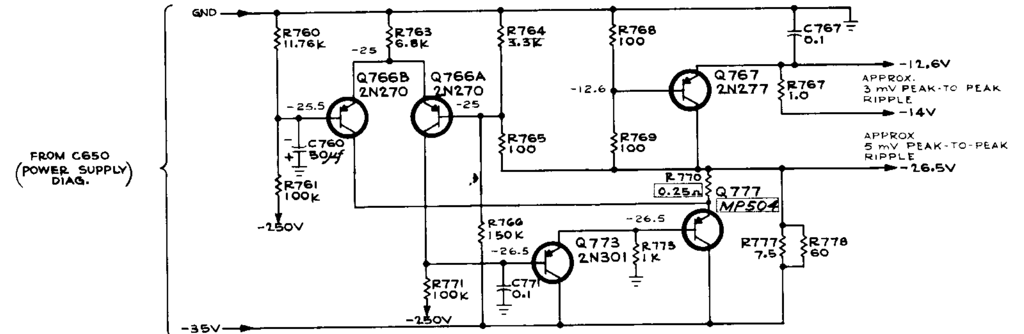
C1



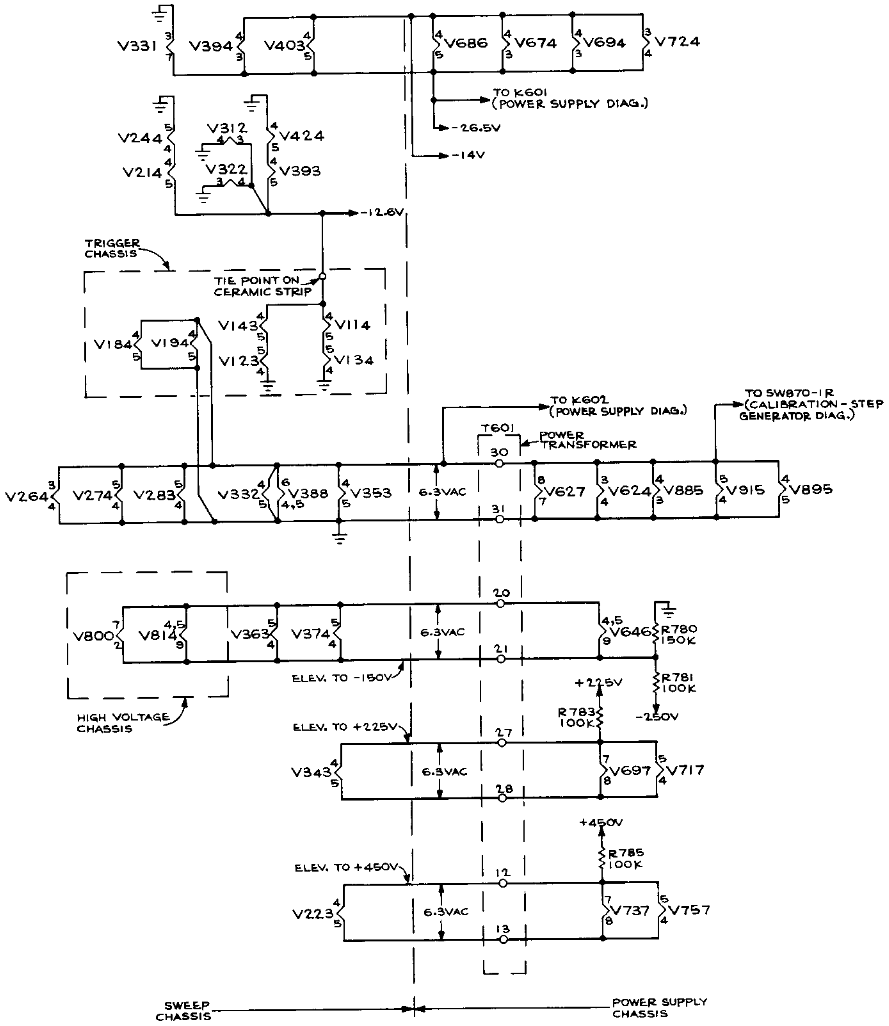
C₁

TIMING SWITCH

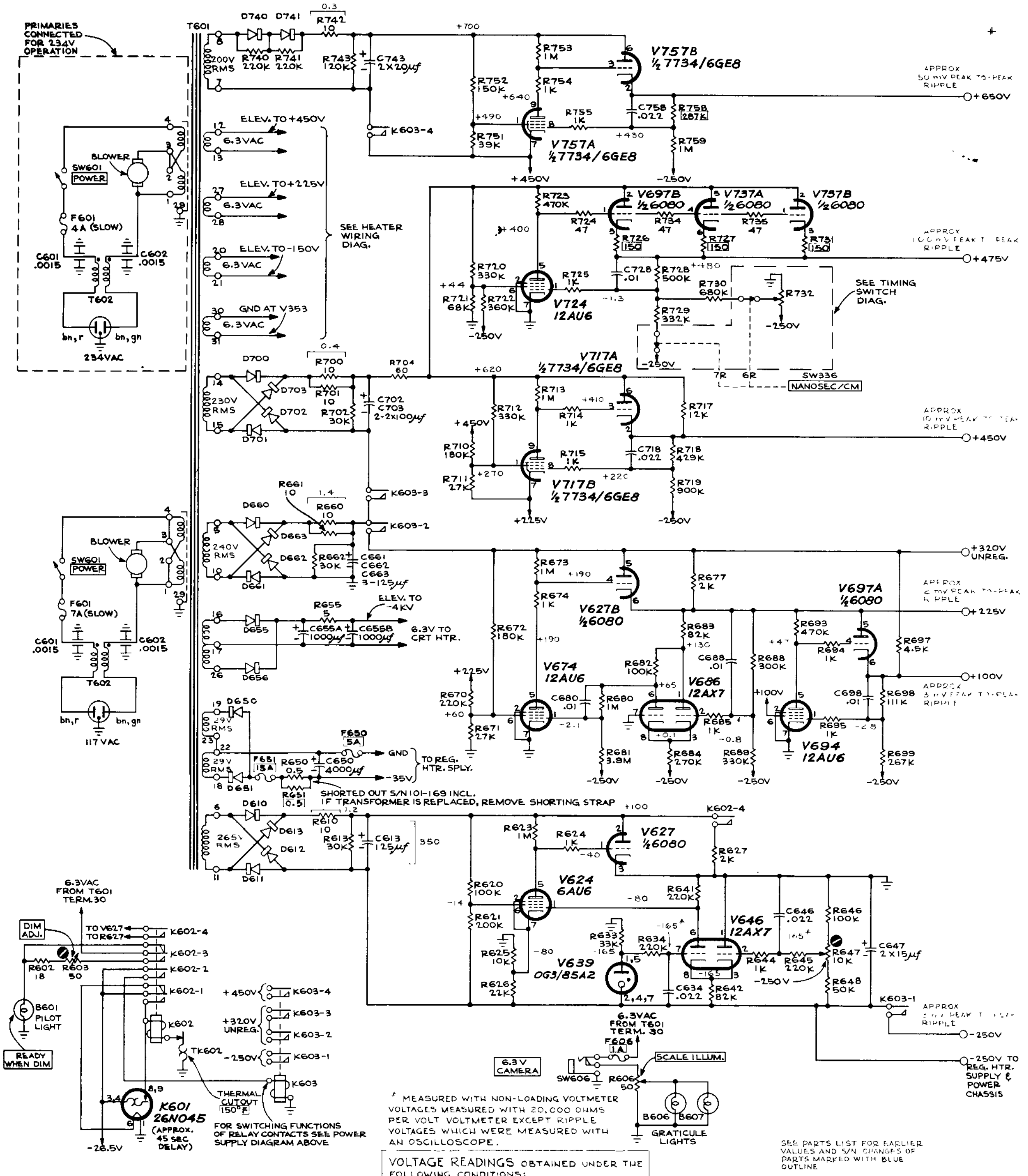
GAB
1263



REGULATED HEATER SUPPLY



REGULATED HEATER SUPPLY
& HEATER WIRING DIAGRAM



* MEASURED WITH NON-LOADING VOLTMETER
VOLTAGES MEASURED WITH 20,000 OHMS PER VOLT VOLTMETER EXCEPT RIPPLE VOLTAGES WHICH WERE MEASURED WITH AN OSCILLOSCOPE.

VOLTAGE READINGS OBTAINED UNDER THE FOLLOWING CONDITIONS:

LINE VOLTAGE	117VOLTS
NANOSEC/CM	20
PULSE AMPLITUDE OR SYNC.	CCW
FUNCTION	PULSE
MULTIPLIER	OFF
RANGE	STANDBY

519 PWR SUP

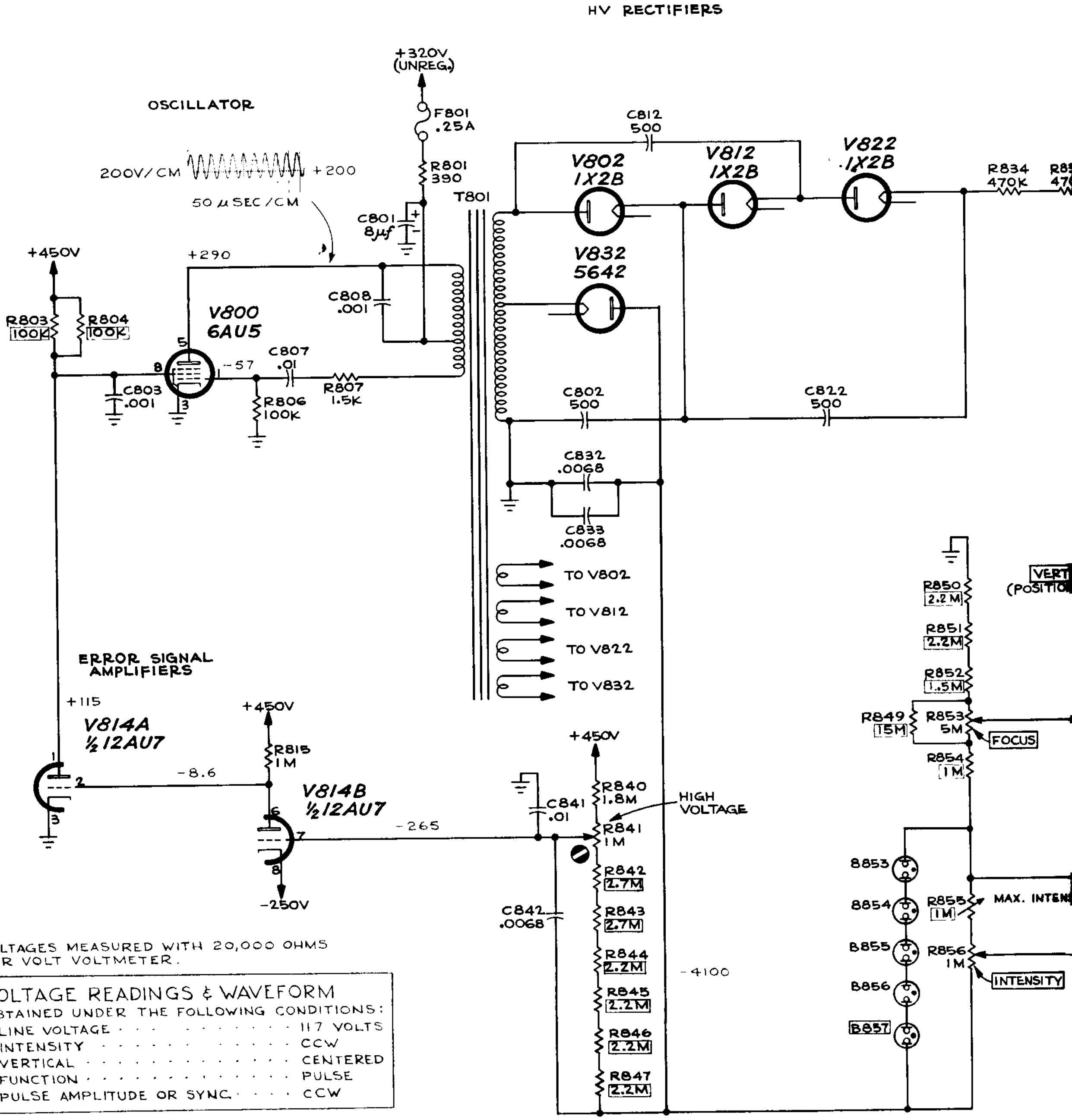
G

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

TR 864

POWER SUPPLY

CIRCUIT NUMBERS
601 THRU 785

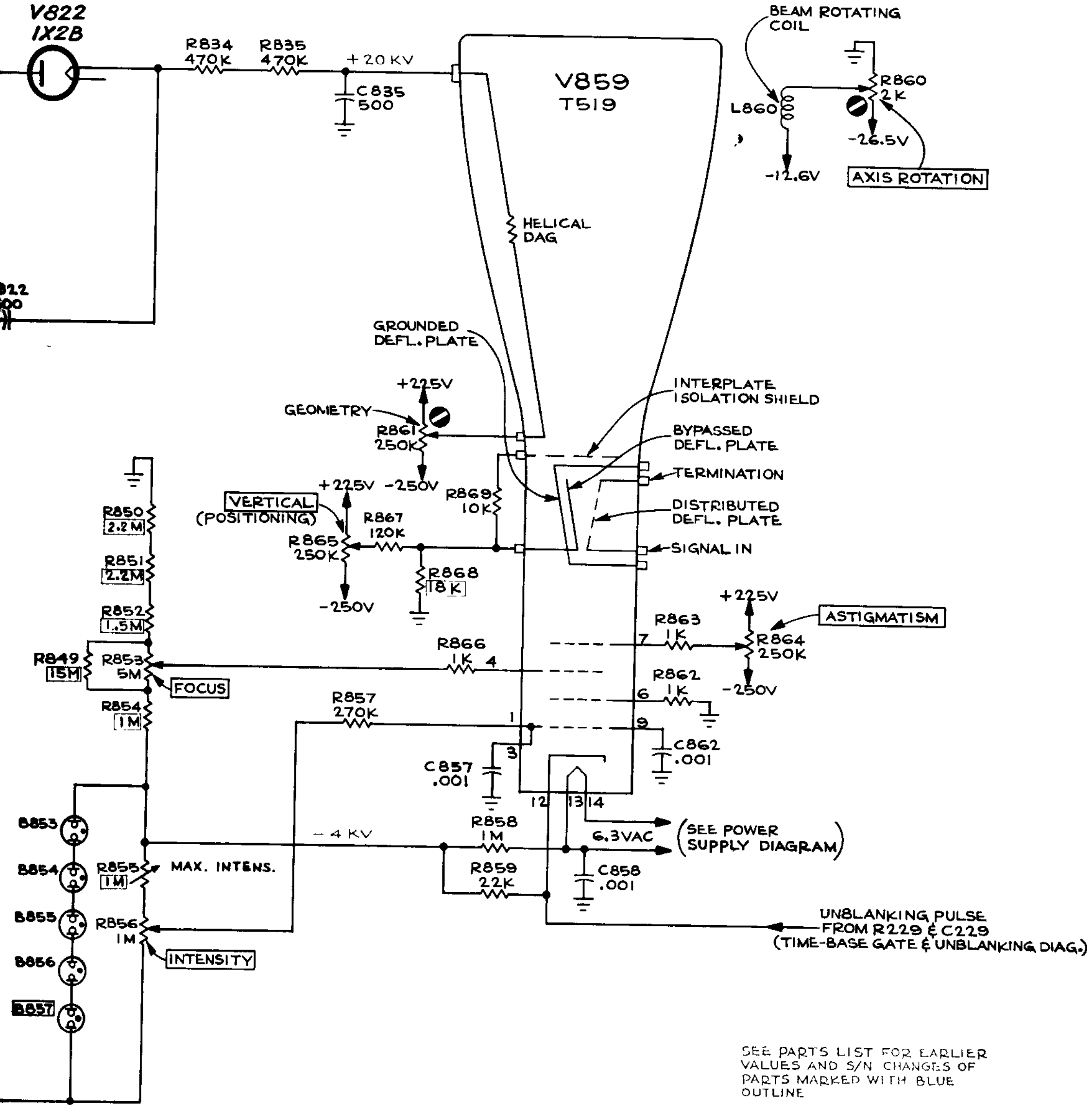


VOLTAGES MEASURED WITH 20,000 OHMS PER VOLT VOLTMETER.

VOLTAGE READINGS & WAVEFORM
OBTAINED UNDER THE FOLLOWING CONDITIONS:

LINE VOLTAGE	117 VOLTS
INTENSITY	CCW
VERTICAL	CENTERED
FUNCTION	PULSE
PULSE AMPLITUDE OR SYNC.	CCW

TYPE 519 OSCILLOSCOPE



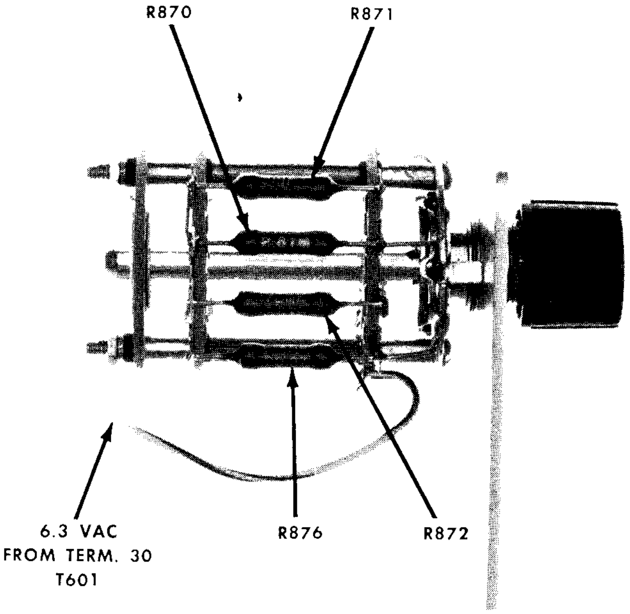
SEE PARTS LIST FOR EARLIER VALUES AND S/N CHANGES OF PARTS MARKED WITH BLUE OUTLINE

1263
TP-

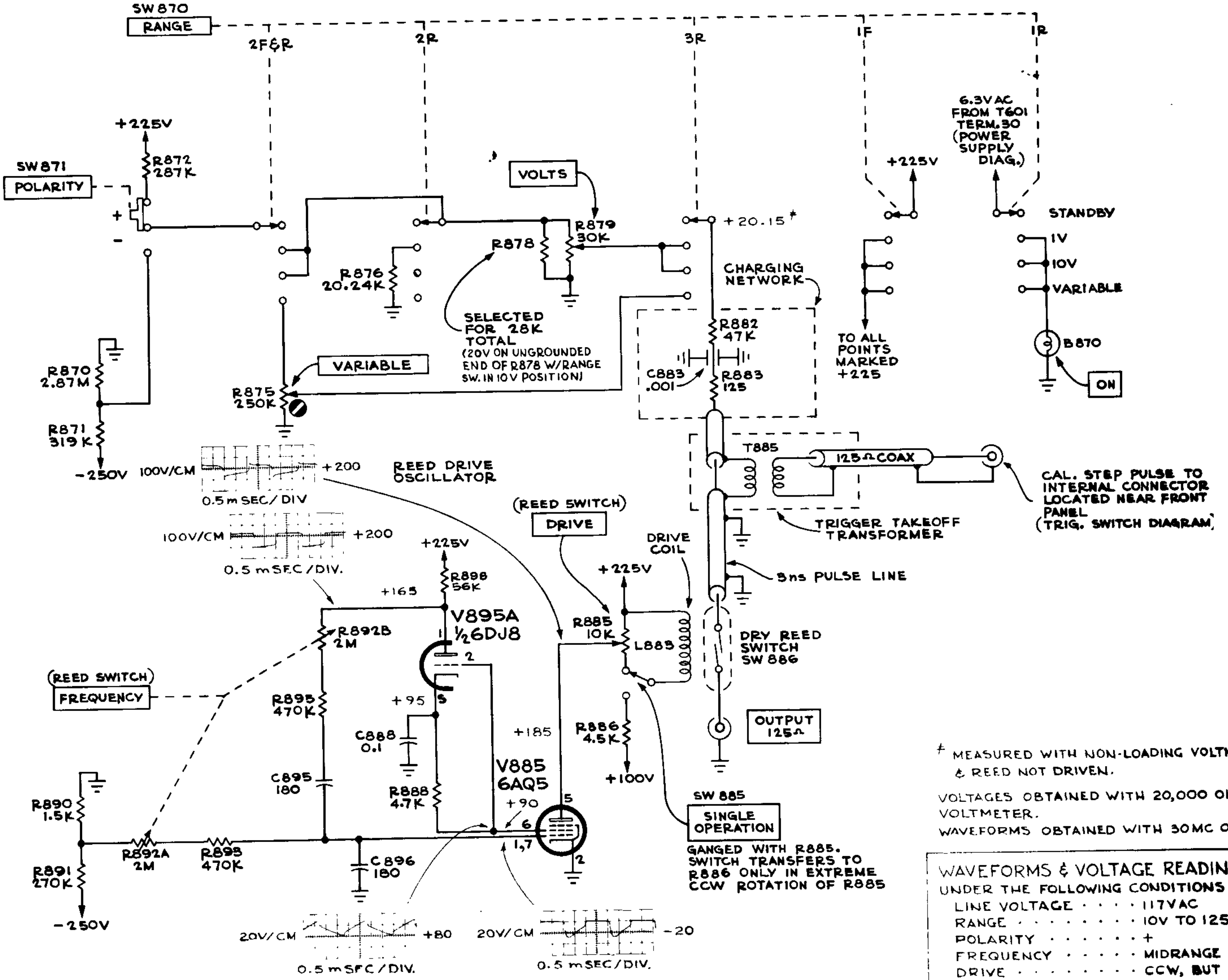
CRT CIRCUIT

CIRCUIT NUMBERS
800 THRU 869

CRT CIRCUIT
800 THRU 869



LEFT SIDE RANGE SWITCH



‡ MEASURED WITH NON-LOADING VOLTMET
& REED NOT DRIVEN.

VOLTAGES OBTAINED WITH 20,000 OHM
VOLTMETER.

WAVEFORMS OBTAINED WITH 30MC OSC

WAVEFORMS & VOLTAGE READINGS
UNDER THE FOLLOWING CONDITIONS:

LINE VOLTAGE	117VAC
RANGE	10V TO 125Ω
POLARITY	+
FREQUENCY	MIDRANGE
DRIVE	CCW, BUT NO TO SINGLE O
VOLTS	10.0

519 A

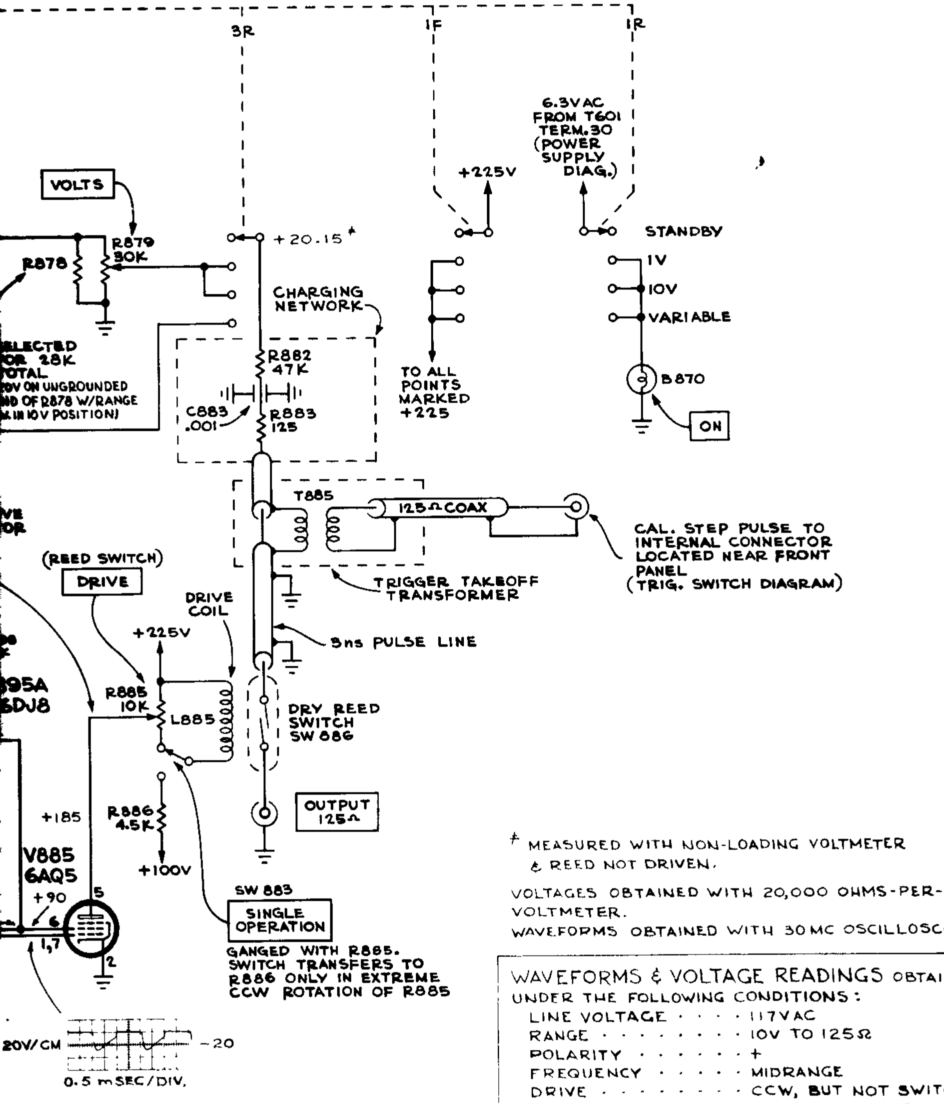
TYPE 519 OSCILLOSCOPE

A₁

CALIBRATION – STEP GENERATOR

GAB
10-7-60

CIRCUIT NUMBERS
870 THRU 898



* MEASURED WITH NON-LOADING VOLTMETER & REED NOT DRIVEN.

VOLTAGES OBTAINED WITH 20,000 OHMS-PER-VOLT VOLTMETER.

WAVEFORMS OBTAINED WITH 30MC OSCILLOSCOPE.

WAVEFORMS & VOLTAGE READINGS OBTAINED UNDER THE FOLLOWING CONDITIONS:

LINE VOLTAGE	117VAC
RANGE	10V TO 125Ω
POLARITY	+
FREQUENCY	MIDRANGE
DRIVE	CCW, BUT NOT SWITCHED TO SINGLE OPERATION.
VOLTS	10.0

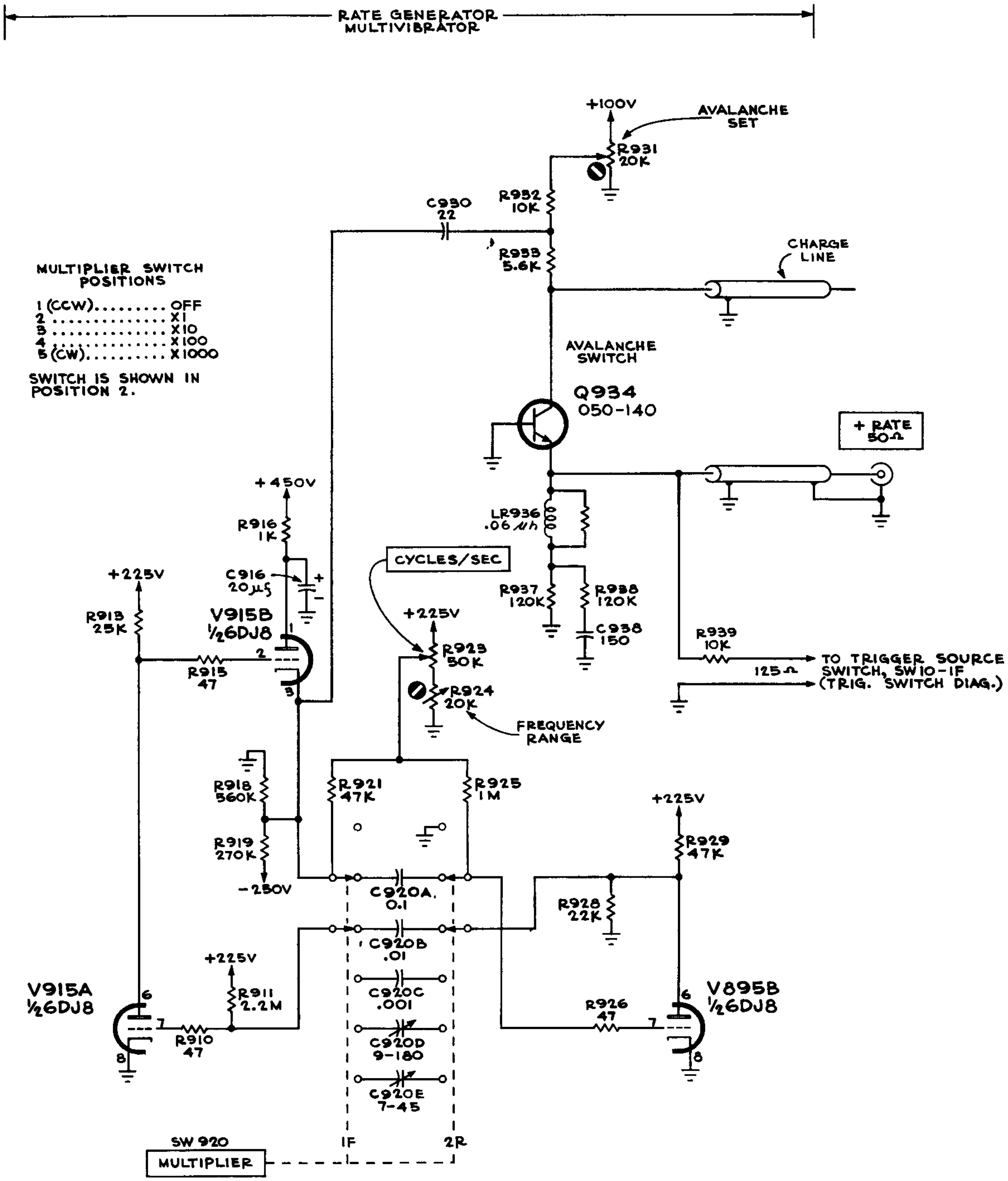
519 A CALIB - STEP GEN.

A1

CALIBRATION – STEP GENERATOR

GAB
10-7-60

CIRCUIT NUMBERS
870 THRU 898



MULTIPLIER SWITCH POSITIONS

1 (CCW).......... OFF
2 .... X1
3 .... X10
4 .... X100
5 (CW)........... X1000

SWITCH IS SHOWN IN POSITION 2.

S/N 101 – 481

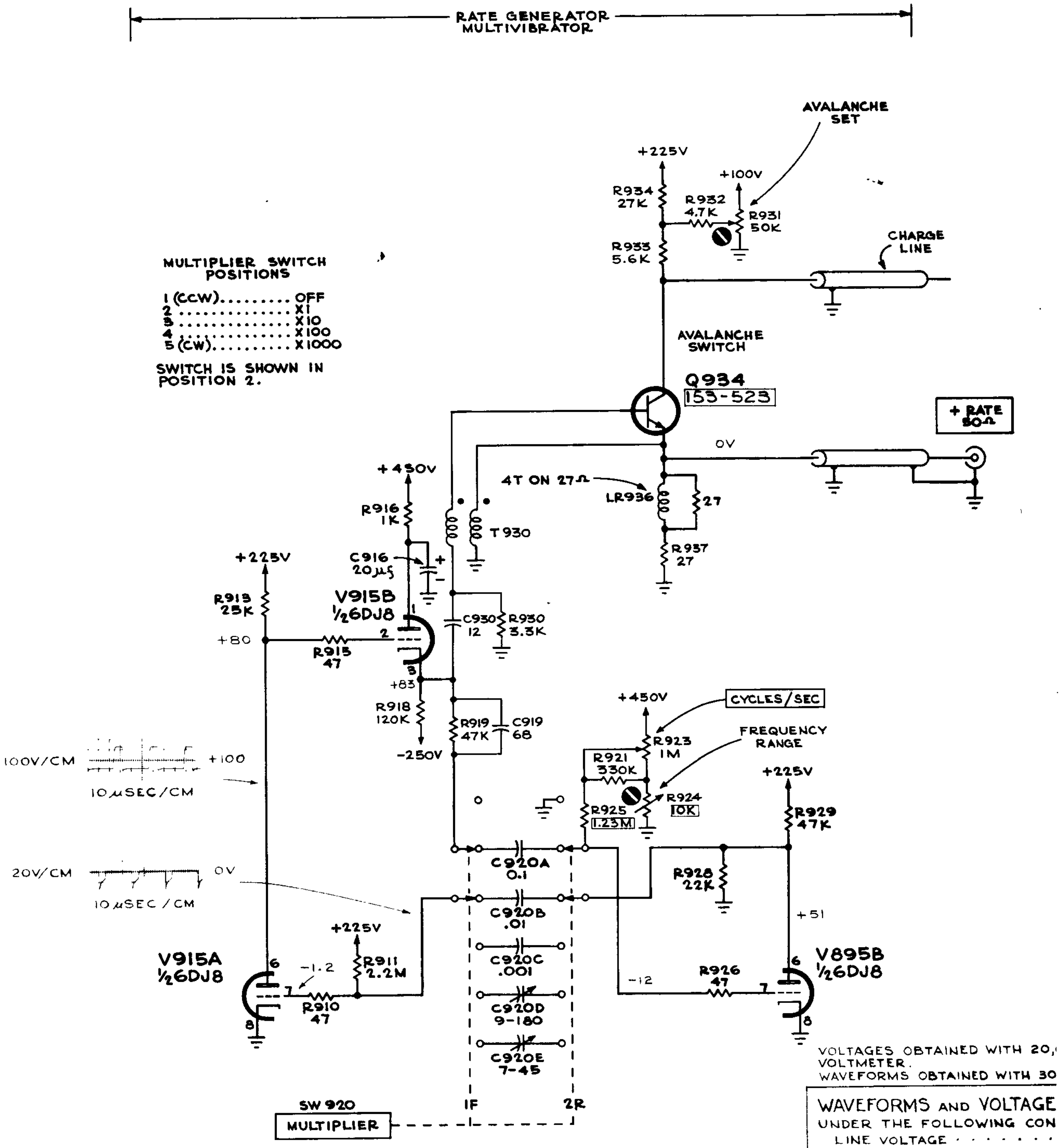
GAB
1263

TYPE 519 OSCILLOSCOPE

A2

RATE GENERATOR

CIRCUIT NUMBERS
910 THRU 939
ALSO V895B



MULTIPLIER SWITCH POSITIONS

1 (CCW)	OFF
2	X1
3	X10
4	X100
5 (CW)	X1000

SWITCH IS SHOWN IN POSITION 2.

VOLTAGES OBTAINED WITH 20,
VOLTMETER.
WAVEFORMS OBTAINED WITH 30

WAVEFORMS AND VOLTAGE
UNDER THE FOLLOWING CON
LINE VOLTAGE · · · · · · ·
MULTIPLIER · · · · · · · ·
CYCLES/SEC · · · · · · ·

519

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

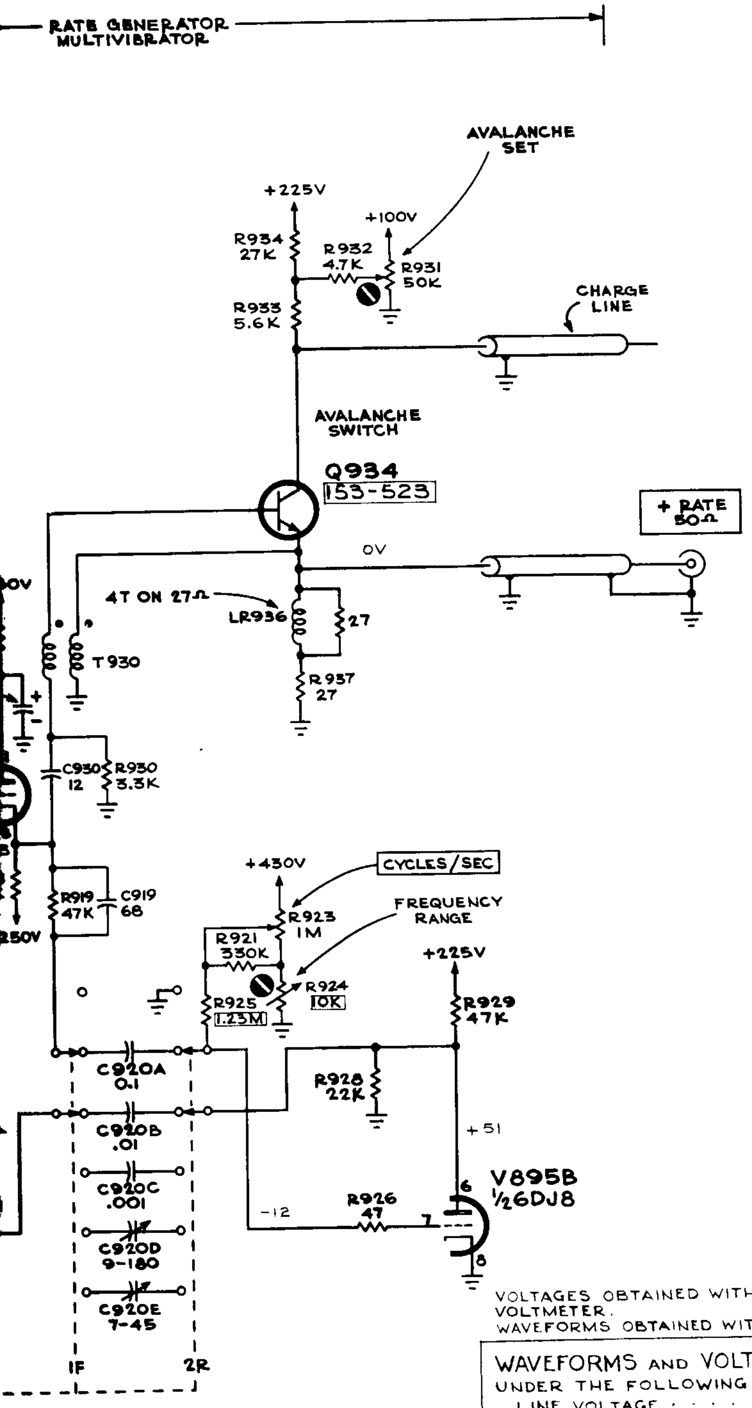
GAB
364

TYPE 519 OSCILLOSCOPE

B

RATE GENERAT
S/N 482-UP

CIRCUIT NUMBERS
910 THRU 939
ALSO V895B



VOLTAGES OBTAINED WITH 20,000 OHMS-PER-VOLT VOLTMETER.
WAVEFORMS OBTAINED WITH 30MC OSCILLOSCOPE.

WAVEFORMS AND VOLTAGE READINGS OBTAINED UNDER THE FOLLOWING CONDITIONS.	
LINE VOLTAGE · · · · · · · · · · · ·	117 VOLTS
MULTIPLIER · · · · · · · · · · · · ·	X1000
CYCLES/SEC · · · · · · · · · · · · ·	30

519

RATE GEN.

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

B

GAB
364

RATE GENERATOR

S/N 482-UP

CIRCUIT NUMBERS
910 THRU 939
ALSO V895B

TYPE 519 -- TENT. S/N 680

PARTS LIST CORRECTIONS

CHANGE TO:

Q70	2N967	151-0107-00
Q180	2N967	151-0107-00

TYPE 519 -- TENT. S/N 660

PARTS LIST CORRECTION

CHANGE TO:

V184	6DJ8	154-0187-00
V194	6DJ8	154-0187-00

TYPE 519 -- TENT. S/N 653

PARTS LIST CORRECTIONS

CHANGE TO:

Q238	2N2148	151-137
Q328	2N2148	151-137
Q773	2N2148	151-137

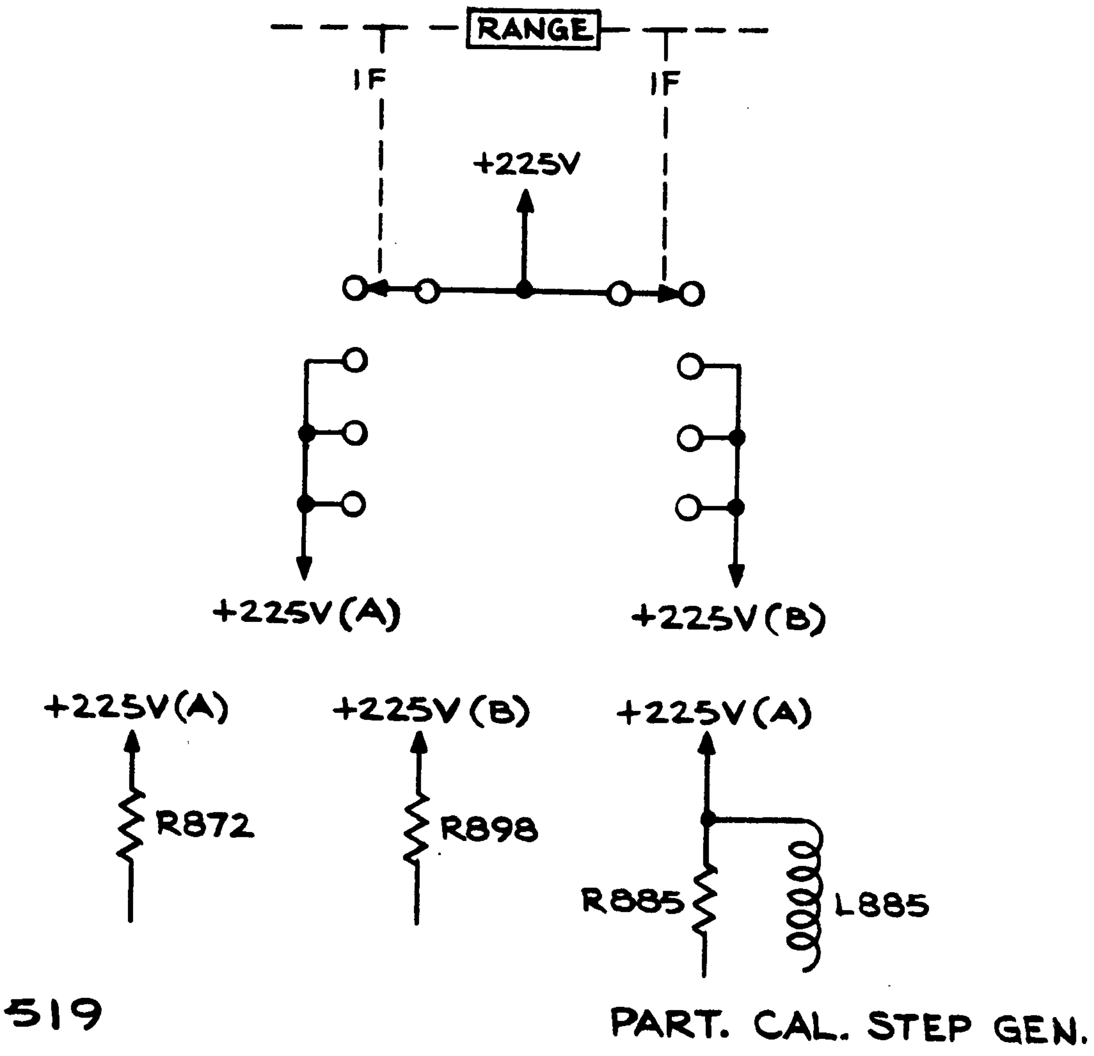
TYPE 519 -- TENT. S/N 611

PARTS LIST CORRECTION

CHANGE TO:

SW886	Starved Mercury Reed	SINGLE CLOSURE	*260-693

SCHEMATIC CORRECTION



TYPE 519 -- TENT. S/N 611

PARTS LIST CORRECTION

ADD:

R628 *	100 Ω	2 w	306-101

* Remove strap between pin 3 and socket ground lug of V627. Add this resistor between pin 3 of V627 and a socket ground lug of V674.

TYPE 519 -- TENT. S/N 579

PARTS LIST CORRECTION

CHANGE TO:

C334A	.02 µf	Cer.	1400 v	283-022
C334B	.02 µf	Cer.	1400 v	283-022
C356	.02 µf	Cer.	1400 v	283-022
C357	.02 µf	Cer.	1400 v	283-022

TYPE 519 - TENT. S/N 575

PARTS LIST CORRECTIONS

CHANGE TO:

D50	Diode, Tunnel	RCA 37181	152-159

TYPE 519 - TENT. S/N 575

PARTS LIST CHANGES

ADD:

R726	150Ω	1w	304-151
R727	150Ω	1w	304-151
R731	150Ω	1w	304-151

These resistors are added as follows:

R726, between pin 3 of V697B and the +475v supply
R727, between pin 6 of V737A and the +475v supply
R731, between pin 3 of V737B and the +475v supply

TYPE 519
MOD 6353 (37)

Resistors

R803	Change to	100k	2w	306-104
R805	Change to	100k	2w	306-104
R855	Change to	1m	Pot. (Max. Intensity)	311-126

Neon Bulbs

B853	Change to	NE23	150-027
B854	Change to	NE23	150-027
B855	Change to	NE23	150-027
B856	Change to	NE23	150-027
B128	Change to	NE23	150-027

INSTRUCTIONS FOR SETTING MAX. INTENSITY CONTROL

With the PULSE AMPLITUDE or SYNC. control fully counterclockwise and the FUNCTION switch in the PULSE position, slowly rotate the INTENSITY control until a low intensity spot appears on the CRT. Use the FOCUS and ASTIGMATISM controls to bring the spot into sharp focus. Rotate the MAX INTENSITY control to the full counterclockwise position and the INTENSITY control to the full clockwise position. Slowly turn the MAX INTENSITY control clockwise until the spot reappears and a halo forms around the spot. Then turn the MAX INTENSITY control counterclockwise until the halo just disappears.

product modification

050-0258-02
M9691-2,M10528,
M10802,M11580
Type 519

7548 VACUUM TUBE REPLACEMENT

For TEKTRONIX® Type 519 Osicllоscope

Serial Numbers 105-742

Type 12HG7 vacuum tubes, PN 154-0496-00, replace type 7548 secondary emission tubes, PN 154-0310-00, which are no longer available. The 7548 tubes were used in the Delayed Gate and Unblanking Amplifier, V214, and the Sweep Gate Amplifier, V244.

Both V214 and V244 must be replaced at the same time because of the different filament current and grid-cathode bias requirements.

The Dynode Regulator circuit, V374A, for the 7548 tubes is removed. The Unblanking Pulse Clamp circuit, V223, is replaced with a diode semiconductor clamp circuit having considerably less input capacity.

The Delayed +Gate, which was previously derived from the Dynode element of V214, is now provided by adding two transistor Delayed +Gate Amplifiers, Q214 and Q215.

The Delayed +Gate Amplifier circuit and the Unblanking Pulse Clamp circuit are wired on a sub-assembly which plugs into the old V223 tube socket. The remainder of the modification is installed by rewiring the V223, V214 and V244 circuitry.

> NOTE: If the serial number of your instrument is above those listed, or if this kit has been installed, disregard the instructions as PN 154-0496-00 is a direct replacement.

##Indicates change since last publication.

7-21-71
Supersedes: 10-18-68

INSTRUCTIONS

IMPORTANT: When soldering to the ceramic strips, use the silver-bearing solder supplied with this kit.

A. Remove the following wires and components from the chassis, directly beneath the CRT: (Refer to Fig.1)

( ) 1. V214, a 7548 tube.

( ) 2. V244, a 7548 tube.

( ) 3. V223, a 6DJ8 tube.

( ) 4. V859, the CRT. The CRT and SHIELD should be removed as a SINGLE unit. To remove the unit, first disconnect all leads to the CRT. Disconnect the input coaxial cable and termination from the mounting board. Disconnect the CRT socket from the CRT base by pressing back on the plastic flanges attached to each side of the socket. The socket can be worked loose by pressing first on one flange and then the other until the socket is free of the CRT. Remove the four slotted graticule nuts which hold the graticule cover and mask assembly in place. Remove the graticule cover and mask. Disconnect the rear supports of the CRT shield and gently remove the complete CRT assembly through the front panel opening of the oscilloscope, taking extreme care of exposed hardware.

( ) 5. R236, a 150k 1W 10% resistor, connected between CSC-6 and CSE-7.

( ) 6. R237, a 1M 1/2W 1% resistor, connected between pin 2 of V374 and CSR-4.

( ) 7. R238, a 1.11M (or 1.5M) 1/2W 1% resistor, connected between pin 2 of V374 and CSR-5. (R238 is a selected component and may be a value other than those listed.)

( ) 8. A bare wire that connects pin 1 of V374 to CSR-4.

( ) 9. R223, a 10Ω 1/2W 10% resistor, connected between pin 1 of V223 and CSE-3.

( ) 10. R224, a 10Ω 1/2W 10% resistor, connected between pin 6 of V223 and CSE-2.

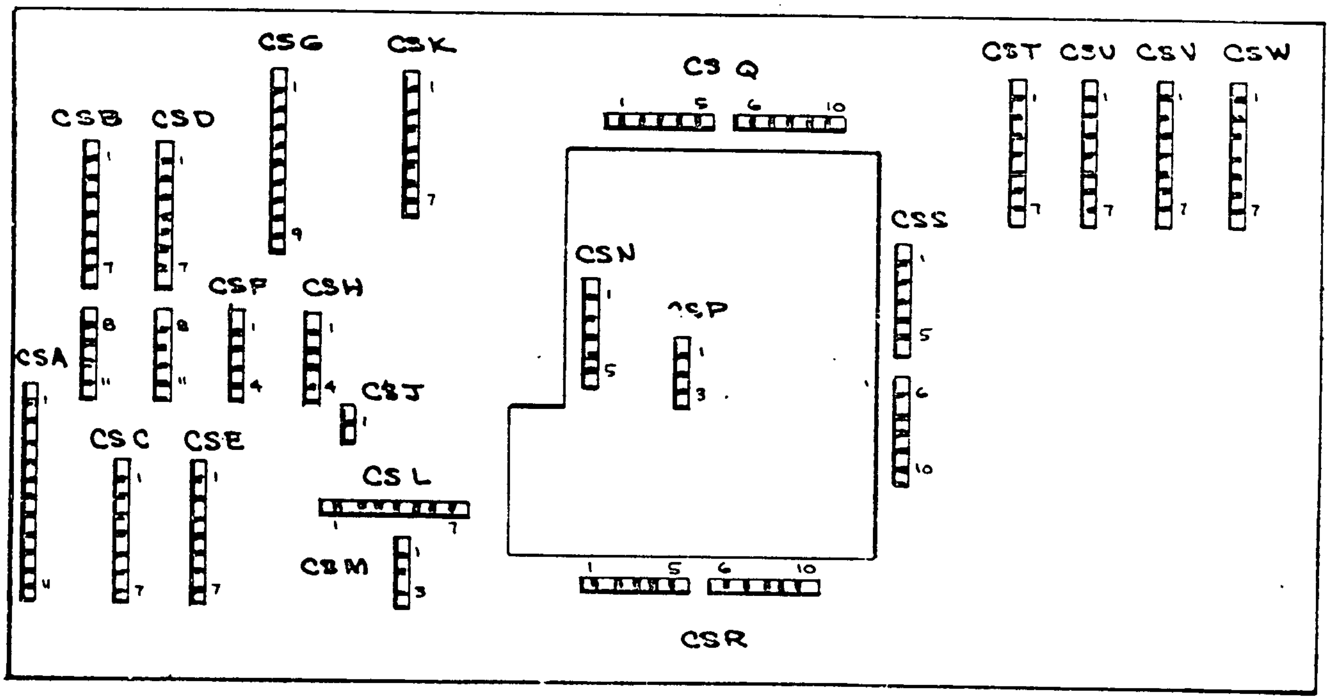


FIG. 1

INSTRUCTIONS (A. cont)

( ) 11. R225, a 470Ω 1/2W 10% resistor, connected between CSC-4 and CSE-4.

( ) 12. R221 and R222, 15Ω 1/4W 10% resistors, connected between pin 7 of V223 and CSE-5, and between pin 2 of V223 and CSE-5, respectively.

( ) 13. C211, an 0.02 μF 500V capacitor, connected between pin 7 of V214 and ground lug.

( ) 14. C222, an 0.01 μF discap, connected between pin 2 of V223 and ground lug.

( ) 15. R228, a 100Ω 1/2W 10% resistor, connected between pin 3 of V223 and CSC-1.

( ) 16. R227, a 1k 1/2W 10% resistor, connected between pin 3 of V223 and CSC-3.

( ) 17. C225, an 0.22 μF 1000V chassis-mounted capacitor connected to CSE-2.
NOTE: It is not necessary to physicclly remove C225. Unsolder the capacitor wire from CSE-2 and cut it off close to the capacitor.

( ) 18. A bare wire that connects CSE-2, CSE-3 and CSE-4.

( ) 19. A bare wire that connects pin 3 to pin 8 of V223.

( ) 20. R216, a 1k 1/2W 10% resistor, connected between pin 9 of V214 and CSB-10.
NOTE: For easier access, it may be necessary to temporarily remove C228, an 0.0025 μF 6kV capacitor over V214 socket.

21. The following combination, tied together in a 3-way junction:

( ) R217, a 27Ω 1/2W 10% resistor, connected to coax center conductor, near C200.
( ) R218, a 22Ω 1/2W 10% resistor, connected to C200 ground lug.
( ) C217, an 0.02 μF 500V discap, connected to pin 9 of V214.

( ) 22. R230, a 56k 2W 5% resistor, connected between CSB-2 and CSD-2.

( ) 23. R241, a 10Ω 1/2W 10% resistor, connected between pin 9 of V244 and C240A.

( ) 24. C241, an 0.02 μF discap, connected between pin 9 of V244 and ground lug.

( ) 25. C244, a 275 μF 6V chassis-mounted capacitor, connected to pin 1 of V244.
NOTE: DO NOT REMOVE BARE WIRE BETWEEN PINS 1 AND 3 OF V244.

( ) 26. A bare wire between pin 5 of V244 and ground lug.

( ) 27. A bare wire that connects pins 6 and 7 of V244.

( ) 28. A bare wire that connects pin 8 of V244 to CSL-1.

( ) 29. R246, a 10Ω 1/2W 10% resistor, connected between pin 7 of V244 and C240B.

( ) 30. C246, an 0.02 μF 500V capacitor, connected between pin 7 of V244 and ground lug.

( ) 31. A bare wire that connects pins 6 and 7 of V214.

( ) 32. R229 and C229, [illegible] 1/4W 10% resistor and a 22 pF capacitor, connected between CSA-4 and CSA [illegible]

( ) 33. Two white-red wires, one connected between C240A and CSE-7, and the other between C240A and CSR-4 (remove both wires from cable).

( ) 34. C214, a 275µF 6V chassis-mounted capacitor, connected to pin 3 of V214. NOTE: DO NOT REMOVE BARE WIRE BETWEEN PINS 1 AND 3 OF V214.

( ) 35. The '7548' silkscreening near V214 and V244, on both sides of chassis, with lacquer thinner.

( ) Peel off the paper backing and fasten one '12HG7' tube identification tag on top of the chassis, near V214, and the other near V244.

( ) 36. D220, a Zener diode, connected between CSC-5 and CSE-5.

B. Unsolder the following wires (refer to Fig. 1A):

( ) 1. A white-blue-yellow wire from pin 4 of V223.

( ) 2. Two white-blue-yellow wires from CSV-1.

( ) Using an ohmmeter, determine which of the wires was connected to pin 4 of V223. Cut this wire off at both ends where it enters the cable and reconnect the other wire to CSV-1.

( ) 3. A white-blue-green wire from pin 5 of V223.

( ) 4. Two white-blue-green wires from CSV-2.

( ) In a manner similar to step B-2, determine which wire was connected to pin 5 of V223 and cut it off at both ends where it enters the cable, and reconnect the other wire to CSV-2.

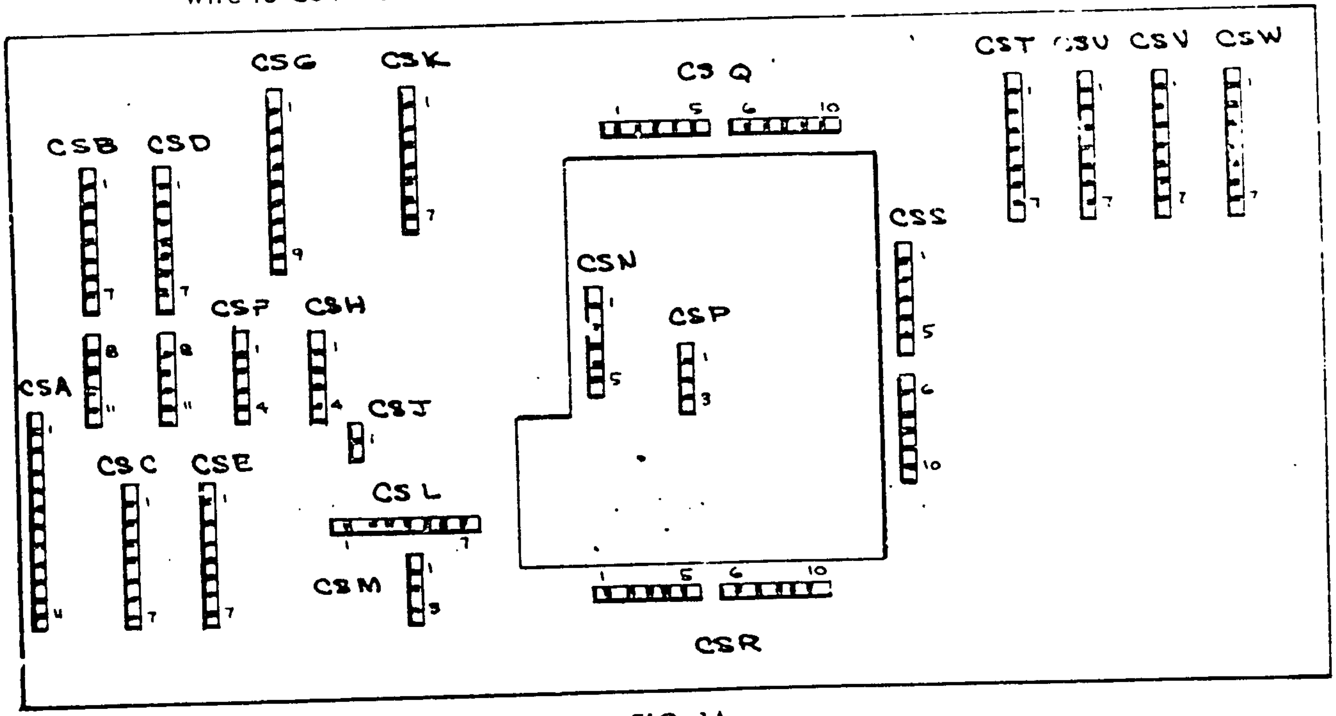
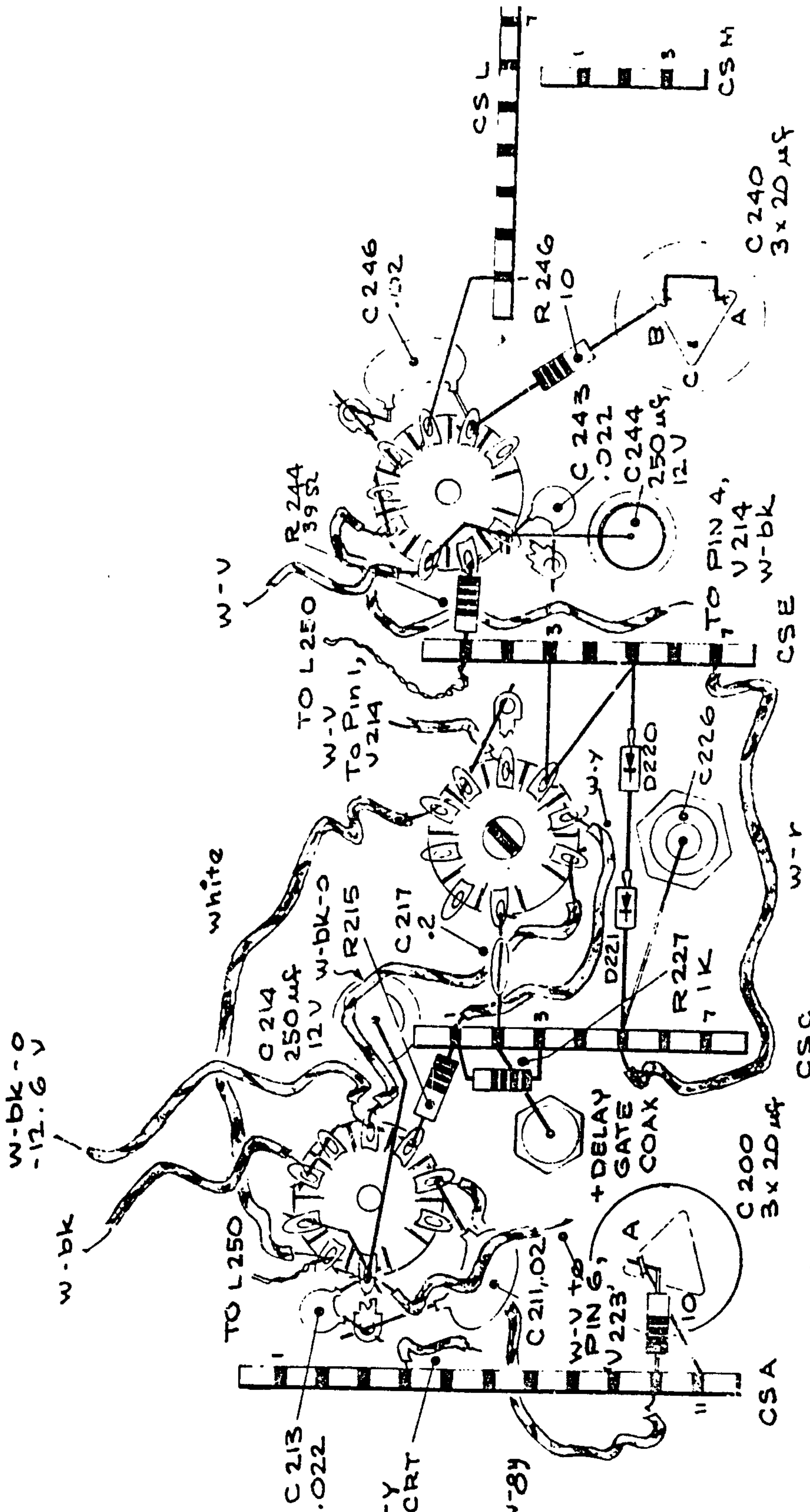


FIG. 1A



NOTE:
ON SOME INSTRUMENTS C240A
AND C240C MAY BE REVERSED
IN LOCATION.

FIG. 2

INSTRUCTIONS (cont)

C. Relocate the following wires (refer to Fig. 2):

( ) 1. A white-black-orange wire from pin 5 of V214 to pin 6 of V214.

( ) 2. A white-yellow wire from pin 8 of V214 to CSC-1.

( ) A white-gray wire from pin 7 of V214 to pin 8 of V214.

( ) 3. The bare wire (from L250) connected to pin 2 of V244 to CSE-1.

D. Install the following wires and components from the kit (see Fig. 2):

( ) 1. A bare wire between pin 7 of V244 and CSE-1.

( ) 2. A bare wire between pin 6 ov V244 and the ground lug.

( ) 3. A bare wire between pins 4 and 5 of V244.

( ) 4. A bare wire from pin 5 of old V223 socket to ground lug.

( ) 5. A bare wire between pins 4 and 5 of V214.

( ) 6. A bare wire between C240A and C240B.

( ) 7. A bare wire from pin 7 of old V223 socket to CSE-3 and CSE-5.

( ) 8. A 4 in. white-red wire from CSC-5 to CSE-7.

( ) 9. A bare wire from coax center conductor (near C200) to CSC-2.

( ) 10. R215, a 470Ω 1/2W 5% resistor, between pin 7 of V214 and CSC-1.

( ) 11. R227, a 1k 1/2W 10% resistor, between CSC-1 and CSC-3.

( ) The series combination of D226 and D227 (two silicon type diodes) in parallel with R227 (a 1k 1/2W 10% resistor), connected between CSC-1 and CSC-3. Install with the cathode (banded end) toward CSC-3.

( ) 12. R229, a 240Ω 1/2W 5% resistor, between CSA-4 and CSA-6 (resistor value may be changed later).

( ) 13. C211, an 0.02 μF capacitor, between pin 8 of V214 and ground lug.

( ) 14. C244, a 250 μF 12V capacitor assembly, using the old C244 mounting holes (mount on bottom of chassis). Connect the capacitor lead to pin 1 of V244.

( ) 15. C231, an 8 μF 450V capacitor, between CSE-7 and C240A (positive lead to CSE-7). NOTE: C231 is not shown in Fig. 2.

( ) 16. C243, an 0.022 μF discap, between pin 1 of V244 and ground lug.

( ) 17. R230, a 25k 7W resistor, between CSB-2 and CSD-2 (see Fig. 1 or 1A).

( ) 18. C214, a 250 μF 12V capacitor assembly, using the old C214 mounting holes mount on bottom of chassis). Connect the capacitor lead to pin 1 of V214.

( ) 19. C217, an 0.2µF 25V capacitor, between CSC-2 and pin 1 of old V223 socket.

( ) 20. A 2-1/2 in. white-black-orange wire between pin 6 of V214 and pin 9 of old V223 socket.

( ) 21. C213, an 0.022µF discap, between pin 1 of V214 and ground lug.

( ) 22. A 4" white-violet wire between pin 1 of V214 and pin 6 of the old V223 socket.

( ) 23. A 3" white wire from pin 2 of V214 and pin 4 of old V223 socket. Dress this wire as much in the open as possible.

( ) 24. Delayed +Gate Amplifier assembly as follows:

( ) Remove the 1 in. FHS screw from the socket side of the assembly.
( ) Install the assembly in the old V223 socket.
( ) Reinstall the 1 in. FHS screw through the socket.

( ) 25. C230, a 5µF 150V capacitor, between CSC-3 and CSE-3 (positive lead to CSC-3). NOTE: C230 is not shown in Fig. 2.

( ) 26. C246, an 0.02µF capacitor, between pin 8 of V244 and ground lug.

( ) 27. R246, a 10Ω 1/2W 10% resistor, between pin 8 of V244 and C240B.

( ) 28. A 12HG7 in V214 tube socket.

( ) 29. A 12HG7 in V244 tube socket.

( ) 30. R244, a 39Ω 1/2W 5% resistor, between CSE-1 and pin 2 of V244. See Manual Insert for calibration procedure.

( ) 31. D220 and D221, in series between CSC-5 and CSE-5. Install with cathode (body) to CSC-5.

E. Install new 2NANOSEC/CM clipping line:

NOTE: The following method is used to identify the NANOSEC/CM switch terminals.

The wafers are numbered from front to rear.

The contact mounting holes are numbered 1 through 12 relative to the index key as shown in Fig. 3.

The contacts have an 'F' or 'R' suffix which denotes that they are on the front or rear of the wafer.

Example: W2-7R (denoted by * on Fig. 3) is contact #7 on rear of wafer 2.

(TYPICAL SWITCH CONFIGURATION)

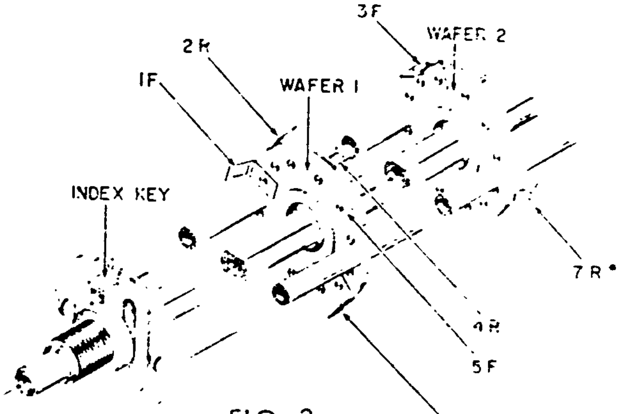


FIG. 3

( ) 1. Unsolder the center conductor of the 93Ω coax from contact W1-11R on the NANOSEC/CM switch.

INSTRUCTIONS (E. cont)

( ) 2. Unsolder the other end of the 93Ω coax, center conductor, from the forward end of L250, on the sweep chassis.

( ) 3. Remove the cable end connector from the sweep chassis near L250.

( ) Remove the cable end connector from the NANOSEC/CM switch bracket.

( ) Remove the cable from the clipping line drum, and remove assembly.

( ) 4. Install the new cable end connector on the sweep chassis and solder the center conductor to L250.

( ) Dress the new coax in the same way as the old, and wrap two turns on the clipping line drum.

( ) Install the cable end connector on the switch bracket and solder the center conductor to contact W1-11R.

( ) Check wiring for accuracy.

( ) Refer to Manual for recalibration, perform steps 3 through 12 as applicable. Also see Recalibration section on Manual insert pages.

( ) Reinstall the CRT

THIS COMPLETES THE INSTALLATION.

( ) Install the insert pages in the Instruction Manual.

( ) Moisten the back of the MODIFIED INSTRUMENT tag (from kit) and place it on the Time-Base Gate and Unblanking schematic in the Manual.

JT:ls

INSTRUCTION MANUAL

MODIFICATION INSERT

7548 VACUUM TUBE REPLACEMENT

TYPE 519 r- SN 105 - 742

Installed in Type 519 SN________ Date____________

This insert has been written to supplement the Instruction Manual for this instrument. The information given in this insert will supersede that given in the manual.

GENERAL INFORMATION

Type 12HG7 vacuum tubes, PN 154-0496-00, replaced type 7548 secondary emission tubes, PN 154-0310-00, which are no longer available. The 7548 tubes were used in the Delayed Gate and Unblanking Amplifier, V214, and the Sweep Gate Amplifier, V244.

Both V214 and V244 had to be replaced at the same time because of the different filament current and grid-cathode bias requirements.

The Dynode Regulator circuit, V374A, for the 7538 tubes was removed. The Unblanking Pulse Clamp circuti, V223, was replaced with a diode semiconductor clamp circuit having considerably less input capacity.

The Delayed +Gate, which was previously derived from the Dynode element of V214, is now provided by adding two transistor Delayed +Gate Amplifiers, Q214 and Q215.

The Delayed +Gate Amplifier circuit and the Unblanking Pulse Clamp circuit were wired on a sub-assembly which plugged into the old V223 tube socket. The remainder of the modification was installed by rewiring the V223, V214 and V244 circtuiry.

RECALIBRATION

If optimum performance of the CRT unblanking is required, this procedure should be used to select R229 for fastest risetime of unblanking waveform.

The risetime of the unblanking waveform determines how soon the CRT will be unblanked after the sweep starts.

The procedure for selecting R229 is as follows:

1. Set TIME BASE NANOSEC/CM switch to 100.
2. Set TRIGGER PULSE AMPLITUDE knob to full clockwise.
3. Set TRIGGER FUNCTION switch to PULSE.
4. Adjust HORIZONTAL POSITION to align the start of sweep with left edge of graticule.
5. Set TIME BASE NANOSEC/CM switch to 2.
6. With normal INTENSITY setting, observe the distance from the left edge of the graticule to the beginning of the trace. This distance should be 1.5 cm.
7. If it is not 1.5 cm, turn instrument off and change the value of R229. (The nominal value of R229 is 240Ω.) R229 should be selected in increments of standard 1/2 W 5% resistor values.
8. Repeat steps 1 through 7 as needed.

Select R244 as follows:

Select R244 for a 50-70V pulse, measured at pin 7 of V244, with a 50MHz test oscilloscope (with 519 sweep speed set at 2 ns). If a 30 MHz test oscilloscope is used, selecte R244 for a pulse of 40-50V.

Nominal installed value is 39Ω.

ELECTRICAL PARTS LIST

Values fixed unless marked variable.

Ckt.No.	Part Number	Description			
		CAPACITORS			
C213	283-0080-00	0.022 μF	25 V	+80% -20%	
C214	290-0217-00	250 μF	12 V		
C217	283-0026-00	0.2 μF	25 V		
C221	Delete				
C225	Delete				
C229	Delete				
C230	290-0149-00	5 μF	150 V		
C231	290-0002-00	8 μF	450 V		
C241	Delete				
C243	283-0080-00	0.022 μF	25 V	+80% -20%	
C244	290-0217-00	250 μF	12 V		
		DIODES			
D214	152-0233-00	Silicon			
D215	152-0233-00	Silicon			
D220	152-0150-00	1N3037B			
D221	152-0150-00	1N3037B			
D226	152-0233-00	Silicon			
D227	152-0233-00	Silicon			
		RESISTORS			
R215	301-0471-00	470 Ω	1/2 W	comp	5%
R216	316-0102-00	1 k	1/4 W	comp	10%
R217	Delete				
R218	Delete				
R221	Delete				
R222	Delete				
R223	Delete				
R224	Delete				
R225	Delete				
R228	Delete				
R229	301-0241-00	240 Ω	(nominal value)*		
R230	308-0213-00	25 k	7 W	WW	5%
R236	Delete				
R237	Delete				
R238	Delete				
R239	316-0221-00	220 Ω	1/4 W	comp	10%
R240	316-0100-00	10 Ω	1/4 W	comp	10%
R241	Delete				
R244**	301-0290-00	39 Ω	1/2 W	comp	5%

*May be selected for optimum risetime and minimum ringing of unblanking waveform.
**Selected.

		TRANSISTORS
Q214	151-0108-00	Silicon, NPN
Q215	151-0133-00	Silicon, PNP

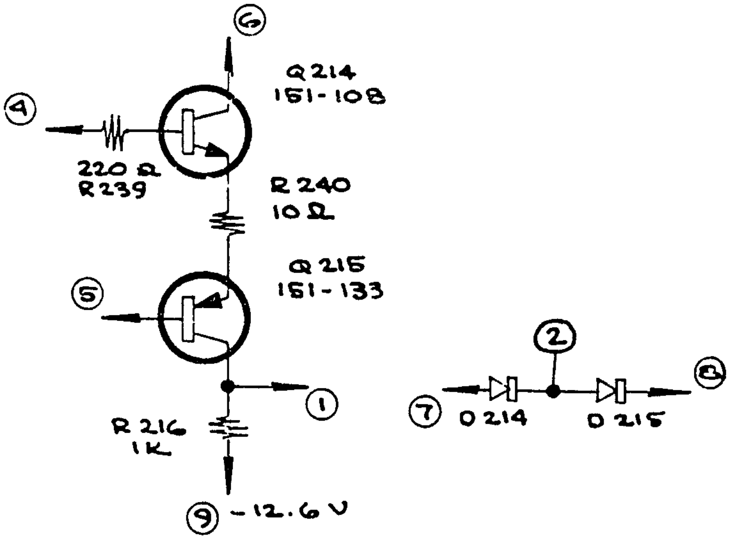
ELECTRICAL PARTS LIST (cont)

Ckt. No.	Part Number	Description
		TUBES
V214	154-0496-00	12HG7
V223	Delete	
V244	154-0496-00	12HG7

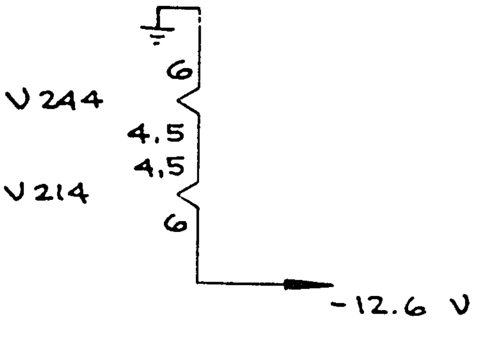
MECHANICAL PARTS LIST

214-0012-00	Bolt, spade, 6-32 x 3/8
343-0005-00	Clamp, cable, 7/16, plastic
210-0003-00	Lockwasher, ext #4
210-0006-00	Lockwasher, int #6
210-0203-00	Lug, solder, SE6 (long)
210-0407-00	Nut, hex, 6-32 x 1/4
386-1030-00	Plate, mounting, semiconductor
354-0234-00	Ring, locking, transistor socket
385-0107-00	Rod, nylon, 1/4 x 3/4, tapped 4- [illegible] thru
211-0012-00	Screw, 4-40 x 3/8 PHS, Phillips
211-0031-00	Screw, 4-40 x 1 FHS
211-0507-00	Screw, 6-32 x 5/16 PHS, Phillips
136-0181-00	Socket, transistor, 3-pin
136-0099-00	Socket, 9-pin, cable end
334-1008-00	Tag, '12HG7'
210-0802-00	Washer, flat, 6L x 5/16 x 0.028

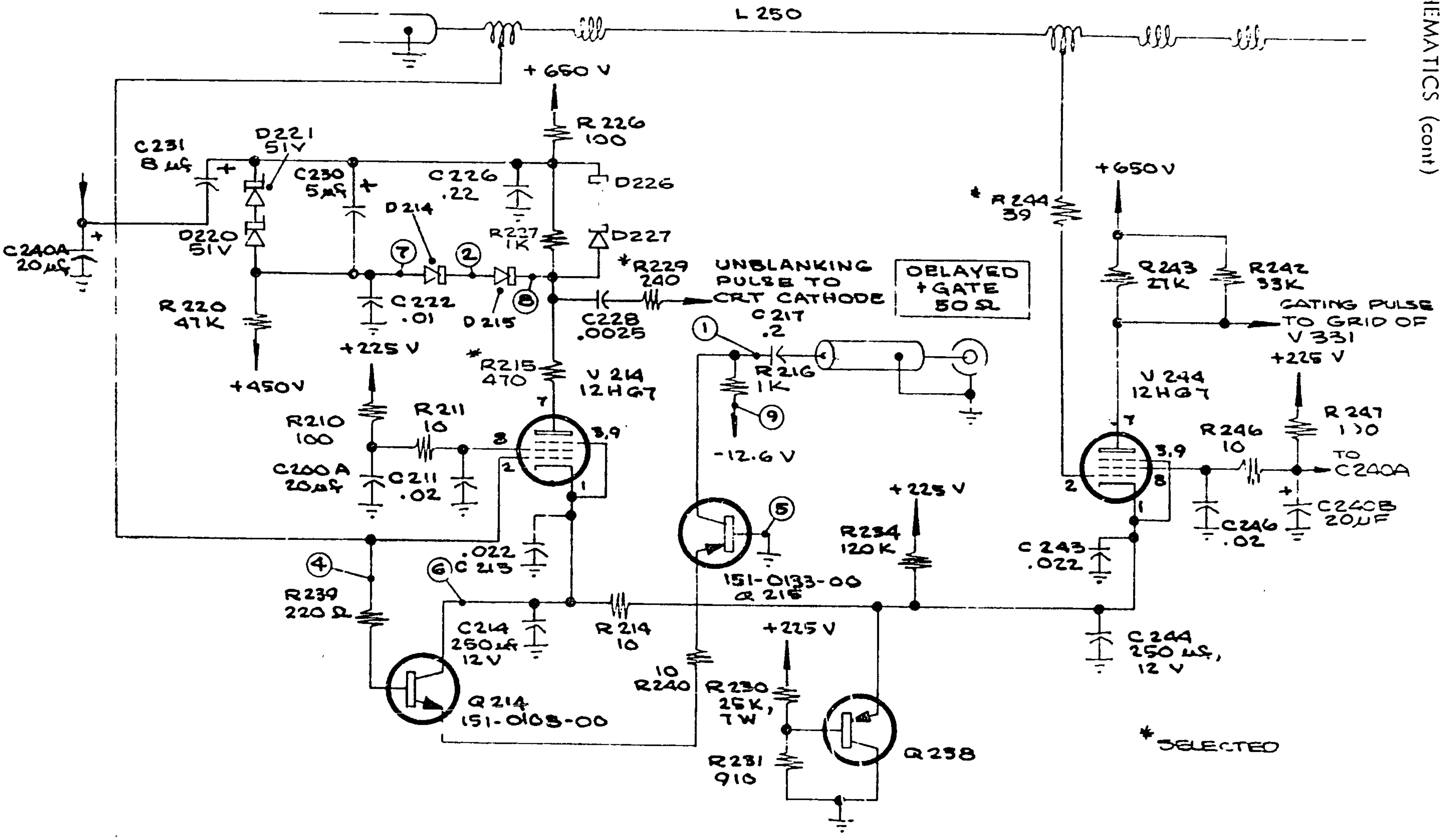
SCHEMATICS



Delayed +Gate Amplifier Diagram
Circled numbers indicate socket pin number



Heater Wiring Diagram
(V214, V244 only)



Partial Diagram TIME-BASE GATE and UNBLANKING
Circled numbers indicate pins on old V223 socket
NOTE: V223 and V374A have been deleted from circuit by this mod.