INSTRUCTION MANUAL

Serial Number ______________

TYPE 3T2 RANDOM SAMPLING SWEEP

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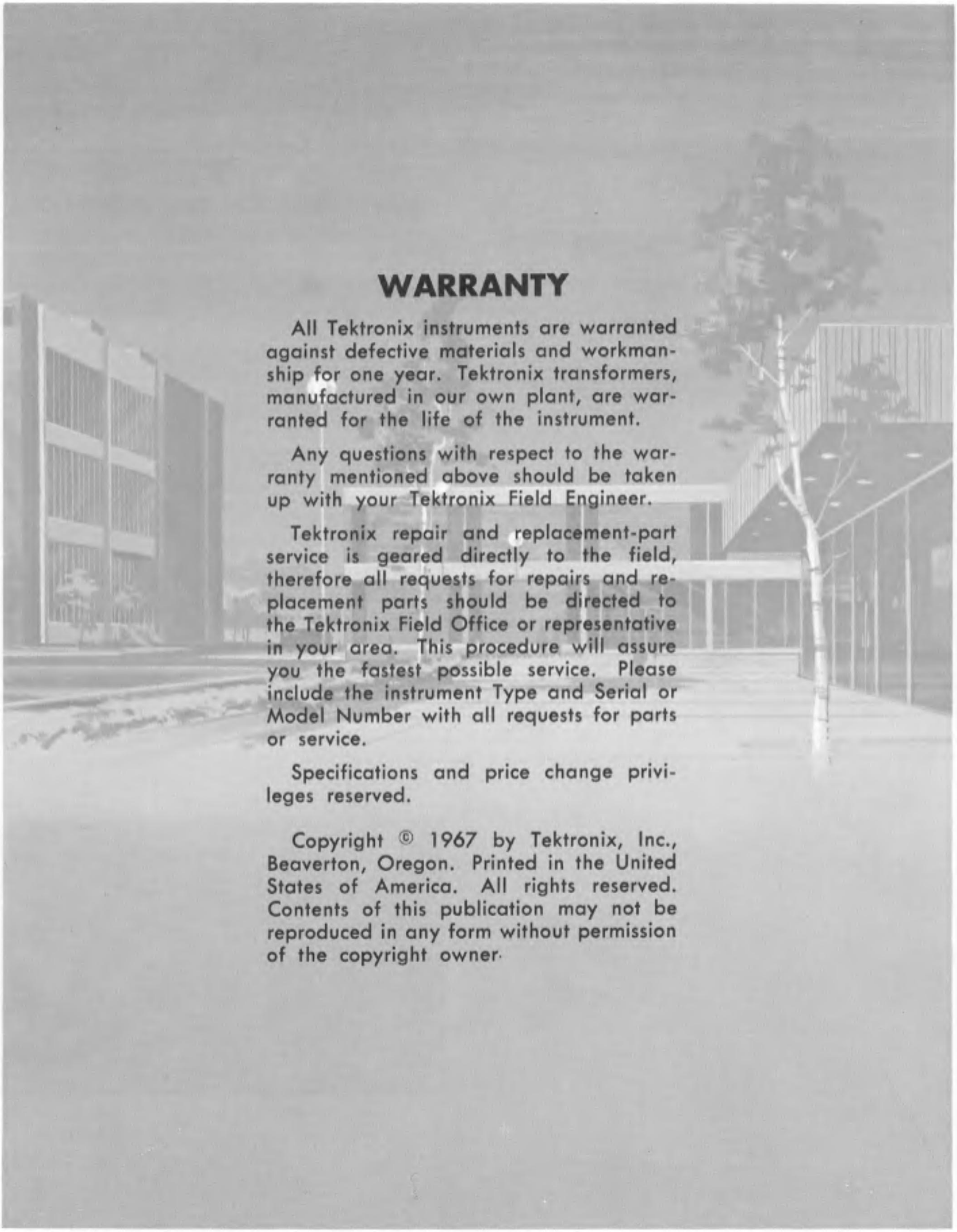

WARRANTY

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

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

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 or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

Fig. 1-1. The Type 3T2 Random Sampling Sweep plug-in unit.

SECTION 1
CHARACTERISTICS

Introduction

The Tektronix Type 3T2 Random Sampling Sweep plug-in unit is a wide range sampling time base designed to provide high speed displays with vertical units that have no signal delay following the trigger take-off point. It will operate in any of the Tektronix 560 Series oscilloscopes except the Type 560 and the Type 561. (It will operate in the Type 561A.) The Type 3T2 provides all the horizontal information needed for time measurements by either Tektronix digital readout system, the Type 567-Type 6R1A, or the Type 568-Type 230.

The Type 3T2 Random Sampling Sweep unit is designed to operate within the Type 561A, RM561A, 564, RM564, 567, RM567, 568 and R568 Oscilloscope main frames, and with the following Tektronix equipment.

Type 3S1, 3S3, or other 3-Series vertical sampling units.

Type 230, 6R1A, and some 6R1 Digital Units, (see below).

Digital readout is available only when the Type 3T2 is operated in a Type 567, RM567, 568 or R568 Oscilloscope main frame.

Controlled Sequence Random Sampling operation is the main feature of the Type 3T2. The sampling process may be changed from random to conventional by one switch (the START POINT switch). Conventional process sampling requires either a vertical unit signal delay after trigger take-off or an external pretrigger signal to the Type 3T2 in order to display the signal point at which triggering occurs. Random process sampling permits the display to start in advance of the triggering event, thus allowing the signal time region to be displayed both before and after the related triggering event.

Critical analysis of low repetition rate signals is possible through the use of either storage oscilloscope or a photograph. Storage displays are obtained by using the Type 3T2 in a Type 564 or RM564 Storage Oscilloscope. Permanent record photographs of CRT displays are possible with any one of several Tektronix Oscilloscope cameras.

ELECTRICAL CHARACTERISTICS

Digital Unit Compatability

The Type 3T2 Random Sampling Sweep unit is compatible for operation with all Type 230 Digital Units and all Type 6R1A Digital Units. It is compatible with all Type 6R1 Digital Units SN 695 and up. Type 6R1 Digital Units SN 101-694 (with exceptions beginning at SN 391) require the installation of Tektronix Modification Kit 040-0342-00 when operated with a Type 3T2. See your Tektronix Field Engineer for details.

The Type 3T2 will perform within all specifications when operated with a Type 6R1A in a Type 567 SN 300-up, or in a Type RM567 SN 130-up. This applies only if the Type 3T2 is operated in a calibrated system. Prime requirement of the oscilloscope power supplies is that all adjustable supplies be within 1% of stated values. If using sampling with the Type 567 and Type RM567, it is best to adjust low-voltage supplies to within 0.5%. If the Type 3T2 is to be operated in earlier 567 oscilloscopes, it is necessary to install Field Modification Kit 040-0319-00. Individually purchased Type 3T2 units (not calibrated in a system at the factory) require calibration in the system into which it is placed if operated with a Type 6R1, and/or in a Type 567 SN 299 or below or a Type RM567 SN 129 or below. Perform the following steps of the Calibration Procedure at the back of this manual: steps 14, 19 and 20.

The following characteristics apply over an ambient temperature range of 0° C to +50° C. These characteristics apply only after the Type 3T2 has been properly mated to the oscilloscope and after suitable warm-up time. For prescribed warm-up time in a particular system, refer to the Main Frame oscilloscope Instruction Manual. A procedure for mating the Type 3T2 to each oscilloscope can be found in the Operating Instructions section of this manual.

ELECTRICAL CHARACTERISTICS

Characteristic	Performance Requirement	Supplemental Information

TRIGGERING

NOTE

In the following trigger section, the amplitudes listed following the Sensitivity Range title, are those in which the TRIG SENSITIVITY control permits triggering at the low amplitude value, and allows the control to hold off the trigger circuits for signals up to the high amplitude value. However, satisfactory triggering can be obtained for most signals at amplitudes up to the maximum permitted:—±5 V External 50 Ω, ±2 V Internal and ±100 V External 1 MΩ/UHF SYNC.

Characteristic	Performance Requirement	Supplemental Information
Sine wave Triggering Internal Frequency Range	100 kHz to 500 MHz	Trigger signal amplitude may have to be adjusted for minimum display jitter, depending upon frequency and RECOVERY TIME control. Minimum display jitter may not meet jitter limits stated below if triggering frequency is other than 30 MHz.
Sensitivity Range	(3S1) 80 mV to 2.00 V P-P at vert input. (3S76) 50 mV to 1.25 V P-P at vert input.	

ELECTRICAL CHARACTERISTICS (cont)

Characteristic	Performance Requirement	Supplemental Information
Sine Wave Triggering (cont) External 50 Ω Input Frequency Range	100 kHz to 500 MHz	
Sensitivity Range	10 mV to 250 mV P-P	
1 MΩ/UHF SYNC Input Frequency Range + POLARITY	10 kHz to 100 MHz, triggered. 500 MHz to 3 GHz, UHF SYNC.	UHF SYNC displays may be affected by the POLARITY switch. Check both positions of the POLARITY switch for best UHF SYNC displays.
— POLARITY	100 kHz to 100 MHz, triggered. 500 MHz to 3 GHz, UHF Sync.	
Sensitivity Range	10 mV to 500 mV P-P	
Pulse Triggering Internal Repetition Rate Range	10 Hz to 600 MHz	Trigger signal amplitude may have to be adjusted for minimum display jitter, depending upon pulse rise rate, repetition rate and RECOVERY TIME control.
Sensitivity Range	(3S1) 80 mV to 1.00 V P-P at vert input. (3S76) 50 mV to 625 mV P-P at vert input.	Applies for pulses of 10 Hz to 100 kHz and low duty factor above 100 kHz. As duty factor approaches 50% (above 100 kHz), maximum amplitude that TRIG SENSITIVITY control can hold off increases to: (3S76) 1.25 V P-P and (3S1) 2.00 V P-P.
External 50 Ω Input Repetition Rate Range	10 Hz to 600 MHz	Trigger signal amplitude may have to be adjusted for minimum display jitter, depending upon pulse rise rate, repetition rate and RECOVERY TIME control.
Sensitivity Range	5 mV to 125 mV	Applies for pulses of 10 Hz to 100 kHz and low duty factor pulses above 100 kHz. As duty factor approaches 50% (above 100 kHz), maximum amplitude that TRIG SENSITIVITY control can hold off increases to 250 mV P-P.
1 MΩ/UHF SYNC Input Repetition Rate Range	10 Hz to 100 MHz, triggered. 600 MHz to 3 GHz, UHF SYNC.	
Sensitivity Range	10 mV to 250 mV	As duty factor approaches 50% (above 10 kHz), maximum amplitude increases to 500 mV.
Trigger Jitter Sinewave Internal	(3S1) $\leq$200 ps when signal is 900 mV P-P at 30 MHz. (3S76) $\leq$200 ps when signal is 500 mV P-P at 30 MHz.	Sine wave display jitter is checked with START POINT switch at WITH TRIGGER only.
External 50 Ω Input	$\leq$200 ps when signal is 100 mV P-P at 30 MHz.	External limits checked for best (least) jitter at + and — POLARITY. Limits valid for one polarity, but not necessarily both polarities.
1 MΩ/UHF SYNC	$\leq$50 ps when signal is 100 mV P-P at 1 GHz.	
Pulse Internal With Trigger	(3S1) $\leq$30 ps when pulse is 400 mV, 2 ns duration. (3S76) $\leq$30 ps when pulse is 250 mV, 2 ns duration.	

ELECTRICAL CHARACTERISTICS (cont)

Characteristic	Performance Requirement	Supplemental Information
Pulse (cont) Before Trigger	(3S1) $\leq$50 ps when pulse is 400 mV, 2 ns duration. (3S76) $\leq$50 ps when pulse is 250 mV, 2 ns duration.	
External (50 Ω Input) With Trigger	30 ps or less trigger jitter with 50 mV, 2 ns duration pulse. 2 ps or less trigger jitter with 150 mV, 2 ns duration pulse.	
Before Trigger	50 ps or less trigger jitter with 50 mV, 2 ns duration pulse.	
Minimum trigger repetition rate in BEFORE TRIGGER operating mode RANGE		
1 ms and 100 μs	10 Hz	LOW REP RATE light turns on and sweep stops when trigger signal is below these limits.
10 μs	100 Hz	
1 μs	1 kHz	
100 ns	10 kHz	
Minimum trigger signal rise rate.	150 mV/μs.	Applies for External 50 Ω input and Internal triggering, — POLARITY only.
Maximum input voltage to external trigger input connectors. 50 Ω Input 1 MΩ/UHF SYNC Input		 ±5 V. ±100 V.

HORIZONTAL DEFLECTION SYSTEM

Characteristic	Performance Requirement	Supplemental Information
Timing Accuracy DISPLAY mag SW: ×1	±3% (±5% on 100 ns Range when TIME MAGNIFIER is at ×5 through ×50.)	Limits apply after adjustment of front panel HORIZ GAIN control. See Step 9 of the Calibration procedure in this manual.
DISPLAY mag SW: ×10	±5% (±7% on 100 ns Range when TIME MAGNIFIER is at ×5 through ×50.)	Measured in graticule center eight divisions and excluding first part of sweep as listed below under RANGE Exclusion.
RANGE Exclusion	Range beginning which is non-linear; above timing tolerances do not apply.	Displayed sweep is fully within limits when TIME POSITION controls position non-linear region to left of time window, off the CRT.
1 ms	First 15 μs. (1.5% of Range)	
100 μs	First 1.5 μs. (1.5% of Range)	
10 μs	First 150 ns. (1.5% of Range)	
1 μs	First 15 ns. (1.5% of Range)	
100 nS	First 10 ns. (10% of Range)	
EXT. HORIZ INPUT Deflection Factor	Adjusted by HORIZ GAIN control to 1.5 V/Div, ±3%.	
MANUAL SCAN Range	Adjusted by HORIZ GAIN control to be 10 divisions.	
Time Magnifier VARIABLE Range	2.5:1	Fully clockwise, fastest sweep rate is approximately 80 ps/div.
SWP OUT Connector signal (SN B080970-up)	1 V/Div, ±5% (through 10 kΩ) 1× MAG 0.1 V/Div, ±5% (through 10 kΩ) 10× MAG	
SWP OUT Connector signal (SN B010100-B070969)	1 V/Div, ±5%	Through 10 kΩ

ENVIRONMENTAL CHARACTERISTICS

Storage

Temperature— −40°C to +65°C.

Altitude—To 50,000 feet.

Operating

Operating Temperature— 0°C to +50°C.

Operating Altitude—To 15,000 feet.

MECHANICAL CHARACTERISTICS

Dimensions—	Height	$6^5/_{16}$ inches.	Approximate dimensions including knobs and connectors.
	Width	$4^5/_{16}$ inches.	
	Length	$14^1/_4$ inches.	

Construction— Aluminum alloy chassis with epoxy laminated circuit boards. Front panel is anodized aluminum.

Accessories— An illustrated list of the accessories with the Type 3T2 is at the end of the Mechanical Parts List pullout pages.

NOTES

SECTION 2
PRINCIPLES OF TYPE 3T2 RANDOM PROCESS SAMPLING

NOTE

A glossary of terms can be found at the end of this section of the manual.

General

The Type 3T2 Random Sampling Sweep unit has two basic modes of operation. The chief difference between them is that one mode constructs the equivalent time sampling display by a conventional process, where the triggering event itself cannot be fully displayed without the use of a second delay line or a pretrigger. Since it is more desirable to view the triggering event fully by somehow starting the sweep early, or by delaying the vertical signal, a second mode of operation is included in the Type 3T2. The second mode can randomly sample the signal time region both before and after the triggering event; so the triggering event itself can be conveniently displayed on the CRT. A fixed range of the signal time region can be viewed by either mode, except that the second (random) process allows the time region range to be positioned to include information before, as well as after, the triggering event. Time positioning of the sampled time region is referred to as the positioning of a time window.

When the Type 3T2 is producing a display by the conventional process, the time window can be positioned to start with (or within a few nanoseconds after, but not before) trigger recognition. When the Type 3T2 is randomly sampling before and after the triggering event, the time window can be positioned to start before trigger recognition. The front panel Time Position Range START POINT switch selects the operating process (WITH TRIGGER or BEFORE TRIGGER) for the Type 3T2. Random sampling permits viewing the triggering event without the use of a vertical-channel delay line or a pretrigger signal. The conventional process sampling circuits are included in the Type 3T2 for operating with very low repetition rate signals that cannot be displayed by random circuitry, and for displaying signals when smoothing must be used in the vertical unit.

The following Logic Description defines conventional-process and random-process sampling within the Type 3T2 by the use of block diagrams and time-ladder waveforms.

Sweep Generation

Sweep generation within the Type 3T2 is different for the two modes of operation. Operation with the START POINT switch at WITH TRIGGER causes the sweep to be driven by a staircase signal. Operation with the START POINT switch at BEFORE TRIGGER causes the sweep to be driven by the output of the horizontal memory, whose DC voltage is determined by a series of ramps interrupted at different amplitudes. Each different ramp amplitude corresponds to a different horizontal dot position on the CRT screen. The two generalized forms of sweep generation signals are shown in the drawings of Fig. 2-1.

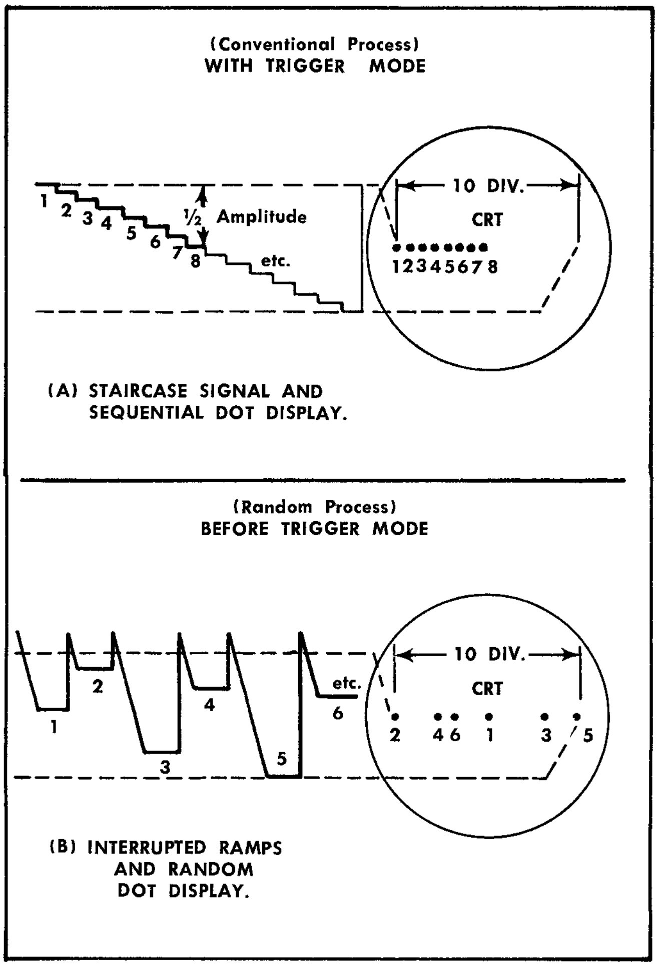

Fig. 2-1. Comparison of CRT horizontal dot display of staircase and interrupted ramps.

Fig. 2-1A is a negative-going staircase signal where each fixed voltage level corresponds to a fixed CRT dot position. The CRT is blanked off during the time the staircase is stepping.

Fig. 2-1B is of a series of negative-going ramp signals each stopped for a definite time. Each fixed voltage level of each interrupted ramp corresponds to a fixed CRT dot postion. The CRT is blanked off when a sample is taken, and unblanked after the horizontal memory is repositioned.

With Trigger Mode (Conventional Sampling Process)

The conventional sampling process (the with-trigger mode) is shown in basic form in Fig. 2-2. The waveforms represent just two samples in a sequence, such as the fifth and sixth dots of a many-dot display. Each waveform is identified with its block or interconnections in the adjacent block diagram.

The trigger regenerator circuit is the master programmer of Fig. 2-2. It delivers a negative step pulse at the time of trigger recognition, T_o, to start the process that takes and displays one sample. Immediately after T_o the trigger circuits lock out any more triggers until the rest of the circuits have operated and the dot has been properly displayed. (The period of time during which triggers are locked out is called the holdoff time, and is made variable by the Type 3T2 front panel RECOVERY TIME control. See the Operating Instructions for RECOVERY TIME control uses.)

At T_o, the trigger circuit starts the timing ramp running in a negative direction. The timing ramp "times" the occurrence of the strobe drive pulse sent to the vertical sampling unit

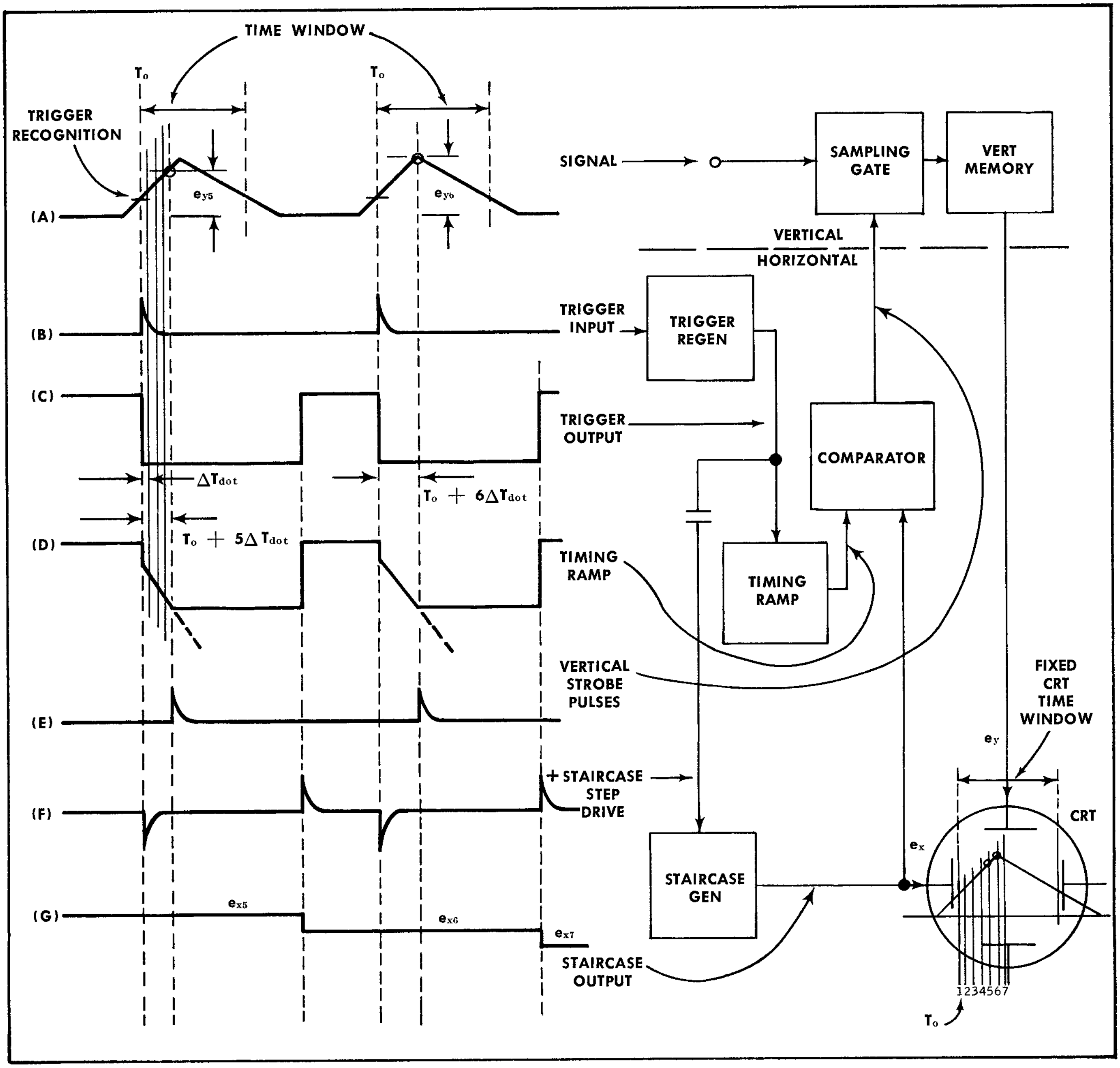

Fig. 2-2. Basic "with trigger" mode sequential sampling oscilloscope.

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as the timing ramp is compared with the voltage of the staircase generator in the comparator block. Since the staircase output signal voltage is different for each trigger circuit output pulse, the timing ramp is allowed to run down farther for each successive sample. The result is a time "slewing" of successive sampling times. The slewing increment is identified in Fig. 2-2 as ΔT_{dot} and is a fixed time increment per sample. ΔT_{dot} is set by both the timing ramp slope and the staircase step amplitude.

The waveforms of Fig. 2-2 imply that there can be a CRT dot displayed from the time of the vertical strobe pulse to the time of the timing ramp reset. Actually the CRT blanking is also controlled by the vertical sampling unit. The vertical unit prevents CRT beam current at the time of the vertical strobe pulse and until the vertical memory is stable, typically for 2 to 3 μs.

Adding Sweep Rate and Movable Time Window Controls

The Time window (sampled signal time domain) identified in Fig. 2-2 can be moved so that a different portion of

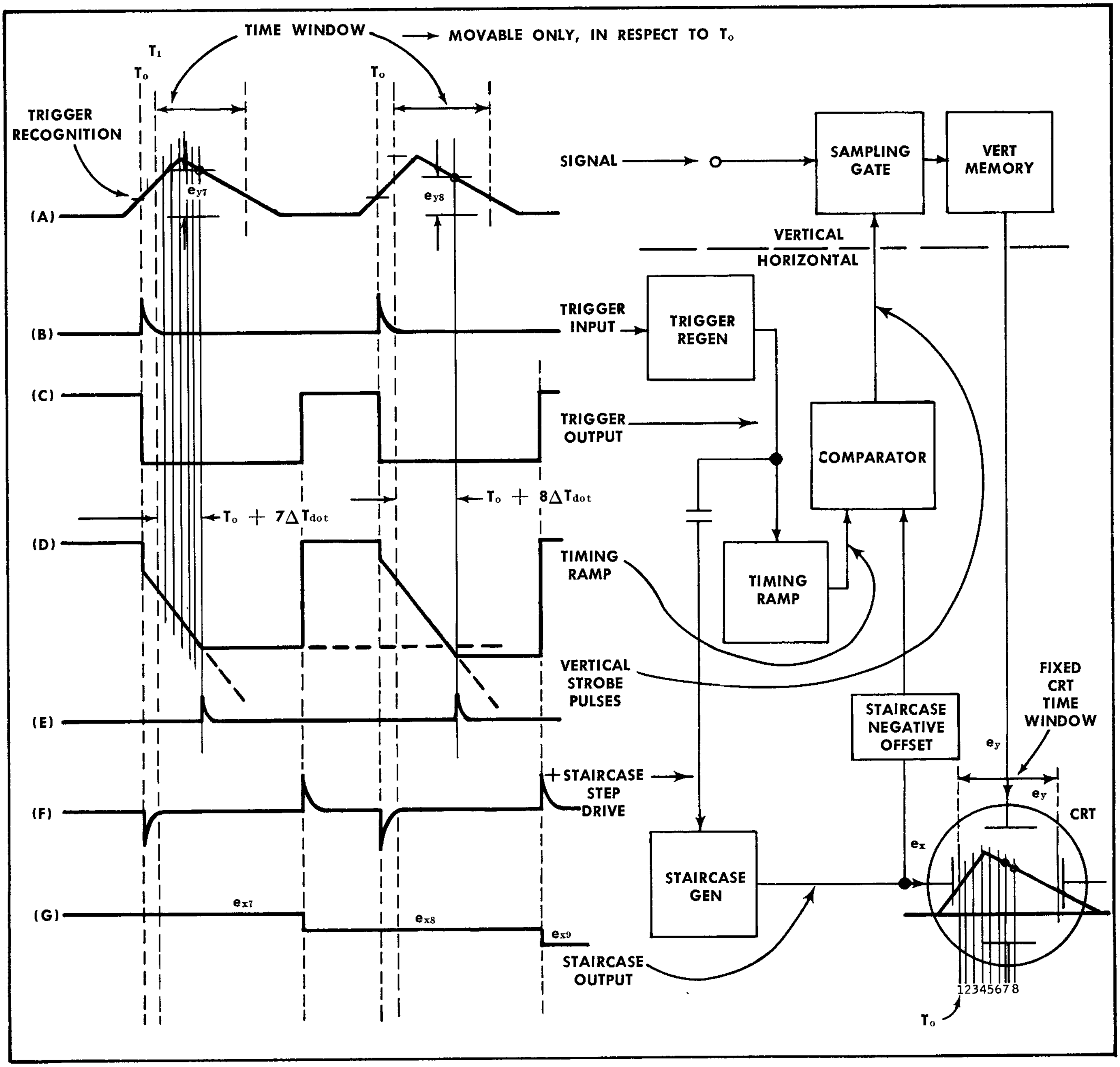


Fig. 2-3. Adding a Time Position control to basic block of Fig. 2-2.

the signal is displayed. Fig. 2-3 shows a Time Position control added between the Staircase Gen block and the comparator block. This new circuit allows a negative DC voltage offset to be applied to the staircase signal that is compared with the timing ramp signal. Since the comparator block is a DC coupled comparator, changing the DC level of the staircase signal in a negative direction causes the timing ramp signal to travel farther negative before comparison occurs. Since the timing ramp signal is a ramp, the more negative comparison results in a later comparison and later vertical strobe pulses than before the staircase signal was offset.

The staircase signal sent to the CRT is not altered; thus, the voltages that set the CRT dot positions are not changed, the first dot occurring at the CRT left side. If the Time Position control applies a negative offset to the staircase signal that feeds the comparator block, the first displayed dot at the CRT left side will have a vertical voltage related to the signal amplitude at time T_1 (see Fig. 2-3 upper left). The result is an apparent horizontal shift of the displayed signal to the left. The circuits of the Type 3T2 allow only a negative offset to be applied to the staircase signal, thus permitting the movable time window to include only portions of the signal AFTER trigger recognition time, T_o.

Fig. 2-3 does not show any method that will alter the equivalent time sweep rate. Three different controls are used to alter the Type 3T2 sweep rate. One is the Range control that alters the slope of the Timing Ramp; another is the Time Magnifier control that alters the amplitude of the staircase signal sent to the Comparator block. The third method is a Display Magnifier which changes the horizontal amplifier gain.

To decrease the rate of fall $\frac{dV}{dt}$ of the timing ramp is to increase the time assigned to ΔT_{dot} (ΔT_{dot} is the equivalent time between dots). Since the staircase signal to the CRT is not altered and the real time presentation of dots is not altered, increasing ΔT makes the display have a slower equivalent time sweep rate (more time per CRT division). A slower sweep rate will allow a longer period of the input signal to be displayed.

To increase the rate of fall of the timing ramp is to speed up the equivalent time sweep rate. The Type 3T2 RANGE control changes the timing ramp rundown rate. (It also alters the trigger circuit holdoff time to avoid display confusion, so the trigger circuits don't recognize the input signal until after the dot has been properly displayed.)

To reduce the amplitude of the staircase signal sent to the Comparator block is to reduce the time assigned to ΔT_{dot}. Since the staircase signal to the CRT is not altered, and the real time presentation of dots is not altered, reducing ΔT_{dot} makes the display have a shorter equivalent time sweep rate (less time per CRT division). The Type 3T2 TIME MAGNIFIER control attenuates the staircase signal (when at other than at $\times 1$) that is sent to the Comparator block.

Manual Scan

The above description of "With Trigger" operation is complete so far as a continuously running sweep display is concerned. The Type 3T2 front panel DISPLAY MODE switch must be at its NORMAL position for the system to function as described. If the DISPLAY MODE switch is placed at MANUAL SCAN, the operator can manually control the horizontal position and rate of movement of the sampling dot, even leaving the dot at a fixed position. Manual Scan operation substitutes a manually variable DC voltage for the staircase signal. The manually variable voltage has the same limits as the staircase signal so that with the MANUAL SCAN control fully counterclockwise, the sampling dot position is at the CRT display left end. With the MANUAL SCAN control fully clockwise, the sampling dot position is at the CRT display right end.

During manual scan operation, Comparator block input signals are the timing ramp and the variable DC voltage. If the variable DC (manual scan) voltage is left at a fixed value, the Comparator block sends a strobe pulse to the vertical sampling unit at a constant interval after each T_o. There is no ΔT_{dot}, and therefore no slewing of the strobe drive in relation to T_o.

Moving the MANUAL SCAN control changes both the voltage level along the timing ramp signal and the voltage sent to the CRT. Since the trigger circuits function exactly as they do during NORMAL scan operation, the operator can now position the dot along the display at a rate to suit his convenience.

External Horizontal Scan

The Type 3T2 DISPLAY MODE switch permits an externally generated variable voltage to scan the sampled display when the switch is placed at its EXT HORIZ position. The external voltage is applied to the comparator block and to the CRT in the same manner as the Manual Scan voltage is applied. Thus, the external voltage can move the CRT dot along the triggered display. Some Y-T recorders can supply a potentiometrically derived voltage corresponding to the T-coordinate of the stylus.

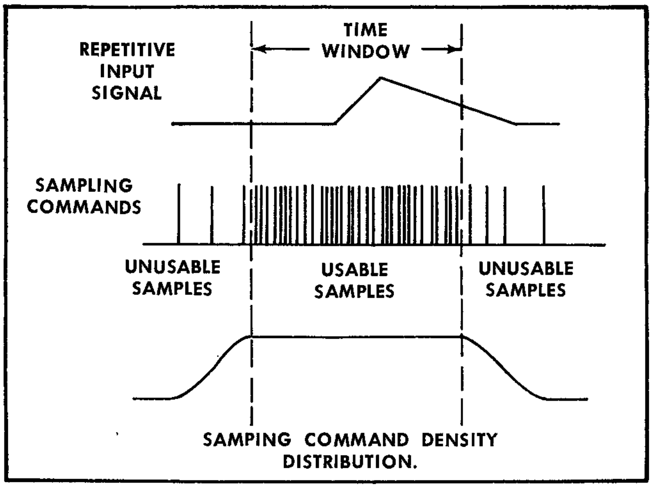


Fig. 2-4. Distribution of random samples related to repetitive input signal and CRT time window.

Before Trigger Mode (Random Sampling Process)

The "Before Trigger" mode or Random process of sampling by the Type 3T2 Random Sampling Sweep unit may be described as a system that produces a CRT display by a series of dots that are usually displayed in a nearly sequential manner from left to right. The dots are presented from left to right with a small region of randomness visible at very slow sweep rates. At fast sweep rates, or when the signal repetition rate is jittery, the display either appears to sparkle, or looks like a normal oscilloscope display.

The circuit processes of random sampling differ from both normal oscilloscope sweeps and conventional sampling oscilloscope sweeps. The processes of a random sampler are divided into two parts: timing the samples to fall somewhere within the CRT time window, and construction of a meaningful display from a series of randomly determined samples. The following description begins with a basic random sampling system and then deals directly with the controlled sequence circuit logic within the Type 3T2.

A Basic Random Equivalent-Time System

Fig. 2-4 shows how random samples may be distributed in relation to a triggering event, then how most of the samples are considered usable. Those samples considered usable are presented in the CRT display time window, and those considered not useful are eliminated by blanking of the CRT. The sampling density distribution shown applies to the Type 3T2 and is described later with the Ratemeter description.

Deriving the two analog signals that produce the coherent display of randomly taken samples is the second part of the random sampling process.

The "y", or vertical coordinate of a sample is obtained by the same sample-and-hold process used in conventional sampling oscilloscopes. This is accomplished by the vertical part of the system as referred to briefly in Fig. 2-5. The "x", or horizontal coordinate of a sample is obtained differently than in conventional sampling and is shown in basic detail in Fig. 2-5.

Five samples, taken on successive repetitions of the signal, are shown at Fig. 2-5A. Trigger recognition of the signal occurs at T_o and starts a timing ramp running up at Fig. 2-5E.

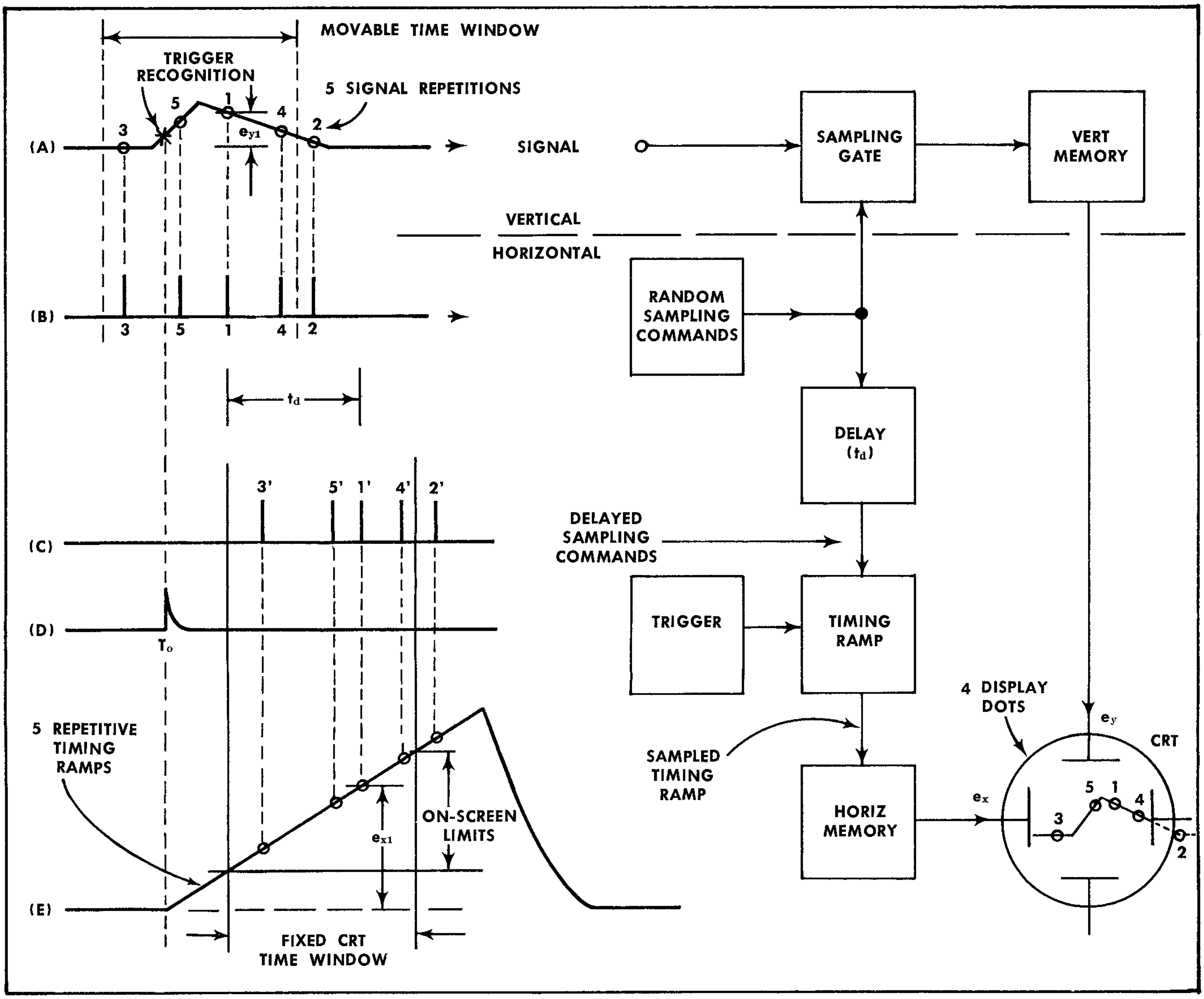


Fig. 2-5. Basic random sampling system derivation of "x" and "y" deflection signals. Signal is repetitive. Sweep rate is "equivalent time".

Each time the vertical input signal is recognized, during or before the timing ramp is started and at some random point the timing ramp, a vertical sample (e_y) is taken. The y-component, e_y, of sample number 1 is held in the vertical Memory, and used to position the CRT spot vertically. The number 1 sampling command (Fig. 2-5B) that takes the first sample is then delayed by a fixed interval t_d, and shown as 1 in Fig. 2-5C. The delayed sampling command samples the timing ramp and places a DC voltage in the horizontal Memory. The resulting "held" sample, e_{x1} is used to position the CRT spot horizontally in agreement with the original horizontal position of sample number 1 in Fig. 2-5A.

By this same process each sample supplies both vertical and horizontal information to deflect the CRT beam from dot to dot to construct a meaningful display of those samples that fall within the time window.

Remembering that the trigger recognition time T_o always starts the timing ramp at the same time with respect to the input signal, an increase in the interval t_d moves the time window to an earlier position along the time axis. Likewise, a decrease in the time interval t_d, moves the time window to a later position along the time axis. The effect is that of a movable time window in relation to the triggering event time T_o. The time window start can be moved to a time earlier than T_o by delaying the sampling commands to the timing ramp, and at the same time causing random sampling commands to occur in advance of T_o. It is through proper time separation of the two groups of sampling commands (Fig. 2-5 B and C) that the CRT display produces an equivalent-time replica of the input signal including information ahead of the trigger recognition time T_o.

A Controlled Sequence Random Process Sampling System

A simplified operational random process sampling system is shown in Fig. 2-6. The system contains a feedback

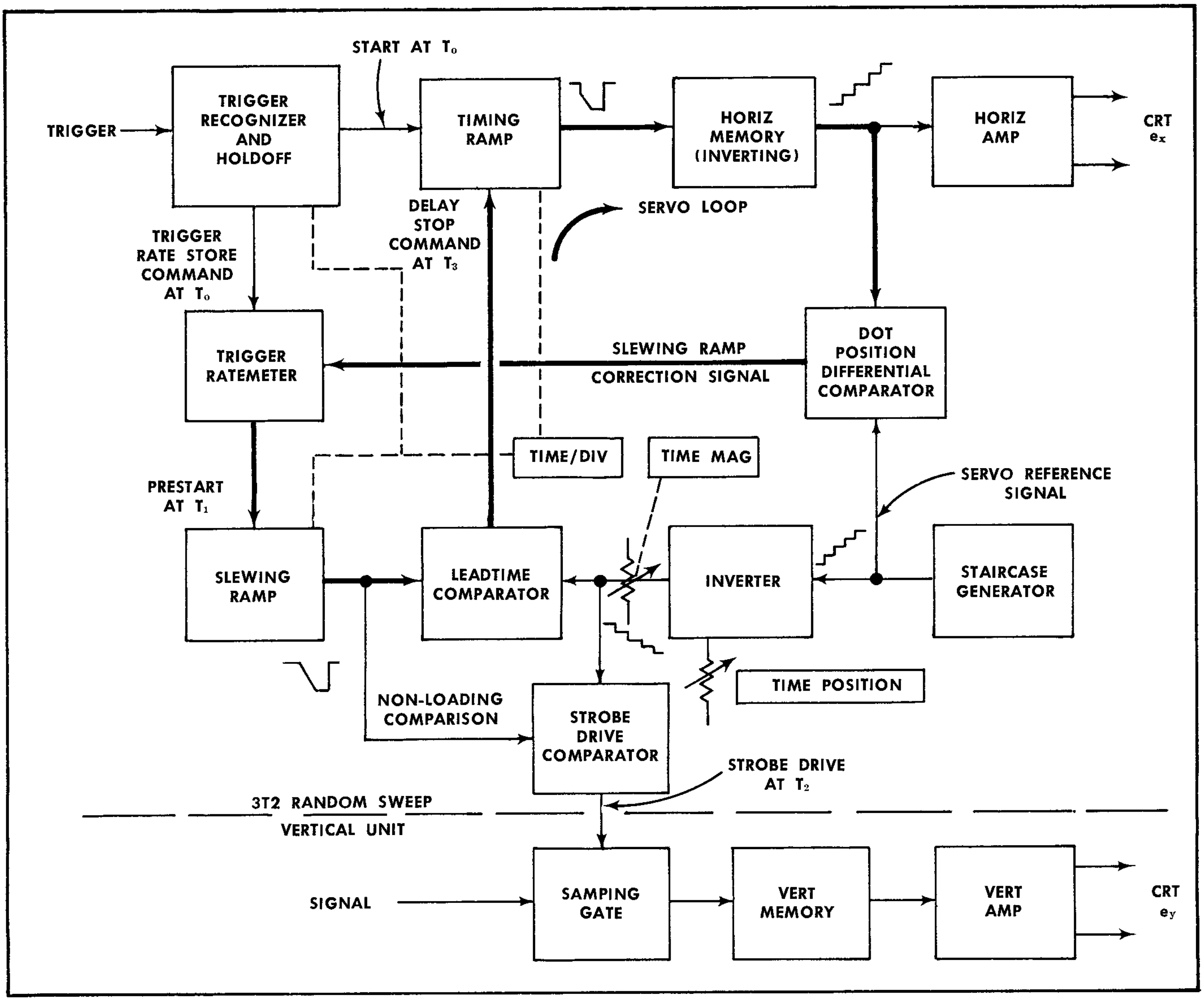


Fig. 2-6. Type 3T2 simplified random sampling process block diagram. See Fig. 3-7 for related waveforms.

loop (Servo Loop) that controls the position of the random distribution of samples across the sampled time window. The blocks belonging to the horizontal portions of the system are those of the Type 3T2 Random Sampling Sweep.

Trigger Recognizer And Holdoff

The Trigger Recognizer And Holdoff block is the master programmer for the horizontal system. This block responds to a suitable trigger signal and immediately starts the Timing Ramp. The holdoff function prevents restarting the Timing Ramp until the whole system has had time to complete its cycle begun at T_0 (when the Timing Ramp was started).

Trigger Ratemeter

The Trigger Ratemeter block is fed signals from the Trigger Recognizer And Holdoff circuits so it can measure the repetition rate of the trigger recognitions over a wide range of trigger repetition rates. On the basis of several sequential trigger rate measurements, plus a correcting signal supplied by the Dot Position Comparator, the Trigger Ratemeter then starts the Slewing Ramp **before** the next trigger recognition. The Slewing Ramp prestart command is the ratemeter's "best guess" as to when to start the Slewing Ramp (in advance of the next Timing Ramp) and may contain considerable time uncertainty from sample to sample. However, if the Slewing Ramp is started too late several times, the Dot Position Comparator recognizes the error of the Horiz Memory signal related to the Staircase signal and sends a correction signal to the ratemeter. The correcting signal causes the ratemeter to start the Slewing Ramp earlier for the next few samples.

Slewing Comparisons

The Slewing Ramp is a linear ramp that runs at the same rate as the Timing Ramp. The Slewing Ramp provides its signal to two comparators. One comparator delivers the strobe signal to the vertical unit for setting the CRT dot vertical position. The other comparator then stops the Timing Ramp, thus setting the CRT dot horizontal position. Each comparison occurs when the relatively fast slewing ramp signal reaches each of two different inverted staircase voltages. See Fig. 2-7M and its description below. Successive excursions of the slewing ramp signal find the two inverted staircase voltages at slightly more negative values. The result is that the two comparisons are successively delayed or slewed in time. The delayed stop command to the timing ramp (from the Leadtime Comparator) is generated in a manner similar to the strobe drive pulses (from the Strobe Drive comparator), but a DC offset is added to the inverted staircase signal in the Leadtime Comparator block. Thus the delayed stop commands occur later than the strobe drive pulses by the fixed time interval t_d.

Servo Loop

The closed loop (Servo Loop) causes a random distribution of samples to slew across the time window under control of the Staircase Generator signal. The resulting sampling distribution is shown in Fig. 2-4. If the uncertainty of the Slewing Ramp prestart signal generated by the Trigger Ratemeter block is purely random, then the skirts of the sampling distribution will have a gaussion shape and the central portion within the time window will contain a uniform distribution of samples. The Servo Loop keeps the average sampling density constant over the time window period in spite of trigger repetition rate jitter or ratemeter uncertainty. Construction of a display with the triggering event at center screen (without a pretrigger signal) is thus possible.

Functional Waveforms

Waveforms of Fig. 2-7 apply to both the simplified random process block diagram of Fig. 2-6 and to the functional Type 3T2. The shaded area of Fig. 2-7 is discussed later under the heading "Type 3T2 Time Position Control". Fig. 2-7 waveforms can be helpful at a time of troubleshooting because they were obtained under actual operating conditions. Two general kinds of waveforms are shown in Fig. 2-7; single line type that apply to only two successive samples, and multiple line type that apply to the samples of one whole sweep. For example, waveforms (A) through (K) and (M) apply to only two samples, and waveforms (L), (N), (O) and (P) apply to a full Type 3T2 sweep. The triggering signal had very little jitter. This caused the ratemeter ramp waveform to be identical and stable for both samples shown.

The triggering event is identified at the figure top by the term T_0. The left T_0 term and the following T_1, T_2 and T_3 terms all apply to one trigger recognition (one sample). Therefore, the shaded area covers those parts of the figure that do not relate to the first T_0, but rather to a previous T_0 that is not shown. The amount of real time included in the CRT equivalent time display is shown at the top of the page at T_0. Obviously that period of real time is presented on the CRT by many dots with an equivalent time sweep rate.

Fig. 2-7 has two columns of waveform identification: on the left, the signal source or circuit element where the test oscilloscope probe was connected. On the right, the name of the function related to particular part of the waveform, and in some cases the relationship of two waveforms or circuits, is stated.

At the time of trigger recognition T_0, the trigger circuits start actions represented by waveforms (B), (F), (G), (H), (I) and (O). These waveforms show; (B) the trigger holdoff time starts; (F) the holdoff circuit delivers a timing ramp start signal; (G) a negative pulse is delivered to the front panel PULSE OUT connector; (H) the ratemeter memory gate is driven to conduction so; (I) the ratemeter memory stores the voltage value of the ratemeter ramp; (O) and the timing ramp starts its rundown.

At the holdoff time half-way point, actions take place that are represented by all the remaining waveforms except (A) and (H). These actions do not all take place simultaneously, but rather in three quick steps. 1)Just before the holdoff waveform reaches its negative turn around point, the horizontal memory is pulsed so it takes a sample of the timing ramp voltage just before the timing ramp resets. 2)About 5 microseconds later, several things happen: a memory circuit is pulsed to memorize the output voltage of the Dot Position Comparator (waveform D), the timing ramp is reset so it can be started at the next T_0 (waveforms F and O), the front panel PULSE OUT signal returns positive, the ratemeter ramp is reset for a new trigger rate measurement (waveform I), the ratemeter output drops below —10 volts and thereby resets

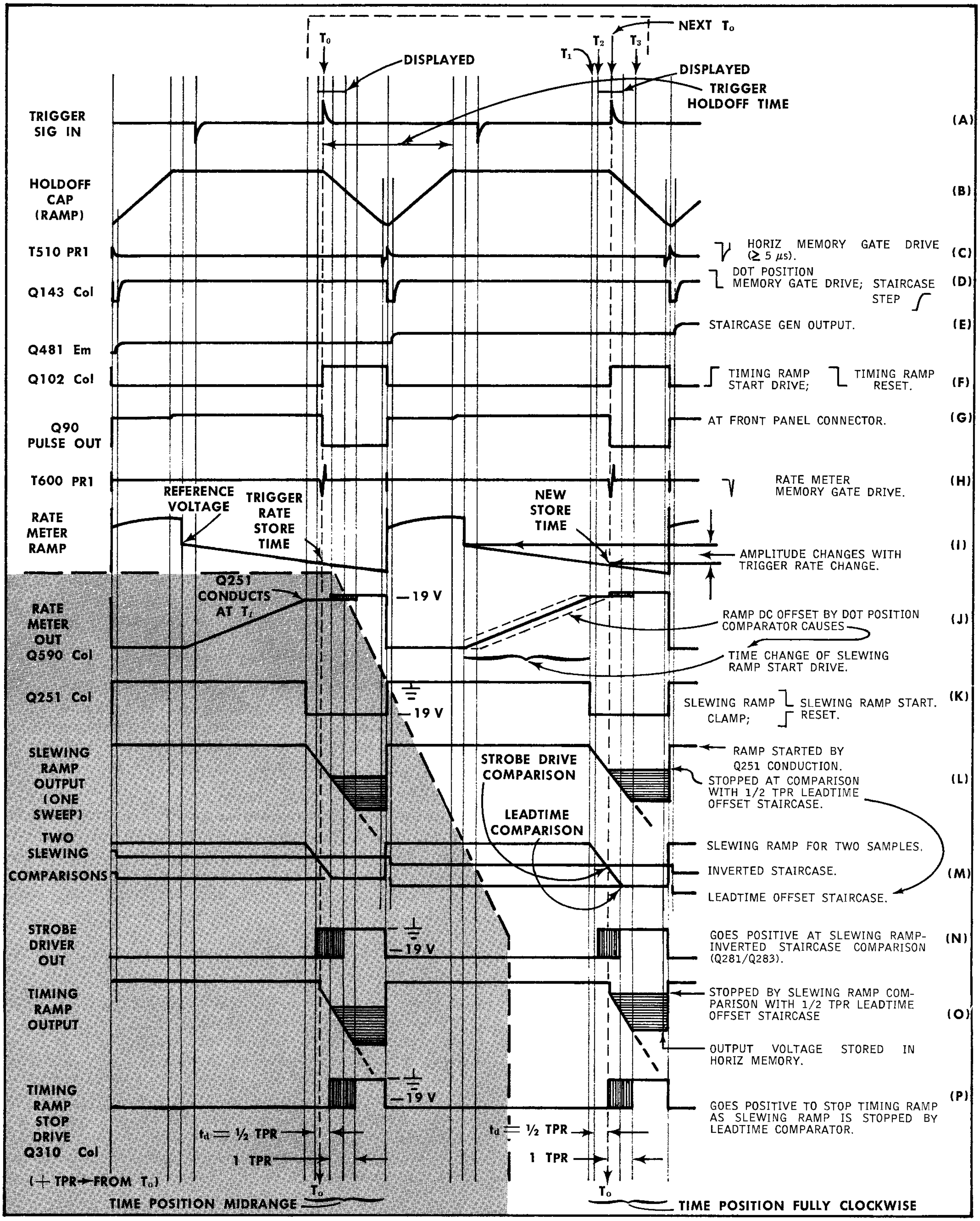


Fig. 2-7. Type 3T2 random process waveforms. Trigger circuits are not counting down.

the previous slewing ramp (waveforms J, K, L and M), and both the strobe driver and the timing ramp stop-circuit reset (waveforms N and P). 3)About 1 microsecond later the holdoff circuit steps the staircase generator (waveforms D and E) which also steps the inverted staircase signals at the slewing comparators (waveform M).

Slewing Ramp Start Time (T_1)

After the third action at one-half holdoff time, the significant circuit is the ratemeter. (The ratemeter ramp circuit operates without any commands until the next one half holdoff time.) After being reset, the ramp voltage rises positive, discharging the ramp slope capacitor. When it reaches bottom, it resets and starts the trigger rate metering ramp rundown. The ramp is designed to run more negative than shown, so that the system will operate properly on reasonably low repetition rate trigger signals.

Four waveforms, (I), (J), (K) and (L) show that the ratemeter rundown ramp (I) is inverted (J) and sets the slewing ramp start time (K) and (L). The inverted ramp (J) receives a DC offset signal from the Dot Position Comparator block to shift the conduction time of the slewing ramp clamp and the time the slewing ramp starts. The DC offset to the inverted ramp is shown in waveform (J) by dashed lines above and below the inverted ramp. It is the inverted ramp, plus the DC offset signal from the Dot Position Comparator that determine when the slewing ramp starts. This time is identified as T_1. T_1 must occur a fixed time in advance (½ Time Position Range) of the next T_o in order for the display to properly show the triggering event. If everything is running smoothly (no trigger jitter and no rate meter uncertainity), there will be no Dot Position Comparator correction signal to the inverted ramp at the ratemeter output circuit.

Leadtime

Shortly after T_1, the two slewing comparisons previously mentioned occur. Fig. 2-7M shows the relationship between the slewing ramp signal and the two inverted staircase signals. The first comparison, at T_2, sends a strobe pulse to the vertical channel. The second comparison, at what might be called T_3, stops both the slewing ramp and the timing ramp and sets the timing ramp voltage for the CRT next horizontal dot position.

The voltage difference between the two inverted staircase signals (M) controls the time difference between the two slewing comparisons. The time difference between the two comparisons sets the amount of time that can be displayed in advance of the triggering event. This advance triggering is known as "leadtime".

In a stable operating system triggered on a jitterless trigger signal, the time between each T_o and its T_1 is fixed. However, the time between T_1 and the sample being taken increases with each successive sample. The time increase between samples is identified as ΔT_{dot} in Fig. 2-2, and is an increment related to the equivalent time sweep rate. ΔT_{dot} is due to each voltage change of the inverted staircase signal at the two slewing comparators. The time between T_1 and T_2 is not dependent upon trigger signal jitter. The time between each T_o and its T_1 is dependent upon trigger signal jitter.

Time Position Range Controls

Fig. 2-7 timing and slewing ramp waveforms (L and O) include extending dashes at the bottom of the sloping portion. The dashes indicate that the ramps can run farther negative if not stopped by inverted staircase comparison. Each of the two ramps is designed to run for at least twice the time required to display one basic equivalent-time time-window (when the Time Magnifier switch is at ×1). This allows the operator to move the time window beginning over a time region of one range, and to view a maximum of two ranges.

The Type 3T2 front panel RANGE switch positions are labeled with values equal to one time-position range, which is ½ the timing ramp maximum rundown time. With the RANGE switch at 10 μs, for example, the timing ramp must have a rundown time longer than 20 μs. With the TIME MAGNIFIER switch at ×1, the sweep rate is 1 μs/Div. With the two TIME POSITION controls fully clockwise, all slewing comparisons are made from essentially the start to half way down each ramp. With the TIME POSITION controls both fully counterclockwise, the inverted staircase signals are made more negative so that the slewing comparisons are made from essentially halfway down the ramps to their maximum negative values.

The timing and slewing ramp waveforms at the right side of Fig. 2-7 represent conditions when both TIME POSITION controls are fully clockwise. The first set of ramp waveforms (in the shaded area) show comparisons beginning down their slopes as if the TIME POSITION controls were somewhere about midrange. Note the changes in time between T_1 and T_2 for the two different TIME POSITION control conditions.

Time Magnifier Control

When the TIME MAGNIFIER switch is at ×1, all comparisons of one sweep occur over approximately half of the timing and slewing ramps' maximum rundown. This is known as "one time-position range". Thus, the Type 3T2 "time window" will cover an equivalent period of time equal to one Time Position Range. The time window start (leadtime related to the next T_o) will be moved over an equivalent period of time equal to one time position range by the TIME POSITION controls. The Time Position Controls shift the slewing comparisons (waveform M) down the slewing ramp when turned away from their fully clockwise positions.

When the TIME MAGNIFIER is at other than ×1, the step amplitude of the two inverted staircase signals to the slewing comparators is attenuated. With the TIME MAGNIFIER at ×2, for example, the step amplitude is halved, and the displayed time window has an equivalent time one half the time window as with the control at ×1. Now the slewing comparisons use only approximately one quarter of the ramps' rundown amplitude for one equivalent time sweep. The TIME POSITION controls can still move the first comparisons of a sweep half way down the ramps. More attenuation of the inverted staircase signals further reduces the amount of the slewing and timing ramps used for one time window scan.

In each case above, the time difference between each slewing ramp/inverted staircase comparison at T_2, and the associated timing ramp/inverted staircase comparison at

T_3 (T_3 of Fig. 2-7) covers one quarter of the timing ramp maximum rundown, or ½ time position range. This term is abbreviated ½ TPR.

½ TPR is obtained by a DC voltage offset to the inverted staircase signal in the "½ TPR Leadtime Comparator" block. The word "leadtime" refers to the prestart time T_1, ahead of timing ramp comparison, and was referred to in Fig. 2-5 and 2-7 as t_d, a delay time. The circuit action is truly a delay down the slewing ramp from T_1, but the result of this delay as displayed on the CRT is time window **leadtime**, showing information ahead of the triggering event when the TIME POSITION controls are clockwise. The display leadtime, with the Time Position controls both fully clockwise is equal to one half of one "basic" time window (Time Magnifier at ×1) regardless of the Time Magnifier control position.

Samples/Div Control

Related to the previous Time Position Range discussion of staircase signal step amplitude is the number of samples per division or samples per sweep. The Type 3T2 SAMPLES/DIV control alters the staircase generator step amplitude without altering its minimum and maximum voltage values. (The Time Magnifier switch alters both the step amplitude and total staircase amplitude.)

The multiple slewing and timing ramp comparisons drawn in Fig. 2-7 represent very few samples per sweep. Counterclockwise rotation of the SAMPLES/DIV control would cause many more samples to be taken in the same amount of ramp time. (Changing the Time Magnifier would keep the number of samples the same, but use less ramp time for a complete sweep.)

GLOSSARY

CRT Blanking	Turning off the Cathode Ray Tube electrons that strike the phosphor, thus turning off any phosphor light output.
Coherent Display	A plot of a set of dots (samples) in which the time-sequence of signal events thus indicated is preserved.
Equivalent Time	The time scale associated with the display of signal events. An apparent sweep rate visible in the CRT display due to the electronic reconstruction of fast signals on a slower piece-by-piece basis.
Holdoff Time	A period of time during which one circuit prevents another circuit from acting.
Leadtime	That part of a display that occurs prior to the displayed trigger recognition.
Pretrigger	An externally derived triggering signal that is sent to the timing unit external trigger input connector in advance of the time related vertical input signal.
Ramp	A changing voltage, where the magnitude of change is constant per unit of time.
Random Sampling	A process of signal reconstruction of an equivalent-time coherent display wherein the dots are not necessarily displayed one after the other spacially across the CRT.
Range	A period of time. (See Time Position Range)
Real Time	The time scale associated with the signal events themselves.
Sample	A voltage obtained by electronically looking at a signal for a very short period of time. The voltage is memorized and displayed with correct X and Y voltage coordinates. One dot of a many-dot sampling display.
Sampling Distribution	A function which describes how the density of a large number of randomly placed samples varies across the observed signal time region.
Sampling Command	Otherwise known as a strobe pulse. The command signal that determines when a sample is to be taken.
Servo Loop	A self regulating feedback system that does not have instantaneous response—that part of the Type 3T2 circuits that assures a minimum amount of dot jitter in a display (randomness) created by a system that has significant time uncertainty between the signal being sampled and the sample-taking operation.
Sampling Dot Density	The number of samples per sweep. Dot density is variable over a range from a point where each dot can be distinguished in the display to a number so large that the dots blend together.
Slewing	The process of incrementally delaying successive samples or a set of samples with respect to the signal being sampled.
Staircase	A ramp constructed of many amplitude-stable steps. The slewing increment between steps is equal for normal process sampling, but not necessarily equal for random process sampling.
Strobe	A sampling command voltage applied to the circuit that samples the vertical signal.
t_d	t = time, sub d = delay. A time delay or fixed period between two events.
ΔT_{dot}	The equivalent time between sampling display dots. ΔT_{dot} is equal to the time slewing increment.
Time Magnifier	A control that speeds up the sweep rate without altering the number of dots per sweep.
Time Position Range	The combination of two controls that allow the Time Window start to be positioned over an equivalent period of time equal to one range (the range equivalent time is set by the RANGE control).
Time Window	The amount of time included between the start and end of the CRT display. The equivalent time for ten divisions of horizontal scan; ten times the sweep rate.

Triggering Event	That time at which the trigger circuits respond to the triggering signal.
Trigger Recognition (T_o)	The process of responding to a suitably applied trigger signal. Such response is the time reference for the time window.
Usable Samples	Those samples that fall within the time window.
Unusable Samples	Those samples that do not fall within the time window.

NOTES

SECTION 3
OPERATING INSTRUCTIONS

Introduction

The Type 3T2 Random Sampling Sweep plug-in unit is a sampling time-base for Tektronix Types 561A, RM561A, 564, RM564, 567, RM567 and 568 Oscilloscopes. Sweep rates and other functions are controlled from the Type 3T2 front panel. The CRT display equivalent time sweep rate is a function of three controls: the RANGE switch, the DISPLAY MAG switch and the TIME MAGNIFIER switch. The display TIME/DIV is automatically presented in the lighted read-out window on the instrument front panel. The Type 3T2 is designed primarily to operate with vertical sampling plug-in units such as Type 3S3, which do not have a delay line between the signal input and the sampling bridge. Operation is also possible with delay line units such as the Types 3S76 and 3S1, however, with increased lead time over that internally provided in these units. Through special circuitry, operation in the BEFORE TRIGGER sampling process allows the Type 3T2 to display the point at which triggering occurs at the center of the screen, regardless of sweep rate.

A variety of display modes is offered in the Type 3T2: SINGLE SWP, NORMAL repetitive scan, MANUAL SCAN (where the operator uses the MANUAL SCAN control to move the spot through the sampled display) and EXT HORIZ; in which mode the operator can use another sweep generator to move the spot through the sampled display.

Triggering is possible either internally from vertical units with trigger takeoff circuits, or externally at one of two trigger input connectors: one having a 50 Ω internal termination resistance, the other having a 1 MΩ internal termination resistance.

The Type 3T2 will work with an unmodified Type 3S76 or Type 3S3[1] vertical plug-in; however, these units need to be modified in order to obtain optimum vertical signal response. See your nearest Tektronix Field Representative for information on how to modify these two units.

WITH TRIGGER Operation

In the WITH TRIGGER system of operation, the Type 3T2 works as a standard sampling sweep unit. Upon receipt of triggers it develops a linear magnitude-of-step staircase for horizontal presentation of samples taken. If the vertical unit does not have a delay line between trigger pickoff and sampling gate (for example, the Type 3S3) there will be no display of the triggering event, even with the TIME POSITION controls fully clockwise. Under these conditions, the sweep will actually be starting about 50 ns after trigger recognition in the 100 ns Time Position Range. To view the triggering event under these circumstances, a 50 to 75 ns delay must be inserted between the point of trigger pickoff and the vertical sampling bridge. The Tektronix Type 113 DELAY CABLE (giving 60 ns delay) can be used for this purpose, or a separate synchronized source of pretrigger can be used. Trigger amplitude limitations are printed on the front panel under the external TRIGGER INPUT being used. The operator can choose either the positive- or negative-going portion of the trigger waveform for recognition with the POLARITY switch, while the recognized trigger voltage is set through the use of the TRIG SENSITIVITY control. Once a display is achieved with this control, it may be necessary to adjust the RECOVERY TIME control for the most stable display (described later in FIRST TIME OPERATION).

BEFORE TRIGGER Operation

In the BEFORE TRIGGER sampling process, the Type 3T2 places Trigger Recognition time (T_o) near the horizontal center of the graticule when the TIME POSITION controls are fully clockwise and all magnification is ×1. When a vertical plug-in unit not equipped with delay line is used, an exception to this statement occurs with respect to operation at the 100 ns position of the RANGE switch. In this case, with the TIME POSITION controls fully clockwise and Magnification ×1, T_o occurs near the left edge of the graticule. The Type 3T2 achieves display lead time by generating sampling commands in front of Trigger Recognition (T_o). The time between Sampling Command and True Trigger Recognition time (T_o) is under continual automatic adjustment by special circuitry. The BEFORE TRIGGER sampling process requires a signal having some minimum repetition rate. The minimum repetition rate is determined by the setting of the RANGE switch. (See Table 3-1 for minimum limitations.) If the repetition rate of the incoming signal is too low, the LOW REP RATE light will come on and the Horizontal Dot Position Lamps will indicate that the dot is off scale to the right. There will be no display at this time.

TABLE 3-1

Minimum Trigger Signal Rep-Rate for BEFORE TRIGGER Process Sampling

Range	Minimum
100 ns	10 kHz
1 μs	1 kHz
10 μs	100 Hz
100 μs	10 Hz
1 ms	10 Hz

The amount of information gathered by the Type 3T2 in a given period of time to present the waveform is proportional to the square of the repetition rate. If the repetition rate is doubled, the number of sweeps is doubled, and so is the number of samples in the same given period of time. Therefore, the higher the repetition rate used the better, up to the Maximum limits where the Type 3T2 starts to count down.

When both TIME POSITION controls are fully clockwise, the sampled display is started by a trigger generated one half the setting of the RANGE switch ahead of True Trigger

[1]All 3S3 units after SN 1000 have been modified at the factory.

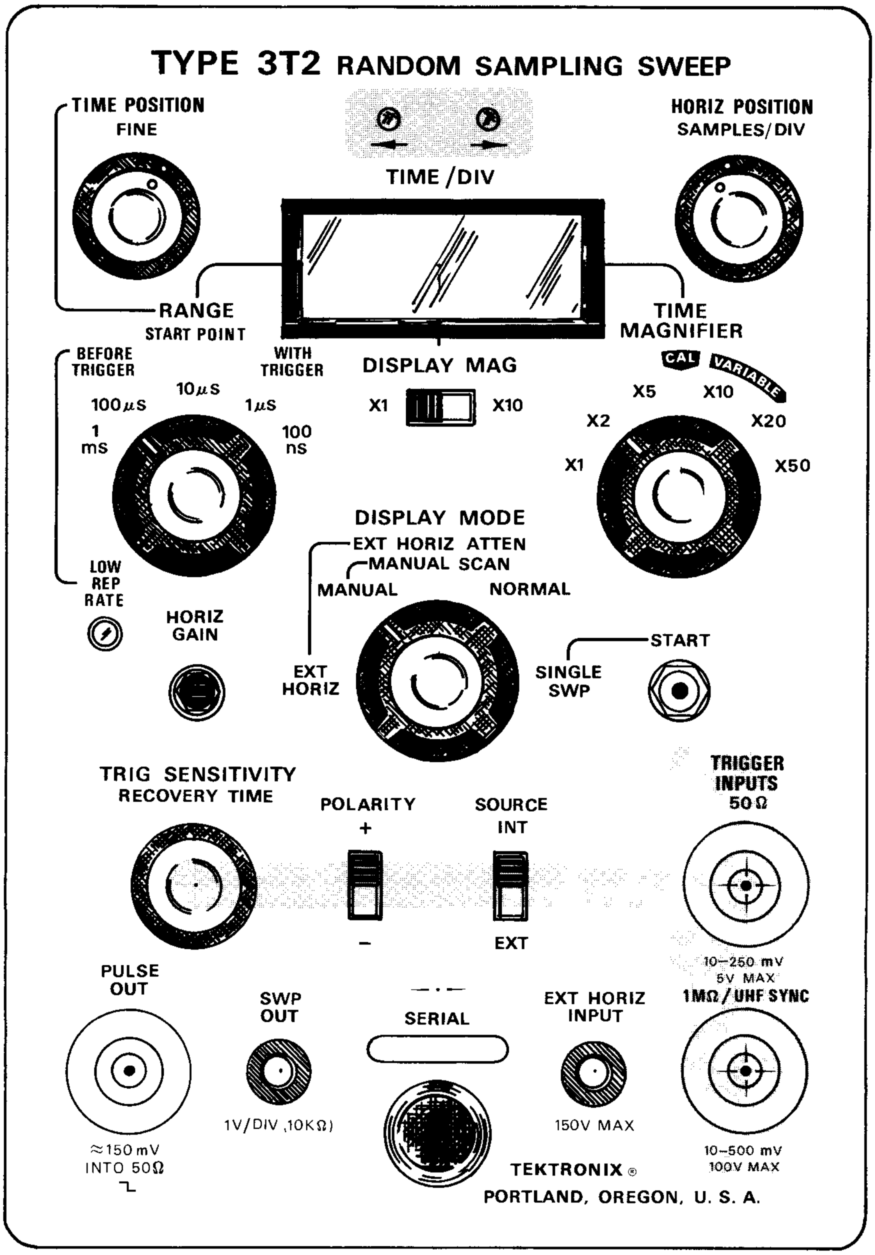


Fig. 3-1. Location of front-panel controls and connectors.

Recognition time (T_o). Without the use of a delay line, this puts the Triggering Event one half a time position RANGE after display start in the center of the CRT.

Since the circuitry involved with starting the display ahead of true trigger recognition time (T_o) is not able to perfectly guess when to take a sample, the samples that make up one sweep are not linearly spaced; nor do the samples that make up one sweep correspond to the samples that make up the next sweep. This is of special interest when the Type 3T2 is used with the Tektronix Type 564 Storage Oscilloscope; a series of sweeps can be used to present a solid line of stored information.

FUNCTIONS OF FRONT-PANEL CONTROLS, CONNECTORS AND INDICATORS

HORIZ POSITION Control — Positions the CRT display horizontally. With the DISPLAY MAG switch at ×1, the positionable display is 10 divisions long. With the DISPLAY MAG switch at ×10, there are 100 divisions of positionable display, made up of the same number of samples as before. This means that the dot density of the picture is reduced by the factor of magnification of this switch.

SAMPLES/DIV Control — Allows the operator to alter the number of samples taken in one sweep, regardless of the time window duration. The number of samples per sweep remains fixed at the value set by this control at all sweep rates. Actually, in the BEFORE TRIGGER system of operation, some of the samples taken may not be usable. This control is disabled when the SAMPLES/DIV switch is in the 100 position.

TIME POSITION Controls — Both knobs allow the operator to position the CRT time window anywhere along the total range selected by the RANGE switch. The ratio of control between the two knobs is about ten to one, with the black knob having the major control.

RANGE Control — Provides five basic equivalent time sweep rates. Each can be expanded through use of the DISPLAY MAG switch and/or the TIME MAGNIFIER switch. Each range is the time for ten divisions of horizontal

TABLE 3-2

Time Window and full-scale Range End related to RANGE and TIME MAGNIFIER controls

RANGE Switch Setting	TIME MAGNIFIER Switch Setting	Time Window 10 Div. Display	Positionable End of Time Window After Range Start
1 ms	×1	1 ms	2 ms
	×2	500 μs	1.5 ms
	×5	200 μs	1.2 ms
	×10	100 μs	1.1 ms
	×20	50 μs	1.05 ms
	×50	20 μs	1.02 ms
100 μs	×1	100 μs	200 μs
	×2	50 μs	150 μs
	×5	20 μs	120 μs
	×10	10 μs	110 μs
	×20	5 μs	105 μs
	×50	2 μs	102 μs
10 μs	×1	10 μs	20 μs
	×2	5 μs	15 μs
	×5	2 μs	12 μs
	×10	1 μs	11 μs
	×20	500 ns	10.5 μs
	×50	200 ns	10.2 μs
1 μs	×1	1 μs	2 μs
	×2	500 ns	1.5 μs
	×5	200 ns	1.2 μs
	×10	100 ns	1.1 μs
	×20	50 ns	10.5 μs
	×50	20 ns	10.2 μs
100 ns	×1	100 ns	200 ns
	×2	50 ns	150 ns
	×5	20 ns	120 ns
	×10	10 ns	110 ns
	×20	5 ns	105 ns
	×50	2 ns	102 ns

display when the TIME MAGNIFIER and DISPLAY MAG are set at ×1. Thus, the 1 ms Range has a basic equivalent sweep rate of 100 μs/division. The TIME POSITION controls allow the CRT time window starting point to be moved anywhere within the basic RANGE setting, so that there is a total viewable time window greater than 10 horizontal divisions long over which the 10-division graticule window can be moved. (See Table 3-2 for additional RANGE and total viewing time window information. See Fig. 3-2 for theoretical illustration.)

START POINT Switch — Provides the operator with a choice of random or sequential sampling process. At WITH TRIGGER, the time window can be positioned to start with, but not before, trigger recognition. At BEFORE TRIGGER, the time window can be positioned to start as much as one half the RANGE before trigger recognition (see Fig. 3-3).

CAL/VARIABLE (Time Magnifier) Control — This control is an uncalibrated magnifier which provides expanded variable sweep rates between TIME MAGNIFIER switch positions. When the VARIABLE control is not at its CAL detent position, the sweep rate is no longer calibrated and readout window UNITS lights are disconnected. The units of time measurement lights operate only when the VARIABLE control is in its CAL position. Clockwise rotation of the VARIABLE control increases the sweep rate.

TIME MAGNIFIER Switch — This switch offers six different factors (×1, ×2, ×5, ×10, ×20 and ×50) which may be used to magnify each of the five settings of the RANGE switch. The starting point for magnification is the first sample of the trace, and is controlled by the TIME POSITION knobs. Thus, a portion of a waveform may be Time Positioned to the first of the trace and the TIME MAGNIFIER used to expand the display across the screen. The new equivalent sweep will be readout in the TIME/DIV window. (Note: at fast equivalent sweep rates, high TIME MAGNIFIER settings in BEFORE TRIGGER operation can give such extreme randomness to the sampling presenting the sweep that if a Type 6R1A Digital Readout system were used, its display would be completely false.) This control magnifies the display while still using the same number of samples to present the trace in any of the six positions.

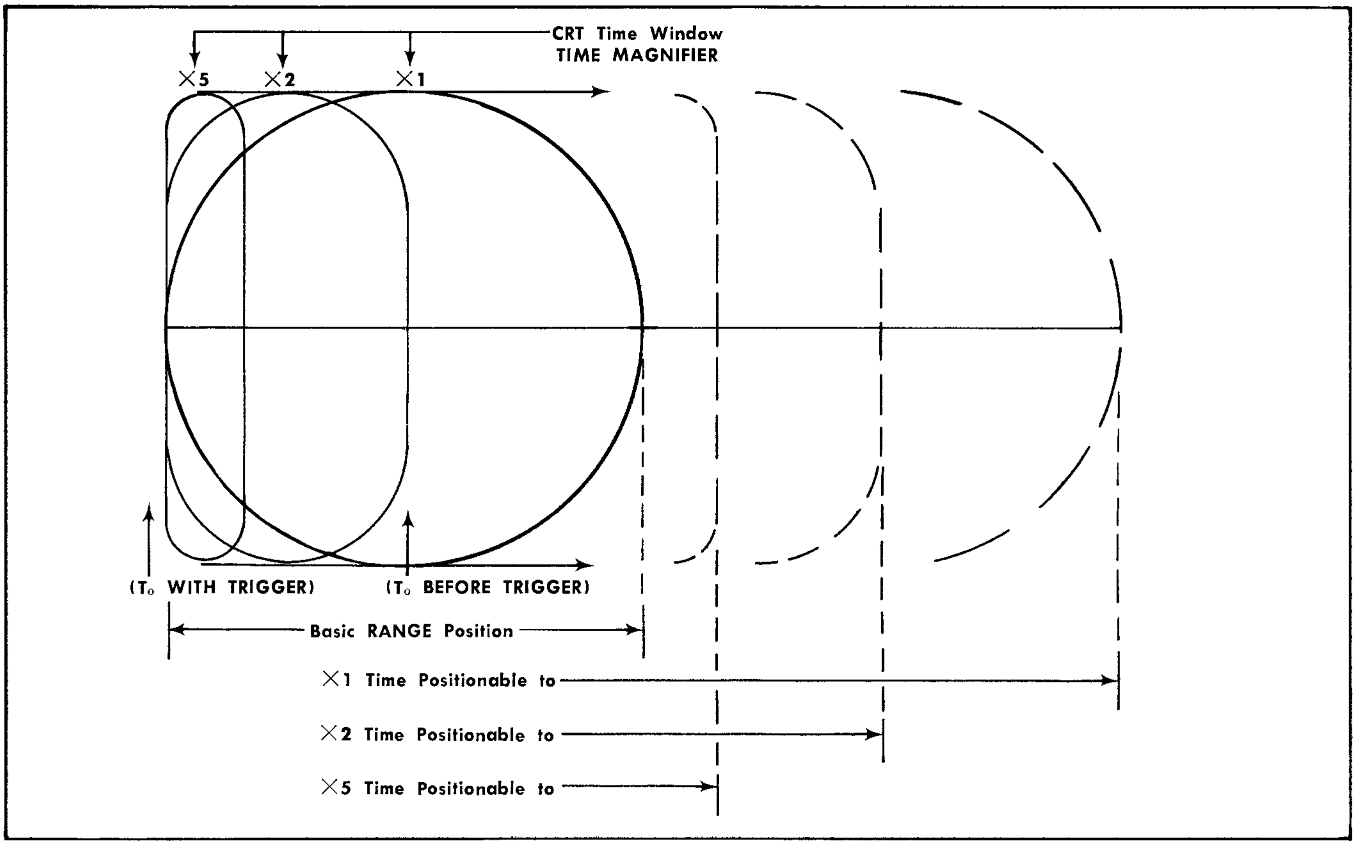
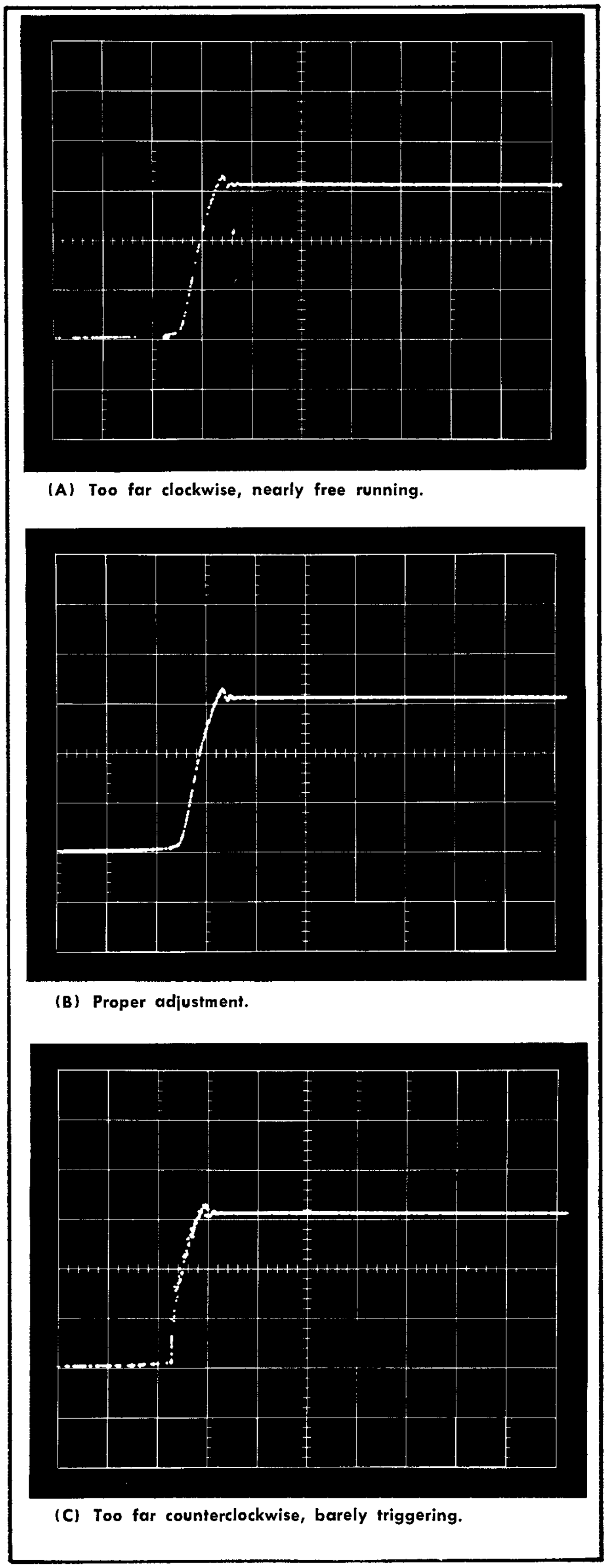


Fig. 3-2. Time window relation to total range available at 3 positions of the TIME MAGNIFIER Switch.



(A) Too far clockwise, nearly free running.

(B) Proper adjustment.

(C) Too far counterclockwise, barely triggering.

Fig. 3-3. Three examples of TRIG SENSITIVITY control adjustment. RANGE 100 ns, START POINT, BEFORE TRIGGER.

DISPLAY MAG Switch	Permits magnifying the CRT display center 1 division by a factor of 10. With switch at ×10, the HORIZ POSITION Control can still birng either end of the sweep into view on the CRT.
HORIZ GAIN (front-panel screwdriver adjustment)	Allows for adjustment of the horizontal amplifier gain to match the oscilloscope main-frame CRT deflection factor. Set the HORIZ GAIN control each time the Type 3T2 is first placed in a different oscilloscope. (See First Time Operation Instruction later in this section.)
DISPLAY MODE Switch	SINGLE SWP: Permits one triggered display after the START button is pressed. (Useful for photographing the display.) NORMAL: Permits a regular repetitive sweep with sample-by-sample advancement through the oscilloscope display. MANUAL: Permits manual scanning of the signal being sampled by turning the EXT HORIZ ATTEN/MANUAL SCAN control, and also provides a calibration reference for setting the HORIZ GAIN control (see First Time Operation instructions in this section). EXT HORIZ: Permits an external sweep signal to control the sampling display scan. For 10 horizontal divisions ×1 display, this waveform should be at least 15 volts peak to peak not over 150 volts peak to peak. The EXT HORIZ ATTEN control must be adjusted for a proper scan.
TRIG SENSITIVITY Control	Varies the trigger circuit sensitivity, allowing the operator to adjust for best display for various trigger signal levels. Also causes the sweep to free run when turned clockwise past about midrange. This latter operation allows synchronization of repetitive signals up to 500 MHz internally, or 3 GHz externally triggered.
POLARITY Switch	Allows Trigger Recognition to occur on either the positive (+) or the negative (—) slope of the triggering signal.
SOURCE Switch	Allows the trigger circuits to operate from internal (INT) information from those vertical units that supply it, or to operate from signals fed to the external (EXT) TRIGGER INPUTS. External triggering is more desirable when operating the Type 3T2 in the BEFORE TRIGGER sampling fashion.
TRIGGER INPUTS BNC Connectors	50 Ω Connector: For triggering from any 50 Ω source. Internally terminated in 50 Ω. Has a sine-wave triggering frequency range from 100 kHz to 500 MHz. 1 MΩ/UHF SYNC Connector: A high im-

pedance trigger input consisting of 1 MΩ shunted by about 15 pF. With POLARITY Switch at +, this input has a sine-wave triggering range from 10 kHz to 100 MHz. With POLARITY Switch at —, this input has a triggering range from 100 kHz to 100 MHz.

When used for UHF SYNC operation, the range of trigger synchronization is 500 MHz to 3 GHZ. (Be sure to observe trigger voltage limitations below each BNC Connector.)

RECOVERY TIME Control	Allows for the adjustment of the trigger hold-off period. Trigger signal time coincidence with the end of the hold-off period can cause a jittery display.
EXT HORIZ INPUT Banana Connector	For use with any 0 to +150 volt external signal drive for the horizontal display. With DISPLAY MODE Switch in the EXT HORIZ position and the DISPLAY MAG Switch ×1, a +15 volt signal at this input produces ten horizontal divisions of display. If a signal greater than +15 volts is used, the EXT HORIZ ATTEN/MANUAL SCAN Control should be adjusted for no more than 10 divisions of display. Input impedance is 100 kΩ.
SWP OUT Banana Connector	A 10 kΩ source of a 1 volt per division signal corresponding to the CRT horizontal spot location. The waveform at this connection is a replica of the horizontal deflection plate drive signal.
PULSE OUT BNC Connector	This is a 50 Ω source of a fast 150 mV negative pulse which is produced coincident with each trigger recognition or free-run trigger pulse.
TIME/DIV Window	Since the Equivalent Sweep Rate is a function of three controls (RANGE, DISPLAY MAG and TIME MAGNIFIER), for the operator's convenience a readout of the Equivalent Sweep Rate of the CRT display is provided.
LOW REP RATE Light	When this light is on, the trigger signal Repetition Rate (frequency) is too low for the Type 3T2 to operate in the BEFORE TRIGGER manner. To obtain a useful display, increase the trigger frequency, change the START POINT switch to WITH TRIGGER position, or switch the RANGE control to the next slower setting.
Position Lamps Horiz Dot	The on/off condition of these lamps indicates the sampling dot (or trace) position relative to CRT horizontal center. The On side indicates that the sweep is on that side of CRT center.
SAMPLES/DIV Switch	On the upper portion of the internal bulkhead immediately behind the front panel. The Type 3T2 must be pulled partly out of the horizontal compartment in order to reach this switch.

IN VARIABLE POSITION: Allows the number of samples per division to be varied with the front panel control (SAMPLES/DIV). With SW450 in this position, the Type 3T2 does not feed proper information to the Type 6R1A Digital Unit for presentation of time measurements. The Units of Time Nixie will not be lit.

IN 100 POSITION: Allows this horizontal plug-in unit to operate at 1000 samples per 10 divisions of horizontal display, and thus feeds proper information to the Type 6R1A Digital Unit for readout of time measurements. With switch in this position, the SAMPLES/DIV Variable control is inoperative.

Installing the Type 3T2 into the Oscilloscope

CAUTION

Turn off oscilloscope power while inserting or removing plug-in units.

The Type 3T2 is designed to provide timing information to the Digital Unit and horizontal deflection signals to the oscilloscope CRT. It is also designed to be of great use in building composite pictures of waveforms for photographic purposes or storage tube presentations. It must be used in the horizontal plug-in compartment of the oscilloscope. Before inserting the Type 3T2 into the horizontal compartment, note the SAMPLES/DIV switch on the upper portion of the bulkhead immediately behind the front panel. When inserting the Type 3T2 into the plug-in compartment, make sure the interconnecting plugs are properly aligned. The Type 3T2 should slip easily into the compartment.

Once the plug-in has been properly seated, turn the knurled aluminum knob a few turns clockwise until it is hand-tight. To remove the plug-in unit, turn the knurled aluminum knob fully counterclockwise, then pull the plug-in unit straight out.

First-Time Operation

The following procedures cover first-time operation of the Type 3T2 in a Type 567 or Type RM567 Readout Oscilloscope. The discussion covers necessary steps to obtain a CRT display, learn the basic operation of each control, and apply timing information to the Digital Unit. Use this procedure in conjunction with the instructions for operating the other units in the oscilloscope system.

a. Make sure the SAMPLES/DIV switch SW450 is at VARIABLE. The SAMPLES/DIV variable control is now operative, but the Type 3T2 will not feed proper information to the Type 6R1A Digital Unit for making time measurements read out. The time measurements Units light will not be on.

b. Insert the Type 3T2 into the horizontal plug-in compartment of the oscilloscope. Set the TRIG SENSITIVITY control fully counterclockwise. Turn on the oscilloscope power and allow a few minutes for warm up.

c. Set the remaining 3T2 front-panel controls as follows:

HORIZ POSITION	Midrange

SAMPLES/DIV	Fully clockwise
TIME POSITION	Both controls fully clockwise
RANGE	10 μs
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
VARIABLE	CAL
DISPLAY MODE	NORMAL
RECOVERY TIME	Fully counterclockwise
POLARITY	Set to polarity of signal to be observed
SOURCE	EXT: Supply this unit with 100 mV peak trigger information through the appropriate External input on the front panei.

d. Apply the signal to be observed to the input connector of the vertical sampling plug-in unit.

e. Slowly advance the TRIG SENSITIVITY control for a stable display. The RECOVERY TIME control may also help stabilize the display if the signal frequency is near or harmonically related to the holdoff time of the instrument.

f. Set the RANGE control to the position where the displayed signal covers the desired number of horizontal graticule divisions.

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

h. With the TIME POSITION control, the display can be further positioned along the Total Time Range available for this setting of the TIME MAGNIFIER switch. (See Table 3-2 and Fig. 3-1).

i. Set the DISPLAY MODE switch to MANUAL and turn the MANUAL SCAN control. Check the intensity for proper brilliance. Note that scanning occurs at the rate at which the control is turned. Adjust the HORIZ GAIN until the MANUAL SCAN control gives exactly 10 horizontal divisions of trace when rotated fully clockwise to fully counterclockwise. The horizontal gain is now calibrated.

j. Set the DISPLAY MODE switch to SINGLE SWP. Press the START button. The Type 3T2 should allow one complete scan of the electron beam to cross the CRT. This is particularly useful for photographing displays at slow pulse repetition rates. The START button can be used to arm the trigger circuits so that a display is presented after triggers are received. If the RANGE switch is moved while the DISPLAY MODE switch remains in SINGLE SWP, be sure to notice from the sweep position lights where the sweep actually is. If it is on the right side of the CRT, return it to the left by pushing the START button once (a partial trace may flash on the CRT at this time, so be sure any camera shutters are closed). Push the START button once more to arm the sweep ready to produce a trace upon receipt of the next trigger signal.

k. Change the START POINT switch to the BEFORE TRIGGER position and note change of display. With the TIME POSITION controls fully clockwise, the point of trigger recognition should be in the center of the CRT display. Return the DISPLAY MODE switch to SINGLE SWP and press the START button several times. Notice that the samples of each sweep seldom duplicate each other. Return DISPLAY MODE switch to NORMAL.

l. Work the DISPLAY MAG switch back and forth from ×1 to ×10 several times, and note that whatever is in the center of the graticule remains stable and the expansion works from the center out in both directions. Return the DISPLAY MAG switch to ×1.

m. With the TIME POSITION control, adjust the CRT display so that some sharp change of signal level occurs during the very first portion of the first horizontal division of trace. Switch the TIME MAGNIFIER slowly through its six positions of magnification, noting that magnification now occurs from the start of the trace. It is of importance to note also that the equivalent sweep rate per horizontal division readout in the TIME/DIV window changes appropriately with either magnifier control. If under high magnification, the sampling becomes too sparse, the SAMPLES/DIV control should be adjusted for a more appropriate display. (This also slows down the sweep repetition rate.)

n. Turn the instrument off. Loosen the knurled aluminum knob and pull the Type 3T2 partly out of the instrument. Flip the SAMPLES/DIV switch to the 100 position. Push the Type 3T2 back into the compartment and turn the instrument back on. In this condition, the Type 3T2 will display 1000 samples for ten horizontal divisions of trace with the START POINT switch set at the WITH TRIGGER position and the TIME MAGNIFIER set low enough for sampling to be absolutely sequential. Operation in the BEFORE TRIGGER setting of the START POINT switch is possible if the random character of the samples is kept to a small percentage of the display. This is most easily accomplished with the TIME MAGNIFIER at ×1 using a high, uniform trigger rate. The SAMPLES/DIV switch in the 100 position also makes the SAMPLES/DIV Variable control inoperative.

HORIZ GAIN Adjustment

a. Set the START POINT control at WITH TRIGGER position.

b. Connect a 1 kHz to 20 kHz 100 mV signal to one of the TRIGGER INPUTS on the Type 3T2 front-panel (50 Ω source of trigger at 50 Ω input—high impedance source of trigger to 1 MΩ/UHF SYNC input).

c. Set the SOURCE switch to EXT.

d. Turn TRIG SENSITIVITY control from fully counterclockwise to the right (in a clockwise direction) for a stable trace (not free-running).

e. While turning the MANUAL SCAN back and forth from fully counterclockwise to fully clockwise, adjust the HORIZ POSITION control so the trace is exactly centered horizontally on the graticule (see Fig. 3-3).

f. Set the HORIZ GAIN adjustment for exactly 10 horizontal divisions of trace when the MANUAL SCAN is turned from fully counterclockwise to fully clockwise. The left end of the trace should be aligned exactly with the left edge of the graticule (MANUAL SCAN fully counterclockwise) and the right end of the trace should be aligned with the right edge of the graticule (MANUAL SCAN fully clockwise).

Triggering the Type 3T2

The Type 3T2 can be triggered either internally or externally. Internal triggering requires no external connections to the Type 3T2, since the triggering signal is coupled internally from the vertical sampling plug-in unit.

External triggering permits stable displays from signals as small as 10 mV peak to peak into the Type 3T2. External triggering is independent of the displayed waveform. Thus, when signals of equal or harmonically-related frequency but different amplitudes are applied to the vertical plug-in unit, the triggering controls do not require resetting for a stable display. However, an external triggering signal must be related in time to the displayed signals to obtain a meaningful display.

The + and — positions of the POLARITY switch determine whether initial triggering takes place on the positive or negative going slope of the triggering signal. The INT or EXT positions of the SOURCE switch determine whether the triggering signal comes from the vertical sampling plug-in unit or from the TRIGGER INPUTS on the Type 3T2 front panel.

Sine wave signals may be used as triggering information to the Type 3T2 but there are magnitude and frequency limitations to this capability. When triggering internally, the sine wave should be at least 80 mV peak to peak at the vertical plug-in front panel and somewhere between 100 kHz and 500 MHz in frequency. This same frequency limitation is also true of the external 50 Ω Input, but signals may be as small as 10 mV peak to jeak. The high frequency sine wave response of the 1 MΩ/UHF SYNC Input is about 100 MHz, and the + polarity low frequency response of this input is about 10 kHz. For UHF SYNC operation, the response of this Input ranges from 500 MHz to 3 GHz.

Pulse trigger recognition of the Type 3T2 is much better than sine wave or slow rise signal trigger recognition. The low frequency response of all three channels is about 10 Hz for this type of signal.

When operating the Type 3T2 in BEFORE TRIGGER sampling, external triggering is more desirable. It will give a more stable and complete display. Because of the capability of the Type 3T2 to sample before true trigger recognition time (T_0), there can be a peculiar effect seen with this instrument that is not seen in conventional sampling units. Any strobe transient signal superimposed on a slowly rising triggering waveform (determining T_0 in the display) can result in a pre-T_0 sample (from the Vertical) being placed at (Horizontal) T_0 time. This results in a "hole" in the display. If If a ringing waveform becomes superimposed on this ramp, there can be several "holes" in the display. Because external triggering gives better isolation for pre-T_0 sampling process signals, its use is recommended.

There are times when the strobe signal at the probe tip of the P6038 probes used with the Type 3S3 vertical unit can be comparable to the trigger signal magnitude when triggering is taken from the same circuit point as the samples. The Type 3T2 cannot tell the difference between these two signals, and it reacts as though the pre-T_0 sample actually occurred at T_0. The Type 3T2 presents this sample at T_0, again resulting in a "hole". If possible, the triggering waveform should be taken from a different point in the circuit under test. However, if this cannot be done, the ×10 attenuator for the P6038 probe should be used to reduce the strobe to trigger-signal ratio.

For the best display, care should also be exercised in the adjustment of the TRIG SENSITIVITY control. Too far clockwise (too close to free run) or too far counterclockwise can result in a poor presentation (see Fig. 3-4). If horizontal pulling of the waveform samples occurs, be sure to readjust the RECOVERY TIME control.

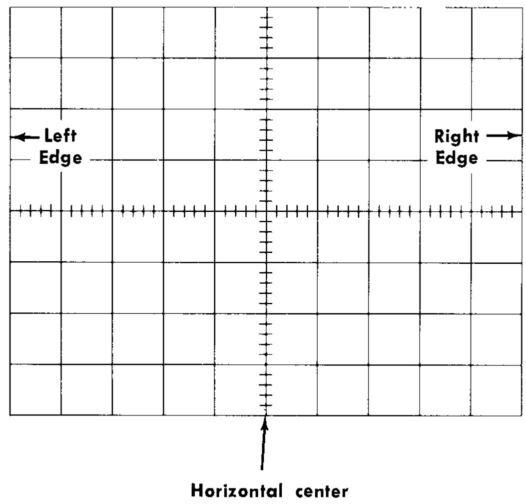


Fig. 3-4. Graticule reference points at which measurements relative to the trace are made.

Selecting Equivalent Sweep Rate from the Front Panel

The Type 3T2 RANGE switch selects calibrated equivalent, time windows or ranges over which the starting point of the display can be moved by the TIME POSITION controls. Each control position produces a display 10 horizontal divisions long. There are five ranges to choose from, varying from 1 ms to 100 ns long with a factor of ten difference between each of the five steps. The actual sweep rate of the display in terms of time per horizontal divisions is automatically read out in the TIME/DIV window on the front panel. This readout incorporates all correction for whatever magnification may be in use. Setting the DISPLAY MAG switch to ×10 selects the CRT center one division for expanded 10-division display, essentially increasing the equivalent sweep rate (on the CRT only) to 10 times that of any setting of the Range and Time Mag switches. For all practical purposes this expands the total sweep length by a factor of ten, with triggering occurring at the same point on the waveform. The HORIZ POSITION control should be used to move this expanded sweep through CRT time window for inspection of whatever part of the original display is desired. The TIME MAGNIFIER (with a choice of six different factors of magnification) operates somewhat differently. It will always function with respect to the first sample of the CRT display, and will not change the number of samples for ten horizontal divisions of the waveform. The first sample of the trace is relative to the setting of the TIME POSITION controls and the setting of the START POINT switch. The START POINT switch at WITH TRIGGER allows the Type 3T2 to operate as a standard sampling unit. If the Vertical plug-in does not have a delay line (or if no external delay line is used), there will be no display of the triggering waveform, since trigger occurs before the first sample can be taken (see Fig. 3-2). The TIME POSITION control can be used to move this first sample anywhere along the RANGE setting, so that 10 divisions of horizontal display is available beyond the end of the RANGE setting.

With the START POINT at BEFORE TRIGGER, the Type 3T2 will operate in the special random sampling manner. This system of operation permits samples to be taken of the signal information before the trigger arrives. With both magnifiers set at ×1 and the TIME POSITION controls fully clockwise, the Type 3T2 will place T_o (trigger recognition time) in the middle of the RANGE setting in all but the two fastest time position ranges. With the RANGE switch in the 100 ns position. T_o is placed approximately one horizontal division into the display. With the RANGE switch at 1 μs, the placement of T_o is approximately 4 horizontal divisions into the display. In all the remaining positions of the RANGE switch, T_o should be in the middle of this display. (See Fig. 3-2.) In this way the Type 3T2 succeeds in presenting the triggering waveform when used with a Vertical plug-in that does not have a delay line and very little external delay is used between trigger pick-off and the sampling gate. In many cases, the trigger may be delayed a hundred nanoseconds or so after the signal event, with a satisfactory display of the event still possible. The actual rate of the CRT 10 horizontal division display is always read out at the TIME/DIV window on the front panel of the Type 3T2.

There will be numerous different combinations of setting of six controls (TIME POSITION, HORIZ POSITION, RANGE, DISPLAY MAG, TIME MAGNIFIER and SAMPLES/DIV) that will trace the waveform at the same equivalent TIME/DIV sweep rate, but will offer different repetition rates and dot densities. Familiarity with these controls will allow for best presentation since some combinations will give a better picture than others.

The VARIABLE time magnifier offers a further magnification of approximately three, which bridges between each of the six settings of the TIME MAGNIFIER switch. However, when this control is in use the Type 3T2 is not calibrated and the units of time within the TIME/DIV window will not light up, nor will the units of time in a Type 6R1A readout (SAMPLES/DIV switch at 100) be lit.

Time Measurement

Since the actual equivalent sweep rate of the CRT display is a combination of the settings of three controls requiring division of the RANGE setting by ten times the product of the DISPLAY MAG setting and the TIME MAGNIFIER setting, the Type 3T2 is provided with a readout which shows the answer automatically. Therefore, whatever measurement is made should be in terms of horizontal divisions multiplied by the rate indicated in the TIME/DIV window.

All RANGE settings of equivalent time are accurate to within 3% with the DISPLAY MAG at ×1. Accuracy of the RANGE settings with the DISPLAY MAG ×10 is held to within 5%. The first 1.5% of each RANGE setting is to be considered non-linear, except for the fastest setting of 100 ns, where the first 10 ns is to be considered non-linear. If the TIME POSITION controls are moved from a fully clockwise position so that this small percentage of each range is no longer displayed, the total 10 horizontal divisions of the display may be considered linear.

An alternative and often more accurate, method of measuring time is to use the Type 3T2 in the Type 567/RM567 Oscilloscope making use of the Type 6R1A Digital Readout unit. Be sure to put the SAMPLES/DIV switch in the 100 position with the START POINT switch at WITH TRIGGER. This assures that the Type 3T2 will build the ten-division display from 1000 samples sequentially taken and thus will feed the Type 6R1A proper information. If the SAMPLES/DIV switch is at VARIABLE, the Digital Readout gives only the number of samples taken from one point in the sweep to another, with no units of time showing. (The SAMPLES/DIV switch must be at 100 and the VARIABLE Magnifier in CAL position for the Units of Time Nixie in the 6R1A to light.) See step (n) in the First Time Operation portion of this section of the manual.

Single Display Operation

The Type 3T2 has a single display feature which is helpful when photographing low repetition-rate signals. To use the single display feature, first obtain a normal triggered display with the DISPLAY MODE switch at NORMAL. Then set the DISPLAY MODE switch to SINGLE SWP. Press the START button, and the CRT will show a single sweep. To make a photographic recording of the single display, open the camera shutter, press the START button, and after allowing sufficient time for a complete display, close the camera shutter. Consult the camera instruction manual for further information on photographic recording.

NOTES

SECTION 4
CIRCUIT DESCRIPTION

General

The circuitry of the Type 3T2 Random Sampling Sweep unit is completely solid state. Major wiring is on etched circuit boards that are interconnected by color coded wires and coaxial cables. Section two describes the unit functions by ladder waveforms and simplified block diagrams. This section of the manual describes individual circuits without emphasis upon interconnections or logic functions. Refer to the diagrams at the back of this manual during the following discussions.

TRIGGER AND HOLDOFF CIRCUITS

The Type 3T2 trigger circuits are all drawn on Diagram 1, the Trigger & Holdoff diagram. Five front panel controls affect the trigger circuit operations. They are the variable TRIG SENSITIVITY and RECOVERY TIME controls, and the POLARITY, SOURCE and RANGE switches. The individual control functions are described in the Operating Instructions section, and below.

Controls

The SOURCE switch selects the triggering signal source (internal or external) by turning on or off appropriate circuits. When the SOURCE switch is placed at EXT, the 1 MΩ to 100 Ω Trigger Amp Q11 and Q12, and the Source Select transistor Q20 are turned on. The internal Source Select transistor Q30 is turned off. When the SOURCE switch is placed at INT, Q30 is on, and Q11, Q12 and Q20 are off.

The POLARITY switch selects one of two common base transistors, Q41 or Q51, to couple the triggering signal from the Source Select circuit to the Trigger Recognizer circuit. When the POLARITY switch is at +, Q41 conducts and passes the triggering signal without inversion. When the POLARITY switch is set at —, Q51 conducts and passes T55 inverted triggering signal to the Trigger Generator.

The TRIG SENSITIVITY control allows the operator to adjust the operating bias of Trigger Recognition tunnel diode D62. The operating bias range is great enough so that the tunnel diode circuit can be made to oscillate, or can be made to require a maximum amplitude triggering signal. Clockwise rotation of the control increases trigger sensitivity until the circuit oscillates. Counterclockwise rotation of the control reduces trigger sensitivity, but will not lock out large amplitude triggering signals.

The RECOVERY TIME control changes the Holdoff Multivibrator period of trigger lockout by changing the holdoff ramp capacitor charging current.

The RANGE control changes the Holdoff Multi holdoff capacitor to assure proper trigger lockout period for each major range of sweep rates.

External Trigger Circuits

Two external input connectors, J1 and J21, offer the option of externally triggering the Type 3T2 with signals from a 50 Ω source or from a high impedance source. The low impedance source signals fed to the 50 Ω input are fed directly into the emitter circuit of common-base amplifier Q20. High impedance source signals are fed to the 1 MΩ/UHF SYNC input and then into an impedance transforming unity gain amplifier (Q11-Q12) that has a bandpass of approximately 100 MHz. The 1 MΩ to 100 Ω non-inverting amplifier couples the signal directly to the emitter of the same non-inverting common-base amplifier used for low input impedance triggering signals.

The collector circuit of the common base amplifier (Q20) is in parallel with the collector circuit of the internal trigger common-base amplifier Q30. Since Q30 is biased to cutoff, its collector circuit does not significantly load Q20 collector, and external signals are properly coupled to the polarity select circuit.

1 MΩ To 100 Ω Trigger Amplifier

External trigger operation is permitted when the SOURCE switch is at EXT. Turn-on bias is applied to Q11 and Q12 by connecting R7 and R18 to —19 volts. Q11 gate lead rests at —9.5 volts due to the voltage division of equal value resistors R5 and R7. The input circuit is AC coupled and an external circuit DC resistance will not change the amplifier input bias and operating point.

Signals into the trigger amplifier pass through a short section of coaxial cable which is looped through a ferrite toroid core three times. The toroid (L1) isolates J1 and J2 ground connections from high frequency ground current signals that could cause false triggering.

Once the signal leaves the cable, it passes through C2, R2 and C5 into Q11 gate. The two diodes, D2 and D3, clamp large input signals to protect the amplifier, and also provide a DC charge path for C2 when a triggering signal source contains DC. R2 limits the changing current of C2 from low impedance signal sources. Thus, the amplifier input impedance is the parallel value of R5 and R7 (1 MΩ) only during times when D2 and D3 are not conducting.

Q11 gate lead input impedance is normally high due to the field effect construction. To assure the high input impedance, Q12 drives Q11 source in phase with the signal. The amplifier can be divided into two parts: Q11 as a source follower (electrically similar to a vacuum tube cathode follower), and Q12 as a bootstrap amplifier driving Q11 source in phase with the signal. Assume a positive signal; Q11 increases conduction, causing its drain lead to go negative. The negative going change at Q11 drain increases Q12 conduction. Q12 collector then goes positive until it takes Q11 source to a point that limits Q11 conduction. Thus, the stage is a self-stabilizing unity gain amplifier with very high input impedance and very low output impedance. The output impedance is then essentially the value of R13. R18/C17 decouple the circuit from the —19-volt power supply. D10 protects Q12 base-emitter junction from reverse bias damage when the SOURCE switch turns the amplifier off for internal triggering operation.

50 Ω Input

Signals connected to the 50 Ω input connector pass through a coaxial cable that is looped three times through a ferrite toroid. The toroid (L21) reduces possible ground currents between J21 and J22 to prevent false triggering. Once the signal leaves the cable, it passes through C24 and R24 to the emitter of common-base amplifier Q20. L22-R22 and C24-R24 in series with Q20 internal emitter resistance present a 50 Ω load to the input signal over a wide range of frequencies.

The amplifier is forward biased into conduction by R15 and the +19-volt supply. Q20 collector return resistor is R39. The signal load varies from 100 Ω (R45) for high frequencies, to 2.7 kΩ (R39) for low frequencies. When the SOURCE switch is placed at INT, Q20 base-emitter junction is reversed biased by electron flow through R27-R26-D24 which places Q20 emitter about —0.6 volt from the base. D24 assures that Q20 base-emitter junction reverse bias does not exceed the transistor ratings (and at the same time does not load input signals when Q20 is conducting). The amplifier input impedance is 50 Ω, unless a high amplitude negative signal causes D24 to conduct. If D24 conducts, R24 limits C24 charging current. Steady DC signals greater than 3.5 volts can damage R22.

Internal Trigger Circuits

Internal triggering signals come from the associated vertical sampling unit, if that unit has a trigger takeoff circuit. The internal signal arrives through the Type 3T2 rear panel interconnecting plug, P21, and enters the shielded trigger circuit at J32. The input coaxial cable is looped three times through a ferrite toriod core just before the signal enters J32. The common base amplifier, Q30, functions identically as described above for Q20. The only circuit difference is that the interconnecting cable termination is 50 Ω for high frequencies only. L32 grounds the input signal path at DC.

Polarity Selection

Triggering signals can be inverted by changing the front panel POLARITY switch setting. The major components of the polarity selection circuit are SW40, T55, Q41 and Q51. They serve to pass the triggering signal to the Trigger Recognizer with the same phase as at the input, or inverted to invert the CRT display of the triggering event.

Non-inverted operation takes place when the POLARITY switch is at +. At + polarity, Q51 is placed at cutoff by current in D53, setting Q51 emitter about +0.4 volt from the base. The electron path is from ground, through D53, T55 secondary, and R58 to the +19-volt supply. Q41 is conducting due to electrons flowing from the —19-volt supply through R46, R45, T55 primary, Q41, R41 and R59 to the +19-volt supply. Q41 (and Q51, when operating) is a common base amplifier. D43 (and D53) are special hot carrier diodes with very low dynamic forward resistance, assuring a good connection when forward biased by the POLARITY switch.

As the triggering signal leaves either Q20 or Q30 and passes through C43, T55 primary passes the signal to Q41 emitter without inversion. Q41 then amplifies the signal without inversion and drives the Trigger Recognizer through C59.

Inverted operation takes place when the POLARITY switch is at —. At — polarity, Q41 is placed at cutoff by D43 forward bias voltage. Q51 is now a common base amplifier receiving inverted signals from T55 secondary. T55 secondary has a low impedance signal path at C55 assuring that secondary signal currents are injected at Q51 emitter. Q51 amplifies the inverted signal without further inversion and drives the Trigger Recognizer through C59. T55 limits the low frequency triggering when at — POLARITY (see the Characteristics section under sine wave triggering).

UHF Sync

The triggering signal paths described above have an upper frequency bandpass limit that is considerably less than the upper frequency limit of the Trigger Recognizer circuit. Two components, C1 and R1 couple very high frequencies around the normal trigger amplifier input circuits directly to the trigger recognition tunnel diode D62.

Trigger Recognizer and Holdoff Multi

The separately identified Trigger Recognizer and Holdoff Multi circuits function as a unit circuit. The Trigger Recognizer drives the Holdoff Multi; the Holdoff Multi then locks out additional trigger recognitions for a period long enough to allow all other Type 3T2 circuits to operate. Trigger recognition lockout is actually performed by the Trigger Lockout double comparators Q70-Q72 and Q80-Q82, but control of the lockout period is by the Lockout Multi.

The trigger recognition circuit contains four major sections: 1) an input trigger recognition pair of diodes, tunnel diode D62 and back diode D66;[1] 2) an output tunnel diode D90; 3) three transistors that drive other circuits: Q90, the PULSE OUT source, Q101 driving the Holdoff Multi and the Rate Meter Memory Gate and Q102 driving the Timing Ramp Clamp; and 4) the Trigger Lockout double comparators Q70-Q72 and Q80-Q82 and their control transistor Q74.

Quiescent Conditions

Trigger circuit quiescent conditions (before the arrival of a trigger signal) depend upon the setting of the front panel TRIG SENSITIVITY control. With the TRIG SENSITIVITY control set counterclockwise from the free-run midrange position, the following conditions exist.

1. Q72 and Q80 are conducting. Q72 and the TRIG SENSITIVITY control supply current to D62. D66 conducts a small amount of current at the low voltage state of D62.

2. D62 is resting at its low voltage state, at a current value near its peak, so that a small drive signal from Q41 or Q51 will cause D62 to switch to its high voltage state.

3. D90 and Q90 are conducting all of Q80 current (~10 mA). D90 is at its low voltage state but near peak current, armed by Q80.

[1]See June, 1966 and August, 1966 editions of Tektronix Service Scope for the article: Tunnel Diode Switching Circuits and the Back Diode.

4. Q90 is a germanium transistor. Q90 +0.27-volt emitter voltage, plus D90 low voltage condition is not enough voltage to forward bias either Q101 or Q102 into conduction.

5. Q101 and Q102 are not conducting. Q102 prevents the Timing Ramp from running, and Q101 permits the Holdoff Multi to rest at its quiescent conditions.

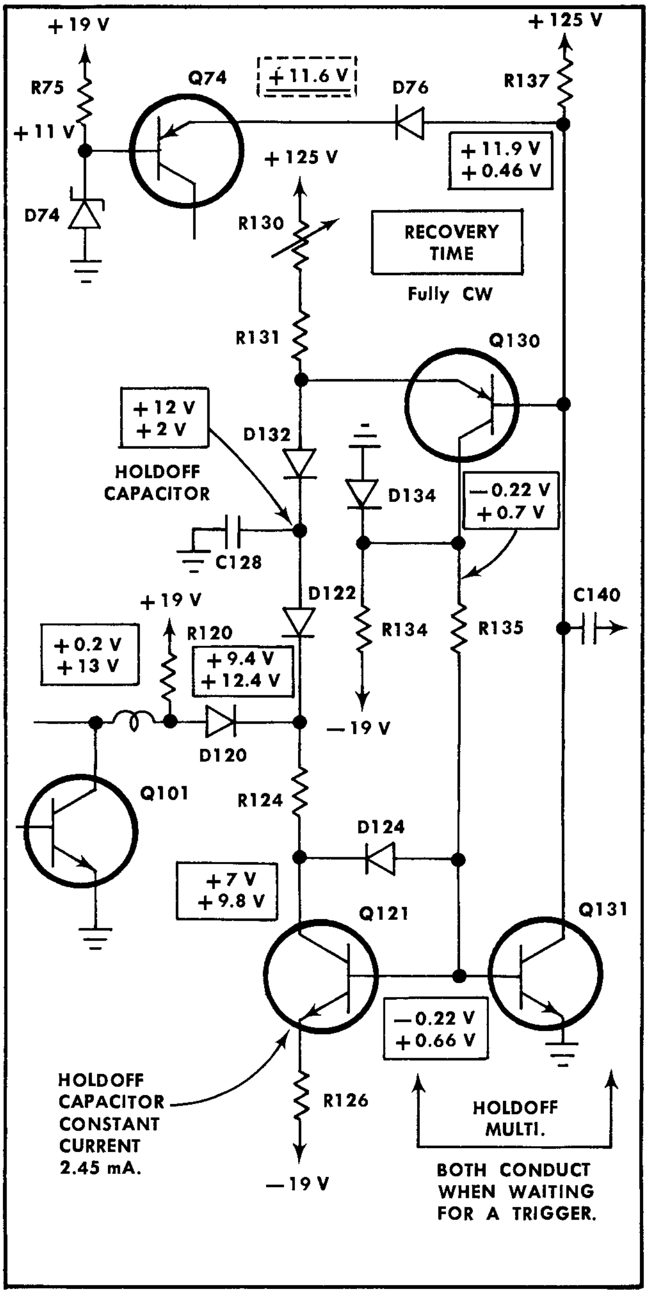


Fig. 4-1 Holdoff multi circuit voltages. Upper voltages: Q101 saturated, Lower voltages: Q101 cut off.

The Holdoff Multi quiescent conditions (see Fig. 4-1) are:

1. Q121 is conducting 2.45 mA through R124, D120 and R120.

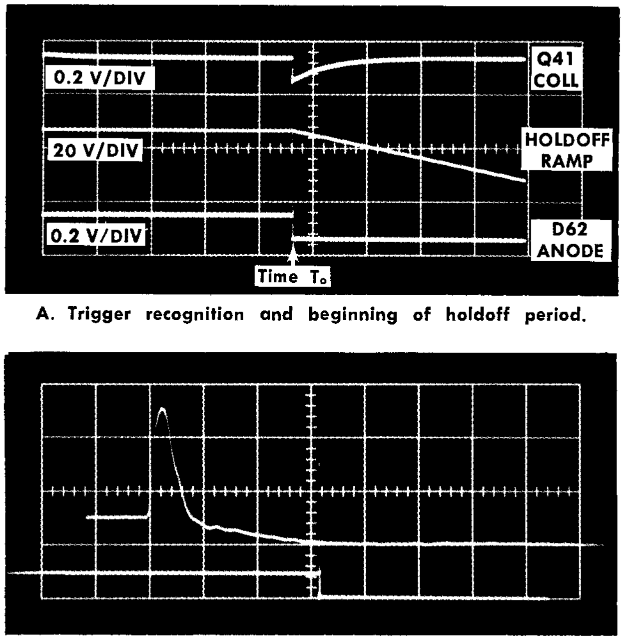
2. Q130-Q131 are both conducting. Q130 emitter voltage is +0.71 volt, and its current path is through the Recovery Time control. Q131 collector voltage is +0.46 volt, which holds Q130 in conduction and reverse biases D76 so Q74 does not conduct.

3. C128 voltage rests at +12 volts where it was left after the previous trigger recognition cycle. Both D122 and D132 are reverse biased.

4. Both D124 and D134 are reverse biased.

Triggered Functions

The previous trigger and hold off circuit quiescent conditions apply at the end of each holdoff period. A trigger signal always applies a positive drive to D62 to start the system operating for each sample taken. The instant when D62 receives enough energy to switch to its high voltage state is identified as T_o (both in this discussion, and in Section 2). Two sets of waveforms in Fig. 4-2 and Fig. 4-3 support the following discussion of one sampling cycle; T_o is identified in each figure.



A. Trigger recognition and beginning of holdoff period.

B. D62 Anode; upper: 0.05 μS/DIV, lower: 0.1 mS/DIV. Both: 0.2 V/DIV.

Fig. 4-2. Trigger recognition waveforms. Test oscilloscope: 85 MHz bandpass.

At the arrival of a positive going signal at D62 anode, D62 switches to its high voltage state and the sequence of actions that occurs is described below.

1. D62 switches to its high voltage state.

2. L62 is a high impedance at switching time, so R62-C62 couple D62 output to D90. Almost immediately, L62 conducts and D62 positive output is coupled to back diode D66.

3. D66 conducts when its cathode reaches +0.25 volt; it then takes all the current from Q72-R68 allowing D62 to switch back to its low voltage state.

4. Before D62 reaches its low voltage state, D90 switches to its high voltage state and saturates both Q101 and Q102. This reduces the current in Q90. The actions that follow D90 switching high occur in two steps: Q90 and Q102 respond to D90 first, because L104 slows the drive to Q101 emitter.

5. As D90 switches to its high voltage state, its anode tries to rise positive, but is prevented by the emitter-base junction of Q102. Q102 emitter can go only about +0.7 volt positive, so D90 cathode must go negative. Q90 is a germanium transistor and does not go to cutoff when its emitter is driven nearly to ground. Instead, its current is reduced causing the Pulse Out signal to make a negative step. At the same time, the current from D90 is reduced from about 10 mA to about 2 mA. (D90 stays at the high voltage side of its valley minimum voltage because its valley current is less than 2 mA.) Thus, the nearly 10 mA current provided by Q80 is now divided between D90-Q90, Q102 emitter current and Q101 base current.

6. As Q102 saturates, the Timing Ramp starts its rundown.

7. L102 slows Q101 collector signal to the Holdoff Multi circuit, allowing D68 to be forward biased before the holdoff ramp starts negative. D68 conduction takes essentially all of Q72 current away from both D62 and D66, locking out any trigger (or self oscillations should the TRIG SENSITIVITY control be turned clockwise into a normal free-run position).

The upper waveform of Fig. 4-2B shows the fast positive, then fast negative voltage change across D62, then the slower slope as Q101-D68 takes all of Q72 current.

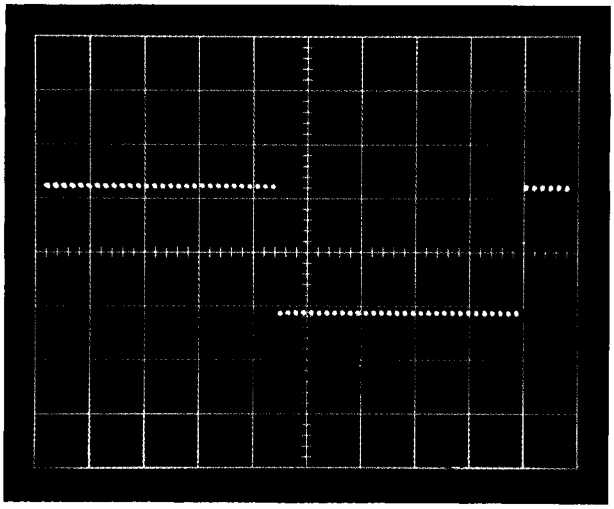
8. As L102 passes Q101 signal to the Holdoff Multi circuit, the current passing in R120 is switched away from D120-Q121 and taken to ground through Q101. This action releases Q121 current and D122 switches it into the holdoff capacitor C128.

9. C128 voltage starts negative at a constant slope controlled by its capacitance and the 2.45 mA of Q121. Fig. 4-3B bottom waveform shows that the holdoff capacitor voltage changes slope just before it switches the Holdoff Multi into non-conduction. The change in slope is due to D124 becoming forward biased and Q131 losing base current before the multi switches. Fig. 4-3B 3rd waveform shows Q130 base —Q131 collector waveform as Q131 starts to turn off. Then as Q131 base-emitter junction becomes reverse biased, the multi switches off rapidly and Q130 base—Q131 collector signal rises positive.

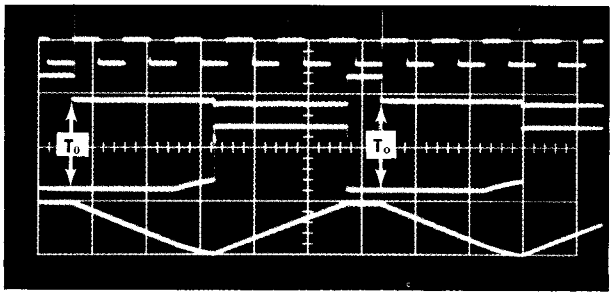
10. Q131 collector signal rises to +11.9 volts in 5 μs; it is stopped as D76 is forward biased and Q74 takes all R137 current.

11. As Q74 conducts, its collector rises positive and switches the two trigger lockout comparators so that Q70 and Q82 conduct. Q72 stops conducting, which removes any possibility of current into either Q101 or D62-D66. Q80 stops conducting, which removes the drive from D90, Q101 and Q102. Q82 current all passes into Q90 emitter and restores the positive Pulse Out waveform. Now D90, Q101 and Q102 are all without current.

12. As Q101 stops conducting, R120 raises D120 anode positive. This forward biases D120. R120 current is greater than the Recovery Time maximum current, so Q121 collector



A. "With Trigger" display of 1 kHz square wave. 100 μs/DIV.



B. Upper: 1 kHz signal.
2nd: D62 anode. 0.2 V/DIV.
3rd: Q130 base, Q131 collector. 20 V/DIV.
Lower: Holdoff cap. 20 V/DIV.
All: 1 mS/DIV.

Fig. 4-3. Trigger circuit waveforms for two samples of upper display.

rises positive and reverse biases D122. With D122 reverse biased and Q130 not conducting, all the Recovery Time control current is switched into C128, charging it in a positive direction.

13. In steps 9 and 10 above, as Q131 collector signal goes positive at the holdoff period half-way point, C140 couples a turn-on signal to the Logic Drivers Q141 and Q143. Both Logic Driver transistors were previously not conducting. As Q141 conducts to saturation, C142 is charged for a limited time turn-on pulse to Q143 after Q141 stops conducting. Thus, the two RC input circuits to Q141 and Q143 cause them to conduct into saturation for a limited period of time, one after the other, just as Q131 collector goes positive.

The action within the rest of the Type 3T2 circuits due to the two successive pulses of the Logic Driver transistors is discussed in detail in Section 2 in the text associated with Fig. 2-7. That basic description is expanded throughout the rest of this circuit description.

14. The Recovery Time control charge of C128 soon takes C128-Q130 emitter voltage far enough positive for Q130 base-emitter junction to be forward biased. As Q130 con-

Ⓐ

ducts, it and Q131 switch rapidly to their previous conducting condition, turning off Q74 and restoring both Trigger Lockout comparators to their Q72-Q80 quiescent conducting conditions. Q72 and Q80 restore the trigger recognition circuit, D62 and D66 (and D90) to an armed state ready for another positive trigger from Q41 or Q51.

Trigger Lockout Comparators

The trigger lockout comparators are both used in a switching mode to control the trigger recognition tunnel diode and output tunnel diode operating conditions. Operating functions are described in the preceding paragraphs. Operating voltages of the circuits are set by Zener diode D74 and the +19-volt supply. D74 sets the base voltage of all four comparator transistors, and of their switching control transistor Q74. When Q74 is not conducting, R77-R78 voltage divider sets the base voltage of Q72 and Q80 about 1 volt negative with respect to Q70 and Q82 base voltage. Thus Q72 and Q80 conduct when the system is armed and ready to receive a trigger signal.

Q72 and D62 current is adjusted during calibration by the TRIG SENS BAL control in the emitter return lead of Q70-Q72. The current value in Q80, D90 and Q90 is adjusted during calibration by the OUTPUT TD BIAS control R82 in the emitter return lead of Q80-Q82. Both adjustments set the two trigger tunnel diodes to their ready or armed current value of slightly less than 10 mA.

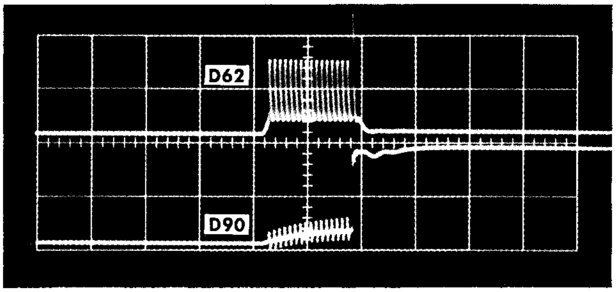
Halfway through a triggered holdoff period, when Q74 conducts, Q74 collector current reverse biases Q72 and Q80 by making their base voltage more positive than Q70 and Q82 base voltage. At this time the current originally supplied to the two tunnel diodes is stopped. The comparators' emitter current is still nearly 10 mA, but is passes through R70 to ground and through R85-Q90 to the —19-volt supply.

At the end of the holdoff period when Q74 emitter releases its current path, the two lockout comparators restore to their original quiescent state. Two capacitors (C80 and C85) slow the collector signals at Q80 and Q82 from the rate of change of Q72 collector signal. These capacitors allow Q72 to arm D62 before D90 is armed, for proper UHF Sync operation.

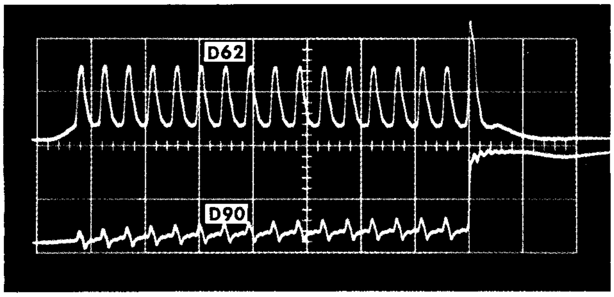
UHF Sync Operation

Tunnel diode D62 and back diode D66 can be biased into oscillation by advancing the TRIG SENSITIVITY control clockwise past its midrange position. Oscillations take place between about 12 and 20 MHz depending upon the TRIG SENSITIVITY control setting. Almost immediately after D62 switches to its high voltage state, L62 lets D66 pull D62 off its high state. Soon after D62 goes back to its low voltage state, D66 stops conducting and the cycle repeats. Oscillations begin right after Q72 conducts at the end of a normal holdoff period.

D62-D66 oscillate through several cycles before D90 is armed. The time difference is about 0.8 μs, caused by the capacitors at Q80 and Q82 collectors. Fig. 4-4 waveforms show D62-D66 oscillations and D90 switching to its high state when the TRIG SENSITIVITY control is fully clockwise (no UHF Sync signal is connected to the Type 3T2). Note that D90 switches to its high voltage state (and starts the holdoff period for one sample) just as D62 anode goes positive.



A. 0.5 μS/DIV sweep rate.



B. 0.1 μS/DIV sweep rate.

Fig. 4-4. D62 and D90 UHF Sync waveforms. Test oscilloscope: Externally triggered; 85 MHz bandpass.

UHF Sync operation results when a high frequency signal arrives at D62 anode through C1 and R1 causing D62 to switch positive slightly in advance of its normal switching time. D90 goes to its high voltage state exactly as shown in Fig. 4-4, but at a time when the UHF Sync signal switches D62. The normal holdoff period and functions previously described follow D90 switching positive.

RAMP GENERATORS

The Ramp Generators diagram at the back of this manual contains the following circuits: Timing Ramp, Slewing Ramp, Staircase Inverter, Leadtime Comparator, Timing Ramp Comparator, Slewing Ramp Comparator, Vert Strobe Drive, Time Position Offset and Timing Ramp amplifier. Circuits used during With Trigger operation include only the Staircase Inverter, Timing Ramp, Timing Ramp Comparator and the Vert Strobe Driver. Circuits used during Before Trigger operation include all but the Timing Ramp Comparator. The following description begins with the system operating with the START POINT switch at BEFORE TRIGGER and concludes with the START POINT switch at WITH TRIGGER.

Before Trigger Operation

During Before Trigger operation, the circuits diagrammed on the Ramp Generators page serve a special coordinating function of the CRT display horizontal and vertical deflection voltages. The deflection voltages are not generated there, but each dot horizontal position is determined.

A detailed block diagram of the Ramp Generators is shown in Fig. 4-5. Using Fig. 4-5, the purpose of the ramp generators is to relate the ratemeter-started slewing ramp and the trigger-started timing ramp to the reference staircase signal to produce horizontal signals that are properly related to the vertical strobe drive pulses. The horizontal output signals span a fixed voltage range equal to the CRT horizontal scan, regardless of sweep rate or time window location (Time Position control setting). Section 2 controlled sequence random sampling system description implies (at waveform (O) of Fig. 2-7) that the timing ramp stopped voltage is memorized as it comes out of the Timing Ramp generator. This is not true. It is true that the Timing Ramp generator output voltage does operate through a variable range when turning the Time Position controls, but that voltage is not memorized. The variable range of Timing Ramp output voltage is a side effect of varying the slewing ramp output voltage range for proper operation of the Slewing Ramp Comparator. If the range of Timing Ramp output voltages was fed to the horizontal memory, the physical position of the CRT display would shift. Instead, only the time window shifts across a fixed CRT display.

The Timing Ramp movable output voltage range is converted to a fixed voltage scan at the output of the Timing Ramp Amplifier. The fixed scan is referenced to the fixed staircase signal steps fed in at the Staircase Inverter Amplifier input. Two front panel controls that affect the Timing Ramp range of output voltage are the TIME MAGNIFIER and the TIME POSITION controls. These controls alter the Slewing Ramp stopped voltage range within the Ramp Generators circuits, and then cancel the associated Timing Ramp changes at the Timing Ramp Amplifier output. Equal and opposite changes to the system are introduced. The TIME MAGNIFIER control alters the Staircase Inverter Amplifier output by decreasing its gain. It therefore alters the Timing Ramp Amplifier output by increasing its gain an identical amount. Likewise, the TIME POSITION controls apply a negative offset to the Staircase Inverter Amplifier output (when other than fully clockwise). They therefore alter the Timing Ramp Amplifier output in a positive manner exactly equal and opposite to that of the Staircase Inverter Amplifier output. The result then

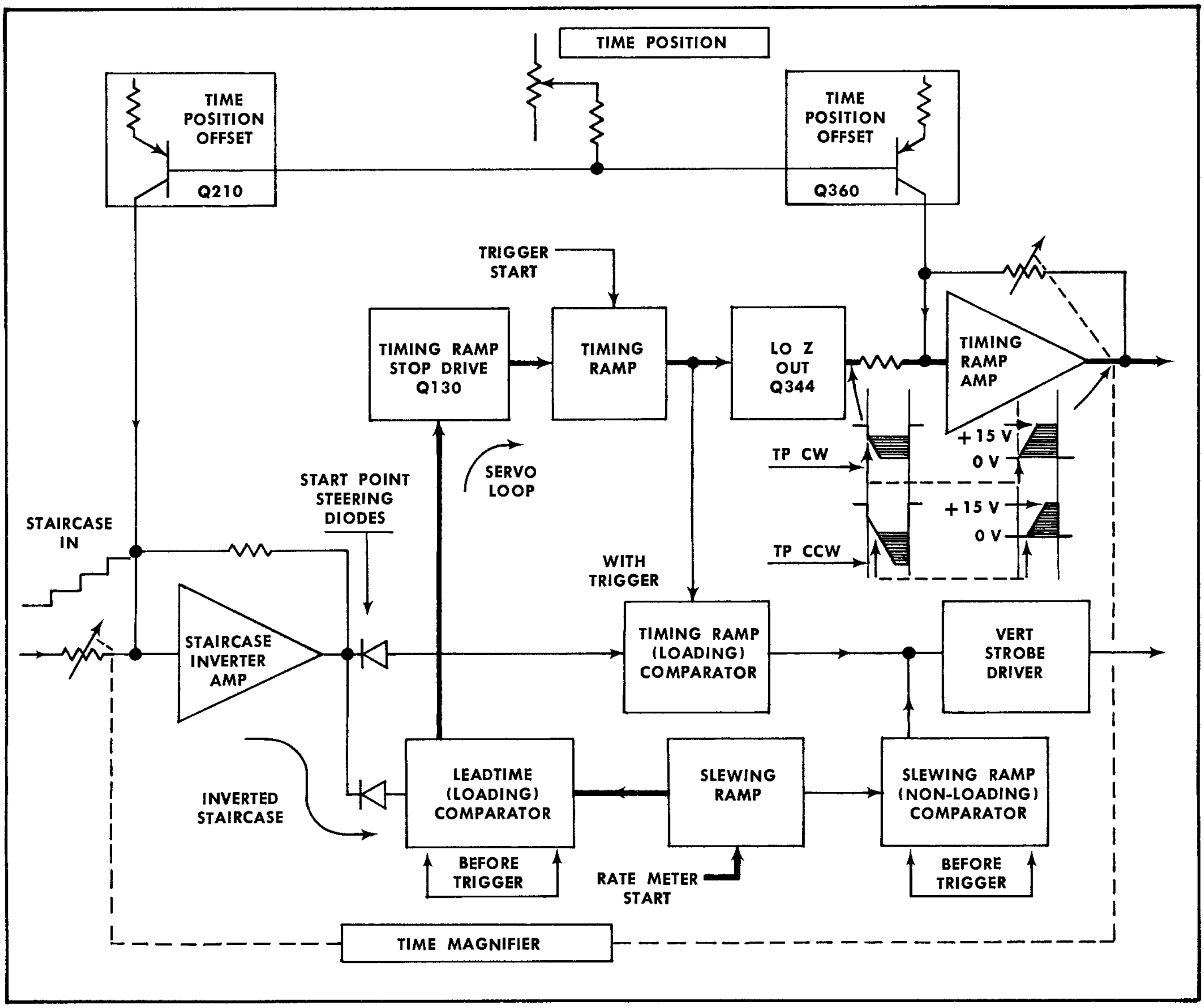
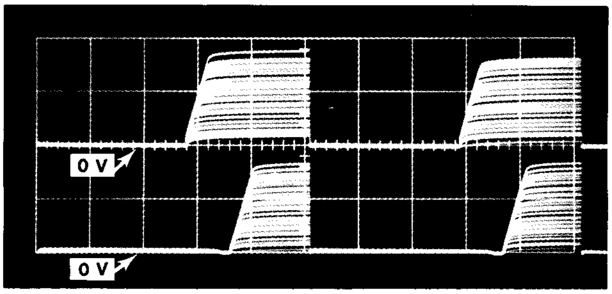


Fig. 4-5. Ramp Generators block diagram.

is that the Timing Ramp signals out of the Timing Ramp Amplifier always stay within the same zero volt to +15 limits. Four drawn waveforms near the Timing Ramp Amplifier in Fig. 4-5 and the waveforms of Fig. 4-6, show the Timing Ramp Amplifier output signals when the TIME POSITION controls are at their two extremes. Descriptions of the individual circuits follow.



Test oscilloscope: 10 V/DIV.

Fig. 4-6. Timing Ramp output signal. Upper: TIME POSITION fully cw. Lower: TIME POSITION fully ccw.

Timing Ramp Generator

The Timing Ramp Generator consists of five selectable constant current transistors and 5 capacitors that charge at a linear rate; a clamp circuit to hold the output voltage near ground, and then release the chosen ramp circuit to run negative upon trigger circuit command; a four transistor high impedance to low impedance output circuit; and a Stop Drive transistor that responds to the Leadtime Comparator during Before Trigger operation. Many diodes are used in the overall Timing Ramp circuit for signal switching with low impedance, no loss conduction, and high impedance low leakage reverse bias nonconduction. Connections from the trigger circuit to the Timing Ramp Clamp, and three of the five ramp generators are shown in Fig. 4-7.

Timing Ramp Clamp

When the trigger circuit is armed and ready, Q102 nonconduction places the Timing Ramp Clamp transistors in their quiescent conducting condition and the Timing Ramp generator output is clamped near ground. Q301 and Q302 are not saturated due to the two-diode voltage difference between Q302 collector and Q301 emitter, and the voltage at Q301 base. Q302 collector pulls toward ground due to Q301 collector current drive to Q302 base. D306-D307 pull Q301 emitter up until Q301 current is reduced, reducing Q302 base current. The clamp then holds itself with Q302 about —0.4 volt from ground. Q102 conduction takes Q301 collector current away from Q302 base, cutting Q302 off. The negative voltage change at Q302 collector reverse biases D307, which then lets R306 set Q301 maximum current at about 1 mA. D306 is reverse biased by any negative change at Q306 emitter, assuring that Q301 does not load the Timing Ramp rundown. At the end of a Timing Ramp period, when Q102 is cut off and Q301 collector current (1 mA) is switched into Q302 base, C300-R300 limit the rate at which Q302 base receives its turn-on drive. C300-R300 then slow the rate at which the Timing Ramp is reset; which assures that the Horizontal Memory circuit has enough time to properly store the stable stopped Timing Ramp voltage.

Ramp Generator Circuit

One of five ramp generator circuits is selected by the front panel RANGE switch. The one selected conducts a constant current all the time, while the other four are cut off with no emitter return circuit. Fig. 4-7 shows two of the ramp generators, with the RANGE switch drawn connected to Q325 emitter and the 10 μs range in operation. Constant current is assured by the pentode-like collector characteristics of Q325 and the large value of resistance between its emitter and the —100-volt supply. The collector voltage range is from about —3.3 volts when Q302 conducts, to about —19 volts when the Time Position controls are both fully counterclockwise and the Time Magnifier switch it at ×1. This change in collector voltage may change the transistor bias a fraction of a volt, but not enough to significantly change the 7.5 mA current through R335 and R336.

There is no loading comparison made between the inverted staircase and the timing ramp. Instead, the inverted staircase is compared with the slewing ramp at Q231, the Leadtime Comparator. Q231 collector current is less than 1 mA before the slewing ramp forward biases D236. After D236 is forward biased, the slewing ramp 7.5 mA flows through Q231 and the current forward biases the Timing Ramp Stop Drive transistor Q310. Prior to this event, Q310 is cut off due to R311 current through D311. Before Q310 conducts, its collector circuit rests at —19 volts, reverse biasing D325, D327 etc. When Q310 conducts, D314 forward voltage drop places D325 anode sufficiently positive to take all of the 7.5 mA through R335 and the Timing Current control, R336. This takes current from Q325 and stops charging C324, which stops the ramp running negative.

With Trigger Operation (Fig. 4-8)

As Q302 cuts off, Q325 7.5 mA current has four possible paths: 1) C324 the capacitor between its collector and ground; 2) R330 to ground; 3) Q306 base current and 4) D277 and Q271 emitter. At the beginning of the timing ramp rundown, almost all of the 7.5 mA is used to charge C324. Almost no current is required by Q306 base because its emitter circuit current is used only to charge C308 and almost no current flows in R330. As C324 charges negative, the ramp voltage soon is stopped going negative by the loading comparison with the inverted staircase. The loading comparison takes place at Q271 base-emitter junction and all of Q325 7 mA then flows through the series connections of D324, D330, D277 and Q271.

Special Timing Ramp Components

Several component functions within the Timing Ramp circuit are not obvious from the previous descriptions. R332 and C332 decouple the —19-volt supply from the Ramp Generator base circuit. R333 and C333 add stabilization to the active transistor emitter-base circuit to prevent parasitic oscillations. D330 disconnects the other ramp generators when the 100 ns ramp is in use (Q329). R330 then provides leakage current (I_{CBO}) to the cutoff ramp transistors and assures that D330 cathode remains essentially at ground.

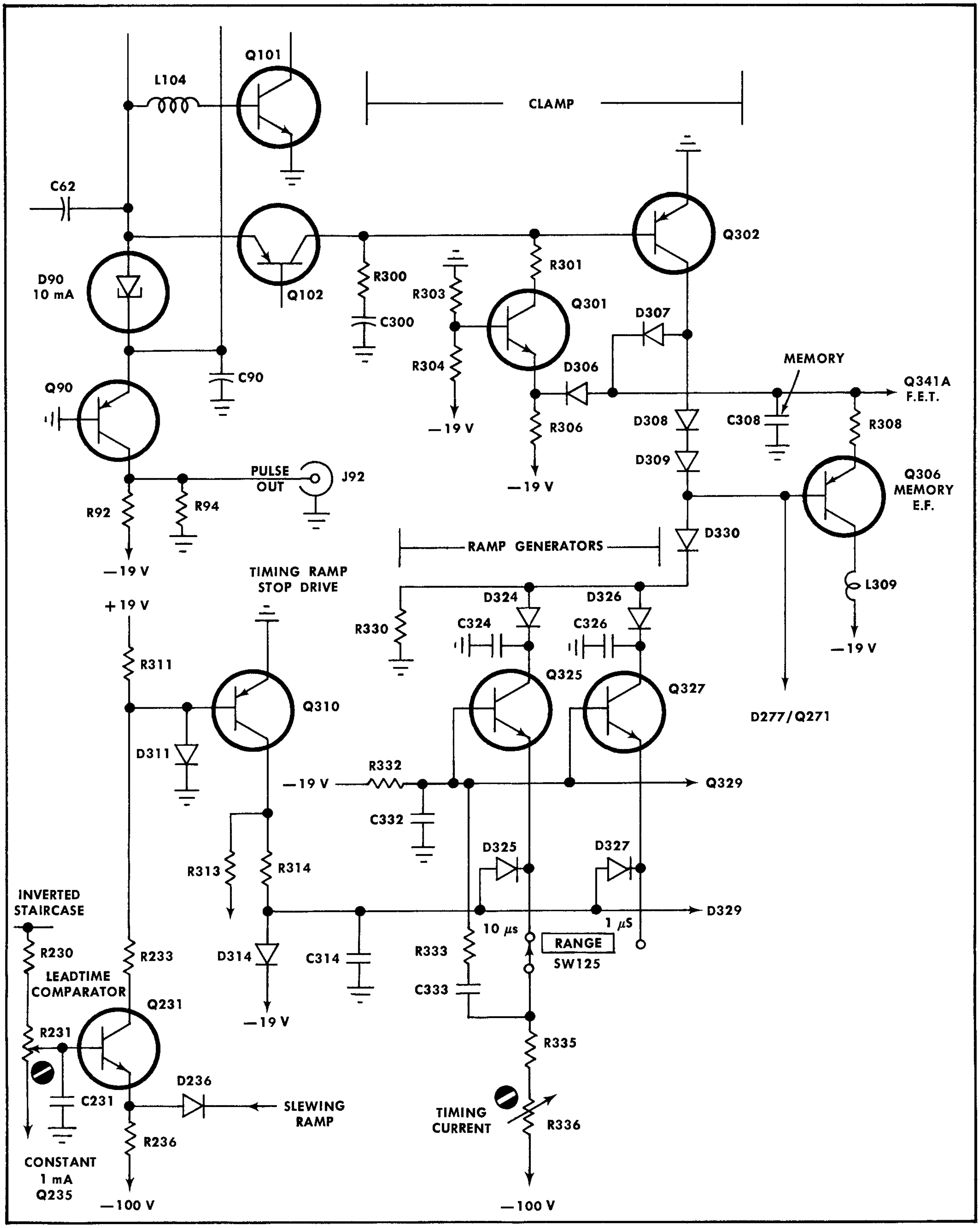


Fig. 4-7. Before Trigger Timing Ramp Connections.

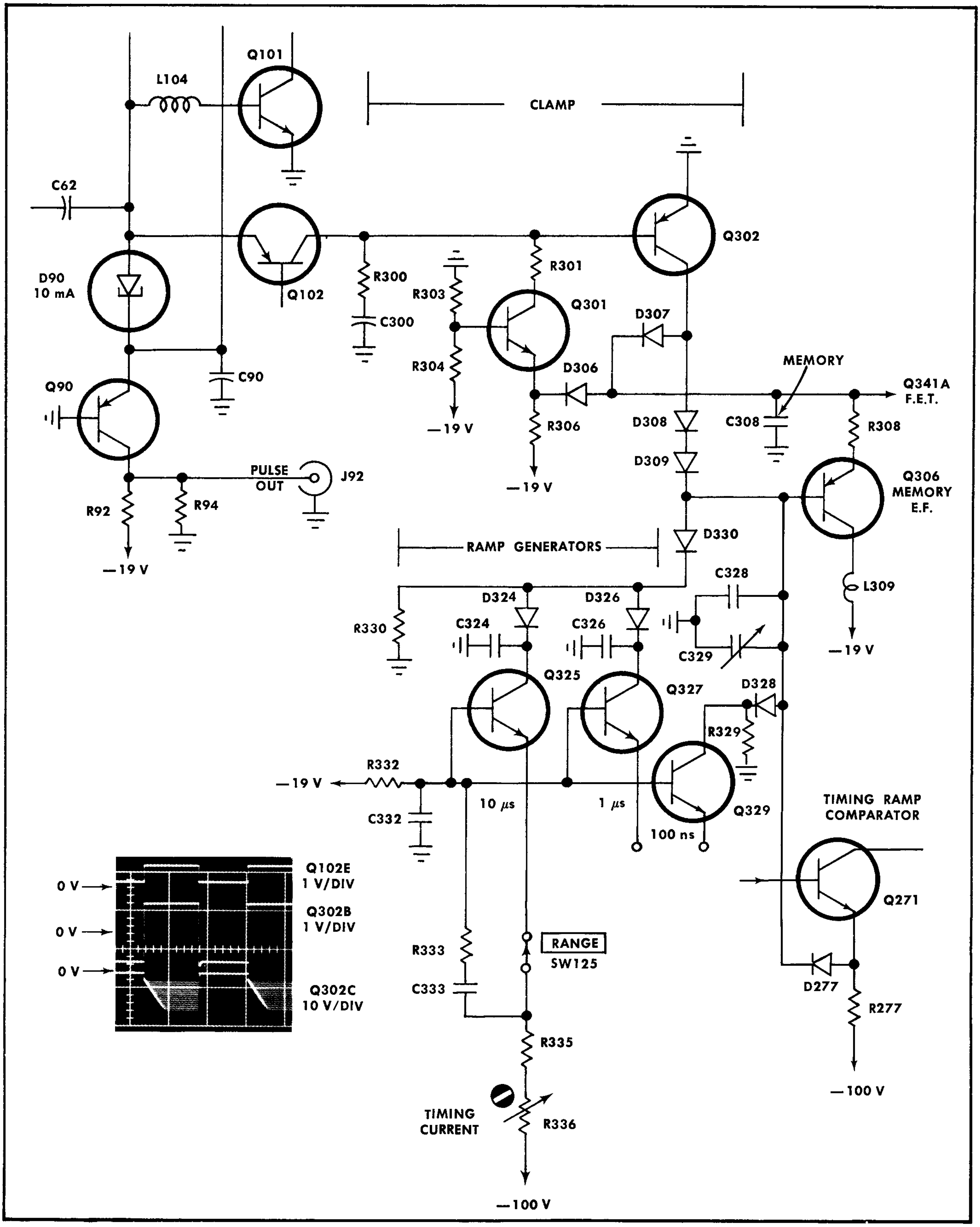


Fig. 4-8. With Trigger Timing Ramp Connections.

D328 and R329 perform the same disconnect function when Q329 is not in use.

Two diodes between Q302 collector and Q301 emitter limit the self-generating drive and prevent both Q301 and Q302 from saturating. D306 disconnects Q301 and R306 from the released negative-going ramp signal. D307 discharges C308 memory capacitor at the time the Timing Ramp is reset.

Memory and Memory E.F.

The memory capacitor C308 and emitter follower Q306 serve to stablize the timing ramp voltage between the time when the rundown is stopped and the circuit is reset. C308 is about 7 times larger then the100 ns ramp capacitors, providing about one seventh the rate of leakage that would exist if C328-C329 were connected directly to Q341A gate lead. Q306 provides current gain during the ramp rundown, which isolates C308 charging current from the ramp generator collector current. Then as the ramp stops running negative, C308 stores the stopped ramp voltage with several times the stability that can be obtained from C328-C329.

Q306 does not provide the discharge current for C308 during ramp reset. Instead, C308 is discharged by Q302 and D307. D308 and D309 forward voltage drop (during reset) assures that Q306 base voltage never completely cuts off collector current. Then, when the timing ramp is released for another rundown, Q306 is already conducting and the ramp signal out of Q306 emitter (and C308) starts linearly with no delay.

High Impedance to Low Impedance Driver

Fig. 4-9 includes the Timing Ramp output transistors, Q341 and Q344. Q341A, Q341B, D343 and Q344 are connected so that Q341A input gate voltage and Q344 emitter output voltage are essentially identical. If there is any voltage difference, it never exceeds about 20 or 30 millivolts. The input-output voltage equality with high impedance input to low impedance output is accomplished by special attention to transistor bias voltages.

Q341B is a zero biased constant current stage. Zero bias is assured by directly connecting the gate to the source. The zero bias connection firmly fixes the channel current at the natural value for zero bias. With the two halves of Q341 matched chips mounted in the same can, the zero bias channel current of one half equals the zero bias channel current of the other half. Thus with Q341B forced to conduct a channel current at its natural zero bias value, Q341A (in series) also conducts at its natural zero bias value. Q341B also temperature compensates Q341A, automatically changing the zero bias channel current for both halves to maintain Q341A zero bias operation.

Q341A is connected as a source follower (similar to an emitter follower) that drives a junction transistor emitter follower. Since Q341A source voltage equals its gate voltage, the second transistor base-emitter drop is compensated by D343. The forward voltage drop across D343 is almost equal to the forward voltage drop across Q344 base-emitter junction, thus setting Q344 emitter at the same voltage as Q341A gate. D343 temperature compensates Q344, making the two followers unusually stable over a normal operating temperature range.

Q344 emitter signal drives the input resistance of the Timing Ramp amplifier, R348 and R349. The emitter signal swings from about —1 volt to about —13.3 volts throughout the range of Timing Ramp signal.

Timing Ramp Amplifier

The Timing Ramp Amplifier consists of two operational amplifiers, one inverting, the other non-inverting. The inverting amplifier is always used, and the non-inverting amplifier is used only when the Time Magnifier control is at ×10, ×20, or ×50. Each time the Time Magnifier switch is advanced away from ×1, the Timing Ramp signal amplitude out of Q344 emitter is reduced. However, the feedback resistors of the Timing Ramp Amplifier increase its gain an equal amount so the output swing limits never change. The same is true when using the Time Magnifier VARIABLE control. Table 4-1 lists the input signal changes and amplifier gain changes through the range of Time Magnifier switch positions.

The Timing Ramp one time-window range of signal amplitude is 7.5 volts (at Time Magnifier = ×1). Add to this the Timing Ramp Amplifier basic ×2 gain, and the Timing Ramp 7.5 volt range of output signals is converted to a 15 volt signal. Then as the Slewing Ramp - Inverted Staircase comparisons reduce the Timing Ramp amplitude through the Time Magnifier switch positions, the final Timing Ramp Amplifier range of output signals remains at 15 volts.

Special use of a differential comparator at the inverting amplifier input (Q371 allows the amplifier input voltage to be set to to zero when the Timing Ramp is running down. The adjustment is made at Q371B base, compensating for any transistor unbalance of the differential pair. The in-

TABLE 4-1

Timing Ramp Amplifier Gain

Switch position TIME MAG	Input signal attenuation[2]	Feedback Gain[3]	Gain out of Q381 emitter	Gain out of Q395 emitter	Total Amplifier gain
×1	×1	×2	×2	not used	×2
×2	1/2	×4	×4	not used	×4
×5	1/5	×10	×10	not used	×10
×10	1/10	×2	×2	×10	×20
×20	1/20	×4	×4	×10	×40
×50	1/50	×10	×10	×10	×100

[2]**Attenuated at Staircase Inverter input, which attenuates negative run of both Slewing and Timing Ramps.**

[3]**Input Resistance is 2.5 kΩ, feedback resistance is 5 kΩ.**

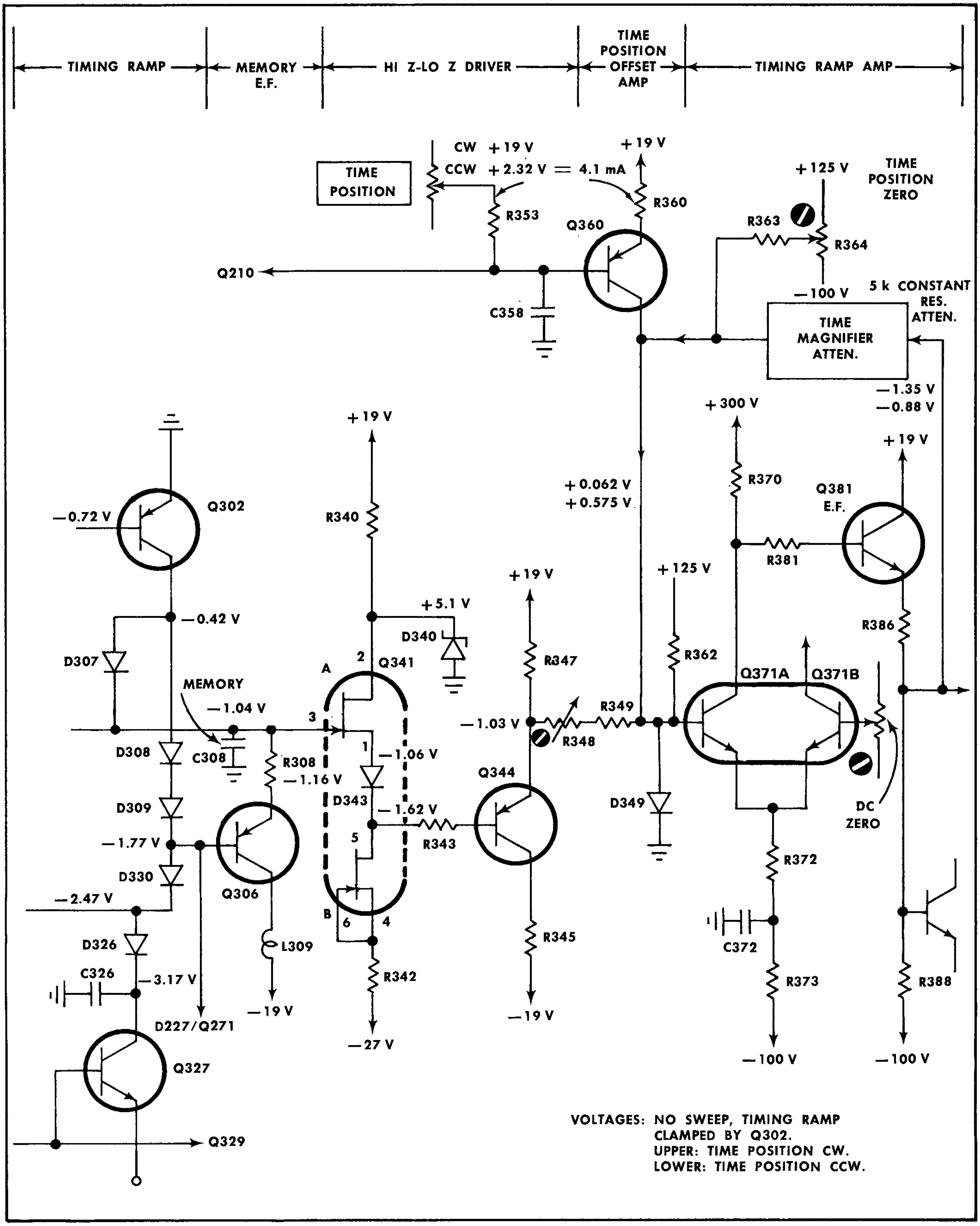


Fig. 4-9. Timing Ramp output, Time Magnifier circuit and Time Position control.

verting operational amplifier (Q371 and Q381) has a very high open loop gain so that essentially all of the input signal current (through R348 and R349) passes into the feedback resistance of the Time Magnifier switch. This assures the usual virtual signal ground at the base of Q371A. It is the voltage of the virtual signal ground input that is adjusted to zero volts while the amplifier is operating through its dynamic range. Once the virtual signal ground input is at zero volts, then the current injection input from the Time Position Zero control (R364) is adjusted so the output first stopped ramp voltage at each sweep start is no more positive than the clamped voltage value.

The feedback resistance on the Time Magnifier attenuator remains at 5 kΩ. This is done so the 10 kΩ maximum resistance VARIABLE control will increase the Timing Ramp Amplifier gain by a factor of 3 for all positions of the Time Magnifier switch. The Variable control also reduces the inverted staircase signal amplitude by a 3 to 1 factor, assuring that the Timing Ramp Amplifier output signal range remains zero to 15 volts for all positions of the VARIABLE control.

The non-inverting amplifier gain is ×10, set by feedbak resistors R395 and R396. The amplifier plus input (Q391A base) receives the signal from Q381. Since the amplifier is not inverting, the feedback is applied to the minus input, Q391B base. Emitter follower Q395 drives both the output lead and the feedback resistors to Q391B. Q395 is not connected to the Time Magnifier attenuator feedback resistors that control the gain of the inverting amplifier.

Special components associated with the Timing Ramp Amplifier that have functions not obvious from the above description are described here. D349 clamps Q371A base at a maximum positive value of +0.6 volt when the timing ramp is clamped and the Time Position controls are fully counterclockwise. The clamp prevents the amplifier output voltage from reaching its most negative value and assures linear operation. R362 provides an offset signal to compensate for the normal quiescent —1 volt output from Q344 emitter. C372-R373 prevent any noise on the —100-volt supply from getting into Q371 emitter and being amplified. C376 assures that Q371B base has a low impedance for high frequencies; otherwise, R376 impedance to ground would limit the stage gain. C370, R381, R383, R391 and R399 all are high frequency oscillation dampers that keep the amplifier stable.

Time Position Offset

The Time Position Offset amplifier Q360, shown in Fig. 4-9, is a high impedance current source for the Timing Ramp Amplifier input. Q360 converts a variable voltage at its base (variable by the Time Position controls) to a variable current into Q371 equivalent signal ground input. Q360 conducts no current when both Time Position controls are fully clockwise, and conducts a maximum of 3.1 mA when the controls are fully counterclockwise. The current value at any Time Position control setting is set by Q360 base voltage (minus the silicon base-emitter drop), and R360 between Q360 emitter and +19 volts.

Voltage limits of the Time Position controls (diagrammed with the Ramp Generators at the back of this manual) are set by the series resistors R357 and R356, in parallel with the resistance of the controls. Diode D355 offsets the maximum positive control output from +19 volts to about +18.4 volts. The voltage across D355 is just sufficient to forward bias Q360 into conduction, giving the controls the ability to alter Q360 current all the way to their fully clockwise rotation stop. If D355 were not there, the Time Position controls would have no effect upon the display time window during the last 2 or 3 degrees of clockwise rotation.

Function of the Time Position controls is described earlier in the test that refers to Fig. 4-6.

Slewing Ramp Generator

The Slewing Ramp Generator is nearly identical to the Timing Ramp Generator previously described. The clamp circuit differs, but once released, the slewing ramp operates at the same rate on the same principle as the timing ramp. Basic differences from the Timing Ramp Generator are: the constant current transistor base voltage is —25.2 volts instead of —19 volts; the ramp negative run is stopped only by a loading comparison with the inverted staircase signal (rather than by a stop drive circuit); there is no memory capacitor or memory emitter-follower output circuit; and the clamp circuit does not hold the clamped output positive with respect to the starting ramp voltage (as the Timing Ramp Clamp does to the Timing Ramp).

Slewing Ramp Clamp

The Slewing Ramp Clamp is made up of three transistors Q251, Q252 and Q254. Quiescently, Q251 and Q252 do not conduct, but Q254 does conduct (without going into saturation), clamping the Slewing Ramp generator at about —0.6 volt. Fig. 4-10 shows the connections of the Slewing Ramp. The clamp is controlled by the Ratemeter Comparator. (See Fig. 2-7 block diagram. There, the Slewing Ramp is driven by the Trigger Ratemeter.) When the Ratemeter Comparator output goes positive, Q590 drives Q251 into saturation. Q251 collector at essentially ground, D256 connects Q252 collector to Q254 base and cuts off Q254 current. This releases the Slewing Ramp generator to run negative.

Halfway through the trigger holdoff time, the Ratemeter ramp is reset and the Ratemeter Comparator turns off Q251. Q251 turn off, soon turns off Q252. The small delay due to both Q251 and Q252 being in saturation does not disturb the circuit operation. As Q252 cuts off, its collector drops to —9 volts and D256 then disconnects Q254 base. Now, R259 (through D258) applies turn-on bias to Q254. Q254 conduction discharges the ramp capacitor much more rapidly than it charged negative. Then, as the voltage at Q254 collector rises positive enough for D259 to conduct, Q254 collector and D259 limit the drive to Q254 base and prevent saturation. Q254 is kept from saturation so it will quickly release the Slewing Ramp at the next Ratemeter "best guess" start command.

Slewing Ramp

The Slewing Ramp consists of five selectable constant current transistors and five different precision capacitors. The front panel RANGE switch selects one of the constant current transistors by connecting its emitter lead to R268 and R269 and the —100-volt supply. Each current transistor base lead is connected to a Zener diode-regulated —25.2-volt supply. Thus, with a fixed base voltage, the current transistor must

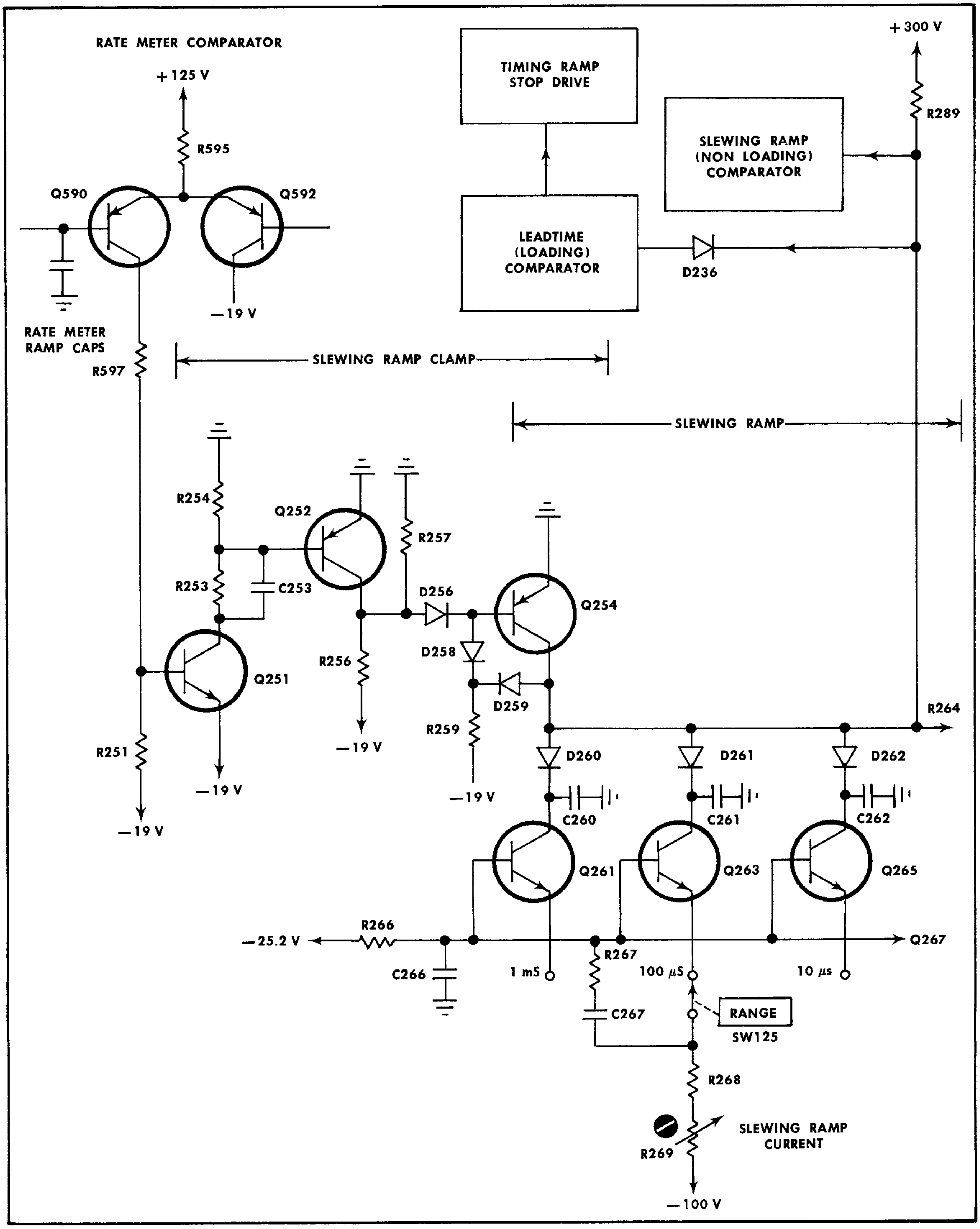


Fig. 4-10. Slewing ramp control and output connections.

conduct a value of current set by the value of R268-R269 and the voltage drop across them. It is the pentode-like characteristics of the transistor collector that then causes the associated ramp capacitor (C260 through C265) to charge negatively at a very linear rate. The selected constant current transistor conducts the same current value whether the clamp circuit holds the output voltage at —0.6 volts or cuts off and releases the ramp to run negative.

While the clamp circuit conducts, all ramp capacitors hold a —0.2-volt charge. Then when one capacitor starts its negative charge, the diodes connected to the other ramp capacitors are reverse biased. Turned-off constant current transistor leakage is not great enough to charge any of the unused timing capacitors sufficently to disturb the rate of fall of the capacitor in use. The 620 kΩ resistor (R289) connected between all the ramp disconnect diodes and +300 volts, assures that the diode connected to the operating ramp capacitor conducts slightly while the ramp runs negative.

The Slewing Ramp output signal drives both the Slewing Ramp Comparator and the Leadtime Comparator.

Slewing Ramp Comparator

The Slewing Ramp Comparator, Q281, D284 and Q283, is a non-loading comparator of the inverted staircase and slewing ramp signals. At the time of comparison, Q281 drives the Vert Strobe Driver avalanche transistor into conduction with very little change in the rate of fall of the slewing ramp signal.

With both Time Position controls fully clockwise and before a sweep is started, conditions are: Q281 base voltage is —1 volt, and its collector current is about 0.75 mA; Q282 base voltage is —0.6 volt and its collector current is about 2.6 mA; and D284 is reverse biased so the two transistor emitters are not connected together.

As the sweep starts, Q281 base remains at essentially —1 volt for the first inverted staircase voltage (regardless of the Time Magnifier or Variable control conditions). As Q283 base goes negative at the slewing ramp signal rate, its emitter also goes negative. As soon as Q283 emitter is about ½ volt below Q281 emitter voltage, D284 parallels R285 across R284 and increases Q281 collector current to about 3.5 mA. Q281 collector then drives essentially all of that current into Q290 base causing the Q290 to avalanche and drive the vertical unit strobe generator. As D284 conducts, Q283 is cut off during the rest of the slewing ramp negative run.

The loading comparison of the inverted staircase and the slewing ramp signals is described below under the Leadtime Comparator discussion.

Vertical Strobe Driver

An avalanche transistor Q290 drives a fast rise differentiated positive pulse to the vertical unit strobe generator each time there is a slewing ramp comparison. (In With Trigger operation, the strobe drive pulse occurs at each timing ramp comparison, described later under With Trigger Operation.) A second DC coupled output from Q290, drives the blanking circuits (diagram 5). The DC coupled signal blanks the CRT from the time of the slewing ramp comparison with the inverted staircase, until the slewing ramp is reset at ½ the holdoff period.

The avalanche transistor operates in its avalanche mode of ionized conduction only during the time it takes for the collector voltage to go from —19 volts to about —6 volts. After that, it goes into saturation as a normal junction transistor. It is the avalanche conduction period that produces a very fast output pulse for proper drive to the vertical unit strobe generator. In Q290 emitter, R292 and L295 limit high power ground currents so other circuits are not disturbed. L291 essentially disconnects the drive circuit to Q290 base during the very high frequency portion of the avalanche conduction period, then permits a steady DC forward bias for the duration of the interdot blanking period. D282 sets the reverse bias at +0.6 volt during the time Q290 is cut off.

Leadtime Comparator

The Leadtime Comparator is a loading comparator of the inverted staircase and slewing ramp signals. Both the slewing and timing ramps are stopped at the time of comparison. Before comparison, Q231 conducts about 0.8 mA, not enough current to turn on the Timing Ramp Stop Drive transistor Q310. Q231 base voltage is offset from the inverted staircase signal by constant current transistor Q235 and R230-R231. The voltage offset is about —3.75 volts (½ the 7.5 volts of one Time Position Range), and remains a fixed value regardless of inverted staircase voltage. The pentode-like characteristics of Q235 collector, and its fixed base voltage and emitter resistor, set the current through R230 and R231 at a constant 1 mA regardless of voltage changes by the inverted staircase signal.

Q231 emitter voltage and the normal silicon diode drop of D236, add about —1.2 volts to Q231 base voltage. Thus, the slewing ramp signal must go about 4.7 volts more negative than the inverted staircase voltage at each comparison. This voltage difference is converted then to a fixed time delay from the slewing ramp start. Q231 is adjusted so the time delay is equal to one half of a Time Position Range, described near the end of Section 2, Principles of 3T2 Random Process Sampling.

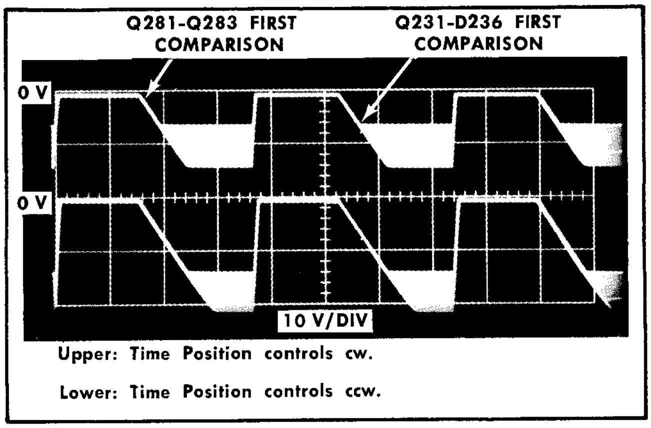


Fig. 4-11. Slewing ramp signal at Q254 collector, D236 anode. (Double exposure.)

Fig. 4-11 shows a double exposure of two slewing ramp waveforms, showing the comparison points for the first sample of a sweep. As shown in the illustration, the Type 3T2 is operating at 1 μs/DIV (10 μs RANGE and ×1 TIME MAG-

NIFIER), and the exposures were made first with the TIME POSITION controls fully clockwise then fully counterclockwise. Each exposure is a time exposure of sufficient time to show all the stopped slewing ramp voltage values for one sweep. Comparing Fig. 4-11 with waveform (O) of Fig. 2-7 may aid in understanding the time window movement action caused by rotation of the TIME POSITION control.

Staircase Inverter Amplifier and Time Position Offset

The Staircase Inverter Amplifier is a three transistor operational (feedback) amplifier with a maximum gain of one-half. The input resistance is the constant resistance 5 kΩ Time Magnifier attenuator, and the feedback resistance is R214. The amplifier is driven (at the Time Mag atten input) with a 0 to +15-volt signal from the Staircase Generator, and by the Variable current from Q210, the Time Position Offset amplifier. Output is from Q220 emitter, which is fed to the two Start Point Steering diodes. The maximum inverted staircase signal output is a 7.5 volt amplitude signal at Q220 emitter ranging from about —2 to —9.5 volts when the Time Position controls are fully clockwise, to about —9.5 to —17 volts when the Time Position controls are fully counterclockwise. Minimum inverted staircase signal output is 150 mV when the Time Magnifier switch is at ×50. (Earlier it was stated that the Timing Ramp Amplifier gain changed from ×2 to ×100 at the two extremes of the Time Magnifier switch positions.) The total range of gain change of the Staircase Inverter Amplifier is from ×0.5 to ×0.01 at the two extremes of the Time Magnifier switch positions. Note that the total gain from the input terminal of the Staircase Inverter Amplifier to the output of the Timing Ramp Amplifier is always unity, even when using the VARIABLE control.

Q212 and Q214 are a differential pair with Q214 temperature-compensating Q212. The inverted signal at Q212 collector drives the output emitter follower Q220. Q220 emitter is returned to Q214 collector so that the amplifier output can rapidly return positive at the staircase signal reset time, and so that equal power is dissipated in Q212 and Q214 collectors.

The Time Position Offset amplifier Q210 is identical with the offset amplifier connected to the Timing Ramp Amplifier. With the Time Position controls fully clockwise, no current is injected into Q212 base. With the Time Position controls fully counterclockwise, Q210 injects about 3 mA offset current into Q212 base, offsetting the Staircase Inverter amplifier output a total of —7.5 volts.

Staircase Inverter amplifier parts with functions not obvious from the above are: R213, which offsets the amplifier output voltage so that the Timing Ramp Comparator (described below) operates correctly for With Trigger operation; R220-C220, R218, and R223, all stabilizing components to assure that the amplifier does not oscillate and C223, which reduces the amplifier high frequency response to reject unwanted short term transient signals.

With Trigger Operation

The following description of the Timing Ramp Comparator and the Start Point Steering diodes, completes the Ramp Generator circuit description.

Start Point Steering Diodes and START POINT Switch

The START POINT switch selects the Before Trigger or With Trigger form of operation. When the switch is at Before Trigger, D228 is biased into conduction, and the Leadtime Comparator and Slewing Ramp Comparator are ready to operate. D225 and Q271 are reverse biased to —19 volts by R275, assuring that the Timing Ramp and Inverted Staircase signals cannot be compared at Q271-D277.

When the START POINT switch is at With Trigger, D225 and Q271 are biased into operation. Q235 saturates taking D228 anode, Q231 base and Q281 base all to —24 volts. This reverse biases D284 in the Slewing Ramp Comparator and assures that the Slewing Ramp and the Inverted Staircase signals cannot be compared.

During With Trigger operation, the START POINT switch disables the Horizontal Dot Position Comparator Memory Gate circuit. The Horizontal Memory will then hold its part of the Servo Loop charged properly for the last triggering rate. Thus, if while operating from a stable trigger the START POINT switch is changed from Before Trigger to With Trigger for a few minutes, and then returned to Before Trigger, the display will return to stable Before Trigger operation without the delay that would be caused if the Horizontal Memory charge were not protected. Fig. 4-12 shows circuit connections to the START POINT switch contacts that are diagrammed with the Ramp Generators.

Two other sections of the START POINT switch serve two other circuit functions. One section prevents the front panel LOW REP RATE lamp from lighting when the switch is at WITH TRIGGER (lower left of diagram 4). The other section selects the proper signal source for the Horizontal Amplifier and Blanking circuits (located at the left edge of diagram 5). The Horizontal Amplifier input signals are plainly identified on the complete block diagram. When the START POINT switch is at WITH TRIGGER, the signal is from the Staircase Generator emitter follower output circuit. When the switch is at BEFORE TRIGGER, the signal is from the Horizontal Memory circuit, Q531 emitter.

Timing Ramp Comparator

Timing Ramp Comparator, Q271-D277, delivers a command signal to the Vertical Strobe Driver transistor when the Timing Ramp and Inverted Staircase signals are compared. This action properly coordinates the X and Y voltages at each CRT dot. The principles of With Trigger operation are described in the first part of Section 2.

Q271 always conducts current during With Trigger operation. Before a comparison, its current is about 0.75 mA, and after comparison its current is about 0.75 mA, and after comparison its current is about 7.5 mA. Before the Timing Ramp starts running negative, D277 is reverse biased and Q271 emitter voltage is set by the inverted staircase signal. As the Timing Ramp rundown voltage reaches about —0.6 volt more negative than Q271 emitter voltage, D277 causes all of the Timing Ramp current to flow in Q271. Q271 collector circuit applies most of that current to Q290 base and a vertical unit strobe drive pulse is formed. Since the Inverted Staircase signal steps a bit more negative for each sample, the comparison times are slewed away from the triggering event time causing the vertical unit to sample the input signal in time agreement with the CRT horizontal dot position.

During With Trigger operation, The Slewing Ramp Generator may or may not run from about ground to —26 volts each sample. It also may be clamped near ground, or rest at —26 volts full time. Any one of these conditions is normal and will not affect the With Trigger CRT display. Also, the circuits of the Timing Ramp from Q306 through the Timing Ramp Amplifier will continue to operate with no effect upon the CRT display.

STAIRCASE GENERATOR

General

The Staircase Generator circuit (Block diagram in Fig. 4-13) contains a single transistor Trigger Amplifier And Staircase Stepper (Q401) that drives the rest of the circuits. The circuits driven by Q401 are: a Clock Pulse Amplifier that drives an associated digital unit, a Sweep Gating Multivibrator that starts each staircase run, and the Staircase Generator stepping circuit. Other circuits not driven by Q401 are: the Upper Limit Reset circuit that automatically limits the staircase generator maximum amplitude, a Sweep Gate Inverter that drives as associated digital unit, and the Staircase Emitter Follower output stage that drives three loads: 1) the Time Magnifier Variable control at the Staircase Inverter Amplifier input, 2) the Horizontal Amplifier during With Trigger operation, and 3) the Horizontal Dot Position Comparator (Q533).

Trigger Amp and Staircase Stepper

Q401 base circuit is AC coupled and diode clamped so that the Logic Driver output trigger signal positive rise drives Q401 into saturation. C401-R401 discharge and Q401 carrier storage then stretches the trigger pulse so that Q401 collector drives the Staircase Generator circuits with a negative pulse of about 8 or 10 μs duration. The negative step of Q401 collector signal is used once each sweep to trigger the Gating Multi into cutoff and release the Staircase generator to be stepped. The negative portion also discharges the staircase "ladle" capacitor into the staircase generator input. The time sequence of the Logic Driver trigger signal relationship to each step of the staircase signal is shown in Fig. 2-7 at waveform (D) and (E). The time stretching of the trigger signal by Q401 circuit assures that the staircase generator input capacitor has sufficient time to fully transfer its change into the feedback capacitor C448 each step.

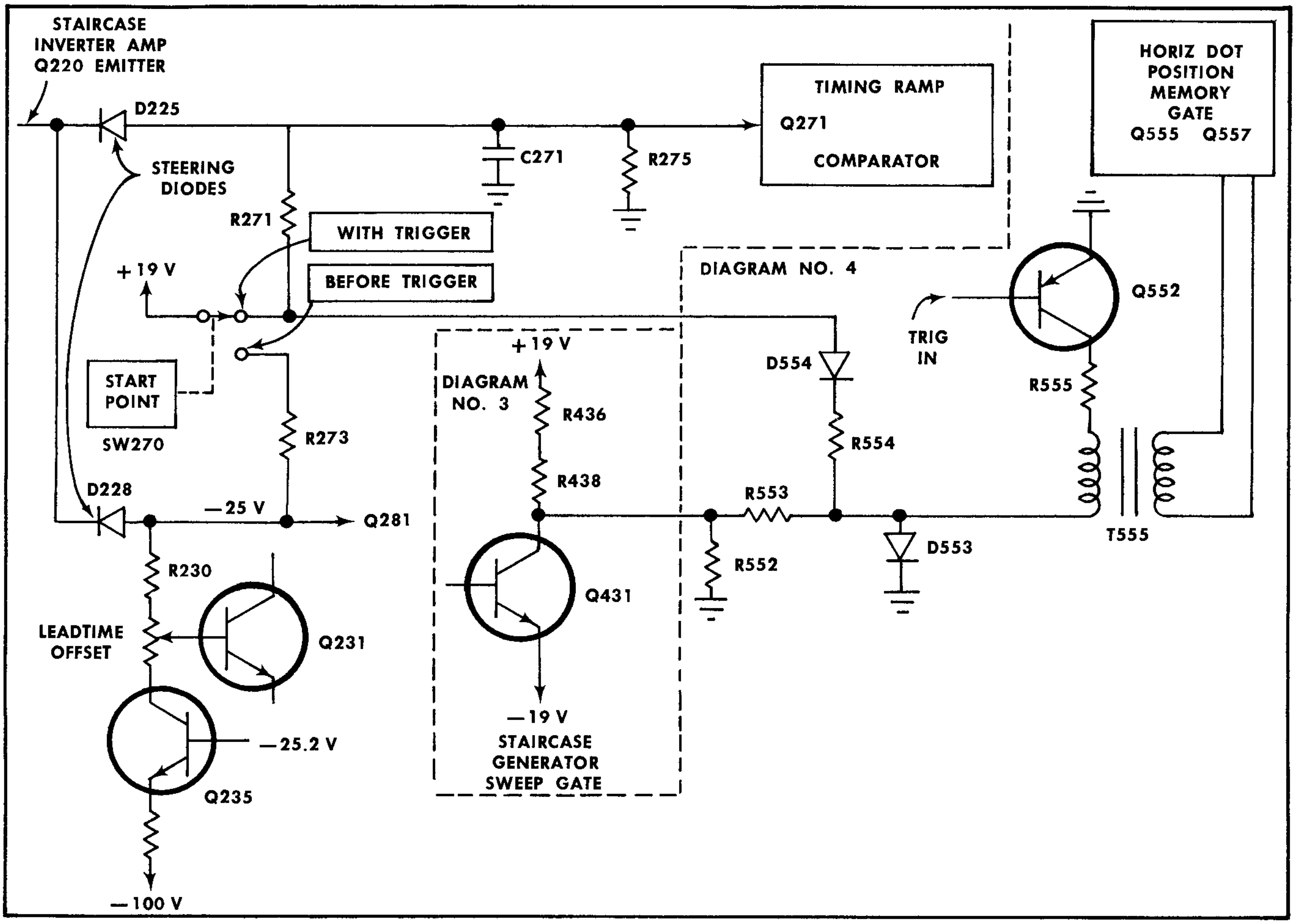


Fig. 4-12. START POINT switch connections.

Staircase Generator Operation (Variable Samples/Div)

Assume during the following discussion that the Gating Multi is conducting so the Staircase Generator can respond to the Logic Driver trigger signal.

The Staircase Generator Amplifier (Q457, Q461, Q465 and Q467) is a high gain operational (feedback) amplifier with capacitors as input and feedback elements. The input "ladle" capacitor is C454 when the SAMPLES/DIV control is in operation, (and C452 in parallel with C453 when the samples per division is calibrated). When Q401 is not conducting, (between trigger pulses) the "ladle" capacitor C454 charges through D454 and R452 to a voltage set by the SAMPLES/DIV control. Then as Q401 collector signal goes negative, C454 charge becomes a current pulse into the amplifier input. The gate lead of Q457A starts to go negative, but the amplifier inverts the signal and applies it back to the input through "bucket" capacitor C448. As soon as C454 is discharged, the output stops charging C448 and the output voltage remains stable until the next trigger pulse. The ratio of input capacitance to feedback capacitance is greater than 10 to 1. Thus, if the input capacitor is charged to +10 volts before Q401 collector goes negative, the output voltage changes less than 1 volt per step as C448 receives the same number of electrons that the ladle capacitor loses during its discharge. Q457A gate lead has a very high leakage resistance, so C448 retains its charge for a considerable amount of time.

When the internal SAMPLES/DIV switch (SW450) is switched up to its 100 position for calibrated digital use, R449 conducts about 1 mA to keep D404 conducting even when Q401 is turned off. When Q401 is turned off, the current passes through D405, D404 and R449 in series. R449 thus assures that driven plates of the staircase ladle capacitor always charges positive to two diode junction drops above +19 volts (when Q401 is cut off), and negative to one diode junction drop above ground (when Q401 saturates).

Each time the ladle capacitor is discharged into C448 (by amplifier feedback action) the output voltage steps positive from its previous value. As the output voltage reaches +52.5 volts, D423 conducts and the Upper Limit Reset transistor (Q420) saturates causing the Gating Multi to cut off; the staircase amplifier then discharges C448. The discharge action amounts to Q431 releasing D448 anode from —19 volts permitting R436-R438 to apply about 5.4 mA positive drive to Q457A gate. This turns Q461 on to heavy conduction, and Q461 collector applies a fast negative signal to C448 through D463. (Q465 is cut off by Q461 fast negative shift and D463 passes the full discharge current to C448.) As soon as C448 and D447 cathode discharge to about 0.3 volts more negative than D447 anode, D447 conducts and stops Q461 turn on by passing the 5.4 mA into Q467 collector. At this time the Staircase Generator output remains at essentially zero volts until the Gating multi is driven into conduction again. (Q467 always conducts 6.3 mA, therefore only 0.9 mA passes through Q465.)

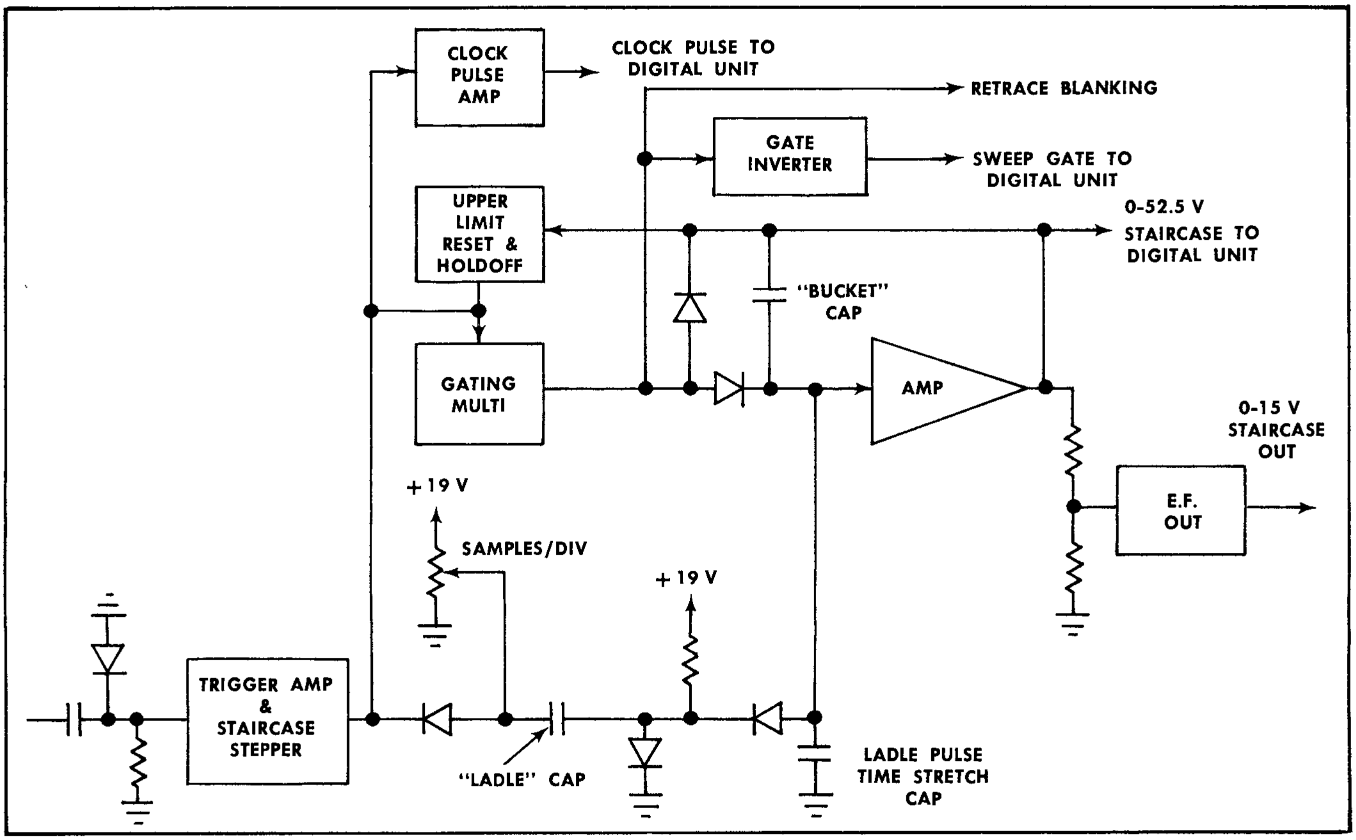


Fig. 4-13. Staircase Generator block diagram.

Q457A gate lead high impedance, plus several matched diode voltage drops, assure that the staircase amplifier input and output leads will both be within a few millivolts of ground when the Gating Multi is cut off. Q457B bias is set to about —0.6 volt by the one-diode drop of D459. The —0.6 volt bias sets Q457B current. Since the two halves of Q457 are essentially identical, Q457B current sets Q457A channel current to its normal value with —0.6 volt bias. Now if Q457A gate voltage is set to zero volts, Q457A source lead biases Q461 into light conduction. Q461 does not quite saturate, and its collector rests at about +1.2 volts. Then Q465 and D464 in series add —1.2 volts' drop to Q465 collector voltage, making the output at D464 cathode zero volts.

With the Gating Multi cut off, D464-Q467 junction goes to zero volts forward biasing D447. D448 applies successively smaller amounts of current to C448, until there is ultimately zero volts drop across it. This then places Q457A gate back to zero and the staircase generator is in a stable condition. If, while the staircase output voltage is held at zero (Single Sweep Operation), trigger recognitions occur, Q401 continues to charge and discharge the ladle capacitor. The ladle ca-

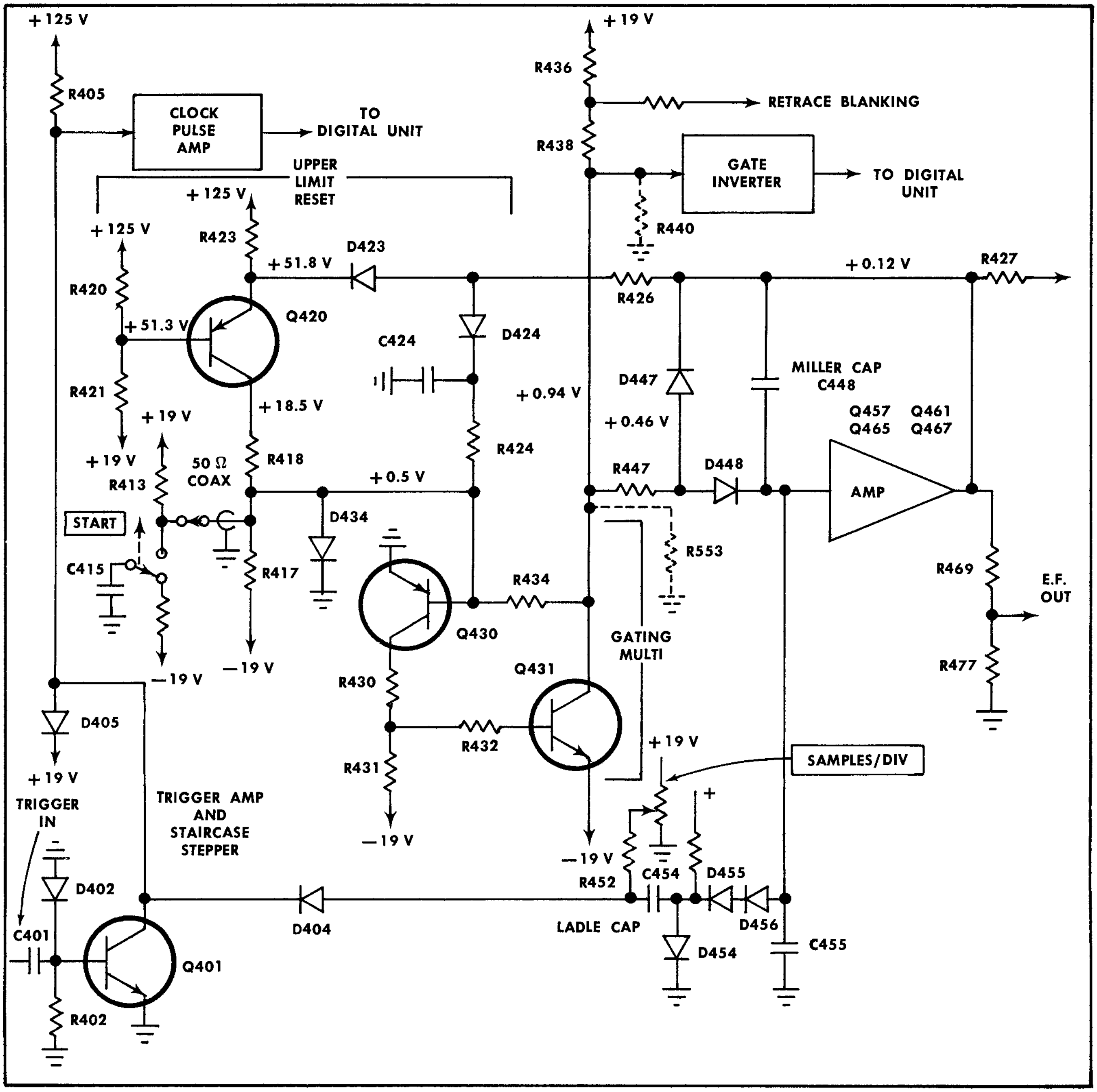


Fig. 4-14. Staircase Generator control circuits.

pacitor charge and discharge current develops a small voltage drop change across the dynamic resistance of D448, and the staircase amplifier output swings about 100 millivolts above and below ground. This action is minimized by C455 between Q457A gate lead and ground. C455 also serves to store the ladle capacitor stepping charge while the staircase amplifier responds at a rate slower than Q401 collector swings.

Functions of some components in the Staircase Generator that are not obvious from the above description are: 1) R454 assures that D454 is conducting slightly when the ladle capacitor starts to charge, which assures a constant number of samples per staircase (sweep) regardless of trigger recognition repetition rate. 2) The series diodes, D455-D456 remain reverse biased except then Q401 is pumping the ladle capacitor charge into C448. D456 assures minimum leakage and D454 provides fast turnoff. The two diodes combine to be almost like a single low-leakage fast turnoff diode. 3) R451 in series with the SAMPLES/DIV control, sets the minimum voltage charge value of the ladle capacitor so full counterclockwise rotation of the SAMPLES/DIV control causes the CRT dot to move one division in ten seconds or longer. 4) R461-C461 and R463-C465 serve to stablize the amplifier and prevent parasitic oscillations. 5) R457 limits the dissipation of Q457A.

Upper Limit Reset and Gating Multi

Fig. 4-14 is a combined schematic and block diagram of the Staircase Generator control circuits. It is drawn with part of the front panel DISPLAY MODE switch and R140 both missing. This then permits the control circuits to be described on a SINGLE SWP basis. NORMAL display mode operation is summarized at the end of the Single Sweep description. Refer to Fig. 4-14 during the following.

The Upper Limit Reset and Gating Multi circuits operate at very low current values. Voltages listed in Fig. 4-14 are obtained when Q401 is receiving 25 kHz triggers, and the front panel DISPLAY MODE switch is at SINGLE SWP. The two resistors, R413-R417 divide the +19 and —19-volt supplies so their junction is zero volts. The 0.25 mA through R418 then forward biases D434 and reverse biases Q430. With Q430 cut off, all drive is removed from Q431 base, and it too is cut off. The circuit will remain in this condition until a negative pulse is received at Q430 base.

As the operator presses the front panel START button, C415 (charged to —19 volts) sends a negative pulse through a 50 Ω coaxial cable to Q430 base. Q430 saturates and drives Q431 to saturation. R434, between Q431 collector and Q430 base, holds the multi in conduction after C415 charge is gone. This action releases the Staircase Generator to step, as described earlier.

Two capacitors, C448 the staircase Miller capacitor, and C424 the Holdoff Capacitor, are charged positive at each staircase step. As the staircase voltage reaches +52.5 volts, D423 is forward biased and Q420 saturates. Q420 collector rises from +18.5 to +51 volts, and R418 current increases from 0.25 mA to about 0.6 mA, just enough to reverse bias Q430 and cut the Gating Multi off. At the time Q431 collector voltage goes positive, more current passes through R424 than when the staircase is reset. When reset occurs, C424 sustains the higher current for a short time. The holdoff action is not significant during Single Sweep operation, but when Q401 drives Q431 base negative during NORMAL operation, C424-R424 prevents the trigger signal from starting a staircase until it is fully reset to zero volts. Refer to diagram number 3 at the back of this manual for the remainder of the Staircase Generator description.

CLOCK Pulse Amplifier

Q401 collector signal swings between essentially ground and +19 volts. The positive value is limited by D405 and the +19-volt supply. The collector signal drives Q406 base through R406 causing Q406 to saturate during the time Q401 is saturated. Q406 collector circuit resistors divide the output signal down to the proper +1.9-volt signal required by the digital unit clock pulse circuits.

Gate Inverter

Q441 inverts the signal from Q431 collector and applies a +7-volt sweep gate signal to an associated digital unit. R440 limits Q441 base current drive when Q431 is off. R440-R441 limit Q431 negative base voltage to protect the base-emitter junction from excessive reverse bias. R444-R445 reduce Q441 conducting collector signal to ground level, and R443-R444-R445 limit the positive voltage to +7 volts.

Staircase E. F. Out and DISPLAY MODE Switch

Q480 and Q481 form a high impedance to low impedance output stage for the Staircase Generator, Manual Scan and External Horizontal Input signals. The dual emitter followers provide a stable low impedance output drive without significantly loading any of the three input sources. Q480 PNP transistor adds one diode drop positive offset to the staircase signal, and Q481 NPN transistor cancels the positive offset by adding one diode drop negative offset. Thus the input and output voltage of the dual emitter follower stage is identical.

External horizontal input signals must operate from ground positive for proper control of the horizontal sampling display. If the input signal exceeds +19 volts, and the EXT HORIZ ATTEN control (R475) is fully clockwise, R476 and D476 protect the emitter follower output stage. Likewise, signals that try to go below —19 volts are limited by R476, and by Q480 going into saturation.

In instruments up to SN B020160, the manual scan voltage drive to Q480 is limited to a calibrated 0 V to 15 V value by the voltage divider R472-R473. Instruments SN B020160-up, have an adjustable control in the voltage divider, R474, which allows the +15 V manual scan voltage source to be accurately set.

R478, C480, R482, R485 and C487 all aid in stablizing the stage against parasitic oscillations.

HORIZONTAL MEMORY and RATEMETER

General

Diagram 4 at the back of this manual contains circuits that operate only for Before Trigger random process sampling. The coordination of horizontal dots for controlled sequence displays is accomplished by circuits in diagram 4. Input signals come from the Timing Ramp amplifier, the Staircase E.F. Output stage, the sweep Gating Multi, the Trigger Circuit and Logic Drivers (three inputs), and a control, the

START POINT switch. One signal output drives the Slewing Ramp Clamp to start the Slewing Ramp running at the right time; and the Ratemeter actuates the LOW REP RATE lamp when the ratemeter ramp circuit runs too far negative (runs for too long a time).

Circuits included in diagram number 4 are: 1) the Horizontal Memory, 2) the Dot Position Comparator, 3) the Horiz Dot Position Comparator Memory, 4) the Ratemeter Ramp, 5) the Ratemeter Memory, 6) the Ratemeter Comparator, and 7) the Correction Matrix that assures the display of at least ½ time window leadtime before trigger recognition.

Horizontal Memory

The Horizontal Memory consists of a unity gain class B input amplifier Q501-Q502-Q504, a memory gate (Q511-Q513) driven into conduction for 5 μs by the Trigger Circuit, and a high impedance to low impedance output stage Q515-Q517-Q520 and Q522.

The unity gain class B input stage provides low impedance drive to the memory capacitor C512. It is class B in order to drive the 0.001 μF memory capacitor a full screen 15 volt change either positive or negative. Q504 does not normally conduct for small changes in timing ramp voltage, but does conduct for large negative signals. The stage operates as if Q501 were an emitter follower, with two signal inversions between Q501 base and Q502 collector.

Assume a positive input signal. Q501 emitter follows the signal and the collector inverts the signal. Q502 amplifies Q501 collector signal and drives Q501 emitter through R504-R505. Negative feedback from Q502 collector to Q501 emitter assures that Q501 emitter follows its base input signal without loss and at a very low output impedance. Both Q501 and Q502 negative return path is through D505 and R506. D505 is a germanium diode, and Q504 is a silicon transistor, thus Q504 base-emitter junction does not normally receive a forward bias.

Assume a large negative input signal. Q501 collector rises to +19.6 volts when D501 conducts. D501 reverse biases Q502 and takes all of Q501 collector current which switches all of R506 current into Q504 base. Then Q504 emitter drives the memory gate and memory capacitor. (The memory gate is described below.)

The high impedance to low impedance output stage provides very low leakage (and long stability) to the charge placed on the memory capacitor C512. The output at Q520 emitter is a low impedance and drives current into both the 6 kΩ Horizontal Amplifier input resistance and the Dot Position Comparator. Q517 is a constant current stage that sets Q515 channel current to a value that requires a Q515 gate to source bias of almost zero volts. The Horiz Output Zero control adjusts Q517 base voltage. This sets the voltage drop across R518, which in turn sets Q517 collector current and Q515 channel current. The control is adjusted so Q515 gate is about —0.3 volt with respect to its source lead. This condition assures Q515 gate leakage is lowest, and C512 charge then remains constant until changed by the class B driver and the memory gate. Q522 is a constant current stage for Q520, the emitter follower output.

The total gain from the Timing Ramp Amplifier input to Q520 emitter is unity, and Q520 memorized output voltage is within millivolts of Q501 input voltage. A DC change of —0.6 volt at Q501 base-emitter junction remains fixed through Q515 source lead. Then an equal +0.6 volt change is added at Q520 base-emitter junction assuring that the memorized Timing Ramp signal is nearly equal to Q501 input.

Memory Gate Circuits

Diagram 4 contains three nearly identical memory gate circuits, differing only in the method of drive. Each consists of two silicon NPN transistors connected base to base and emitter to emitter with the two collectors used as input and output. A pulse transformer secondary drives the base and emitter junctions without DC connection to any other part of the circuit. Between trigger recognition times the transformers do not drive any signal to the joint base-emitter circuit, therefore assuring that both transistors do not conduct. The two collectors are then a very high impedance between the input and output. If there is any voltage difference between input and output, one collector-base junction forward biases and the other collector-base junction reverse biases. The reverse-biased junction allows the remainder of the gate circuit (including transformer secondary) to float on the more negative collector lead. Thus there is always one diode junction that is reverse biased when the pulse transformer does not provide any drive.

A proper polarity pulse applied to the pulse transformer primary applies a turn-on drive to the base-emitter junctions of both transistors. When driven, both transistors saturate and the input and output collector leads are a very low impedance, both at the same voltage. During conduction, the gate affects the charge on the output-side memory capacitor with equal effectiveness for both positive and negative input changes. As the pulse transformer primary drive stops, the secondary self inductance voltage back swing is clamped by a silicon signal diode to protect the gate transistor's base-emitter junctions from reverse voltage breakdown.

The gate conduction duration is controlled primarily by the trigger circuit Logic Driver transistors and their period of saturated conduction. For example, Q511/Q513 are held in firm saturation by base-emitter current drive for at least 5 μs. The series resistance of R510 assures that T510 secondary drives the gate transistor into light saturation with minimum carrier storage so the gate stops conducting immediately after drive is removed. Q555-Q557 drive duration is slightly less than 1 μs without regard to carrier storage. Q601-Q603 drive duration is also slightly less than 1 μs, but may consist of two pulses due to C600-T600 ringing, again without regard for carrier storage.

Dot Position Comparator and Memory

If the signal triggering the Type 3T2 contained no jitter or other instability; if the Slewing Ramp start time occured without jitter in relation to T_o, and if there were no drift in amplifiers or memories, the signal from Q520 emitter would be essentially equal to the Staircase Generator output voltage. Such ideal conditions do not exist. Therefore, the memorized Timing Ramp signal (C512) is compared with the reference Staircase Generator signal at the Dot Position Comparator.

The Dot Position Comparator is a linear differential comparator in which both halves conduct. If there is no voltage difference between the memorized Timing Ramp signal at Q531 base and the Staircase signal at Q533 base, Q533 collector signal remains at a fixed reference value. Q533 collector voltage changes only when there is a voltage difference between the two signals. The collector can move ±9 volts as Q535 approximately 0.75 mA current path is changed from Q533 to Q531.

The Servo Loop Bal control allows the constant current of Q535 to be altered during calibration. The current value is correct when a triggered stopped display dot (Display Mode switch at MANUAL SCAN) appears at the same CRT horizontal position for both With Trigger and Before Trigger operation.

Q540 is a common base output stage for the Dot Position Comparator. Q540 collector isolates any load current changes (at the time Q555 and Q557 conduct) from the high impedance collector circuit of Q533. The output signal drives the Horizontal Dot Position Comparator Memory capacitor, C559, through either 100 kΩ (R546) or 1 MΩ (R545) and the memory gate Q555-Q557. R545 or R546 limits the amount of charge C559 can obtain whenever there is a Dot Position Comparator signal change. This results in a rather slow response to errors, and a stable dot correction without overshoot or ringing of the servo loop.

The Dot Position Memory output stage is a +9 to −9 volt dynamic range amplifier with high input impedance and low output impedance. Q561-Q563 form a constant current input, variable current output, unity gain impedance converter. Q561 channel current is kept at a constant value by Zener diode D562 holding a constant voltage across R562. With Q561 channel current held constant, its gate-to-source bias remains constant and it passes the voltage of C559 to Q563 base with no incremental loss. Q565 holds the total stage current constant at 5.9 mA. That current divides: 1.1 mA to Q561 and the rest to D562 with a possible +3 or −3 mA output through R563. Even though the total current remains fixed, Q563 current changes from a maximum of 7.8 mA to a minimum of 1.8 mA depending upon the current magnitude and polarity through R563. The use of the output ±3 mA is described below after the Ratemeter, during the Ratemeter Comparator discussion.

The Dot Position Memory Gate control circuit, Q552, assures that the memory capacitor holds a proper charge during sweep retrace time. When the Staircase Generator resets, none of the other circuits follow it closely and the Dot Position Comparator receives what looks like a large correction signal. Thus the Staircase Generator Gating Multi positive swing during staircase reset is converted by R553-D553 to prevent Q552 from pulsing T555. Conduction in D553 removes all of the collector supply voltage to Q552 that is normally provided when the Gating Multi output is at −19 volts.

Q552 collector supply voltage is also removed during With Trigger operation by the START POINT switch connecting D554 anode to +19 volts. Again D553 conducts, even when the Gating Multi output is at −19 volts. This feature of preventing the Dot Position Memory from receiving signals during With Trigger Operation, permits the memory capaci-

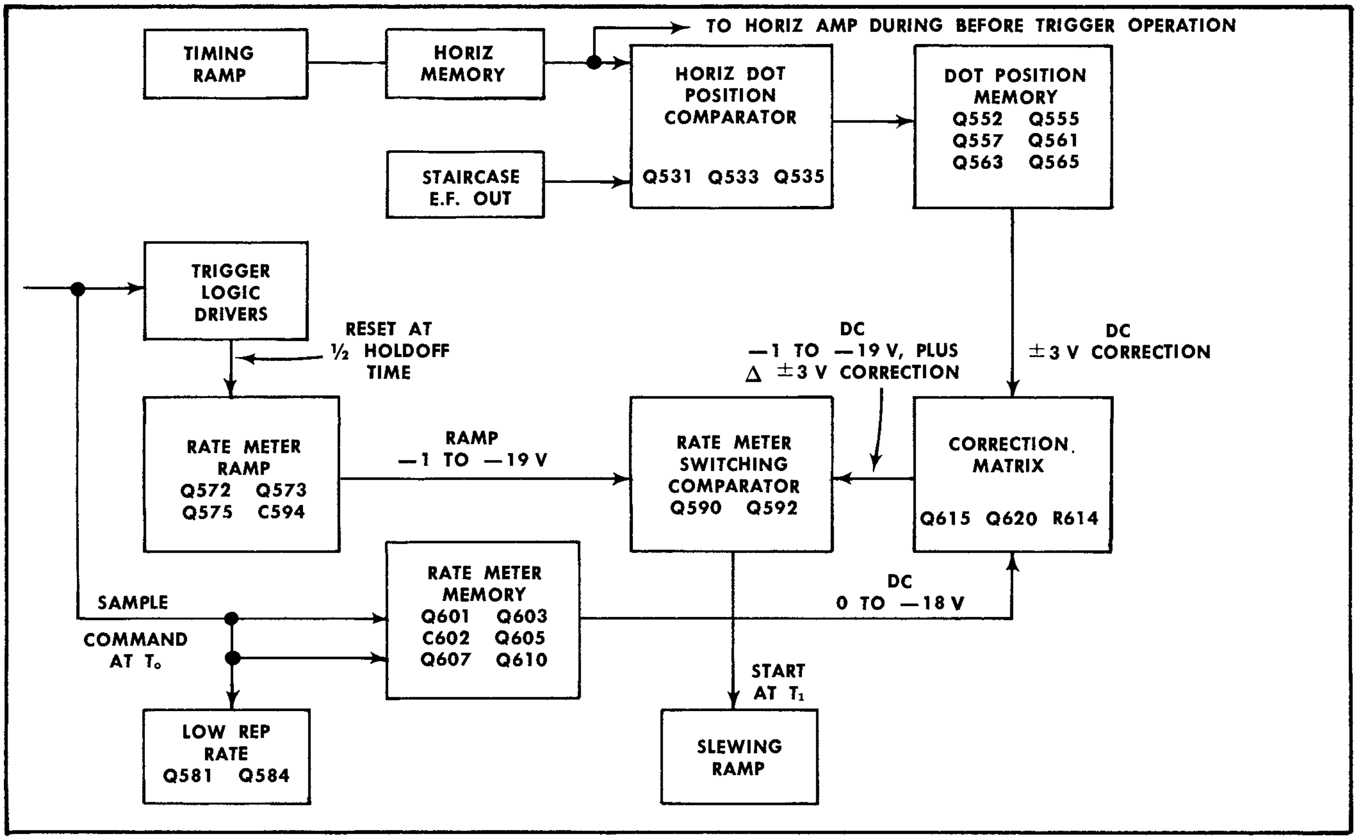


Fig. 4-15. Block diagram of schematic diagram number 4, plus the Timing Ramp. Staircase E.F. Out, and Slewing Ramp blocks.

tor to hold its proper charge for a while when changing the START POINT switch from Before Trigger to With Trigger. Then, if the operator decides to return to Before Trigger operation (while observing the same signal that charged C559) the display will return to the CRT sooner than it would have had the memory capacitor charge been changed by With Trigger operation. D554 disconnects Q552 collector pulses from the (With Trigger) Timing Ramp Comparator and D225 (Start Point Steering Diode) circuits when operating with the START POINT switch at Before Trigger.

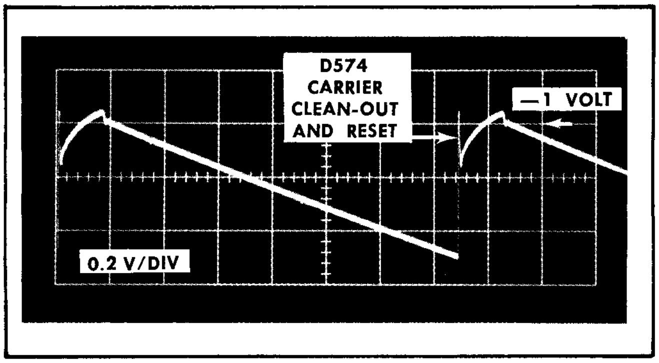


Fig. 4-16. Ratemeter Ramp.

Ratemeter Ramp, Ratemeter Memory, Correction Matrix and Low Rep Rate Circuits

As described in Section 2, the Ratemeter Ramp is reset at one half the holdoff period, restarts automatically, and is sampled at the next trigger recognition, T_0. The Ratemeter Memory does the sampling of the ramp to memorize the ramp voltage. The DC voltage out of the Ratemeter Memory, and the DC voltage out of the Horizontal Dot Position Comparator Memory are both converted into current signals at the Correction Matrix circuit and supplied to the Ratemeter Comparator as one correcting voltage.

See Fig. 4-15 for a block diagram of diagram 4 with three added blocks: the Timing Ramp, the Staircase E.F. Out, and the Slewing Ramp. The Slewing Ramp is started by a signal from the Ratemeter Comparator. The Ratemeter Comparator is a switching comparator that delivers a pulse output signal at the time the Ratemeter Ramp goes more negative than the signal out of the Correction Matrix circuit.

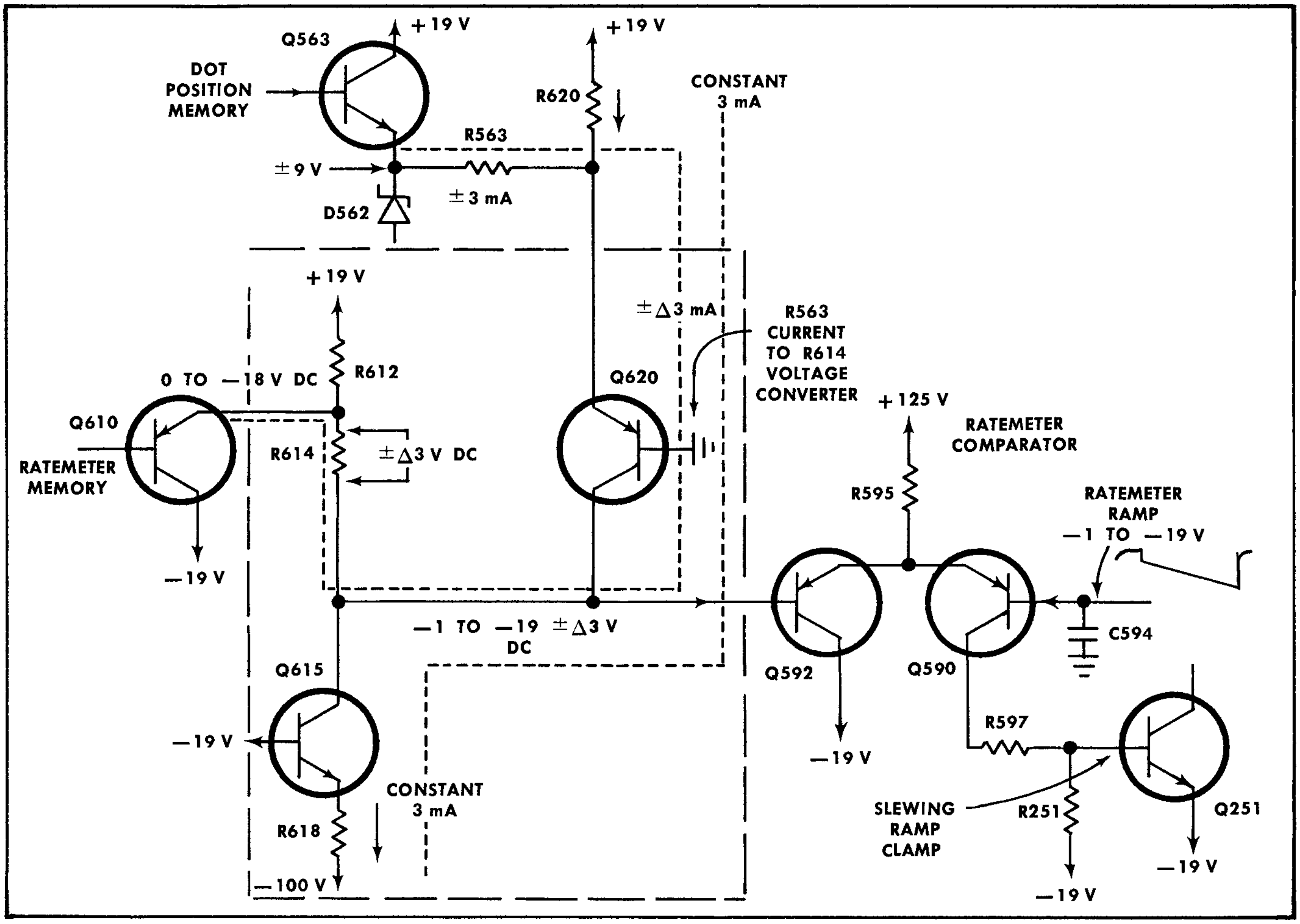


Fig. 4-17. Correction Matrix (outlines) current paths, and voltages applied to Ratemeter Comparator.

The Slewing Ramp start time is alterable by two separate system changes, a change in the trigger signal rate, or a change in the Timing Ramp memorized voltage that is compared to the reference Staircase signal. Both changes cause corrections to the Slewing Ramp start time, but the first is due to external causes, and the second is due to internal causes. Thus the Ratemeter Comparator is the point at which both external and internal timing changes are combined into one common signal that then starts the Slewing Ramp running at a "best guess" time ahead of the next trigger recognition.

The Ratemeter ramp consists of a Reset Multi (Q572-Q573), a constant current capacitor charging transistor (Q575) and the ramp capacitors that are charged at the constant current rate (C591 through C594). The Reset Multi conducts when driven by the Logic Drivers at one half the holdoff period. (See waveform (I) in Fig. 2-7 and Fig. 4-16.) The multi remains in conduction until whatever negative charge was in the ramp capacitor(s) is nearly discharged. When Q573 emitter reaches —0.95 volt, its collector current (mainly from the ramp capacitor) is reduced until R574 current turns D574 on and D572 off, which removes the turn-on bias to Q572. Q572 current drops to zero and both transistors stop conducting. Immediately constant current transistor Q575 starts the ramp capacitor(s) charging negative.

Sometime during the Ratemeter negative ramp, the ramp voltage forward biases the switching comparator transistor Q590 to apply a turn-on pulse to the Slewing Ramp. Then the next trigger recognition causes the Ratemeter Memory Gate to conduct briefly and apply a charge into the memory capacitor C602.

At the next ½ holdoff time the Logic Drivers again pulse the reset multi into conduction. The rate meter ramp capacitor discharge path is through Q573 emitter-collector path, D572, and Q572 base-emitter junction. The base-emitter junction of Q572 is protected from damage when discharging the larger ramp capacitors (C591 or C592) by the 20 Ω resistors in series with the capacitors.

When the Reset Multi is not conducting, R572 assures Q572 remains cut off, and R576 assures Q573 remains cut off.

The Ratemeter Memory capacitor voltage is applied to the Correction Matrix circuit through the high impedance to low impedance circuit of Q605, Q607 and Q610. Q607 is the constant current source for Q605 channel current. With the channel current through Q605 constant, its gate to source bias voltage does not change as C602 voltage changes. Q605 source lead drives emitter follower Q610 base, and Q610 emitter is a low impedance voltage drive source to the Correction Matrix circuit. It is the voltage out of Q610 emitter that receives correction by the Dot Position Memory to alter the Slewing Ramp start time.

The Correction Matrix circuit is redrawn in Fig. 4-17 to show the two electron paths, 1) a constant 3 mA to place Q615 and Q620 into active operation, and 2) a +3 mA to —3 mA signal current to cause a correcting voltage change across R614. Q615 and Q620 collectors are both a very high impedance. The high impedance allows their voltage to be moved by Q610 emitter from about —1 to —19 volts without changing the current in either transistor. Likewise, the Dot Position Memory can change Q620 current, but Q615 "long tail" emitter (constant current, high impedance collector) doesn't recognize the change, forcing Q620 current change to affect only the voltage drop across R614. Thus it is actually R614 that combines the Ratemeter Memory signal and the Dot Position Memory signal to provide the Rate Meter Comparator with one DC correction voltage. The rest of the Correction Matrix is required to force the Dot Position Memory changes into R614 only. The correction signal across R614 does not extend Q592 base signal voltage range greater than 18 volts. The limit is —1 to —19 volts, but Q610 emitter voltage can be corrected as much as ±3 volts within the 18 volt limits. Actual operating conditions require far less than ±3 volts correction. The usual amount at Time Magnifier ×1 is typically —1.4 volts because Q610 emitter is about +1.2 volts from C602 memory voltage.

The 1 ms Correction control (R622 and R623) is used to offset the Dot Position Memory output current (and resulting R614 voltage drop) when operating the RANGE switch at 1 ms. Note that the Ratemeter Ramp capacitor is the same for both the 100 μs and 1 ms ranges. All ranges except 1 ms operate with the rate meter ramp slope 10^3 times longer than the timing ramp slope. At 1 ms range, the rate meter ramp slope is only 10^2 times longer than the timing ramp slope. (The 100 μs Range permits operation down to 10 Hz. Horizontal Memory leakage will not tolerate lower repetition rate operation. Therefore the 100 μs ramp is also used on the 1 ms range.) The additional 1 ms Correction current into Q620 emitter (and resulting voltage across R614) programs the slewing ramp start to be ½ Time Position Range ahead of T_o on the 1 ms range. The 1 ms Correction current speeds servo positioning of the sampling display when changing from the 100 μs to the 1 ms Range.

The Low Rep Rate circuit contains two transistors that are normally biased to cut off. Q581 is in series with neon bulb B580, and Q584 drives Q581. When both transistors are not conducting, B580, the LOW REP RATE lamp is dark. When Q584 is caused to conduct, Q581 saturates and B580 glows.

Q584 emitter circuit is returned to —17.3 volts at the junction of R587-R588. D588 is in series with Q584 emitter to assure no connection of the Ratemeter Ramp to R587-R588 should Q584 base-emitter junction become excessively reverse biased. The Ratemeter Ramp positive voltage takes Q584 base about 16 volts more positive than R587-R588 junction, and D588 assures that Q584 base remains a high resistance and does not load the ramp.

As the Ratemeter Ramp voltage is permitted to run negative to —19 volts (either by very low trigger signal repetition rate, or the TRIG SENSITIVITY control being turned fully counterclockwise and locking out triggers) Q584 is forward biased into saturated conduction by Q575 current. Q584 collector applies turn-on bias to Q581 through R584 and Q581 saturates, turning B580 on. Both transistors turn off whenever the Ratemeter Ramp voltage is more positive than about —18.1 or —18.2 volts. The positive supply to B580 is opened by the START POINT switch for With Trigger Process sampling so the LOW REP RATE lamp will not operate.

HORIZONTAL AMPLIFIER and BLANKING

General

The Horizontal Amplifier and Blanking, diagram 5, contains the transistor CRT horizontal deflection plate drivers, the spot position indicators, and the overscan blanking circuit.

CRT Driver

The CRT Driver amplifier consists of a two transistor operational amplifier, Q741-Q751, and a three transistor variable gain differential output stage, Q761-Q771-Q781. Both amplifiers require external connections in the vertical sampling unit for proper operation. These connections are shown in Fig. 4-18. The external connections control the input signal sources for the differential output amplifier Q771-Q781. When the vertical unit mode is not X-Y, Q781 receives a Type 3T2 staircase signal that horizontally positions the CRT dot, and Q771 base rests at —0.6 volt. When the vertical unit mode is X-Y, Q781 base is held firmly at +9.1 to +9.5 volts and Q771 base is driven with a ±5 volt signal centered on +9.4 volts. (The vertical unit Channel B signal is centered on +10 volts, offset —0.6 volt by emitter follower Q671.)

Input Operational Amplifier. The input operational amplifier, Q741-Q751, operates with a stage gain of 0.66 when the DISPLAY MAG switch is at ×1. The stage gain is 6.66 when the DISPLAY MAG switch is at ×10. Q741 is an inverting high gain amplifier with a collector voltage of ap-

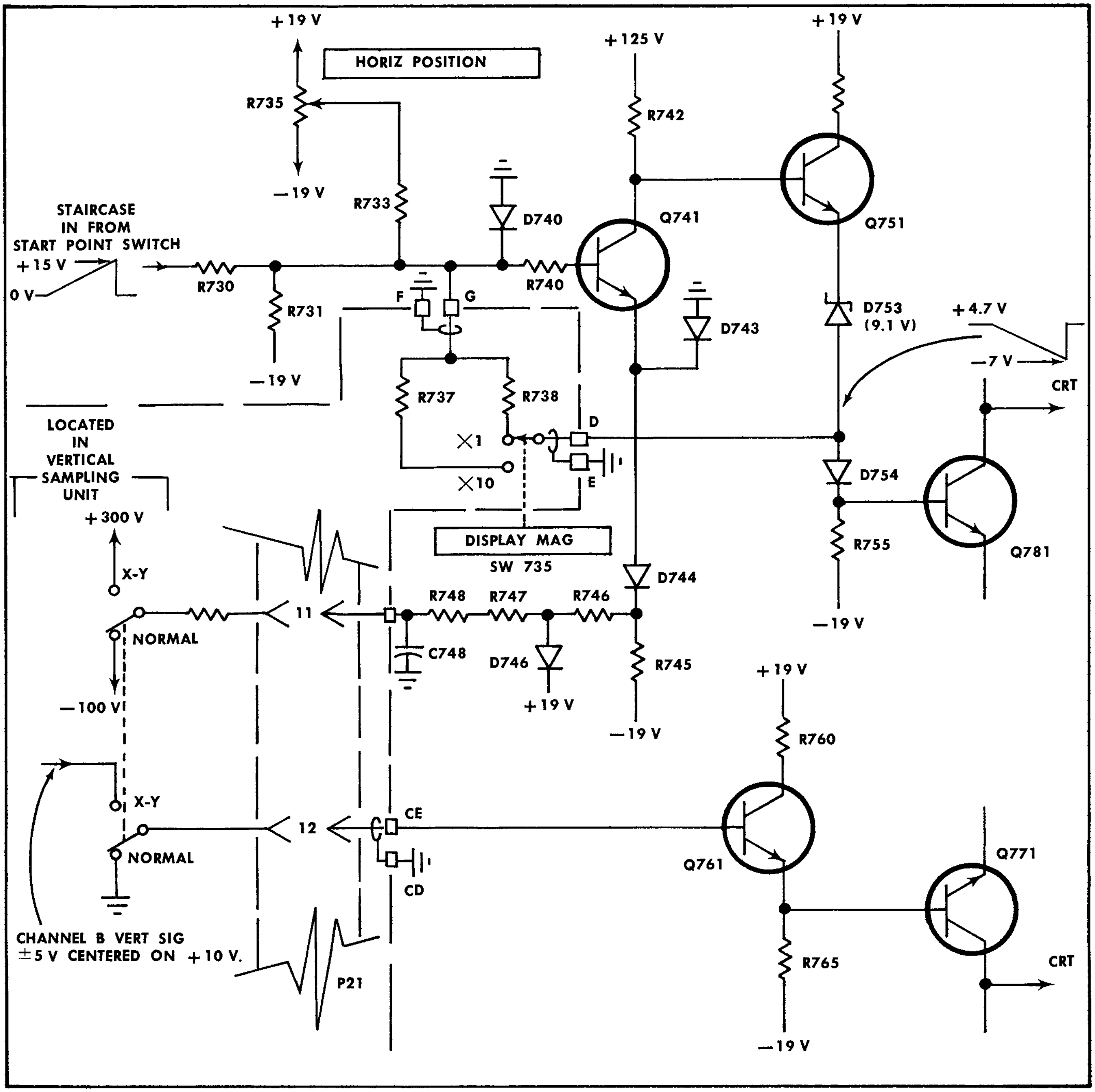


Fig. 4-18. Horizontal amplifier connections from vertical unit.

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proximately +9 volts when the CRT dot is at center screen. Emitter follower Q751 and Zener diode D753 offset Q741 collector +9 volts back to zero volts assuring that Q771 and Q781 are each conducting equally at CRT screen center.

Q741 base lead is the input signal equivalent ground point where input signal current is equaled by feedback current. There are essentially three input resistors, 1) R730 for the staircase input, 2) the HORIZ POSITION control and R733, and 3) R731 provides a DC offset current so that the trace starts at the CRT left edge for zero voltage signals when the HORIZ POSITION control is centered. D740 conducts when Q751 base reaches +19 volts and Q751 emitter stops going positive as the input signal continues negative whenever the spot is driven considerably off screen to the left.

Q741 emitter circuit contains three diodes and associated resistors. When the vertical unit mode is not X-Y, D746 does not conduct, and both D743 and D744 do conduct. D743 is forward biased by both R745 and the circuit of the vertical unit. Thus, Q741 emitter rests at —0.52 volts and D743 is a low resistance between the emitter and ground. When the vertical unit mode is X-Y, D746 does conduct, and D743 and D744 do not, thus removing any current from Q741 emitter. Q741 collector then goes positive until Q751 base-collector diode junction forward biases taking all of R742 current. Q751 emitter rises to nearly +19 volts and D753-D754 sets Q781 base firmly at +9.4 volts.

Q761 base is grounded when the vertical unit mode is not X-Y. When the vertical unit mode is X-Y, Q761 is driven by the Channel B vertical output signal which arrives at a sensitivity of 1 V/Div, centered on +10 volts DC.

Output Differential Amplifier. The linear output differential amplifier employs two special high voltage transistors, Q771-Q781. These transistors have a BV_{CBO} rating of 300 volts, and are used to drive the CRT horizontal deflection plates directly. Both transistor base lead input voltages are limited to operation between —19 and +19 volts. The emitter circuit is both "long tail" and highly degenerative between transistors, assuring that neither transistor cuts off at —19 volts in, nor can one cut the other off if its base goes to +19 volts.

Assume both amplifier bases at zero volts; R774 and R784 assure that both transistors conduct 2 mA. As Q781 base voltage goes positive, its emitter goes positive, applying a positive turn-off signal to Q771 emitter through R782-R785-R772. Q781 then increases its current, and Q771 decreases its current; Q781 collector goes negative and Q771 collector goes positive. The amplifier thus converts a single input signal to a push-pull output signal. The amount of signal coupled from one emitter to the other emitter is made adjustable by the front-panel HORIZ GAIN control, R785. R785 permits the operator to alter the output stage gain sufficiently to mate the horizontal deflection to the particular oscilloscope in which the Type 3T2 is operated.

Spot Position Indicators

The horizontal spot position indicator lamps are driven by a switching comparator amplifier, Q791-Q793. The comparator is driven by the output amplifier emitter circuit by the voltage across the HORIZ GAIN control. If the CRT driver output amplifier transistor conduction differs enough to cause about 0.5 volt difference at Q791-Q793 bases, the most positive-base transistor saturates and the other transistor is cut off. The long tail resistance in the emitter of the lamp drivers permits the CRT driver emitter circuit to float between +19 and —19 volts and still operate the switching comparator properly. Whichever transistor saturates, it then turns on the associated neon lamp in its collector lead. The cutoff transistor assures that its collector circuit lamp has no current and therefore remains dark.

The two series base resistors R790-R792 assure that the pulse caused by neon ignition is not coupled back into the Timing Unit circuits. (Without the series base resistors, each time a neon turns on, its effects would be seen on the CRT.) The large resistance between transistor collector leads assures that the off transistor collector voltage does not rise to +125 volts. When a transistor is cut off, its collector voltage is held at about +70 volts by Townsend (dark) current through the associated neon passing through R796 to the other collector. R796 keeps the off transistor collector about +10 to +15 volts from its emitter (the emitter voltage being set by the other neon drop and its saturated transistor). The circuit never operates with both transistors cut off.

Blanking

The blanking circuits drive one of the cathode ray tube deflection blanking plates to turn off the electron beam whenever the dot is moved, or whenever it exceeds ten divisions of horizontal scan. The circuits have three input signal paths, 1) interdot blanking from the Vertical Strobe Driver (Q290) to D700, 2) retrace blanking from the Staircase Generator (R437) to D701, and 3) the normal horizontal input signal to Q741 at Q722 emitter and D709 cathode. The output negative-going blanking signal is taken from D712 cathode and applied through D713 to the CRT deflection blanking plate pin 6, through pin 13 of the interconnecting plug P21. The output voltage is +125 volts when the electron beam is allowed to strike the CRT phosphor and generate a dot. The output voltage is about +43 volts when the electron beam is deflected and does not reach the phosphor, thus blanking off the dot. Q710 is at cutoff during the blanking time, and conducts only as the CRT deflection blanking plate is taken positive at the end of the blanking time. Q710 charges the circuit capacitance (from +43 volts to +125 volts) much faster than R715 could do alone.

Q705 is the blanking amplifier. It has two input signal paths: 1) into its base for interdot and retrace blanking, and for greater than +15 volt horizontal input signals that would overscan the CRT to the right during Before Trigger process sampling, and 2) into its emitter for horizontal input signals that are negative and would overscan the CRT to the left during Before Trigger process sampling.

Overscan Blanking. See Fig. 4-19. Q705 normally conducts only 1 mA of current, set by: D703-D704 which set Q705 base voltage at +0.9 volt, and 100 kΩ emitter return resistor to the —100-volt supply. At 1 mA current, D712 cathode voltage would be at +200 volts ,except that D715 limits the positive value to +125 volts, and D712 limits Q705 collector to +82 volts. Q710 will conduct any stray CRT deflection blanking electrons to the 125-volt supply, but is considered at cutoff as far as the blanking circuit is concerned.

If the CRT Driver horizontal input signal voltage goes negative, D709 becomes forward biased and connects the driving transistor low impedance emitter (Q520) to Q705 emitter. Q705 increases its current sufficiently to saturate, taking Q710 base to approximately +43 volts, deflecting the CRT beam and blanking the CRT spot. Should the input signal try to go several volts negative, most of Q520 emitter current is taken to ground by D705 (connected to its base lead), and D706, connected between Q705 connector and ground.

If the CRT Driver horizontal input signal voltage goes more positive than about +15 volts, Q722 conducts and applies a positive signal to Q705 base. (Q722, PNP transistor, has a base-emitter junction reverse voltage breakdown rating of 20 volts.) When Q705 base is taken positive, D708 (emitter to ground) is forward biased into conduction, bypassing the degeneration of R708. Q705 is then a high gain amplifier, which saturates, and again places the deflection blanking plate at +43 volts to turn off the overscanned CRT dot.

Interdot Blanking. Fig. 4-19 shows the Vertical Strobe Driver circuit connections to the blanking circuit. The voltage divider, R296-R700, sets D700 anode voltage at about —1 volt when the CRT dot is in view, and at about +1.8 volt when

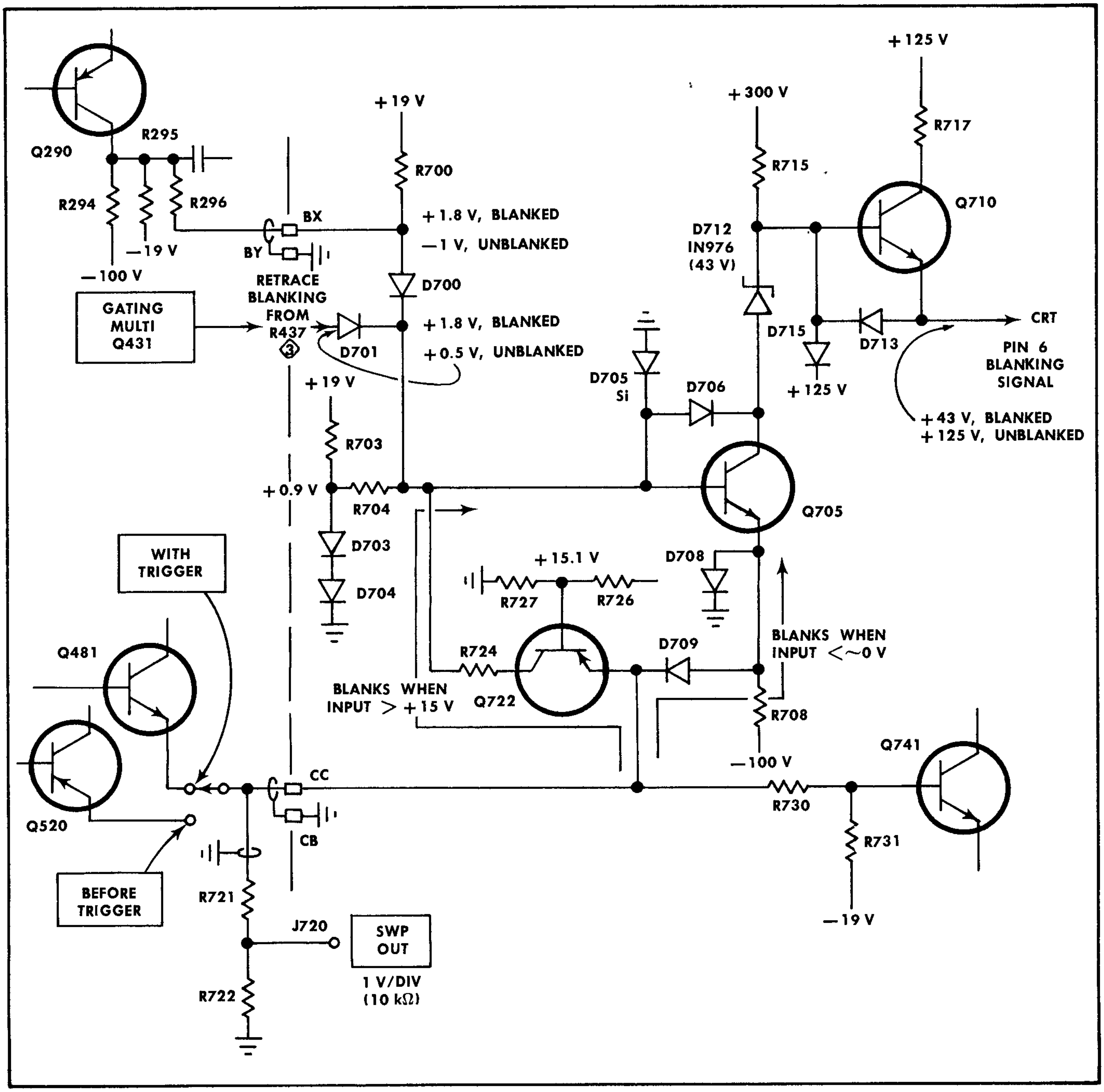


Fig. 4-19. Type 3T2 Blanking circuits.

the dot is blanked. The signal is essentially a square wave that holds the CRT dot blanked for the length of time that Q290 conducts. The positive signal saturates Q705 and blanks the CRT between dots.

Retrace Blanking. The Staircase Generator Gating Multi turns off the CRT beam during staircase reset time. The Gating Multi signal takes D701 anode to +1.8 volts when the staircase is being reset, and rests at about +0.5 volt the rest of the time. The positive signal saturates Q705 and blanks the CRT.

The +1.8 volt maximum positive voltage of the above two blanking signals is set by the diode drops of D708 plus Q705 base-emitter junction and either D700 or D701. Current is limited by the series resistor between the driving transistor and either D700 or D701.

POWER SUPPLY

General

The power supplies and power distribution diagrams show not only the power supply active circuits, but also the interconnections with the oscilloscope and distribution through the Type 3T2 circuits. The oscilloscope main frame provides the —100, —12.2, +125, and +300 Volt power, and 6.3 volts AC to T801 for the internal —19- and +19-Volt Supplies. The —27 Volt supply is a simple shunt Zener diode supplied current by the main frame —100 Volt supply. The —12.2 Volt supply is used only by the incandescent lamps in the front panel TIME/DIV readout panel.

Main Frame Shunts

The main frame power supplies are shunted within the Type 3T2 to provide the correct regulation for the current demanded by the companion Vertical Sampling Unit. Diagram 6 shows the shunts and shunt connections at P21. Pins 15 and 20 are joined, connecting the main frame maximum shunt (minimum resistance) across the 125-Volt supply. In addition, the Type 3T2 allows more +125-Volt supply current to be added to that available from the main frame, taken from the +300 Volt supply by R803. R802, between P21 pins 6 and 10 shunts the main frame +300 supply regulator for proper regulation. R801 shunts the oscilloscope —100-Volt supply for proper regulation.

Internal Supplies

The oscilloscope main frame provides 6.3 volts AC to power transformer T801. The input lead is fused by F801, soldered in place on the readout card. The two transformer secondary windings apply approximately 55 volts AC each to two-diode full wave rectifiers for the —19- and +19-Volt supplies. Each rectifier system is located on the Trigger Board, with the filter capacitors mounted centrally near the instrument rear panel. The —19 Volt supply is the reference for the +19 Volt supply.

—19 Volt Supply

Zener diode D834 provides a zero temperature coefficient 5.1 volt reference for the —19 Volt suply regulator circuit. It is located in the emitter lead of comparator-amplifier Q831. The other Q831 input is at its base lead, taken from voltage divider R840-R841-R842. Q831 is temperature compensated by D832, in series with its base signal.

Correction signals to Q831 are applied directly through D834 to the emitter. Signals applied to the base are an attenuated value of that connected to the emitter. The difference between the two correction signals is amplified by Q831 and applied to emitter follower Q835. Q835 provides current gain to the amplified and inverted correction signals, and drives the series transistor Q841.

Assume the 19-Volt supply load is reduced, making the output voltage more negative. Q831 emitter is driven more negative than the base (the equivalent of a positive base signal) causing the collector current to increase. Increased collector current drives Q835 base more negative, and Q835 emitter drives Q841 base more negative, decreasing its collector current. To decrease Q841 collector current is in essence to increase its emitter to collector dynamic resistance. Increased resistance from Q841 collector to emitter causes the current through it to increase the voltage drop across it. As Q841 voltage drop increases, the rectified 28.5 volts across filter capacitor C825 is shifted positive, which applies the proper polarity correction to the —19 Volt output voltage. The result, then, of supply regulator action is to move the +9.5 volts at Q841 collector in a direction to keep the output —19 volts constant.

Components not described above provide the following functions: C842 assists to reduce the supply high frequency output impedance. R832 provides a small forward bias current to D832, assuring that it always connects the —19 VOLTS control to Q831 base. R834 provides the proper current to D834 to place its operation at its zero temperature coefficient point. C830 stabilizes Q831 against parasitic oscillations. R825 and R827 limit the surge charging currents into filter capacitor C825 to a safe value for both the transformer secondary and the rectifier diodes.

+19 Volt Supply

The +19 Volt supply is almost identical to the —19 Volt supply. The major differences are: Q811 is temperature compensated by D814 at its emitter lead, and the correcting signal is applied to Q811 base only. Regulator action is identical with Q821 collector to emitter resistance varied by feedback action to provide the correct voltage drop across the resistance of the load. The reference voltage is the —19 Volt supply applied to R822 and compared against essentially ground voltage, the voltage at D814 cathode.

Changes of the +19 volts output are divided by R820-R821-R822 and applied directly to Q811 base. Q811 amplifies and inverts the signals to drive Q815, which drives Q821 which in turn changes its resistance to restore the output voltage at its emitter back to +19 volts.

—27 Volt Supply

The —27 Volt supply is taken from Zener diode D850. The two R-C filters between D850 and the two loads filter normal Zener noises from the loads.

READOUT SWITCHING

Four switches on the Type 3T2 front panel affect the illumination of the lamps in the TIME/DIV readout panel. The Time/Div value and unit is affected by three: the RANGE, TIME MAGNIFIER and DISPLAY MAG switches. The readout value is scaled 10×, and the units lamps are turned off any time the switch mounted with the Time Magnifier VARIABLE control is actuated by turning the control away from the CAL position. The logic is all part of the switches, with no transistors or other three-terminal active devices in the circuit. Diodes are in series with each lamp to its common lead to assure isolation between the lamps, so that only the proper one of a group turns on at a time.

DIGITAL SWITCHING

The digital switching diagram 9 contains the circuits of the five switches that affect the associated Digital Unit operation when operating the Type 3T2 in a Type 567 Oscilloscope.

READOUT RESISTOR CARD

The readout resistor card diagram 10 contains all the parts mounted on the card. The parts include part of circuits of 1) the trigger holdoff circuit, 2) the Time Position circuit of the Ramp Generators, 4) the ratemeter of the Horiz Memory & Ratemeter diagram, 6) the Power Supply, and 8) the readout circuit resistors and isolation diodes.

SECTION 5
MAINTENANCE

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 3T2.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis will help prevent instrument failure and will improve reliability of this instrument. The severity of the environment to which the Type 3T2 is subjected will determine the frequency of maintenance.

Cleaning

The Type 3T2 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The side and bottom of the 560 series oscilloscope into which the Type 3T2 fits, provide protection against dust in the interior of the instrument. Operating without the covers in place will require more frequent cleaning.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Some chemicals to avoid are benzene, toluene, xylene, acetone or similiar solvents.

Exterior. Loose dust accumulated on the outside of the Type 3T2 can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

Interior. Dust in the interior of the instrument should be removed ocassionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. Remove any dirt which remains with a soft paint brush or a cloth dampened with mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning circuit boards.

Lubrication

The reliability of potentiometers, rotary switches and other moving parts can be increased if they are kept properly lubricated. Use a cleaning-type lubricant (such as Tektronix Part No. 006-0218-00) on switch contacts. Lubricate switch detents with a heavier grease (such as Tektronix Part No. 006-0219-00). Potentiometers should be lubricated with a lubricant which will not affect electrical characteristics (such as Tektronix Part No. 006-0220-00). Do not over lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix. Order Tektronix Part No. 003-0342-00.

Visual Inspection

The Type 3T2 should be inspected occasionally for such defects as broken connections, improperly seated transistors, damaged circuit boards and heat-damaged parts.

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

Recalibration

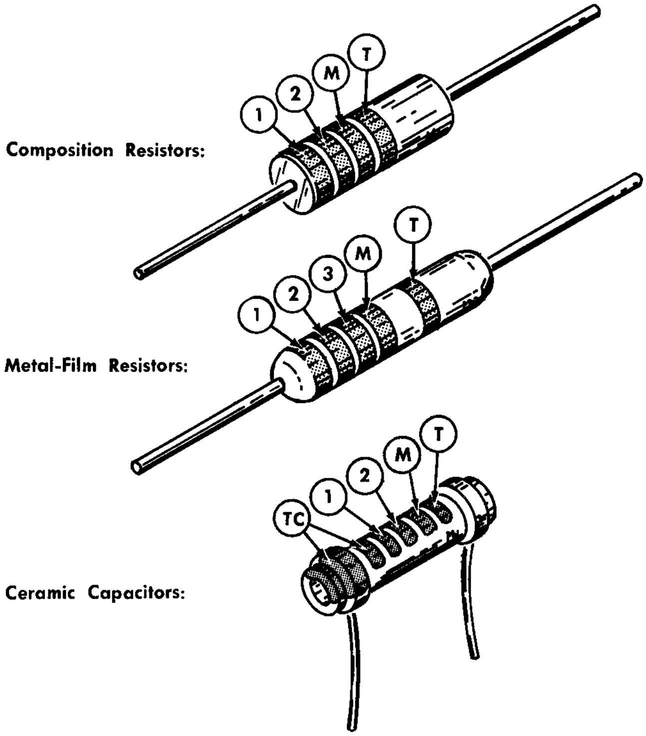
To assure accurate measurements, check the calibration of this instrument after each 500 hours of operation or once every six months.

Parts Identification

Identification of Switch Wafers. Wafers of switches shown on the circuit diagrams are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example, the designation 2R printed by a switch section on a schematic identifies the switch section as being on the rear side of the second wafer when counting back from the front panel.

Wiring Color Code. The wiring in the Type 3T2 is color coded to facilitate circuit tracing. In the case of oscilloscope power-supply leads, the color code indicates the voltage carried, with the widest stripe denoting the first significant figure. Table 5-1 lists the color combinations and the voltages indicated by the colors for both oscilloscopes and Type 3T2 power supplies.

All leads that clip to the permanently mounted circuit boards are color coded. The color code of each lead and the pin lettering is shown in parts location figures later on in this section.



(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier Resistors	Multiplier Capacitors	Tolerance Resistors	Tolerance Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^{2}	10^{2}	±2%	±2%
Orange	3	10^{3}	10^{3}	±3%	±3%
Yellow	4	10^{4}	10^{4}	±4%	+100% —0%
Green	5	10^{5}	10^{5}	±0.5%	±5% or 0.5 pF*
Blue	6	10^{6}	10^{6}	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% —20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

***For capacitance of 10 pF or less.**

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 5-1. Resistor and ceramic capacitor color code.

Resistor Coding. The Type 3T2 uses a number of very stable metal film resistors identified by their gray background color and color coding.

If the resistor has three significant figures with a multiplier, the resistor will be EIA color coded. If it has four significant figures with a multiplier, the value will be printed on the resistor. For example, a 333 kΩ resistor will be color coded, but a 333.5 kΩ resistor will have its value printed on the resistor body.

The color-coding sequence is shown in Fig. 5-1.

TABLE 5-1

Power Supplies Wire Color Coding

Supply	Color Code
+300	Orange/Black/Brown on White
+125	Brown/Red/Brown on White
+19	Red/Black/Black on White
—19	Red/Black/Black on Tan
—12.2	Brown/Red/Black on Tan
—27	Red/Black/Black on Tan
—100	Brown/Black/Brown on Tan

Capacitor Marking. The capitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 3T2 are color coded in picofarads using a modified EIA code (see Fig. 5-1).

Diode Color Code. The cathode end of each glass enclosed diode is indicated by a stripe, a dot or a series of stripes. For normal silicon or germanium diodes the stripes also indicate the type of diode, using the resistor color-code system (e.g., 6185 indicates the type of diode with Tektronix Part No. 152-0185-00). The cathode and anode ends of metal-encased diodes can be distinguished by the diode symbol marked on the body or by the flared end of the diode.

Parts Replacement

All parts used in the Type 3T2 can be purchased directly through your Tektronix Field Office or Representative. However, replacements for standard electronic items can generally be obtained locally in less time than is required to obtain them from Tektronix. Replacements for the special parts used in the assembly of the Type 3T2 should be ordered from Tektronix since these parts are either manufactured or selected by Tektronix to satisfy a particular requirement. Before purchasing or ordering, consult the Electrical Parts List to determine the value, tolerance and ratings required.

NOTE

When selecting the replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. Parts orientation and lead dress should duplicate those of the original part since many of the components are mounted in a particular way to reduce or control stray capacitance and inductance. After repair, portions of the instrument may require recalibration.

Rotary Switches. Individual wafers or mechanical parts of rotary switches are normally not replaced. If a switch is defective, replace the entire assembly. The availability of replacement switches, either wired or unwired, is detailed in the Electrical Parts List.

Circuit Boards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the etched wiring from the base material.

Replacement of Tunnel Diodes. Grasp the TD lead between the body of the TD and the circuit board with a small pair of tweezers.

Touch the tip of the soldering iron to the TD lead where it enters the circuit board. Do not lay the iron tip directly on the circuit board. Gently but firmly pull the TD lead from the hole in the circuit board. If removal of the diode does not leave a clean hole, apply a sharp object such as a tooth-pick or pointed tool while reheating the solder. Avoid using too much heat.

To place the new TD, bend the leads and trim to fit just through the board. Tin each lead while using the tweezers as a heat sink. Place the TD leads in the holes. Apply a small amount of solder, if necessary, to assure a good bond. Use the tweezers as a heat sink and use only enough heat for a good connection.

Replacement of other soldered-in components. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board, as it may damage the board. Refer to Fig. 5-2.

When the solder begins to melt, pull the lead out gently. This should leave a clean hole in the board. If not, the hole can be cleaned by reheating the solder and placing a sharp object such as a toothpick or pointed tool into the hole to clean it out.

Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads so they will just protrude through the board.

Pre-tin the leads of the component by applying the soldering iron and a small amount of solder to each (heat-shunted) lead. Insert the leads into the board until the component is firmly seated against the board. If it does not seat properly, heat the solder and gently press the component into place.

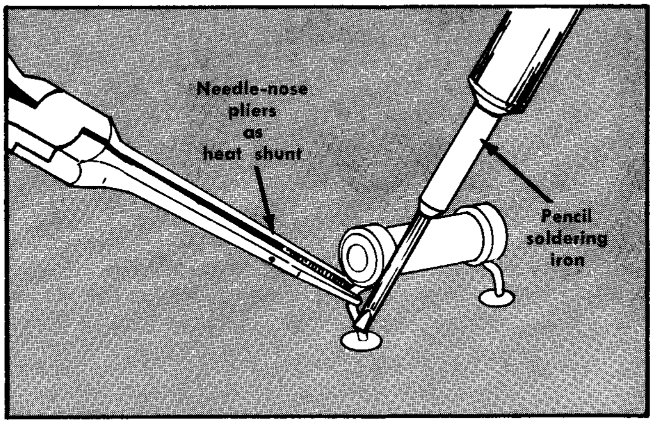


Fig. 5-2. Apply the soldering iron to the heat-shunted lead when removing a component from a circuit card.

Apply the iron and a small amount of solder to the connection to make a firm solder joint. To protect heat-sensitive components, hold the lead between the component body and the solder joint with a pair of long-nose pliers or other heat sink.

Clip the excess lead that protrudes through the board, especially in the vicinity of the transformer to avoid possible shorts.

Clean the area around the soldered connection with a flux-remover solvent to maintain good environmental characteristics. Be careful not to remove information printed on the board.

Most of the components mounted on the circuit boards can be replaced without removing the boards from the instrument. However, if the underside of the board must be reached, only the mounting screws need be removed. The interconnecting wires allow the board to be moved out of the way or turned over without unsoldering the leads.

Readout Panel Lamps. The TIME/DIV readout panel lamps are operated at low current for longest lifetime. Yet, they will need to be replaced occasionally. Replacement requires removal of the circuit board to which they are soldered. Removal is explained below as part of the section on Subassembly Removal.

Metal Terminals. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60-40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8 inch wide chisel-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder point, clip off the excess.

4. Clean the flux from the solder joint with a flux-remover solvent to maintain good environmental characteristics.

Subassembly Removal

Circuit Board Replacement. If circuit board is damaged and cannot be repaired, the entire assembly including all soldered-on components should be replaced. The part number given in the Mechanical Parts List is for the completely-wired board.

Procedure for replacing circuit boards follows:

1. The Readout Resistor Card Assembly is secured by one mounting screw. To remove the assembly, loosen the screw and pull straight out from the interconnecting plug.

2. The other circuit boards are secured by screws to the chassis. Most connections are made with miniature coaxial and pin connectors though a few are soldered. To remove the circuit board, remove the screws and the connectors.

3. The Position Indicator board assembly and neon holder is secured by one 4-40 nut to the captive bolt. Remove the neon holder cover by pushing down on the rear to release the catch and then sliding the cover off. Remove the nut with a No. 6 ($^{3}/_{16}$ inch) nutdriver. The entire assembly can then be removed from the bolt.

Replacing Readout Incandescent Lamps. To remove the readout circuit board, use a $^{1}/_{4}$ inch open-end wrench with a 90° end. Remove the 6-32 nuts from the captive bolts; lift the board free of the captive bolts and the board can then be brought out the instrument left side.

Lamp removal and replacement requires a pair of tweezers and a small soldering iron. Withdraw the burned-out lamp. To install the new lamp, cut the leads to proper length, and then bend them into the same shape as found in the original lamp.

After soldering the new lamp in place, check that there is no excess solder to short between a hot terminal and ground.

Position the lamp the same as all other lamps in the assembly.

Place the board back onto the captive bolts and replace the 6-32 inch nuts.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 3T2 if trouble develops. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in Section 9. The circuit number and electrical value of each component in this instrument are shown on the diagrams. Important voltages and waveforms are also shown on the diagrams.

Component Numbering. The circuit number of each electrical part is shown on the circuit diagram. Each main circuit is assigned a series of circuit numbers. Table 5-2 lists the main circuits in the Type 3T2 and the series of circuit numbers assigned to each.

TABLE 5-2

Circuit Numbers on Schematics	Circuit
1-149	Trigger & Holdoff
200-399	Ramp Generators
400-499	Staircase Generator
500-699	Horiz Memory & Rate Meter
700-799	Blanking & Horizontal Amplifier
800-899	Power Supply
900-999	Readout Switching

Table 5-3 lists the physical location of the circuits by the transistor numbers.

TABLE 5-3

Circuit and Circuit Number	Location
Trigger Amplifier Q11, Q12 Source & Polarity Select Q20, Q30, Q41, Q51 Trigger Recognizer Q70, Q72, Q74, Q80, Q90, Q101, Q102	Trigger Board Right side
Holdoff Multivibrator & Logic Drivers Q121, Q130, Q131, Q141, Q143	Logic Board Left side
Time Position Offset Q210 (Q360 on logic board) Staircase Inverter Amplifier Q212, Q214, Q220 Leadtime Comparator Q231, Q235 Slewing Ramp Clamp Q251, Q252, Q254 Slewing Ramp Q261, Q263, Q265, Q267, Q269 Timing Ramp Comparator Q271 Slewing Ramp Comparator Q281, Q283 Strobe Driver Q290 Timing Ramp Clamp Q301, Q302 Stop Drive Q310 Timing Ramp Q306, Q321, Q323, Q325, Q327 Q329, Q341, Q344	Trigger Board Right side

TABLE 5-3 *(cont)*

Circuit and Circuit Number	Location
Time Position Offset Q360 (Q210 on trigger board) Timing Ramp Amplifier Q371, Q373, Q381, Q391, Q393 Q395 Staircase Generator Q401, Q406, Q420, Q430, Q431, Q441, Q457, Q461, Q465, Q467 Staircase E.F.'s Q480, Q481 Horizontal Memory Q501, Q502, Q504, Q511, Q513, Q515, Q517, Q520, Q522 Dot Position Comparator Q531, Q533, Q535, Q540 Dot Position Memory Q552, Q555, Q557, Q561, Q563, Q565 Rate Meter Ramp Q572, Q573, Q575 Rate Meter Comparator Q590, Q592 Low Rep Rate Q581, Q584 Correction Matrix Q615, Q620 Ratemeter Memory Q601, Q603, Q605, Q607, Q610 Blanking Q705, Q710, Q722 Horizontal Amplifier Q741, Q751, Q761, Q771, Q781 Power Supply Q811, Q815, Q831, Q835	Logic Board Left side
Power Supply Q821, Q841	Readout Resistor Card
Horizontal Position Indicators Q791, Q793	Position Indicator Board

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given in this section.

1. Check Associated Equipment. Before proceeding with troubleshooting of the Type 3T2 check that the equipment used with the Type 3T2 is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. Also, check the power source.

2. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. For example, incorrect setting of the TRIG SENSITIVITY control appears as defective sweep or trigger circuit. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

3. Check Instrument Calibration. Check the calibration of the instrument, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment or may be corrected by calibration. Complete instructions are given in the Calibration section of this manual.

CAUTION

It is important not to adjust any power supply voltages unless a total calibration effort is planned. Changing power supply voltages alters the whole instrument calibration. Other steps of the Calibration Procedure can be performed in any sequence unless otherwise stated.

4. Isolate the Trouble to a Circuit. If the trouble has not been corrected or isolated to a particular circuit with the preceding steps, make the following checks if possible.

a. Check for the correct resistance readings at the interconnecting plug terminals, as indicated in Table 5-4.

If the resistance values at the interconnecting plug are equal or higher than stated in Table 5-4, proceed with the next step.

TABLE 5-4

P21 Interconnecting Plug Resistance Checks Type 3T2 disconnected from Oscilloscope

Pin Number	Resistance to Ground
1	inf
2	inf
3	0
4	0
5	inf
6	25 kΩ
7	inf
8	inf
9	0
10	20 kΩ
11	100 kΩ
12	3.5 kΩ
13	23 kΩ
14	inf
15	10 kΩ
16	75 Ω
17	75 kΩ
18	inf
19	90 Ω
20	11 kΩ
21	75 kΩ
22	4 kΩ
23	10 kΩ
24	inf

b. Connect the Type 3T2 to the oscilloscope in which it will normally operate. Use the flexible cable extension, Tektronix Part No. 012-0066-00. Turn on the instrument and allow at least 5 minutes warmup time.

Check the power supply voltages.

Incorrect operation of all circuits often indicates trouble in the power supplies. Check first for correct adjustment of the individual supplies. However, a defective component elsewhere in the instrument can appear as a power-supply trouble and may also affect the operation of other circuits.

Table 5-5 lists the tolerances of the power supplies in the Type 3T2. If a power-supply voltage is within the listed tolerance, the supply can be assumed to be working correctly. If outside the tolerance, the supply may be misadjusted or operating incorrectly. Use the procedure given in the Calibration section to adjust the power supplies.

TABLE 5-5

Type 3T2 Power Supply Tolerances

Power Supply	Tolerance
+300 Volt	Typically +299 volts[1]
+125 Volt	Typically +124 volts[1]
+19 Volt	±3% (limits: +18.43 to +19.57)
—19 Volt	±3% (limits: —18.43 to —19.57)
—27 Volt	Typically —26 volts[1]
—100 Volt	Typically —99 volts[1]

[1]Value is based upon a series decoupling resistor within the oscilloscope. If voltage is significantly less (several volts) examine the associated decoupling resistor network in the oscilloscope.

NOTE

Voltages and waveforms given in the Circuit Decription are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first schematic page.

c. Special servicing of the Before Trigger Servo Loop is possible by the use of an external power supply. In the event that normal operating procedures fail to produce a valid Before Trigger display, or if the Before Trigger circuits cannot be calibrated, (and assuming everything works properly for the With Trigger sampling process), go through the following first two steps to check the operation before doing any servicing:

1. Obtain a stable display with the START POINT switch at With Trigger.

2. Change the START POINT switch to Before Trigger and advance the TRIG SENSITIVITY control fully clockwise. If no trace appears, some portion of the Servo Loop is at fault. If a display appears, then check the triggering signal connections and triggering signal amplitude. If a free-run display appears, and then counterclockwise rotation of the TRIG SENSITIVITY control causes the LOW REP RATE lamp to light dimly, flicker, or light brightly, the Rate meter is functioning properly.

3. If step 2 does not produce a free-run display, or the LOW REP RATE lamp won't light, servicing is needed. Begin by opening the servo loop at Q563 emitter (Dot Position Memory circuit) and applying an external voltage to the junction of R563-D562 (after removing Q563 from its socket).

Use an electronically regulated, low ripple, adjustable supply. Very slowly (500 mV per minute) change the supply voltage from +9 to —9 volts. If during this procedure a trace does not appear, the trouble is within the servo loop. Refer to the circuit description for waveforms and voltages, and use normal servicing techniques to find the trouble.

4. If the external power supply produces a display, then the trouble may be between the Dot Position Comparator and Q563. Use the circuit description, and oscilloscope, a multimeter, and normal servicing techniques to locate the problem.

Transistor Checks

Transistors should not be replaced unless they are actually defective. Transistor defects usually take the form of the transistor opening, shorting or developing excessive leakage. To check a transistor for these and other defects, use a transistor curve display instrument such as a Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal-tracing, by making in-circuit voltage checks, by measuring the transistor forward-to-back resistance using proper ohmmeter resistance ranges, or by using the substitution method. The location of all transistors is shown in the parts location figures later in this section.

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages and determine if

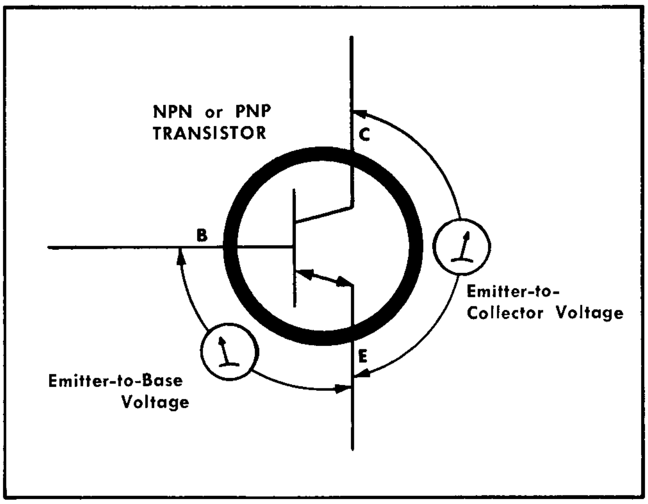


Fig. 5-3. In-circuit voltage checks NPN or PNP transistors.

the voltages are consistent with the normal resistances and currents in the circuit (see Fig. 5-3).

To check a transistor using an ohmmeter, know your ohmmeter ranges, the currents they deliver, and the internal battery voltage(s). If your ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current will flow through the transistor under test. Excessive current and/or high internal source voltage may permanently damage the transistor.

NOTE

As a general rule, use the R × 1 k range where the current is usually limited to less than 2 mA and the internal voltage is usually 1½ volts. You can quickly check the current and voltage by inserting a multimeter between the ohmmeter leads and measuring the current and voltage for the range you intend to use.

When you know which ohmmeter ranges will not harm the transistor, use those ranges to measure the resistance with the ohmmeter connected both ways as given in Table 5-6.

TABLE 5-6

Transistor Resistance Checks

Ohmmeter Connections[2]	Resistance Reading That Can Be Expected Using the R × 1 k Range
Emitter-Collector	High readings both ways (about 60 kΩ to around 500 kΩ).
Emitter-Base	High reading one way (about 200 kΩ or more). Low reading the other way (about 400 Ω to 2.5 kΩ).
Base-Collector	High reading one way (about 500 kΩ or more). Low reading the other way (about 400 Ω to 2.5 kΩ).

[2]Test prods from the ohmmeter are first connected one way to the transistor leads and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.

If there is doubt about whether the transistor is good, substitute a new transistor; but first, be certain the circuit voltages applied to the transistor are correct before making the substitution.

Only two transistors have soldered leads, Q41 and Q51. Q821 and Q841 are both mounted by nuts; requiring No. 8 (¼ inch) nutdriver, and soldered. All other transistors have sockets or are mounted to the circuit board without solder.

When checking transistors by substitution, be sure that the voltages on the transistor are normal before making the substitution. If a transistor is substitutted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

CAUTION

Be careful when making measurements on live circuits. The small size and high density of components used in this instrument result in close spacing. An inadvertent movement of the test probes, or the use of oversized probes may short between circuits.

Diode Checks

A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of about 1.5 volts, the resistance should be very high in one direction and very low when the leads are reversed.

CAUTION

Do not us an ohmmeter scale that has a high internal current. High currents may damage the diode. Do not measure tunnel diodes with an ohmmeter; use a dynamic tester (such as Tektronix Type 575 Transistor-Curve Tracer).

Field Effect Transistors

Field Effect transistors in the Type 3T2 should not be tested with an ohmmeter. If you suspect trouble in a dual FET, pull the unit out of the socket and rotate it 180° and re-insert it. The leads are arranged in a manner to permit the unit to be installed with the guide pin either straight up or straight down.

Actual condition of an FET can be checked using a Tektronix Type 575 Transistor Curve Tracer. Follow the lead identification of Fig. 5-4 when making connections at the curve tracer sockets.

Set the curve tracer controls:

COLLECTOR SWEEP Controls

PEAK VOLTS RANGE	0.200
POLARITY	+ (NPN)
PEAK VOLTS Control	Fully counterclockwise
DISSIPATION LIMITING RESISTOR	2 K

VERTICAL Controls

CURRENT OR VOLTAGE	1 COLLECTOR MA
POSITION	Spot at lower left corner of graticule

HORIZONTAL Controls

VOLTS/DIV	10 COLLECTOR VOLTS
POSITION	Spot at lower left corner of graticule

BASE SWEEP GENERATOR Controls

REPETITIVE/OFF/SINGLE FAMILY	REPETITIVE

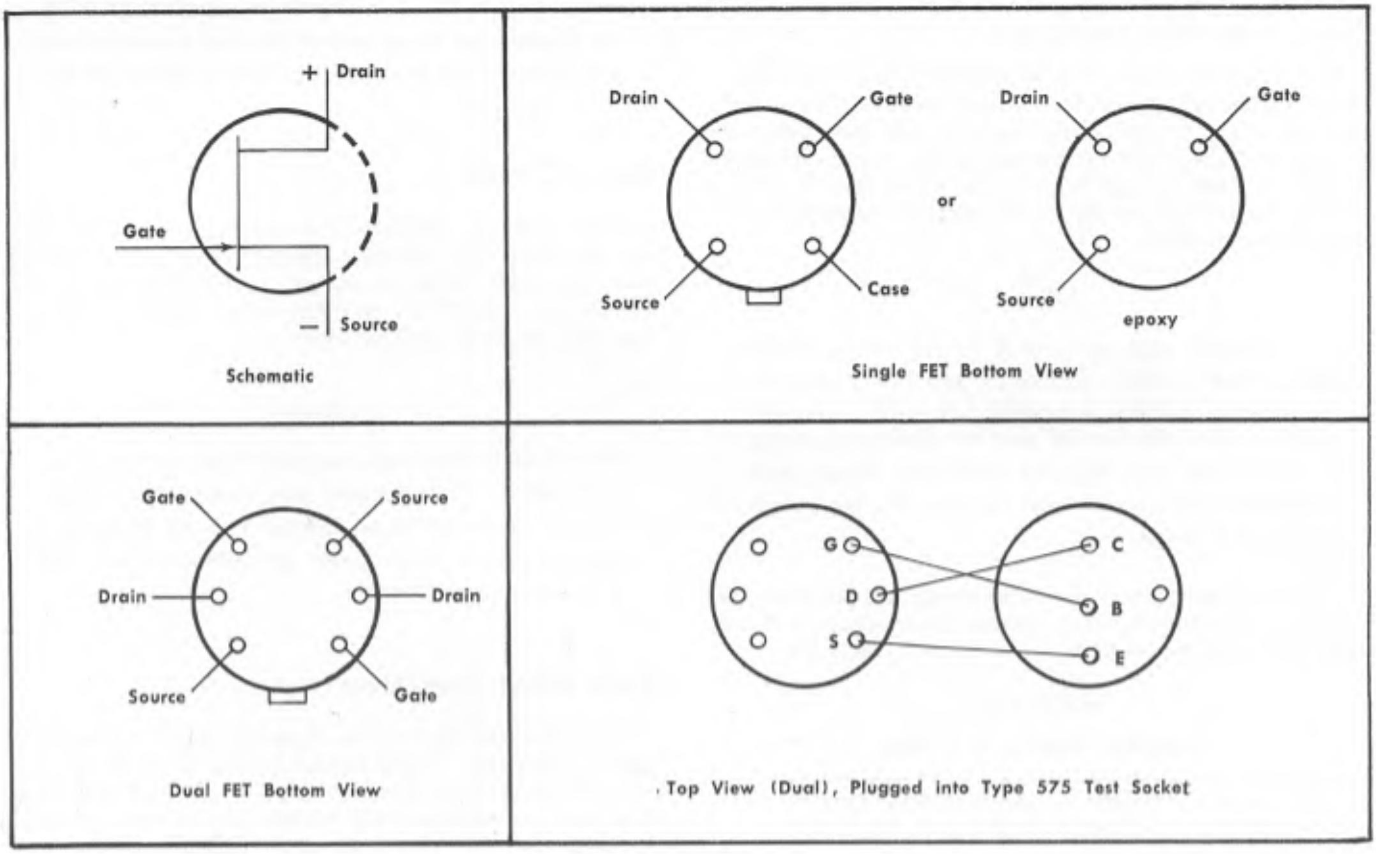


Fig. 5-4. Pin arrangement in FET's used in Type 3T2.

STEPS/FAMILY	Fully counterclockwise
POLARITY	—
STEPS/SEC	120 (up)
SERIES RESISTOR	Optional
STEP SELECTOR	.2 MA PER STEP

Sloping Panel Controls

Center rotary switch	EMITTER GROUNDED

Connect a 1000 Ω (1% or 5%) ½ watt resistor between the B and E binding posts on which ever side of the sloping panel you plan to test the FET. This resistor develops a voltage bias for the Gate lead at 1 volt per mA base step current.

Since the leads of the FET are short, you can avoid bending them (with a chance of breakage) by building an adapter out of a spare transistor socket and wire leads to the sloping panel binding posts. Follow Fig. 5-4 when making connections.

FET 151-1004-00 has a typical zero-bias channel current between 0.5 and 3.0 mA at 10 volts. Minimum gm is 1000 μmhos at 10 volts and zero-bias channel current.

FET 151-1007-00 has zero-bias channel current at a 1.5 mA minimum at 10 volts. Minimum gm is 1000 mhos at 10 volts and 1 mA.

Major Circuit and Parts Locations

The remainder of this section includes photographs of sections of the Type 3T2. Major circuit areas are identified. All components mounted on circuit boards are identified by circuit numbers. All circuit board connections are identified by pin number and color code.

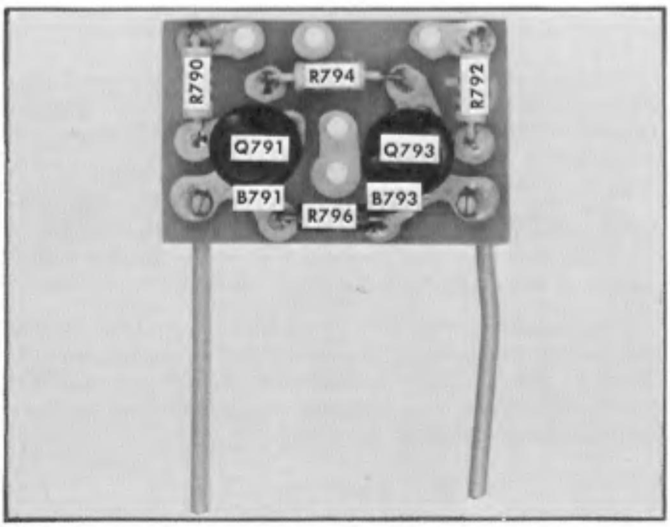


Fig. 5-5 Position Indicator Board.

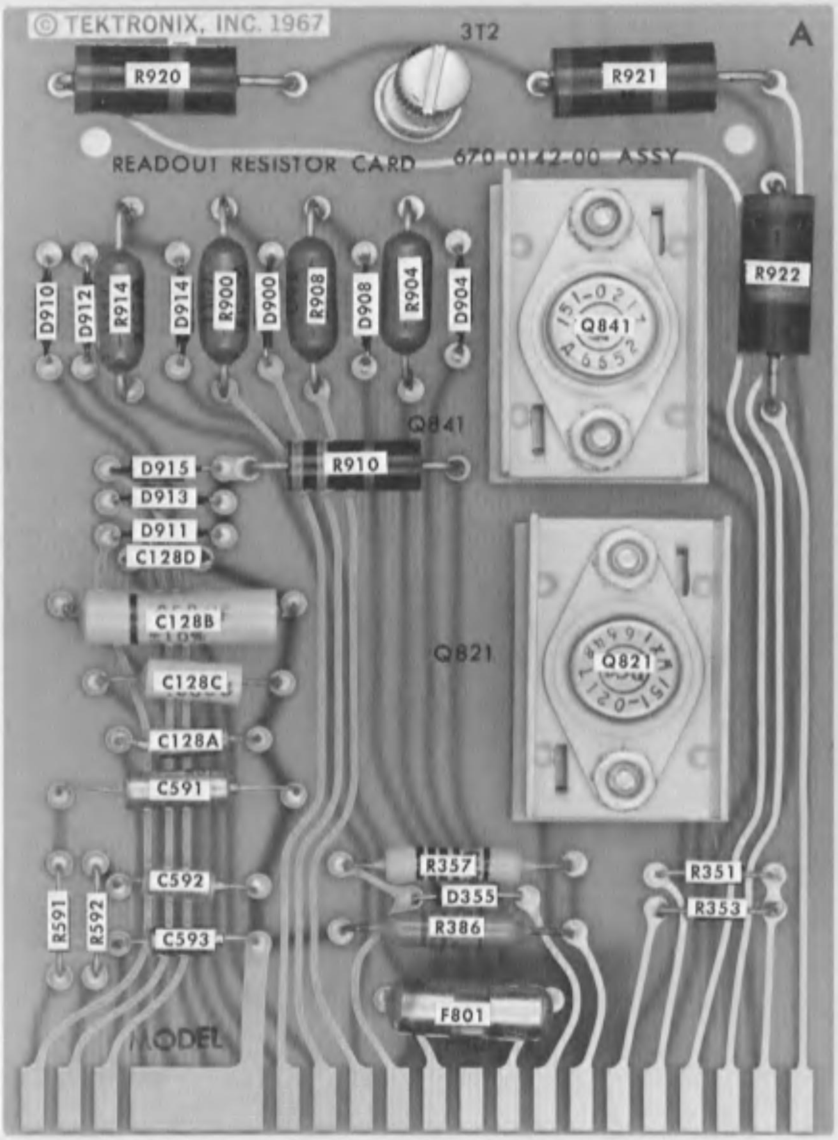


Fig. 5-6. Readout Resistor Card.

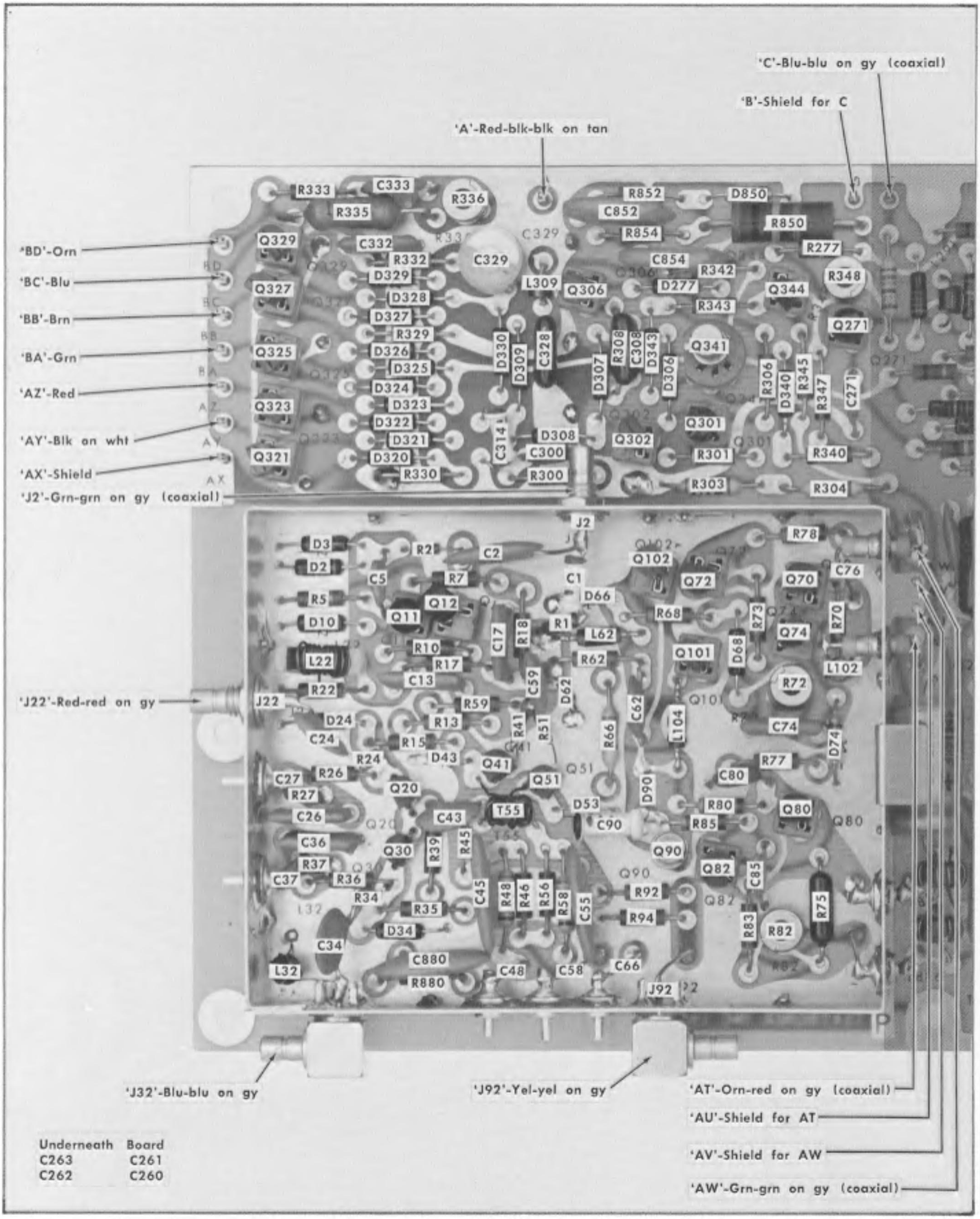


Fig. 5-7A. Trigger Board, Left.

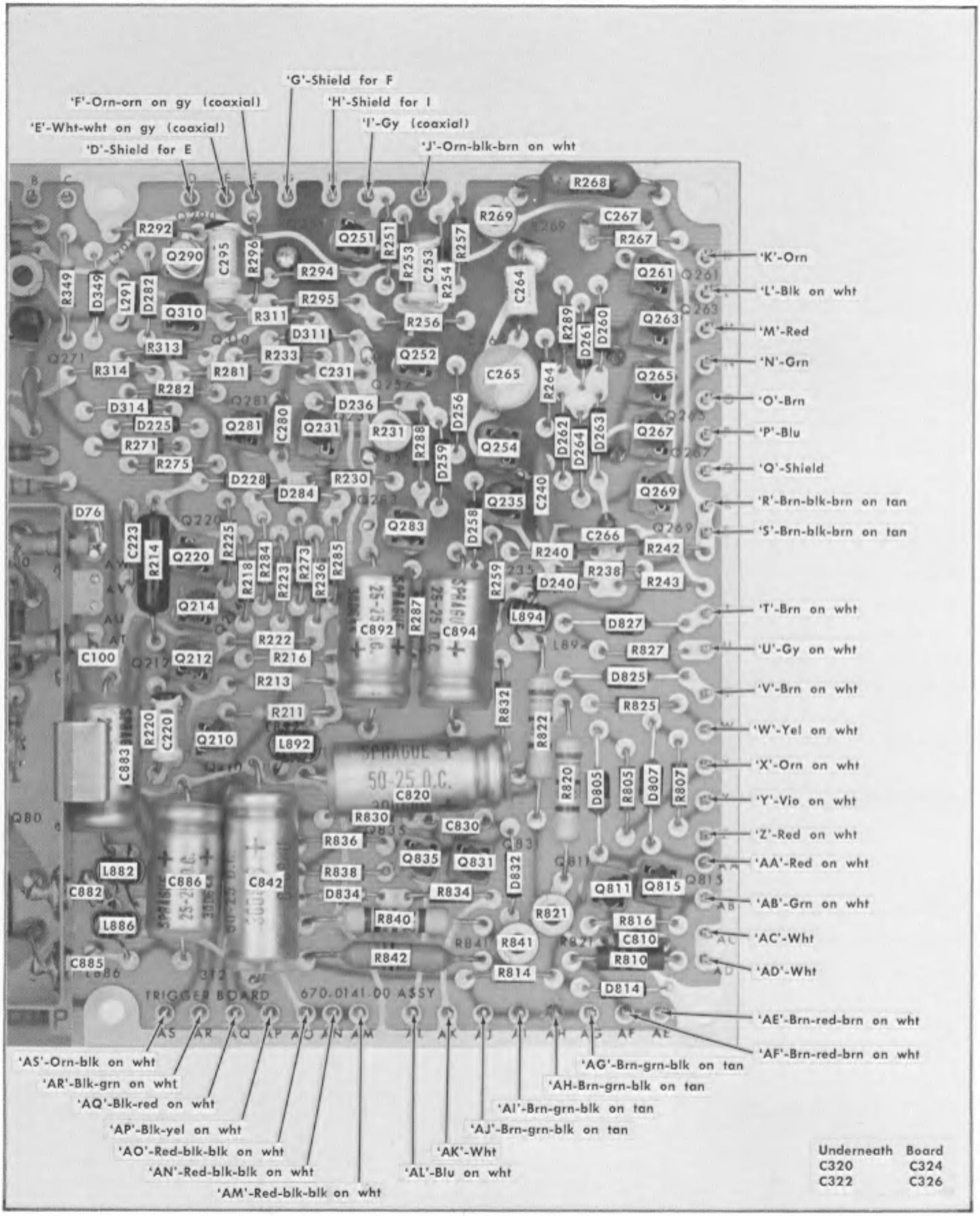


Fig. 5-7B. Trigger Board, Right.

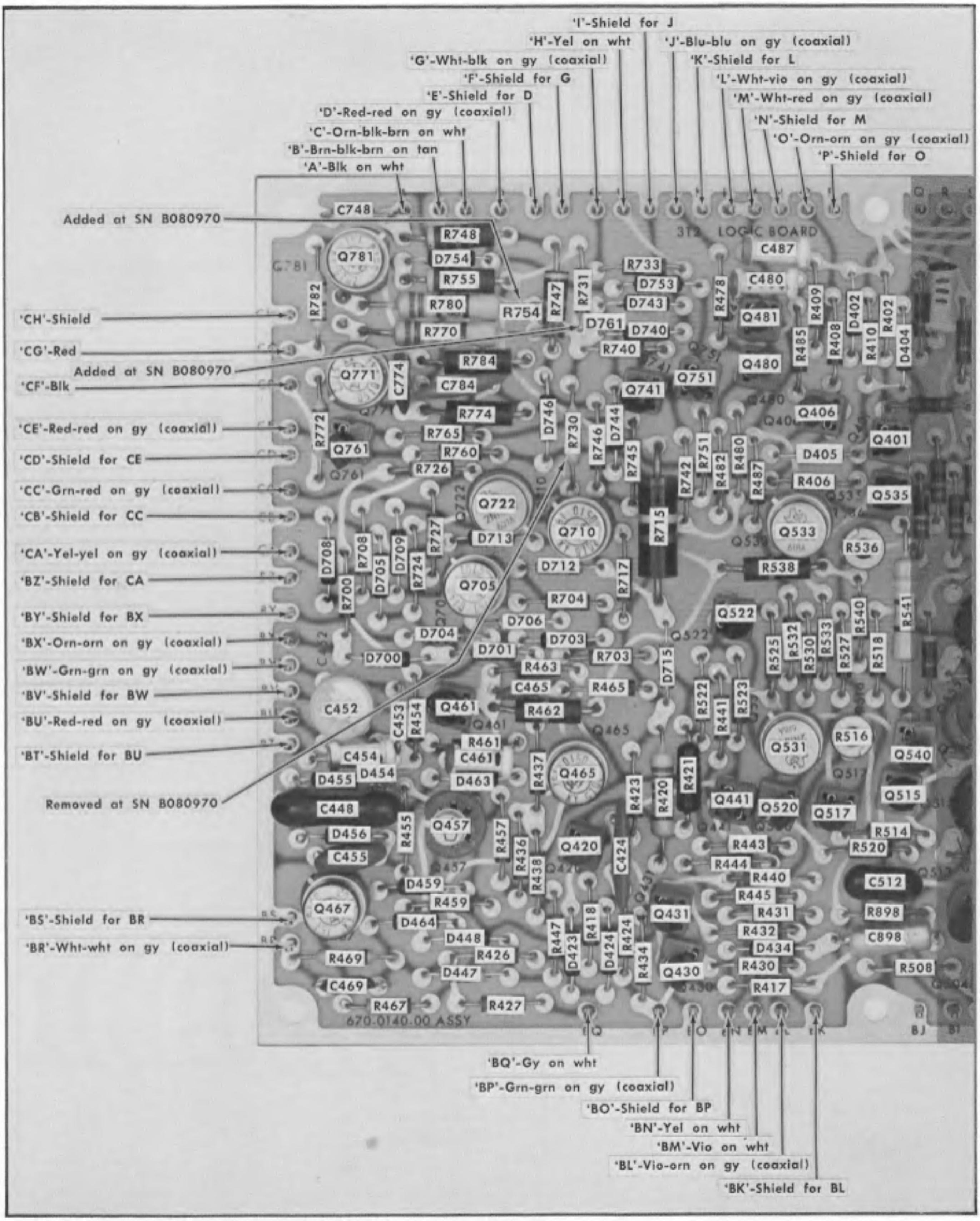


Fig. 5-8A. Logic Board, Left.

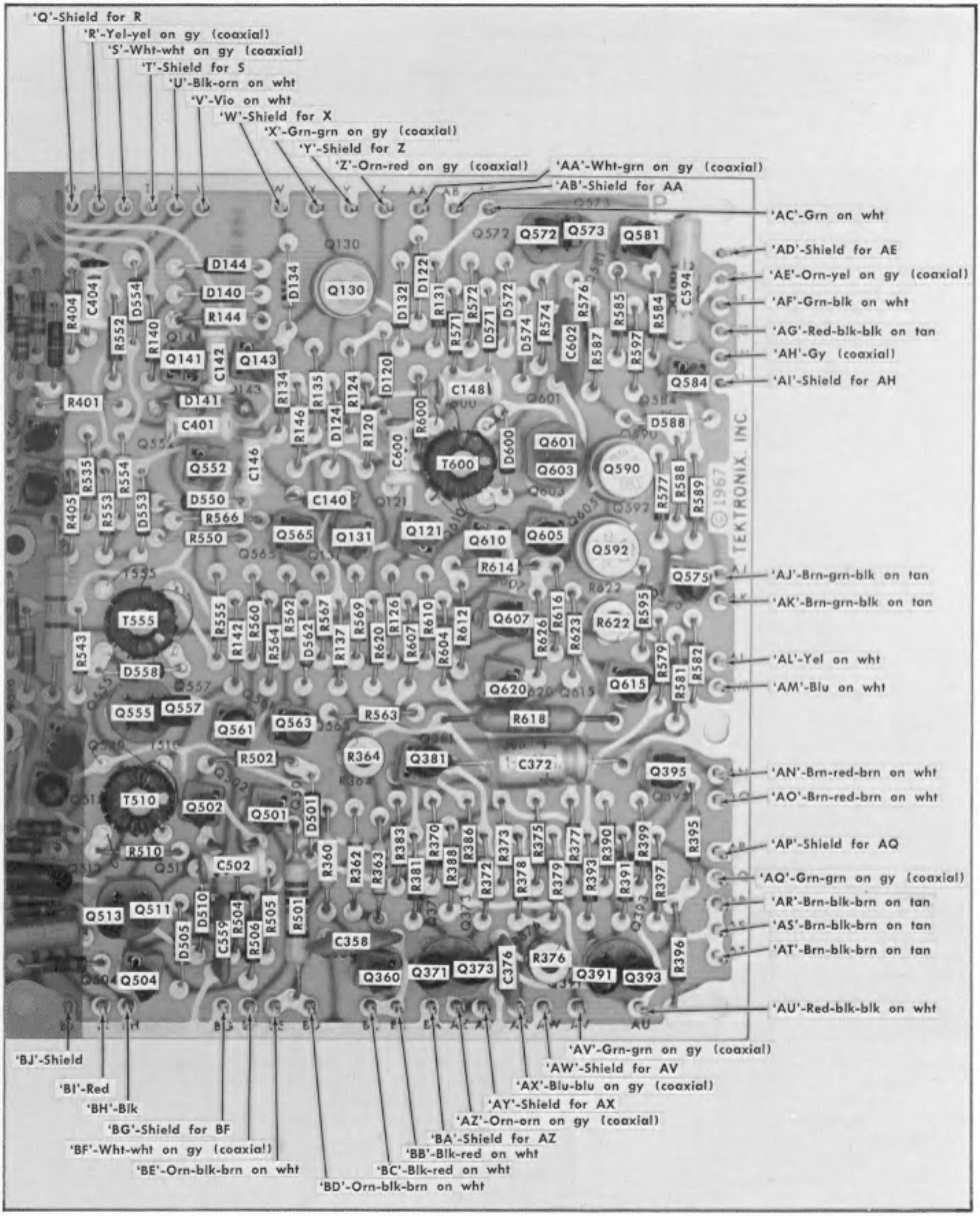


Fig. 5-8B. Logic Board, Right, SN B010100 through B060759.

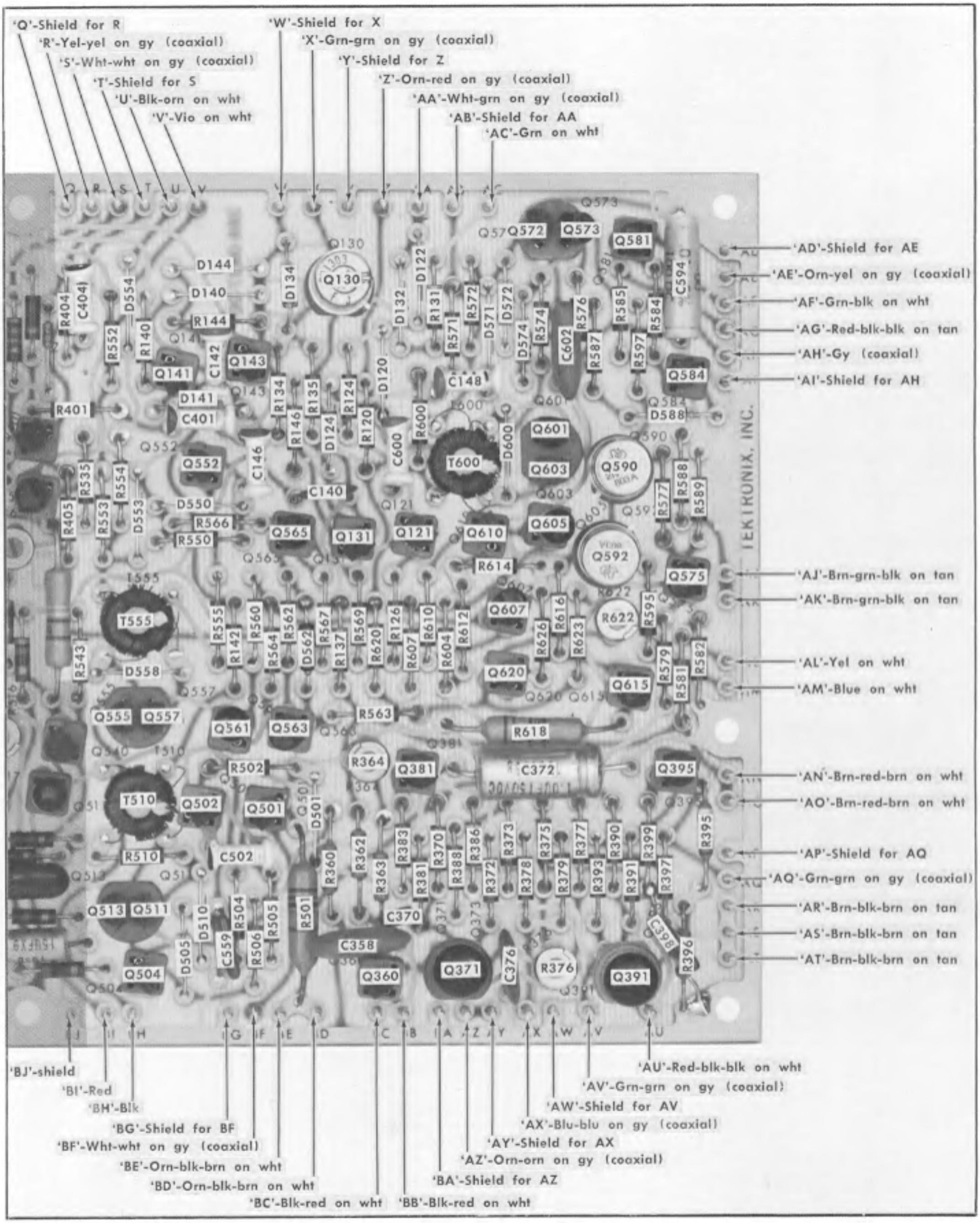


Fig. 5-8B. Logic Board, Right, SN B070760-up.

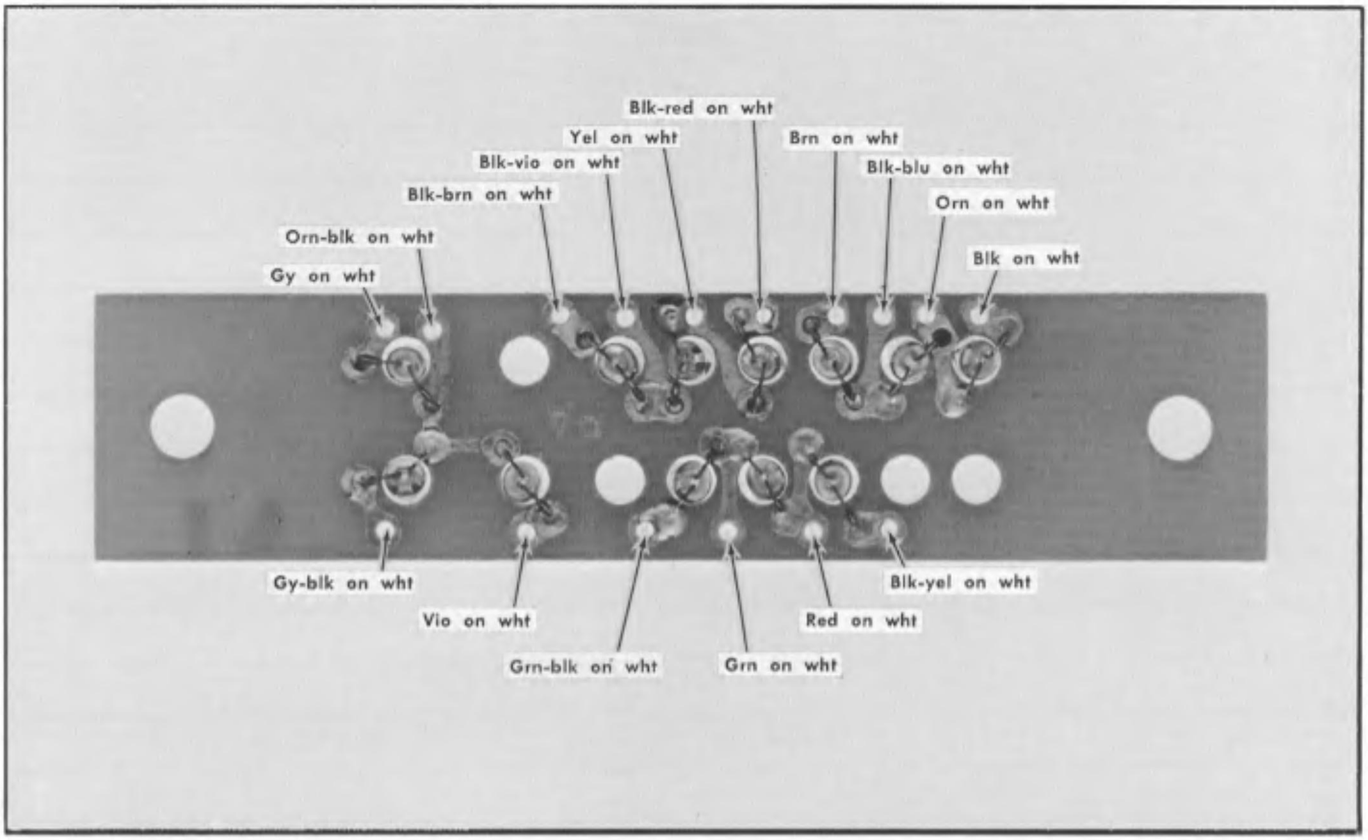


Fig. 5-9. Readout incandescent board assembly.

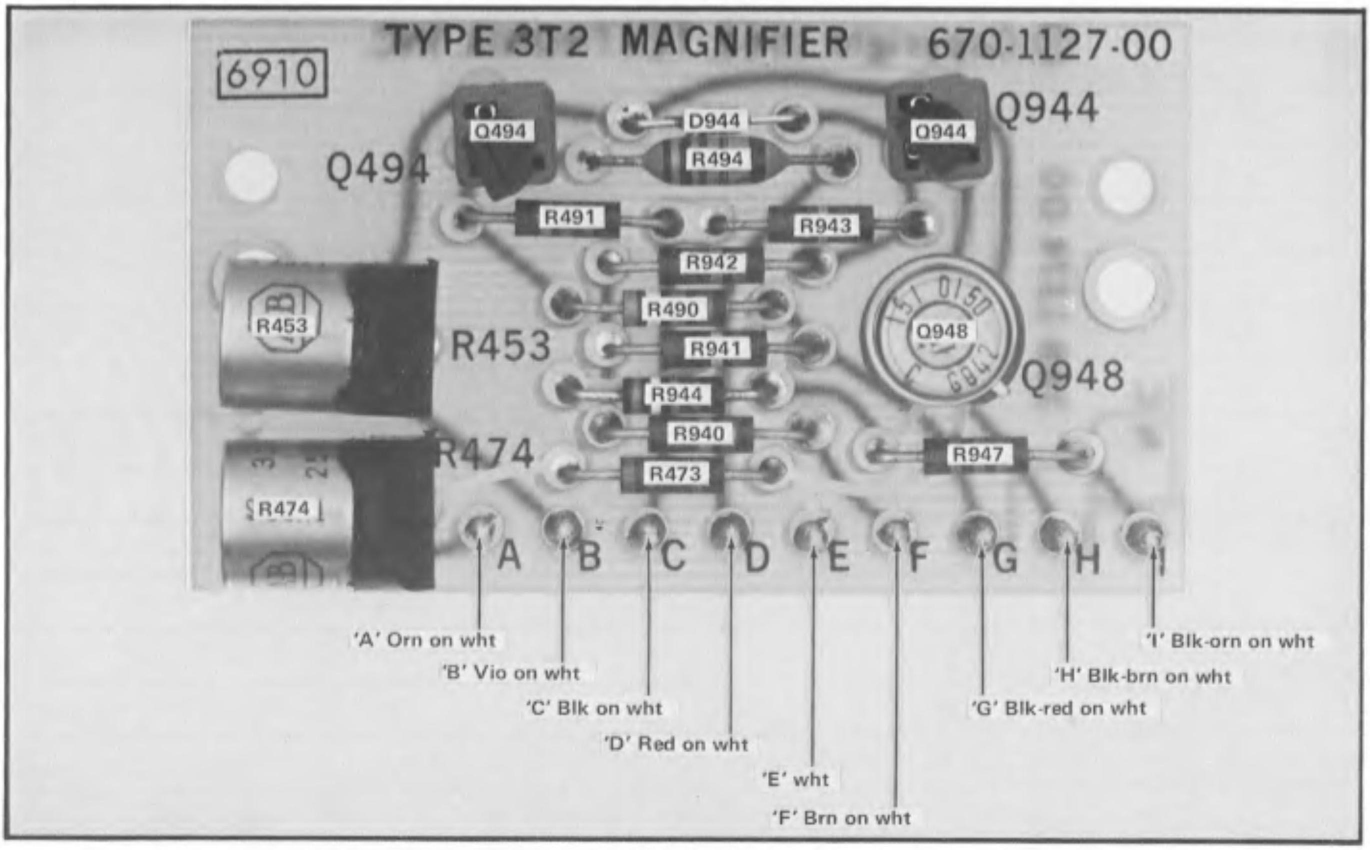


Fig. 5-10. ×10 Magnifier board.

NOTES

SECTION 6
PERFORMANCE CHECK

Introduction

This section of the manual provides a means of rapidly checking the performance of the Type 3T2. It is intended to check the calibration of the instrument without the need for performing the complete Calibration Procedure. The Performance Check does not provide for the adjustment of any internal controls. Failure to meet the requirements given in this procedure indicates the need for internal checks or adjustments, and the user should refer to the Calibration Procedure in this manual.

EQUIPMENT REQUIRED

The following (or equivalent) items of equipment are required for a complete performance check of the Type 3T2. Equipment requirements given here are the minimum requirements for making the sequence of checks. All test instruments are assumed to be calibrated and operating within their rated specifications. If substitute equipment is used, it must equal or exceed the given requirements in order to check the Type 3T2 to the given accuracy.

1. Calibrated indicator oscilloscope, such as the Tektronix Type 561A with Type 3S1 vertical sampling plug-in unit. Alternate requirements: Compatible with the Type 3T2; vertical deflection factors from 2 mV/div to 200 mV/div. If the sampling unit with no trigger take-off is used, provision must be made for externally pretriggering the Type 3T2. A Tektronix CT-3 current take-off, used with a Type 113 Delay Cable, is recommended for deriving the pretrigger pulse.

2. Calibrated test oscilloscope, such as the Tektronix 540-series with the Type W Comparator Plug-In Unit, Type 545B and Type W Unit recommended. Alternate requirements: Deflection factor of 50 mV/cm minimum, and a voltage comparator with a voltage accuracy of 0.5% at 1 volt.

3. Time-mark generator, Tektronix Type 184. Minimum alternate requirements: Marker or sine-wave outputs of .5 ms, .1 ms, 50 μs, 10 μs, 1 μs, .5 μs, .1 μs, 50 ns, 20 ns and 10 ns with an accuracy $\pm$0.3%.

4. Low-frequency sine-wave generator, such as General Radio Type 1310-A. Minimum requirements: Output frequency 10 kHz and 100 kHz; output amplitude at least 2 volts into 50 ohms. An adapter will be required with this instrument to connect a coaxial cable to its output. Tektronix Part No. 013-0076-00, clip-lead adapter, may be used.

5. Mid-frequency sine-wave generator, Tektronix Type 191 Constant Amplitude Signal Generator. Minimum alternate requirements: Output frequency of 30 MHz; output amplitude variable from approximately 30 mV to approximately 2.5 volts into 50 ohms.

6. UHF Oscillator, such as General Radio Type 1361-A. Minimum alternate requirements: Output frequency 1 GHz and output amplitude of a least 2 volts into 50 ohms.

7. Pulse generator, Tektronix Type 111 recommended. Minimum alternate requirements: Positive-going and negative-going pulse outputs; pulse risetime less than 1 ns; pulse duration 2 ns; repetition rate 100 kHz; pulse amplitude at least 2 volts into 50 ohms. The Type 111 has an output pulse amplitude of 10 to 20 volts and is the amplitude assumed in the connections used in the procedure.

8. One 42-inch coaxial cable with BNC connectors. Characteristic impedance approximately 50 ohms. Tektronix Part No. 012-0057-01.

9. 5-ns coaxial cable, type R213/U, with GR 50 ohm connectors. Tektronix Part No. 017-0502-00.

10. Two 2-ns coaxial cables, type RG58C/U, with GR 50 ohm connectors. Tektronix Part No. 017-0505-00.

11. 5-ns coaxial cable, Type RG58C/U,with GR 50 ohm connectors. Tektronix Part No. 017-0512-00.

12. 50-ohm 10× attenuator with GR connectors. Tektronix Part No. 017-0078-00.

13. 50-ohm 5× attenuator with GR connector. Tektronix Part No. 017-0079-00.

14. 50-ohm 2× attenuator with GR connectors. Tektronix Part No. 017-0080-00.

15. Variable attenuator with GR 50-ohm connectors. Tektronix Part No. 067-0511-00.

16. Pocket-type screwdriver. Blade width less than 1/8 inch.

17. Coaxial T connector with GR 50-ohm connectors. Tektronix Part No. 017-0069-00.

18. Coaxial T connector with GR 50-ohm connectors, 50 Ω GR-TPD. Tektronix Part No. 017-0082-00.

19. BNC plug to GR connector adapter. Tektronix Part No. 017-0064-00.

20. BNC jack to GR connector adapter. Tektronix Part No. 017-0063-00.

21. 50 Ω termination, BNC connectors. Tektronix Part No. 011-0049-00.

22. 10× probe, Tektronix P6006, with BNC connector. Tektronix Part No. 010-0127-00.

PERFORMANCE CHECK PROCEDURE

Equipment used in the following procedure is that listed under Equipment Required. If substitute equipment is used, connections and control settings may need to be changed to correspond to the characteristics of the equipment used.

To identify the two oscilloscopes used in the procedure, the one that is operated in conjunction with the Type 3T2 is called the indicator oscilloscope and the one that is used for making waveform and voltage checks is referred to as the test oscilloscope. Also in this procedure, the words division and div are used as contractions for the phrase "major division of the CRT graticule."

PRELIMINARY PROCEDURE

1. Install the Type 3T2 and the vertical sampling unit in the indicator oscilloscope.

2. Connect the two oscilloscopes and the test equipment to the power lines.

3. Turn on the instruments and allow at least 20 minutes warm up at 25° C ±5° C (77° F ±9° F) before starting the check procedure.

4. After the 20-minute warm-up period, check the DC balance of the test oscilloscope.

5. Set the instrument controls as follows:

Indicator Oscilloscope

Intensity	Fully counterclockwise
Calibrator	Off
CRT Cathode Selector	Chopped Blanking

Type 3T2

TIME POSITION	Centered
Time Position FINE	Centered
HORIZ POSITION	Centered
SAMPLES/DIV	Centered
RANGE	100 ns
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
EXT HORIZ ATTEN/ MANUAL SCAN	As desired
TRIG SENSITIVITY	Centered
RECOVERY TIME	Centered
POLARITY	+
SOURCE	INT
Internal Samples/Div	100

Vertical Sampling Unit

Vertical Mode	A Only
Smooth-Normal	Normal
Position	Centered
mV/Div	100
mV/Div Variable	Calib
Norm-Inv	Norm
DC Offset	Center of range
Internal Trigger	A

1. Adjust Horiz Gain

Requirement—Exactly 10 div displacement of spot with MANUAL SCAN control turned from fully counterclockwise to fully clockwise setting.

a. Set the TRIG SENSITIVITY control for a free running trace and change the DISPLAY MODE switch to MANUAL.

b. Set the MANUAL SCAN control fully counterclockwise and the HORIZ POSITION control so the spot is at the zero graticule line.

c. Set the MANUAL SCAN control fully clockwise and check that the spot is at the tenth graticule line.

d. Adjust the HORIZ GAIN control so the spot moves exactly 10 div as the MANUAL SCAN control is turned from fully counterclockwise to the fully clockwise position; see Fig. 6-1.

e. Set the DISPLAY MODE switch to NORMAL.

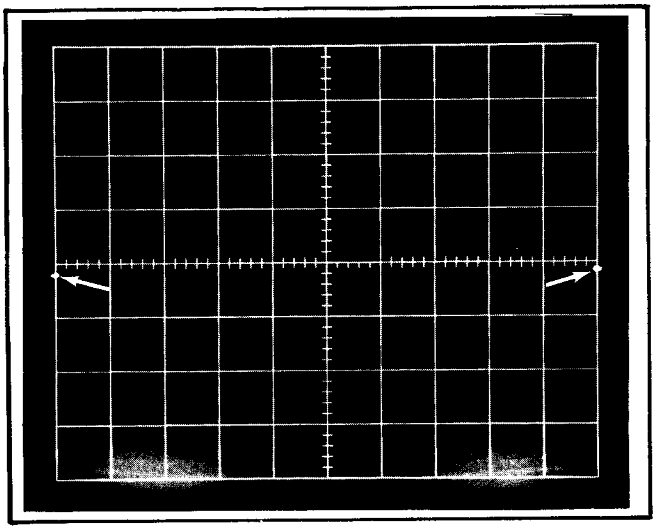


Fig. 6-1 Double exposure of Indicator Oscilloscope display of Manual Scan control range.

2. Check Trigger Jitter

Requirement—**Sine Waves, WITH TRIGGER sampling mode only.** 30 MHz, 200 ps or less with following equipment and signal amplitudes: Internal triggering with 900 mV P-P signal to a 3S1 input or 500 mV P-P to a 3S76. External triggering, 200 ps or less when 30 MHz signal of 100 mV P-P is applied to the 50 Ω external trigger input connector, and 50 ps or less when 1 GHz signal of 100 mV P-P is applied to the 1 MΩ/UHF SYNC connector.

Pulses: 2 ns duration, either plus or minus polarity. WITH TRIGGER mode; External 50 Ω input: 20 ps or less with 150 mV peak pulse; 30 ps or less with 50 mV peak pulse. Internal triggering: 30 ps or less with 400 mV peak pulse to a 3S1 or 250 mV peak pulse to a 3S76. BEFORE TRIGGER mode, External 50 Ω input only: 50 ps or less with a 50 mV peak pluse.

Trigger jitter is defined as the horizontal width of the trace when 5% of the dots on both the left and right are ignored.

30 MHz Sine Wave

a-1. Connect the Type 191 to the GR Tee connector through a 5 ns cable; connect one side of the Tee connector to the Vertical Sampling Input A connector through a 2 ns cable, and the other side of the Tee connector to the Type 3T2 50 Ω TRIGGER INPUT through a 2 ns cable, a 5× attenuator and a GR to BNC adapter.

a-2. Set the Type 191 for an output signal of 30 MHz and the amplitude for 5 divisions of display; see Fig. 6-2A. Use 8 divisions for display amplitude if the Vertical Sampling Unit is a Type 3S1.

a-3. Obtain a stable display with the TRIG SENSITIVITY control set clockwise into free-run operation. Center the display with the DC Offset control.

a-4. Set the TIME MAGNIFIER switch to ×50 and center the rising portion of the display with the TIME POSITION control, Fig. 6-2B.

a-5. Set the Vertical mV/div switch to 2 and re-center the display with the TIME POSITION control. Readjust TRIG SENSITIVITY and RECOVERY TIME controls for stable display.

a-6. Check that the trigger jitter is not greater than 1 div, 200 ps. See Fig. 6-2C.

a-7. Change the SOURCE switch to EXT and again check that the jitter is within 200 ps. Use 5 divisions display amplitude with a Type 3S1.

a-8. Set the POLARITY switch to — and check that jitter is not greater than 200 ps, Fig. 6-2D.

a-9. Set the POLARITY switch to + and check that jitter is within 200 ps.

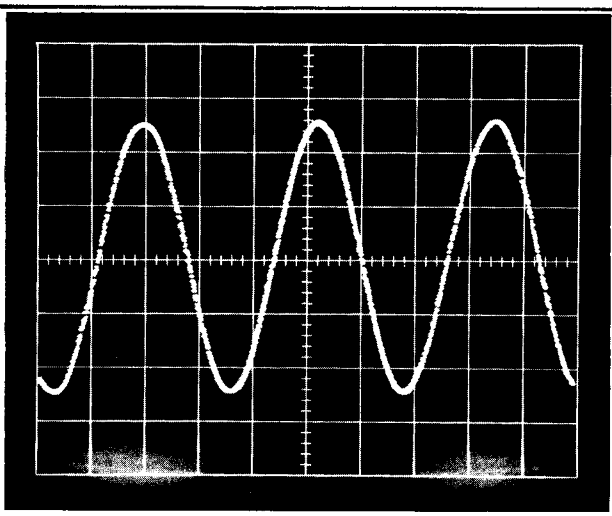
a-10. Disconnect the signal cable from the Type 191.

1 GHz Sine Wave

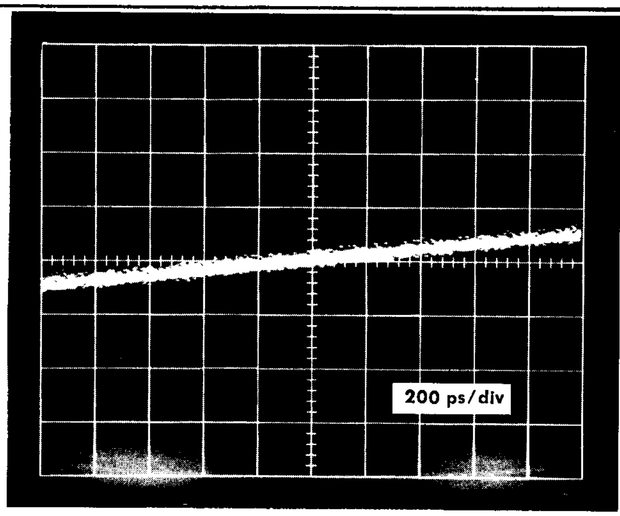
b-1. Set the Vertical mV/div switch to 100 and the Type 3T2 SOURCE switch to EXT.

b-2. Connect the 1-GHz Oscillator to the variable attenuator, 5 ns cable, 2× attenuator and GR TPD connector. Connect one side of the TPD connector to the Vertical Input A connector through a 2 ns cable, and connect the other side of the TPD connector to a 5× attenuator, a 2 ns cable and a GR to BNC adapter to the 1 MΩ/UHF SYNC TRIGGER INPUT connector.

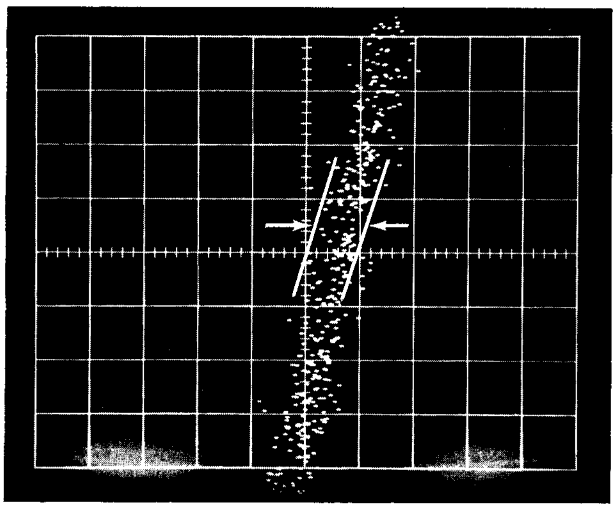
b-3. Set the variable attenuator for an amplitude of 3.5 div; see Fig. 6-3A.



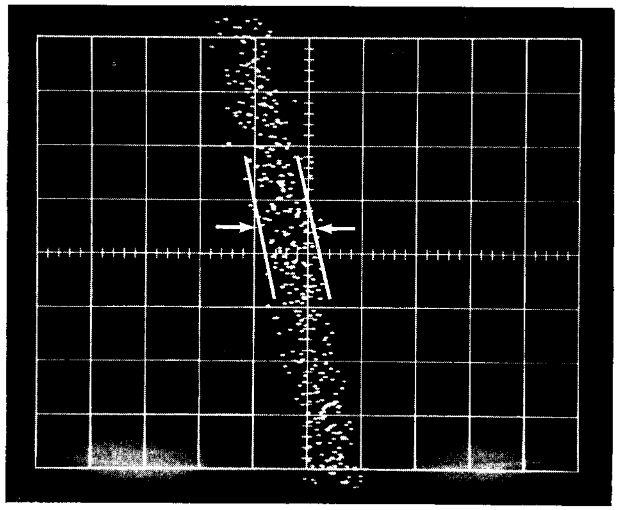
(A) Amplitude of signal adjusted for 5 div of deflection (100 mV EXT±; 500 mV INT±).



(B) Time Position rising portion of signal to center of graticule.



(C) Trigger jitter should be 1 div (200 ps) or less (INT+ or EXT+).



(D) Trigger jitter should be 1 div (200 ps) or less (INT— or EXT—).

Fig. 6-2. Typical displays for checking 30 MHz jitter.

b-4. Obtain a stable display with the TRIG SENSITIVITY control in free-run operation, nearly at full clockwise setting.

b-5. Set the Type 3T2 DISPLAY MAG switch to ×10 and the TIME MAGNIFIER switch to ×50. Use the TIME POSITION control to center the rising portion of the sine wave.

b-6. Set the Vertical mV/div switch to 10 and use the DC Offest control to center the rising portion of the signal.

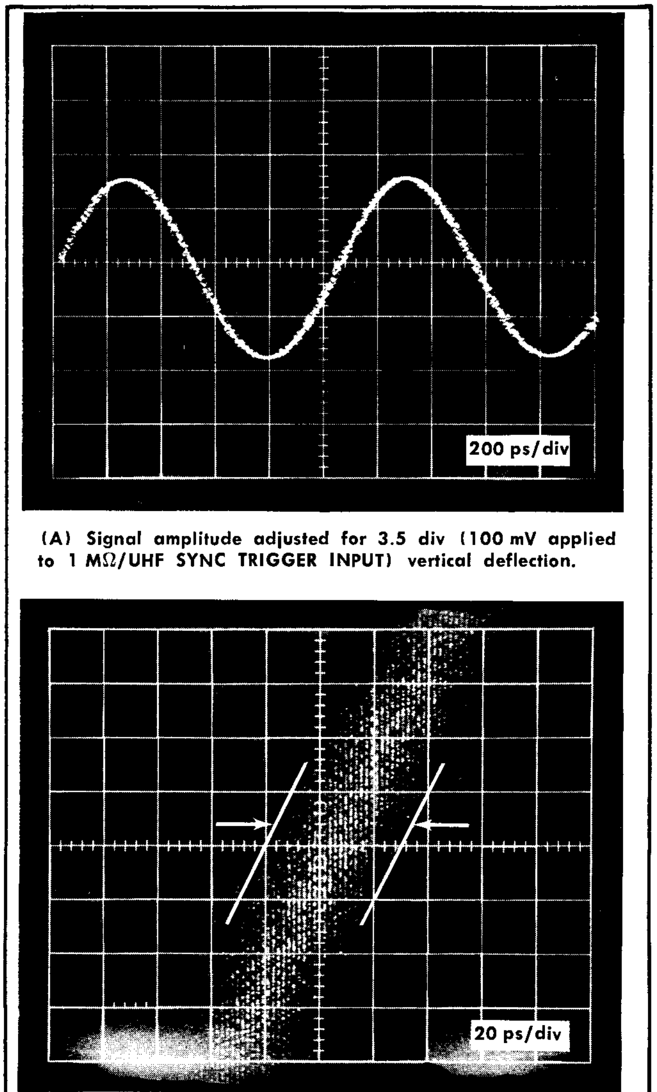
b-7. Check that the trigger jitter is not more than 50 ps; see Fig. 6-3B. (Set the POLARITY switch to —, and check for best synchronizing.)

b-7. Disconnect the oscillator.

2 ns ± Pulse

c-1. Set the Type 3T2 controls as follows:

START POINT	WITH TRIGGER
TIME POSITION	Fully clockwise
DISPLAY MAG	×1
TIME MAGNIFIER	×10
SOURCE	INT
POLARITY	+



(A) Signal amplitude adjusted for 3.5 div (100 mV applied to 1 MΩ/UHF SYNC TRIGGER INPUT) vertical deflection.

(B) Trigger jitter should be 2.5 div (50 ps) or less (EXT±).

Fig. 6-3. Typical displays of 1 GHz trigger jitter. (B) is a 2 s exposure.

c-2. Connect the Pulse Generator, set for 100 kHz and + Output, through a 10× attenuator, variable attenuator, 5 ns cable and GR Tee connector. Connect one side of the Tee connector to the Vertical Input A through a 2 ns cable. Connect the other side of the Tee connector to a 5× attenuator, a 2 ns cable and a GR to BNC adapter to the 50 Ω TRIGGER INPUT connector.

c-3. Center the 2 ns pulse with the TIME POSITION control, set the TRIG SENSITIVITY control for a stable display and set the variable attenuator for a display amplitude of 5 div (with Type 3S76), see Fig. 6-4A, or for a display amplitude of 8 div (with Type 3S1).

c-4. Set the DISPLAY MAG switch to ×10 and the TIME MAGNIFIER switch to ×50. Use the TIME POSITION control to set the rising portion of the pulse at the center of the graticule.

c-5. Set the Vertical mV/div switch to 10 and use the DC Offset control to center the rising portion of the pulse on the graticule.

c-6. Check for 30 ps or less of time jitter; see Fig. 6-4B. Change the signal amplitude so the trigger circuit receives a 150 mV peak pulse and check for 20 ps or less time jitter.

c-7. Check the 2 ns pulse trigger jitter as listed in Table 6-1. In all cases the trigger jitter should not exceed 20 ps for 150 mV pulses or 30 ps for 50 mV pulses with the START POINT switch at WITH TRIGGER, and 50 ps with the START POINT at BEFORE TRIGGER.

TABLE 6-1

START POINT	SOURCE	POLARITY	2 ns Pulse Output
WITH TRIGGER Fig. 6-4B	INT	+ —	+ —
	EXT	— +	— +
BEFORE TRIGGER Fig. 6-4C	EXT	+ —	+ —
	INT	— +	— +

NOTE

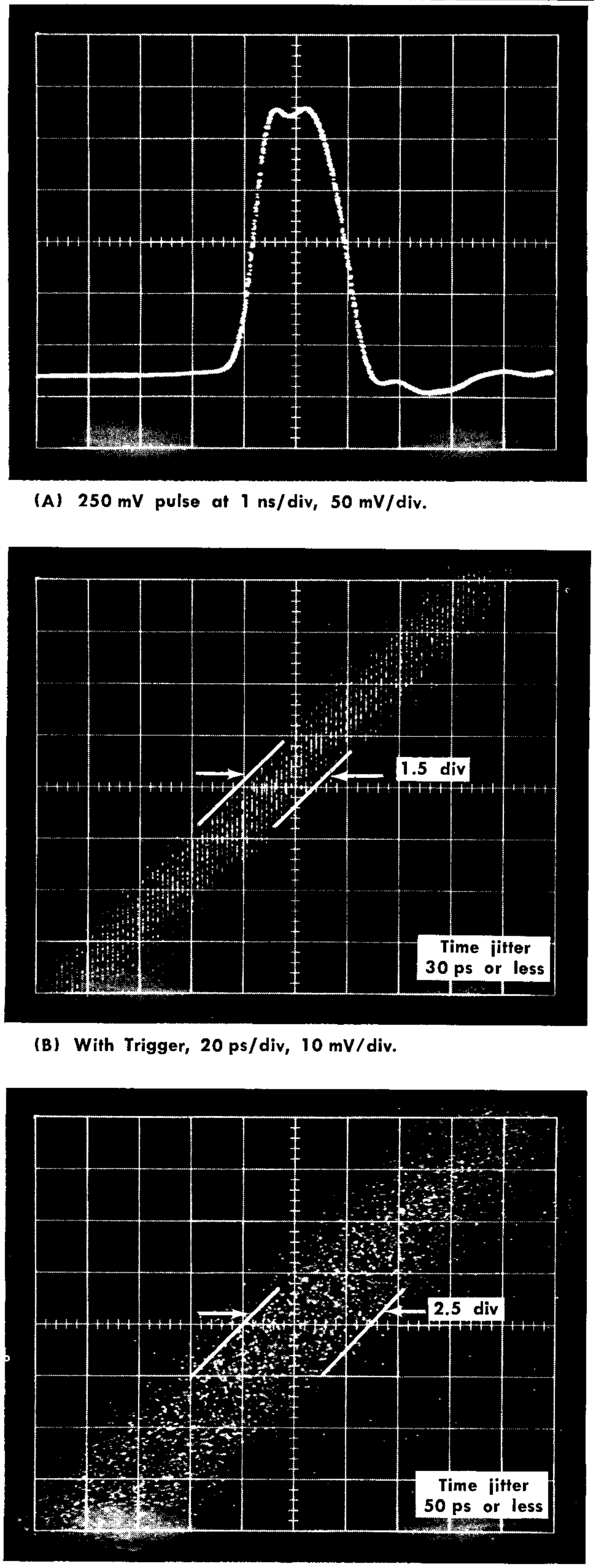
A Type 3S76 may not permit a jitter free display with greater than 5 division display amplitude.

The Type 3S1 may require adjustment of the DTR control for low jitter.

3. Check Triggering Frequency Range

Requirement—Correct triggering on 10 kHz and 100 kHz sine wave. The 1 GHz triggering capability has previously been checked in the Trigger Jitter check.

a. Connect the low Frequency Oscillator through a clip-lead adapter, a 50 Ω coaxial cable, a BNC to GR adapter and GR Tee connector. Connect one side of the Tee connector



(A) 250 mV pulse at 1 ns/div, 50 mV/div.

(B) With Trigger, 20 ps/div, 10 mV/div.

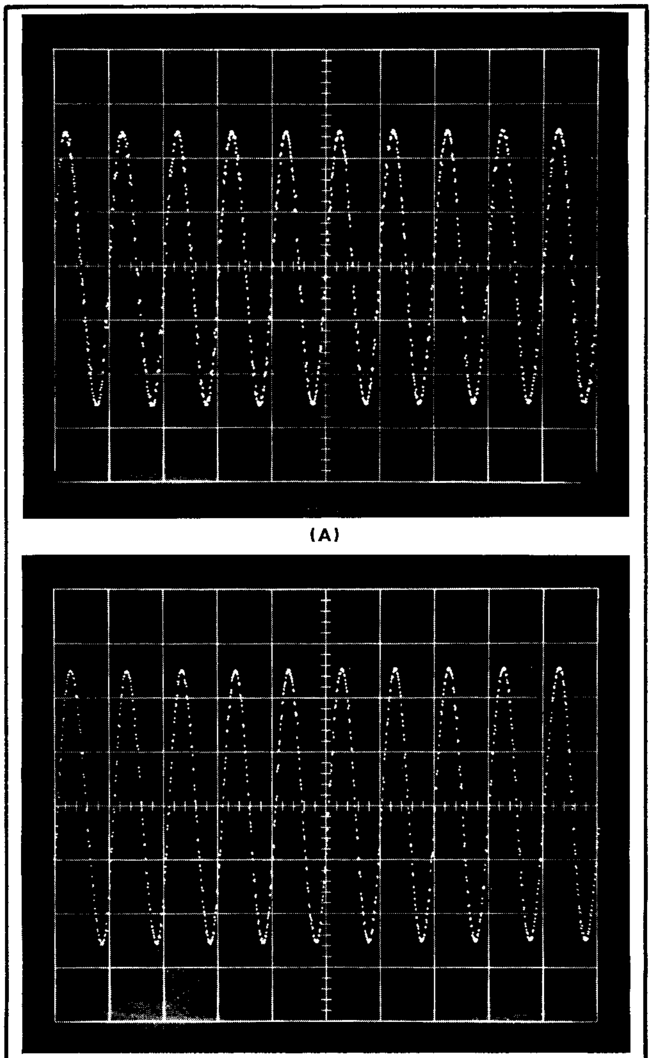
(C) Before Trigger, 20 ps/div, 10 mV/div.

Fig. 6-4. Typical displays of 2 ns pulse trigger jitter. (B) and (C) are 2 s exposures.

through a 2 ns cable to the Vertical Input A, and the other side through a 5X attenuator, 2 ns cable and GR to BNC adapter to the 1 MΩ/UHF SYNC TRIGGER INPUT connector.

b. Set the Vertical mV/div switch to 100 and adjust the Oscillator for a display amplitude of 5 div at 10 kHz.

c. Set the SOURCE switch to EXT, POLARITY switch to +, RANGE switch to 1 ms, DISPLAY MAG switch to X1 and the TIME MAGNIFIER switch to X1.



(A)

(B)

Fig. 6-5. Typical triggered displays of (A) 10 kHz and (B) 100 kHz sine waves.

d. Check that a stable display is obtained with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls; see Fig. 6-5A. Set the POLARITY switch to — and check for a stable display with adjustment of TRIG SENSITIVITY and RECOVERY TIME controls.

e. Set the Oscillator for 100 kHz and set the RANGE switch to 100 μs.

f. Check that a stable display is obtained with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls; see

Fig. 6-5B. Then, set the POLARITY switch to + and check for a stable display with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls.

g. Change the Trigger input connection to the 50 Ω TRIGGER INPUT connector and check for stable triggering in both + and − POLARITY of the 100 kHz sine wave.

h. Disconnect the oscillator. Set the RANGE switch to 100 ns.

4. Check Trigger Sensitivity Range

Requirement—Free-run trigger circuit operation only with the TRIG SENSITIVITY control at midrange ±20%.

a. Set the TRIG SENSITIVITY control fully counterclockwise, then slowly turn it clockwise.

b. Check that the trace appears within 20° right or left of the midrange position.

5. Check Trigger Kickout

Requirement—Trigger kickout not greater than ±20 mV into 50 Ω.

a. Connect a 2 ns cable and a GR to BNC adapter from the Vertical Sampling Unit Input A to the Type 3T2 50 Ω TRIGGER INPUT connector.

b. Set the POLARITY switch to +, the SOURCE switch to EXT and turn the TIME POSITION controls fully clockwise.

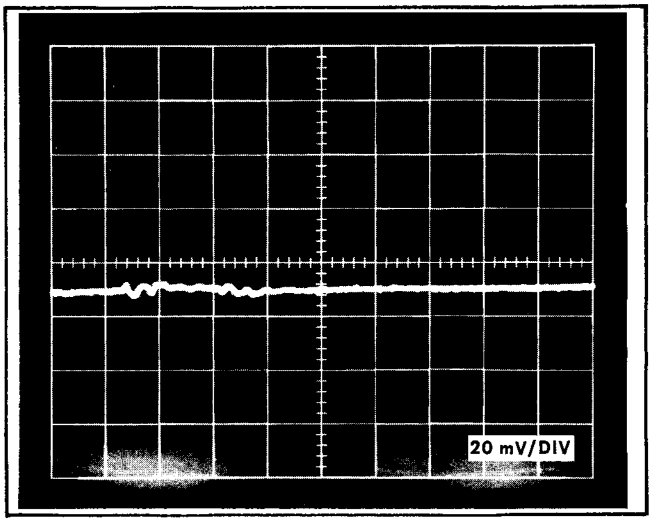


Fig. 6-6. Typical display of Trigger Kickout.

c. Set the TRIG SENSITIVITY control for a free-running trace and measure the amplitude of the pulse on the Indicator Oscilloscope, Fig. 6-6.

d. Check that the Trigger Kickout Pulse is ±20 mV or less.

e. Disconnect the 2 ns cable and set the mV/div switch to 100.

6. Check Pulse Out Amplitude

Requirement—Amplitude at least 150 mV into 50 Ω.

a. Connect the PULSE OUT connector to the Test Oscilloscope Vertical Input A through a 50 Ω coaxial cable and a 50 Ω termination.

b. Set the Test Oscilloscope Millivolts/cm switch to 5, Input Atten switch to 10 and the Time/cm switch to 50 μs. Measure the amplitude.

c. Check that the pulse amplitude is at least 150 mV; see Fig. 6-7.

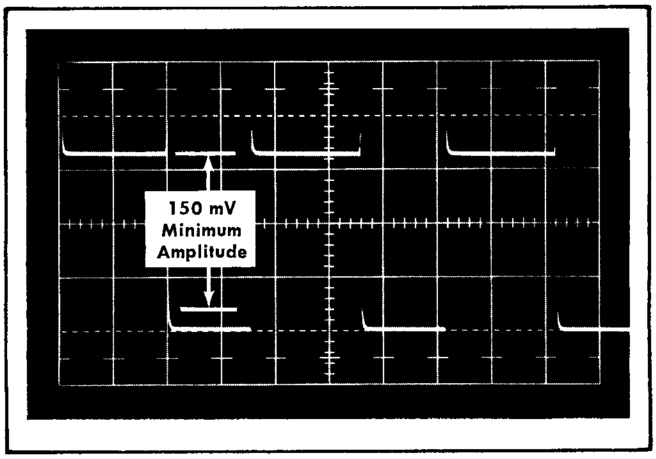


Fig. 6-7. Typical display showing the Pulse Out.

d. Set the Test Oscilloscope Time/cm switch to 10 μs.

7. Check Minimum Trigger Holdoff

Requirement—Correct trigger holdoff times on all sweep rates as listed in Table 6-1; variable by approximately 25% with the RECOVERY TIME control.

a. Set the TRIG SENSITIVITY and RECOVERY TIME controls fully clockwise.

b. Check the trigger holdoff times as given in Table 6-2. Reset the Test Oscilloscope sweep rate as required for the checks. Holdoff is the time between the falling portions of adjacent trigger pulses (see Fig. 6-8A).

TABLE 6-2

Trigger Holdoff Time

Type 3T2 RANGE	Minimum Trigger Holdoff	Test Oscilloscope Time/cm
100 ns and 1 μs	20 μs	10 μs
10 μs	40 μs	20 μs
100 μs	400 μs	.2 ms
1 ms	4 ms	2 ms

c. Set the Type 3T2 RANGE switch to 1 μs and the Test Oscilloscope sweep rate to 5 μs/cm. Use the Test Oscillo-

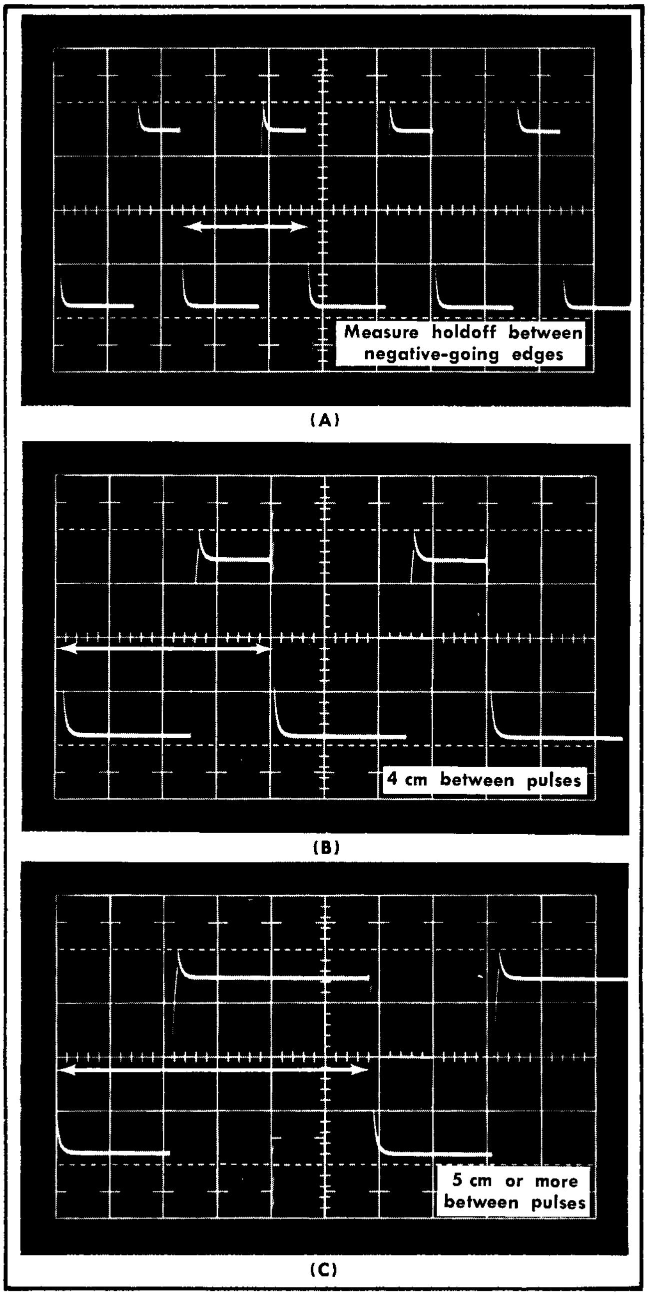


Fig. 6-8. Test Oscilloscope display of (A) Measurement of holdoff, (B) Recovery Time control fully clockwise and (C) Recovery Time control fully counterclockwise.

scope Variable Time/cm control to obtain a display of exactly 1 pulse/4 cm (see Fig. 6-8B) between the leading negative-going edges of the trigger pulses.

d. Turn the RECOVERY TIME control fully counterclockwise.

e. Check that the Test Oscilloscope display is 5 cm or more between the leading negative-going edges of the pulse (see Fig. 6-8C).

f. Disconnect the coaxial cable.

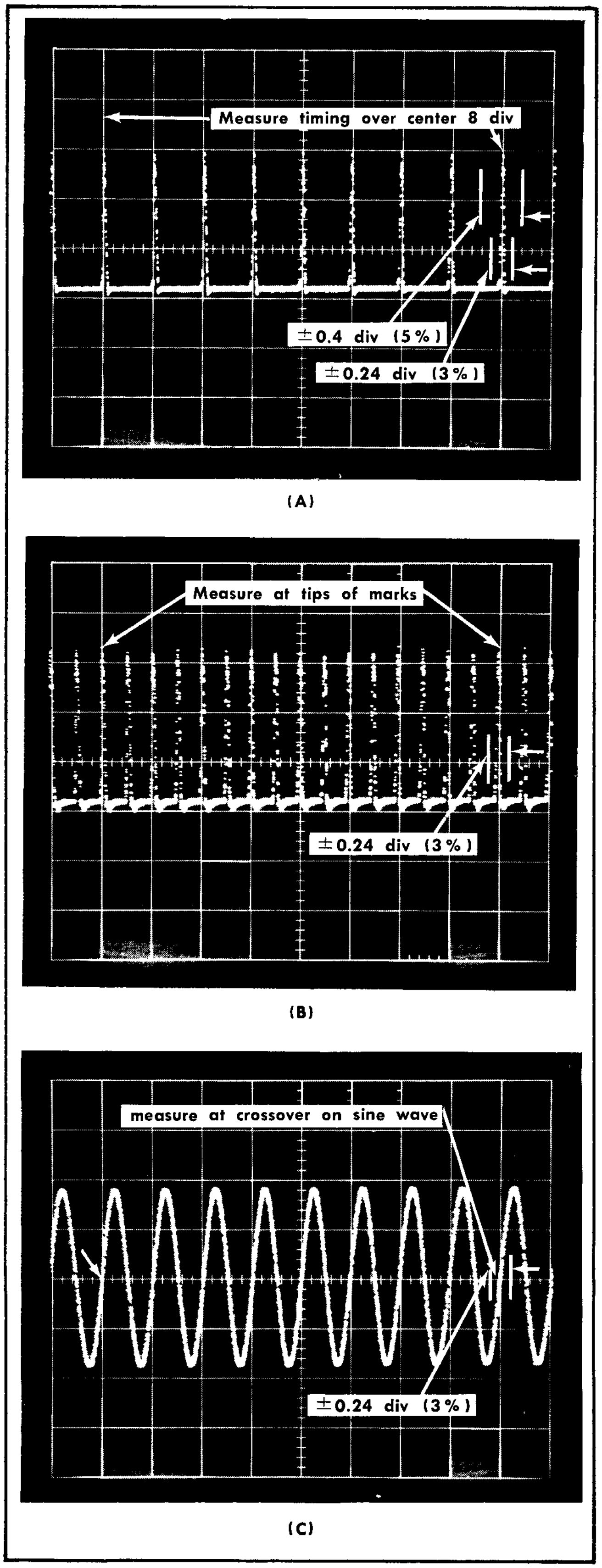


Fig. 6-9. Typical Indicator Displays for checking the timing accuracy.

TABLE 6-3

Timing Checks

Switch	Setting	Input Signal	Display	Noted Tolerance	Exclude from the start of sweep with TIME POSITION control.
DISPLAY MAG	×10 Reset to ×1	10 μs	1 marker/div		150 ns
TIME MAGNIFIER	×2 ×5 ×10 ×20 ×50 Reset to ×1	.5 μs .1 μs .1 μs 50 ns 20 ns	1 marker/div 2 markers/div 1 marker/div 1 cycle/div 1 cycle/div		
RANGE[1]	1 ms 100 μs 10 μs 1 μs 100 ns	100 μs 10 μs 1 μs .1 μs 10 ns	1 marker/div 1 marker/div 1 marker/div 1 marker/div 1 cycle/div		15 μs 1.5 μs 150 ns 15 ns 10 ns

[1]**Check with START POINT switch at WITH TRIGGER and BEFORE TRIGGER settings. 1 ms position, BEFORE TRIGGER, requires use of storage oscilloscope.**

8. Check Timing Accuracy

Requirement—Correct timing on all positions of the RANGE switch within ±3%. DISPLAY MAG switch at ×1, and ±5% DISPLAY MAG switch at ×10; linear over range of TIME POSITION control.

a. Connect the Time Mark Generator to the Vertical Sampling Unit Input A connector through a 50 Ω coaxial cable, BNC to GR adapter and a 5× attenuator.

b. Type 3T2 initial settings:

RANGE	10 μs
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1

c. Set the Time Mark Generator for 1 μs markers and check that the display is exactly 1 marker per division; see Fig. 6-9A.

d. Check timing accuracy of the Type 3T2 according to Table 6-3. Make a note of the tolerance of the DISPLAY MAG and TIME MAGNIFIER positions and compare to the RANGE position tolerance. Check timing with the TIME POSITION control clockwise, centered and counterclockwise with the first part of the sweep excluded as listed in Table 6-3.

e. Check that the algebraic addition of the tolerances at various combinations of settings of the TIME MAGNIFIER and the RANGE switches are within ±3% (0.24 div over 8 div) with the DISPLAY MAG at ×1 and within ±5% (0.4 div over 8 div), with the DISPLAY MAG at ×10.

9. Check Time Position Ranges

Requirement—Correct TIME POSITION control range within ±5% on all RANGE settings.

Referring to Table 6-4, check the positioning range of the TIME POSITION control on each RANGE switch setting as follows:

a. Set the RANGE switch and the Time-Mark Generator as given in the table.

b. Set the TIME POSITION and FINE controls fully clockwise and observe the location of the marker near the left edge of the CRT screen (see Fig. 6-10A). This will be the reference marker position.

c. Turn the TIME POSITION control slowly counterclockwise and count the number of markers that pass through the reference-marker position (see Fig. 6-10C).

TABLE 6-4

TIME POSITION Range Check

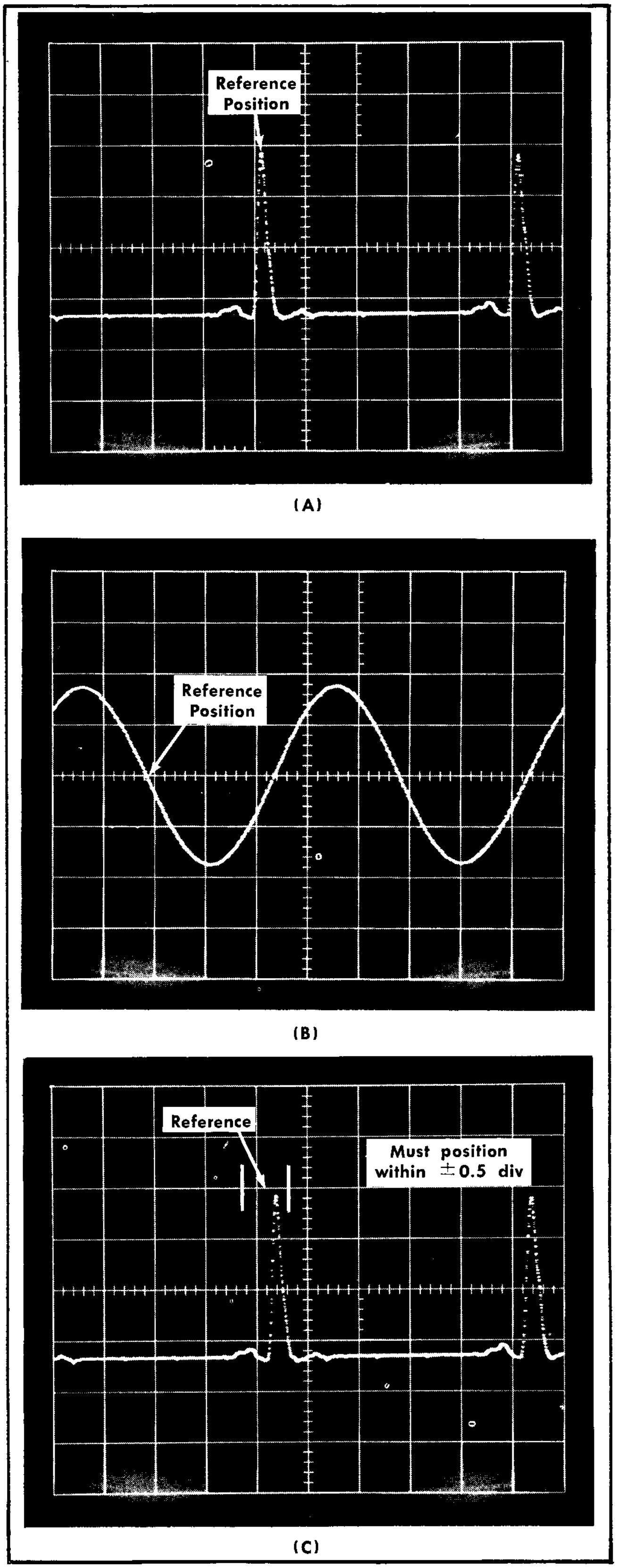
RANGE	Input Signal	Number of Markers to move through reference position
100 ns	50 ns	2 cycles
1 μs	.5 μs	2 markers
10 μs	5 μs	2 markers
100 μs	50 μs	2 markers
1 ms	.5 ms	2 markers

d. Check on the Indicator oscilloscope display that the number of markers passing the reference-marker position equals the number listed in the last column of the table within 0.5 div.

10. Check Time Magnifier Variable Range

Requirement—VARIABLE control expands timing (uncalibrated) by a factor of 2.5 or more.

a. Set the RANGE switch to 1 μs and the TIME MAGNIFIER switch to ×2.



(A)

(B)

(C)

Fig. 6-10. Typical Indicator Oscilloscope displays for checking the Time Position control ranges. (A) and (B) shows reference position and (C) Display after Time Position control is turned fully counterclockwise.

b. Apply .1 μs markers from the Time-Mark Generator and observe 1 marker per two divisions on the CRT, see Fig. 6-11A.

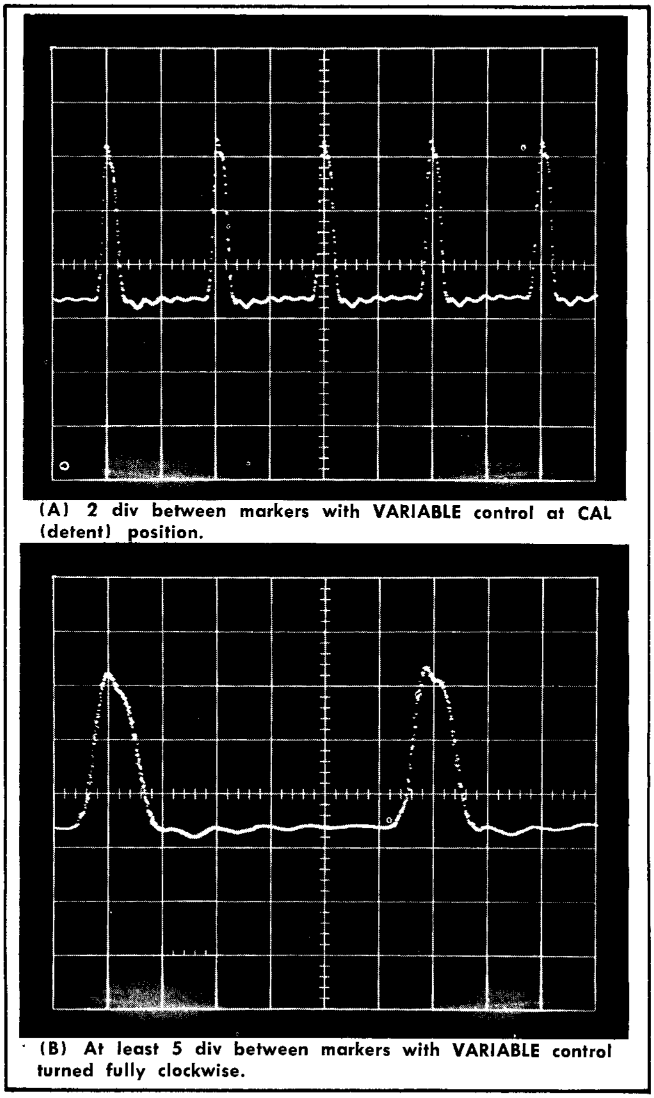
c. Turn the Time Magnifier VARIABLE control fully clockwise and observe the marker display.

d. Check that the markers are at least 5 divisions apart; see Fig. 6-11B.

e. Return the Time Magnifier VARIABLE control to CAL position and set the TIME MAGNIFIER switch to ×1.

11. Check Random Mode Minimum Triggering Rates

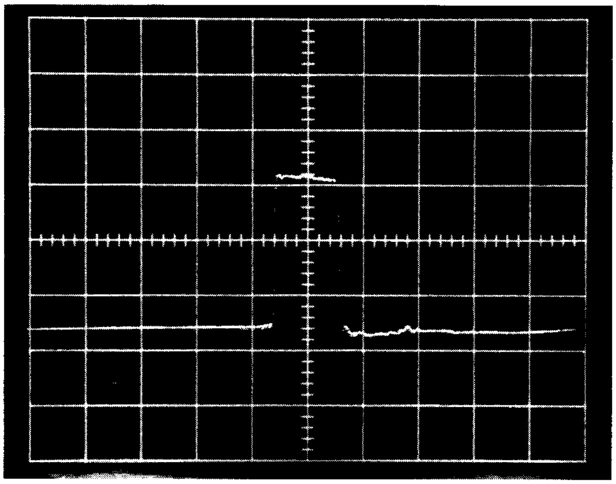
Requirement—Sweep will remain in operation for triggering frequencies at and above the minimums given in Table 6-5.



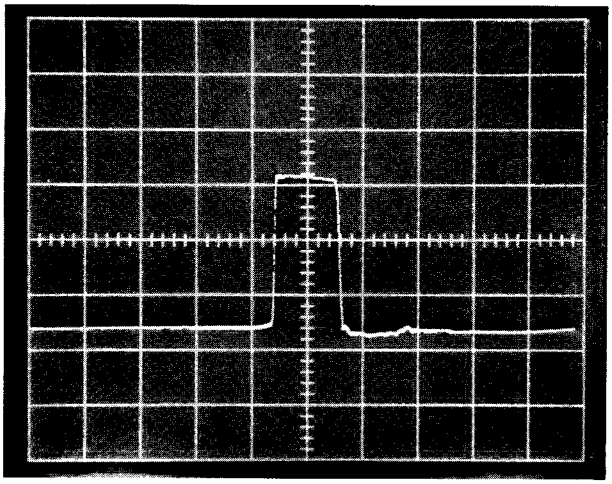
(A) 2 div between markers with VARIABLE control at CAL (detent) position.

(B) At least 5 div between markers with VARIABLE control turned fully clockwise.

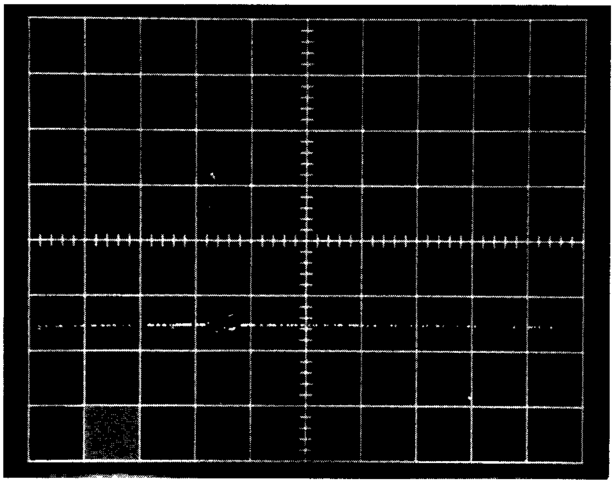
Fig. 6-11. Indicator Oscilloscope displays for checking the Time Magnifier VARIABLE control range.



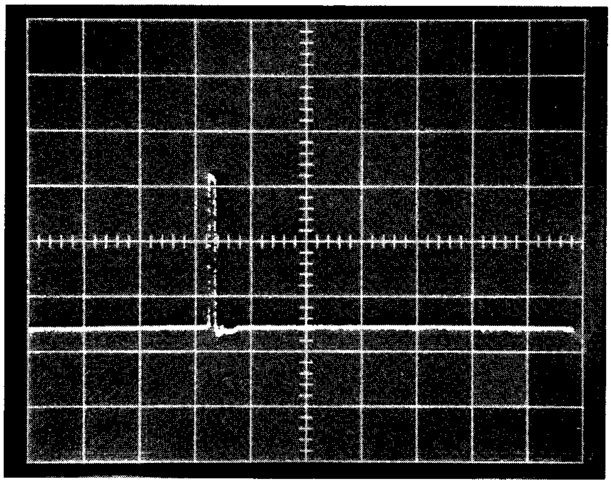
A. Non stored. 10 kHz, 10 ns/div.



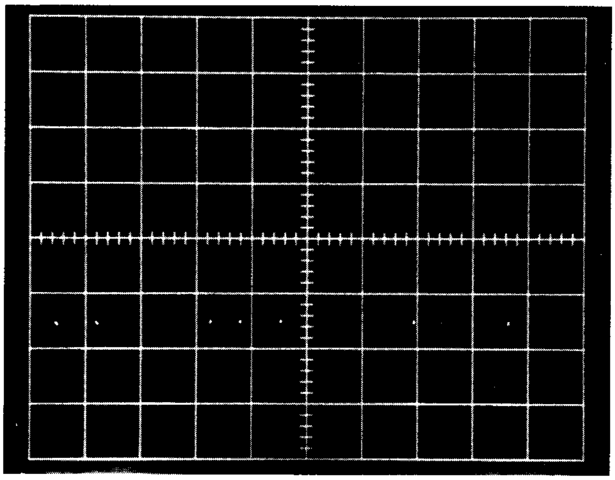
Stored for 1 minute.



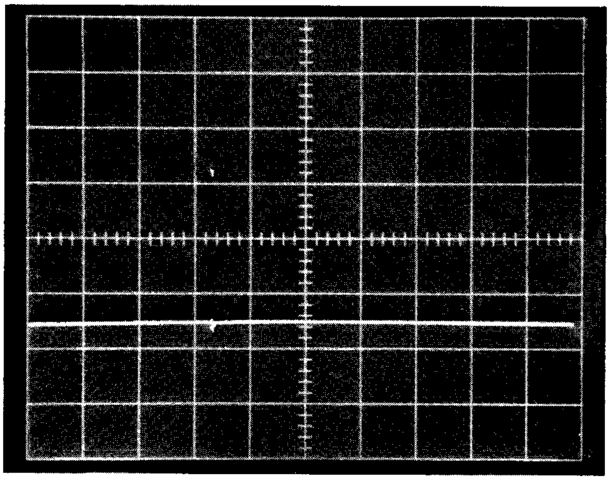
B. Non stored. 1 kHz, 100 ns/div.



Stored for 5 minutes.



C. Non stored. 100 Hz, 1 μs/div.



Stored for 5 minutes.

Fig. 6-12. Indicator Oscilloscope displays for step 11.

TABLE 6-5

Minimum Trigger Signal Rep-Rate for BEFORE Trigger Process Sampling

Range	Minimum
100 ns	10 kHz
1 μs	1kHz
10 μs	100 Hz
100 μs	10 Hz
1 ms	10 Hz

a. Connect the RG213/U 5 ns coaxial cable to the Type 111 Charge Line connector and the RG58C/U 5 ns coaxial cable to the Pulse Output connector. Connect the other end of the RG58C/U cable to the 10X and 2 X 50 Ω attenuators in series. Connect the output attenuator to the sampling unit Input A connector. Set the Type 111 Pulse Generator controls: Repetition rate about 10 o'clock, Range 10 KC and Output Polarity to +.

b. Set the sampling unit for 200 mV/Div deflection factor and for internal triggering from channel A.

c. Type 3T2 control settings:

RANGE	100 ns
START POINT	BEFORE TRIGGER
DISPLAY MAG	X1
TIME MAGNIFIER	X1
Triggering	Internal +

d. Connect the Type 3T2 PULSE OUT connector to the test oscilloscope input through a 42 inch coaxial cable with BNC connector. Set the test oscilloscope for 0.5 V/div vertical deflection factor (Type W Input Atten at 10 and Millivolts/Cm at 50), and a 20 μs/div sweep rate triggered on the negative slope.

e. Adjust the Type 3T2 TRIG SENSITIVITY control for a stable display like Fig. 6-12A and the test oscilloscope triggering controls for a display similar to Fig. 6-13A. Now adjust the Type 111 Repetition Rate control until the pulse period shown by the test osccilloscope is exactly 100 μs. This gives a triggering rate of 10 kHz.

Check that the indicator oscilloscope display is proper and that the LOW REP RATE lamp does not glow, even dimly.

f. Disconnect the signal input to the sampling unit and note that the CRT display stops and that the LOW REP RATE lamp glows. To determine the true useable low frequency trigger rate for the instrument being checked, reconnect the signal cable and turn the Type 111 Repetition Rate control farther counterclockwise until the LOW REP RATE lamp begins to flicker dimly (the CRT display will appear normal). Check the PULSE OUT period on the test oscilloscope; the reciprocal of the pulse period time is the minimum trigger repetition rate.

g. Repeat the above procedure with the test oscilloscope sweep rate at 0.2 ms/div, the Type 3T2 RANGE switch at 1 μs and the Type 111 Range switch at 1 KC.

The indicator oscilloscope display will be similar to Fig. 6-12B and the test oscilloscope display will be similar to Fig. 6-13B.

Check that the indicator oscilloscope display is stable and that the Type 3T2 LOW REP RATE lamp does not glow, even dimly.

h. With the Type 3T2 RANGE switch at 10 μs and the Type 111 Range switch at 100 CPS, the indicator oscilloscope display will be similar to Fig. 6-12C. Here, a storage oscilloscope was used to show that the pulse is still displayed. For this RANGE, and the other longer ranges, do not adjust the Type 3T2 TRIG SENSITIVITY control. The Type 111 pulse was chosen for this check because the triggering circuits respond well to such a pulse regardless of the repetition rate. In addition, the indicator oscilloscope display will appear as just an occasional dot even when the system is performing correctly at the lowest trigger repetition rate of 10 Hz.

i. Check the remaining Type 3T2 RANGE switch positions, using the test oscilloscope display to determine the triggering rate. In each case, adjust the Type 111 Repetition Rate control for the proper triggering rate. Set the test oscilloscope sweep rate at 2 ms/div for a triggering rate of 100 Hz and at 20 ms/div for a triggering rate of 10 Hz. In each case, the test oscilloscope display will be two negative pulses in 10 divisions.

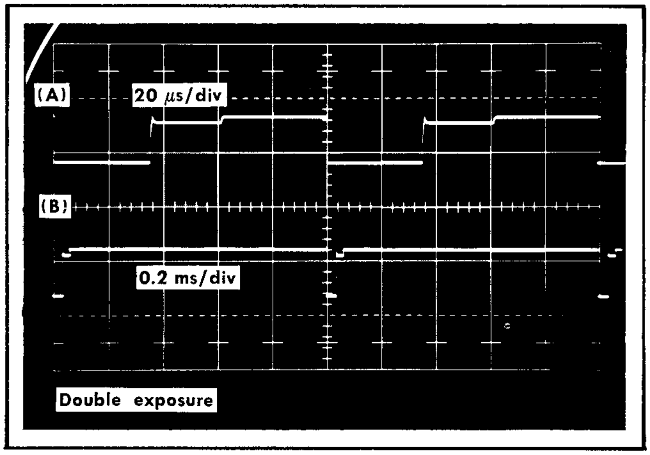


Fig. 6-13. Two cycles of PULSE OUT signal showing trigger signal rate; step 11.

12. Check Dot Density

Requirement—Samples/Div switch at 100 should be within ±0.5% of 100 dots/div; Samples switch at Variable should be variable from 12 dots/div or less to a point where the dot traverses the screen at a rate slower than 10 s/div.

NOTE

The Check of the 100 dots/div switch position need not be performed if the Type 3T2 is not used with a Digital Readout System (567/568 and 6R1A/230).

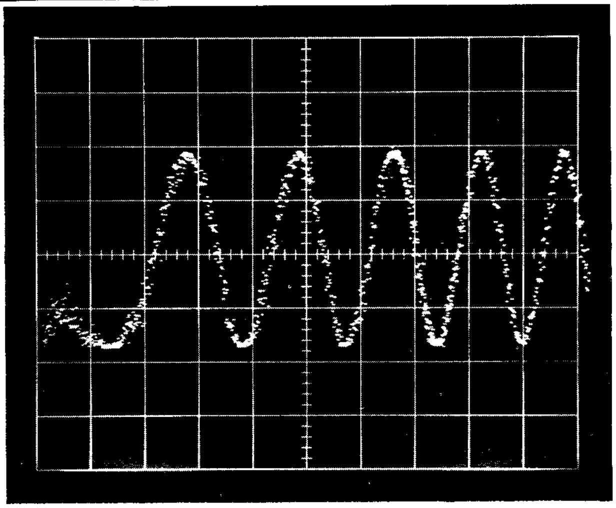
a. Set the RANGE switch to 10 μs and set the Time-Mark Generator for 10 ns sine wave output.

b. Check that the Indicator Oscilloscope display is a single line of dots with no more than 5 cycles over the 10 divisions of the graticule (see Fig. 6-14A). This indicates a dot density accuracy within 0.5% of 100 dots/div.

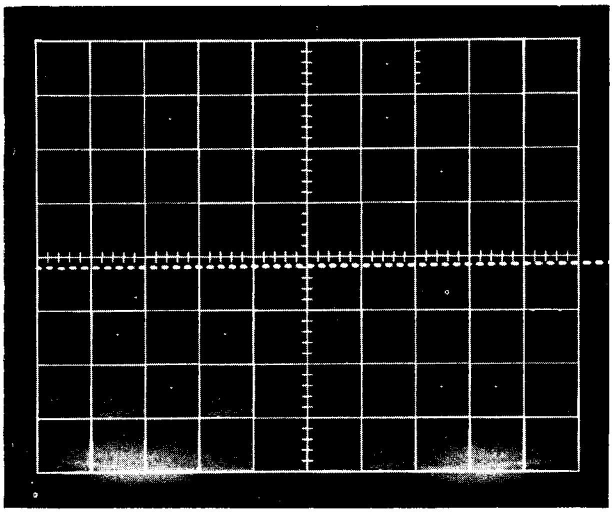
c. Turn off the Indicator Oscilloscope, pull out the Type 3T2 and change the internal SAMPLES/DIV switch to VARIABLE.

d. Re-install the Type 3T2 and turn the Indicator Oscilloscope power on. Allow a few minutes before continuing. Disconnect the Time-Mark Generator.

e. Set the SAMPLES/DIV control fully clockwise and check that a free-running trace consists of 12 dots/div or less; see Fig. 6-14B.



(A) Check for 5 cycles or less over 10 div (100 dot/div).



(B) Observe 12 dots/div or less SAMPLES/DIV fully clockwise.

Fig. 6-14. Indicator Oscilloscope displays for checking dot density.

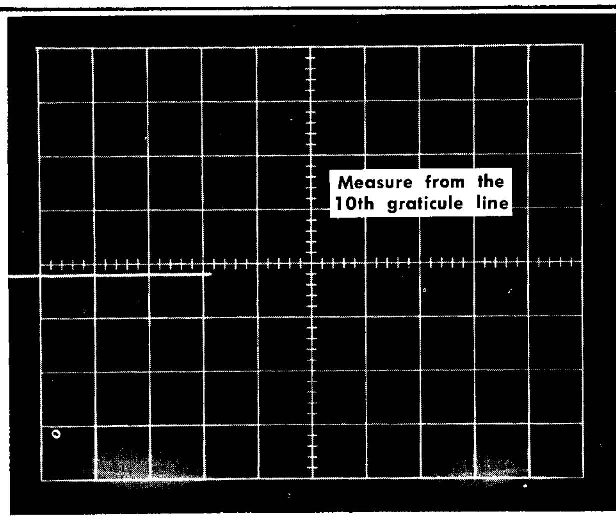
f. Set the SAMPLES/DIV control fully counterclockwise, the RANGE switch to 1 ms and check that the dot traverses the CRT at a rate of 10 s/div or slower.

g. Turn off the Indicator Oscilloscope, pull out the Type 3T2 and set the Samples/Div switch to 100 and the RANGE switch to 1 μs.

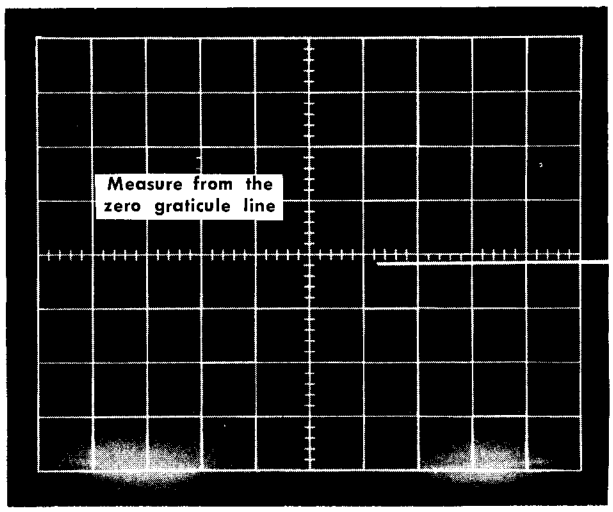
13. Check Sweep Centering

Requirement—HORIZ POSITION control capability of 10 divisions or more, approximately centered about the center vertical line of the graticule.

a. Free run the sweep and turn the HORIZ POSITION control fully counterclockwise. Note the displacement from the tenth graticule line, then turn the HORIZ POSITION control fully clockwise. Note the displacement from the zero graticule line and add the two displacements together; see Fig. 6-15.



(A)



(B)

Fig. 6-15. Indicator Oscilloscope displays of (A) Fully counterclockwise setting of HORIZ POSITION control and (B) Fully clockwise setting of HORIZ POSITION control.

b. Check that the total displacement is 10 divisions or more.

c. Reset the HORIZ POSITION control to center the trace.

14. Check Sweep Out

Requirement—Sweep output of 1 volt (±5%) per division of horizontal deflection on the CRT screen.

a. Connect the Test Oscilloscope 10× Probe to the SWP OUT jack.

b. Set the Test Oscilloscope and Type W Comparator Unit as follows:

Time/Cm	5 mSEC
Triggering	AC and Int, Free run
Millivolts/cm	20
Input Atten	10
Display	A-Vc
Vc Range	0
A Input	DC
Comparison Voltage	0.000

c. Set the DISPLAY MODE to MANUAL and the MANUAL SCAN control fully counterclockwise.

d. Position the Test Oscilloscope trace at the center graticule line with the Position control.

e. Set the Type W Vc Range switch to +1.1 and set the Comparison Voltage dial to position the trace at the center graticule line as the MANUAL SCAN control is turned fully clockwise.

f. Check that the Comparison Voltage dial is between .950 and 1.05, which is 1 volt per division ±5%.

g. Set the DISPLAY MODE switch to NORMAL.

15. Operational Check with Digital Readout System

The following Table and comments apply to the Digital Readout Unit, Type 6R1A or Type 230.

TABLE 6-6

RANGE	TIME MAGNIFIER	Decimal	Units
1 ms	×1 ×2 ×5	0 X[2] 0 0 0	ms
	×10 ×20 ×50	0 0 0 X 0	μs
100 μs	×1 ×2 ×5	0 0 0 X 0	μs
	×10 ×20 ×50	0 0 X 0 0	μs
10 μs	×1 ×2 ×5	0 0 X 0 0	μs
	×10 ×20 ×50	0 X 0 0 0	μs
1 μs	×1 ×2 ×5	0 X 0 0 0	μs
	×10 ×20 ×50	0 0 0 X 0	ns
100 ns	×1 ×2 ×5	0 0 0 X 0	ns
	×10 ×20 ×50	0 0 X 0 0	ns

[2]X indicates decimal neon is lighted.

The SAMPLES/DIV (Internal) switch must be at 100. The Decimal and Units lamps go out when the Time Magnifier VARIABLE is moved from the CAL position or when the DISPLAY MODE switch is at MANUAL or EXT HORIZ.

NOTES

SECTION 7
CALIBRATION

General Information

Performance and/or calibration of the Type 3T2 should be checked after each 1000 hours of operation and at least once every 6 months to assure that the instrument is operating correctly and accurately. Recalibration of the instrument may be performed periodically as part of a regular preventive maintenance schedule or may be done whenever the need is indicated by the performance check procedure. In addition, portions of the instrument will require recalibration if components have been replaced or other electrical repairs have been made in the circuitry.

The calibration procedure given in this section of the manual is a combined verification and adjustment procedure that permits the instrument to be checked to the performance requirements given in the Characteristics section, and to be adjusted for best performance. The procedure given in the Performance Check section also checks the performance and operation of the instrument, but does not provide for adjustment of internal controls.

A calibration record is included at the beginning of the calibration procedure for use as a checklist to verify correct operation of the Type 3T2 and as a calibration guide for experienced calibrators.

The step by step instructions of the procedure furnish an orderly approach to the isolation of possible malfunctions, and thus serves as an aid in troubleshooting and repairing the instrument. Any maintenance that is known to be needed should be performed before starting the calibration procedure. If any troubles become apparent during calibration, these should also be corrected before proceeding. Repair and servicing information is given in the Maintenance section of this manual.

EQUIPMENT REQUIRED

The following (or equivalent) items of equipment are required for a complete calibration of the Type 3T2. The equipment is illustrated in Figs. 7-1 and 7-2. If substitute equipment is used, it must equal or exceed the given requirements in order to calibrate the Type 3T2 to the given accuracy. If the equipment does not meet these requirements, the difference between the accuracy of the equipment used and the accuracy of the specified equipment must be added to the tolerance stated in the calibration step.

1. Calibrated indicator oscilloscope, such as the Tektronix Type 561A with Type 3S1 vertical sampling plug-in unit. Alternate requirements: Compatible with the Type 3T2; vertical deflection factors from 2 mV/div to 200 mV/div. If a sampling unit with no trigger take-off is used, provision must be made for externally triggering the Type 3T2. A Tektronix CT-3 50 Ω Signal Pickoff unit can be used to provide the external trigger signal. Use a Type 113 Delay Cable for delaying the vertical signal for those steps using WITH TRIGGER operation.

2. Calibrated test oscilloscope, such as a Tektronix Type 540-series with Type W Comparator Plug-In Unit, Type 545B and Type W Unit recommended. Alternate requirements: Deflection factor of 50 mV/cm minimum, and a voltage comparator with a voltage accuracy within 0.5% at 1 volt.

3. Time-Mark generator, Tektronix Type 184. Minimum alternate requirements: Marker or sine wave outputs of .5 ms, .1 ms, 50 μs, 10 μs, 1 μs, .5 μs, .1 μs, 50 ns, 20 ns and 10 ns with an accuracy within ±0.3%.

4. Low-frequency sine-wave generator, such as General Radio Type 1310-A. Minimum requirements: Output frequency 10 kHz and 100 kHz; output amplitude at least 2 volts into 50 ohms. An adapter will be required with this instrument to connect a coaxial cable to its output. Tektronix Part No. 013-0076-00, clip-lead adapter, may be used.

5. Mid-frequency sine-wave generator, Tektronix Type 191 Constant Amplitude Signal Generator. Minimum alternate requirements: Output frequency of 30 MHz; output amplitude variable from approximately 30 mV to approximately 2.5 volts into 50 ohms.

6. UHF Oscillator, such as General Radio Type 1361-A. Minimum alternate requirements: Output frequency of 1 GHz and output amplitude of at least 2 volts into 50 ohms.

7. Pulse generator, Tektronix Type 111 recommended. Minimum alternate requirements: Positive-going and negative-going pulse outputs; pulse risetime less than 1 ns; pulse duration 2 ns; repetition rate 100 kHz; pulse amplitude at least 2 volts into 50 ohms. The Type 111 has an output pulse amplitude of 10 to 20 volts and is the amplitude assumed in the connections used in the procedure.

8. Variable autotransformer, such as General Radio, Variac Type W10MT3W. Required only for checking power supply regulation and ripple. Minimum requirements: Output voltage variable from 105 volts to 125 volts AC RMS for 115-volt operation or 210 volts to 250 volts AC RMS for 230-volt operation; output power rating at least 0.1 kVA. If monitor voltmeter is not included, separate AC voltmeter is required with accuracy within 3% over required range.

9. Two 42-inch coaxial cables with BNC connectors Characteristic impedance approximately 50 ohms. Tektronix Part No. 012-0057-01.

10. One 5 ns coaxial cable, Type R213/U, with GR 50 ohm connectors. Tektronix Part No. 017-0502-00.

11. 5 ns coaxial cable, Type RG58C/U, with GR connectors, Tektronix Part No. 017-0512-00 (not shown).

12. Two 2 ns coaxial cables, Type RG58C/U, with GR 50 ohm connectors. Tektronix Part No. 017-0505-00.

13. 50-ohm 10× attenuator with GR connectors. Tektronix Part No. 017-0078-00.

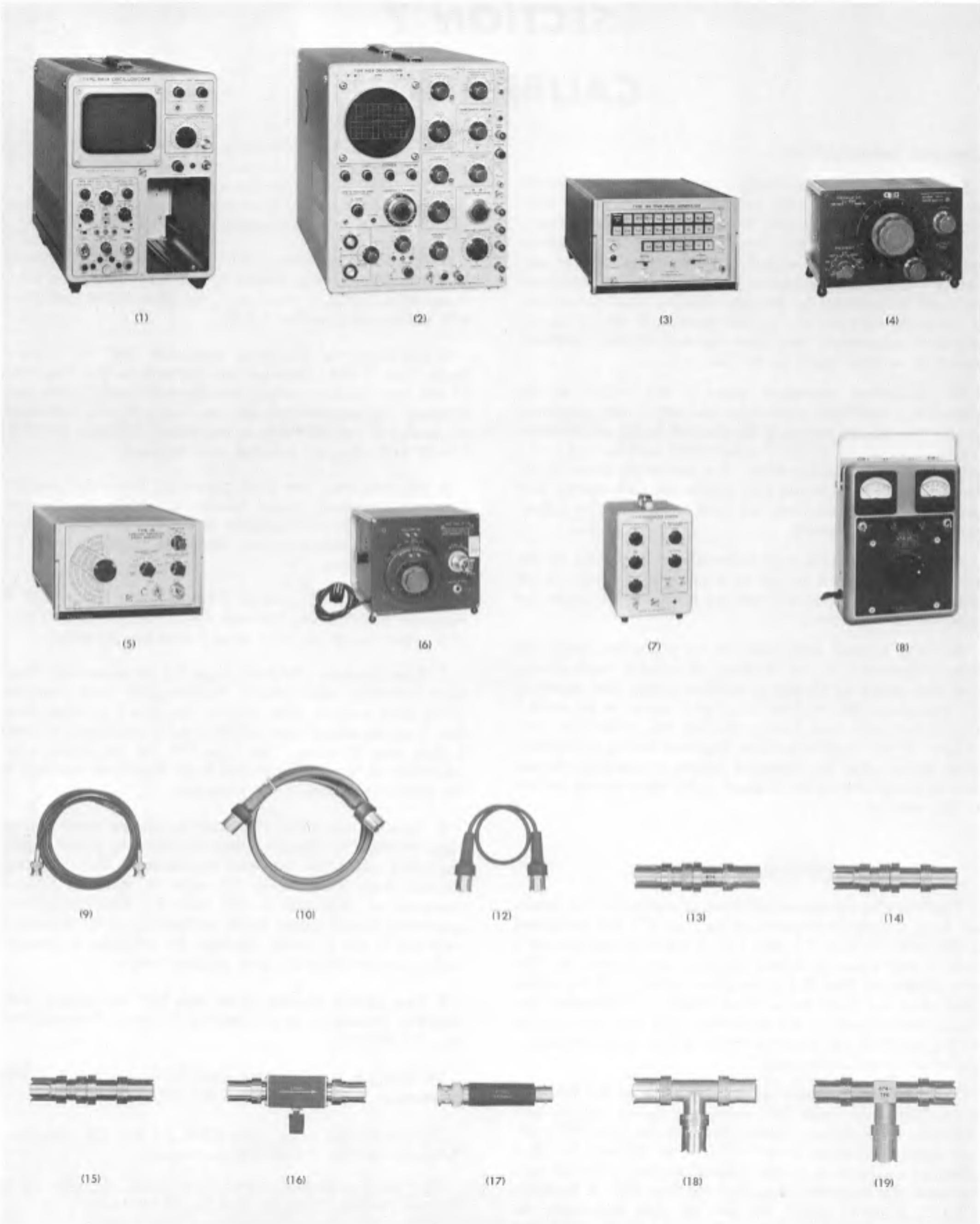


Fig. 7-1. Equipment required for calibration of the Type 3T2.

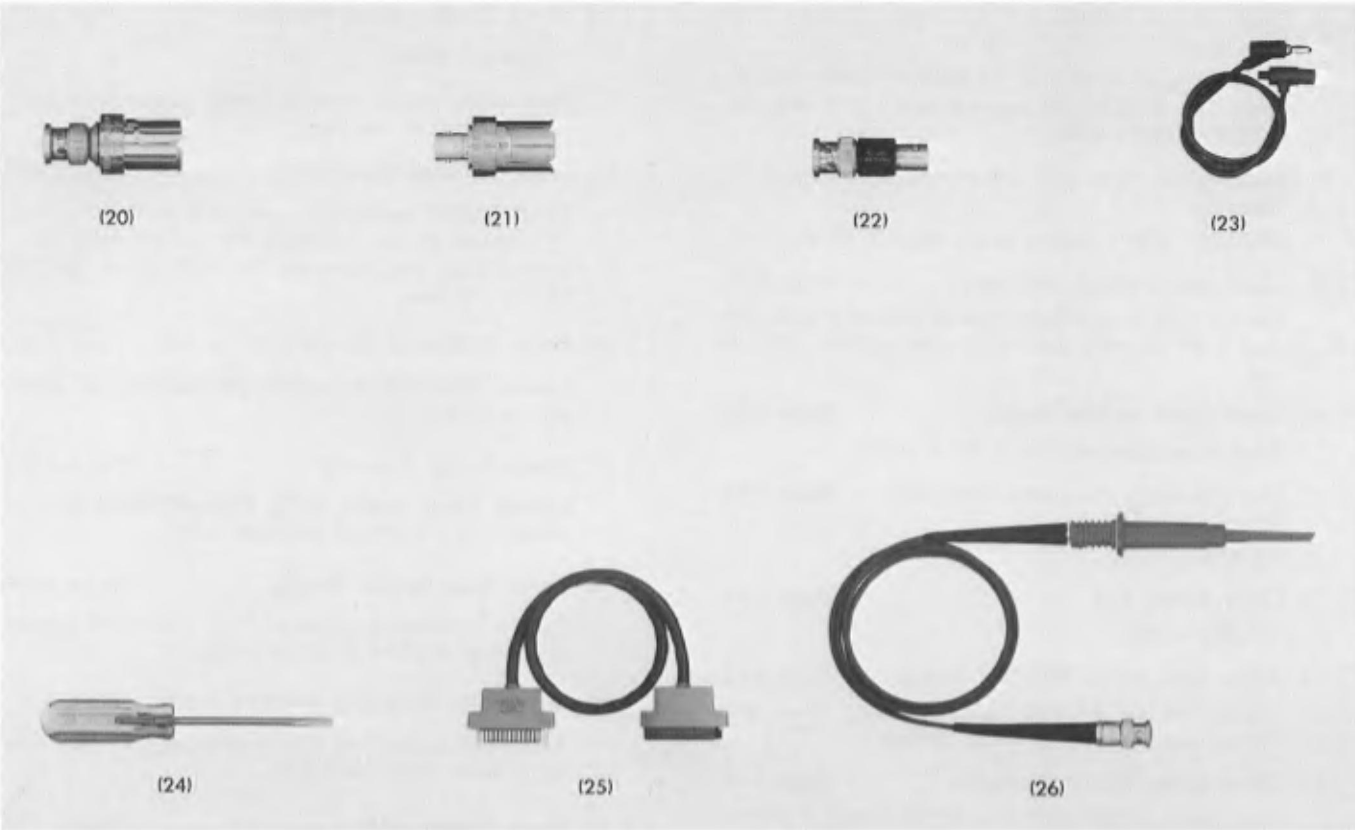


Fig. 7-2. Equipment required for calibration of the Type 3T2.

14. 50-ohm 5× attenuator with GR connectors. Tektronix Part No. 017-0079-00.

15. 50-ohm 2× attenuator with GR connectors. Tektronix Part No. 017-0080-00.

16. Variable attenuator with GR 50-ohm connectors. Tektronix Part No. 067-0511-00.

17. 50-ohm 5:1 attenuator, BNC connectors. Tektronix Part No. 011-0060-00.

18. Coaxial T connector with GR 50-ohm connectors, GR Tee. Teqtronix Part No. 017-0069-00.

19. Coaxial T connector with GR 50-ohm connectors, 50 Ω GR-TPD. Tektronix Part No. 017-0082-00.

20. BNC plug to GR connector adapter. Tektronix Part No. 017-0064-00.

21. BNC jack to GR connector adapter. Tektronix Part No. 017-0063-00.

22. 50 Ω termination, BNC connectors. Tektronix Part No. 011-0049-00.

23. One jumper cord, BNC to Banana plug, 18-inch length. Tektronix Part No. 012-0090-00.

24. Pocket type screwdriver, blade width less than ⅛-inch.

25. 30-inch flexible 560-series plug-in extension cable. Tektronix Part No. 012-0066-00.

26. 1× test probe, Tektronix P6028, with BNC connector. Tektronix Part No. 010-0074-00.

27. 10× test probe, Tektronix P6006, with BNC connector. Tektronix Part No. 010-0127-00 (not shown).

CALIBRATION RECORD AND INDEX

This outline is provided to serve as a verification and calibration record. It may be reproduced for that purpose or for use as a calibration guide for calibrators who are familiar with the procedure.

Type 3T2 Serial Number ____________

Calibration Date ____________

☐ 1. Check Indicator Oscilloscope Power Supply — Page 7-6.
Correct power supply voltages applied to the Type 3T2.

☐ 2. Check or adjust —19 Volts — Page 7-7.
—19 volts ±1%, between —18.81 and —19.19 volts.

☐ 3. Check or Adjust +19 Volts — Page 7-7.
+19 volts ±1%, between +18.81 and +19.19 volts.

☐ 4. Check —27 Volts — Page 7-7.
—27 volts ±7%, between —25.1 and —28.9 volts.

☐ 5. Check Ripple — Page 7-8.
Within 3 mV ripple on —19-volt and +19-volt supplies.

☐ 6. Adjust Trigger Recognizer — Page 7-9.
Correct operation of TRIG SENSITIVITY control.

☐ 7. Check Pulse Out Amplitude — Page 7-10.
Pulse Out amplitude at least 150 mV.

☐ 8. Check Trigger Holdoff and Recovery Time Range — Page 7-10.

Correct trigger holdoff on all RANGE switch settings, Table 7-1. Variable by approximately 25% with RECOVERY TIME control.

☐ 9. Check Manual Scan and Adjust Horiz Gain — Page 7-11.

MANUAL SCAN control range exactly 10 div.

☐ 10. Check Spot Position Indicators — Page 7-11.

Correct right or left Spot Position Indicator is lit with spot 5 div or more from the center vertical graticule line.

☐ 11. Check Horiz Position Range — Page 7-12.

Total trace displacement 10 div or more.

☐ 12. Check External Horizontal Deflection Factor — Page 7-13.

1.5 V/Div, ±3%.

☐ 13. Check Sweep Out — Page 7-14.

1 V/Div ±5%.

☐ 14. Adjust Start WITH TRIGGER Timing — Page 7-15.

Correct timing RANGE switch settings 10 μs and 100 ns; within ±3% at other settings.

☐ 15. Check Single Sweep Operation — Page 7-16.

One sweep on CRT each time START button is pressed (SINGLE SWP. mode).

☐ 16. Adjust DC Zero — Page 7-17.

Waveform at base of Q371 starts at zero.

☐ 17. Adjust Horiz Output Zero — Page 7-19.

Waveform at base of Q501 within 0.3 volt of the DC level at base of Q531.

☐ 18. Adjust Servo Loop Bal — Page 7-19.

DC level at base of Q531 same as at base of Q533.

☐ 19. Adjust Start BEFORE TRIGGER Timing — Page 7-20.

Correct timing RANGE switch setting 10 μs; within ±3% at other settings.

☐ 20. Adjust Slewing Ramps — Page 7-21.

Equal staircase amplitude at bases of Q533 and Q531.

☐ 21. Adjust Time Position Zero — Page 7-22.

Start of sweep at left edge of graticule with TIME POSITION control fully counterclockwise and fully clockwise.

☐ 22. Adjust Lead Time — Page 7-22.

Falling edge of PULSE OUT waveform is at center of graticule.

☐ 23. Adjust 1 ms Correction — Page 7-22.

No shift of spot position as RANGE switch is changed from 100 μs to 1 ms.

☐ 24. Check Random Mode Minimum Triggering Rates — Page 7-22.

Rate Meter ramp remains linear longer than minimums stated in the step.

☐ 25. Check Variable Samples/Div — Page 7-23.

SAMPLES/DIV control fully clockwise, trace consists of 12 dots/div or less; SAMPLES/DIV control fully counterclockwise, dot traverses the CRT at a rate of 10 s/div or less.

☐ 26. Adjust Calibrated Samples/Div to 100 — Page 7-24.

Internal SAMPLES/DIV switch 100 position, 100 dots/div ±0.5%.

☐ 27. Check Timing Accuracy — Page 7-25.

Correct timing within ±3% DISPLAY MAG at ×1; within ±5% DISPLAY MAG at ×10.

☐ 28. Check Time Position Ranges — Page 7-27.

Correct positioning range of TIME POSITION control according to RANGE switch setting.

☐ 29. Check Time Magnifier Variable Range — Page 7-27.

VARIABLE control fully clockwise increases sweep rate by a factor of at least 2.5:1.

☐ 30. Check Trigger Jitter — Page 7-29.

≤200 ps trigger jitter on 30 MHz sine wave, 100 mV EXT± 50 Ω Input, 500 mV (Type 3S76), 800 mV (Type 3S1) INT±;

≤50 ps trigger jitter on 1 GHz, 100 mV EXT± 1 MΩ/UHF SYNC Input;

≤20 ps trigger jitter on 2 ns puulses, WITH TRIGGER mode, 150 mV peak pulse to Ext 50 Ω input.

≤30 ps trigger jitter on 2 ns pulses, WITH TRIGGER mode, 250 mV (Type 3S76), 400 mV (Type 3S1) INT±; 50 mV EXT±; 50 Ω Input;

≤50 ps trigger jitter on 2 ns pulses, BEFORE TRIGGER mode, 250 mV (Type 3S76), 400 mV (Type 3S1) INT±; 50 mV EXT±, 50 Ω Input.

☐ 31. Check Triggering Frequency Range — Page 7-33.

Stable triggering of 10 kHz and 100 kHz sine wave, 100 mV EXT± 1 MΩ/UHF SYNC Input; 100 mV EXT± 50 Ω Input.

☐ 32. Check Trigger Kickout — Page 7-34.

Trigger Kickout Pulse not more than ±20 mV at 50 Ω Trigger Input.

☐ 33. Operational Check With Digital Readout System — Page 7-34.

Units and Decimal lamps to be lit with setting of RANGE and TIME MAGNIFIER switches; see Table 7-7.

CALIBRATION PROCEDURE

The following procedure is arranged in a sequence that allows the Type 3T2 to be calibrated with a minimum of adjustment interaction. Each step contains complete information for executing that step. The sequence includes procedures for checking performance as well as those required for adjusting the calibration controls. Nearly every adjustment step provides a check of the particular characteristic before the adjustment is made. When doing a complete recalibration of the instrument, best overall performance will be provided if each adjustment is made to the exact setting, even if the observed performance is within the allowable tolerance. When doing only a partial recalibration, however, do not readjust any controls unless the performance requirements are not met in the checks.

To make only the control adjustments without completely checking performance of the instrument, do only the Adjust steps. The symbol ◐ is provided to help locate these steps. Any equipment connections or control settings that are changed during the omitted steps must be noted and performed if necessary. If any adjustment steps are done individually or out of sequence, subsequent steps may also need to be checked, since some adjustments affect the calibration of other circuits.

To identify the two oscilloscopes used in the procedure, the one that is operated in conjunction with the Type 3T2 is called the indicator oscilloscope and the one that is used for making waveform and voltage checks is referred to as the test oscilloscope. Also in this procedure, the words division and div are used as contractions for the phase "major division of the CRT graticule."

Do not preset any calibration adjustment unless they are known to be significantly out of adjustment or unless repairs have been made in the circuit. In these cases, set the particular controls to midrange.

Use short ground leads on the test probes. Whenever a probe is connected to a test point, clip the ground lead to chassis ground. Failure to ground the probe cable may result in the appearance of ringing on the signal.

An initial test equipment setup picture is shown for each major group of adjustments and/or checks. Following each setup picture is a complete list of front-panel control settings of the Type 3T2 plus significant control settings of other instruments. Any control that has been changed from the settings at the end of the preceding step is given in boldface type.

PRELIMINARY PROCEDURE

a. Check all front-panel controls for proper indexing. check the variable controls for smooth operation and correct any defects found.

b. Remove the right side cover from the Indicator Oscilloscope except Type 567, and connect the Type 3T2 to the Indicator Oscilloscope horizontally mounted interconnecting plug by means of the flexible extension cable.

c. Connect the Indicator Oscilloscope power cord to the output of the variable autotransformer.

d. Turn on the instrument power and adjust the autotransformer for an output of 117 volts or other voltage for which the instrument is wired. Allow 15 minutes for warm up and stabilization.

e. Turn on all test equipment. Set the instrument controls as given under Fig. 7-3.

NOTES

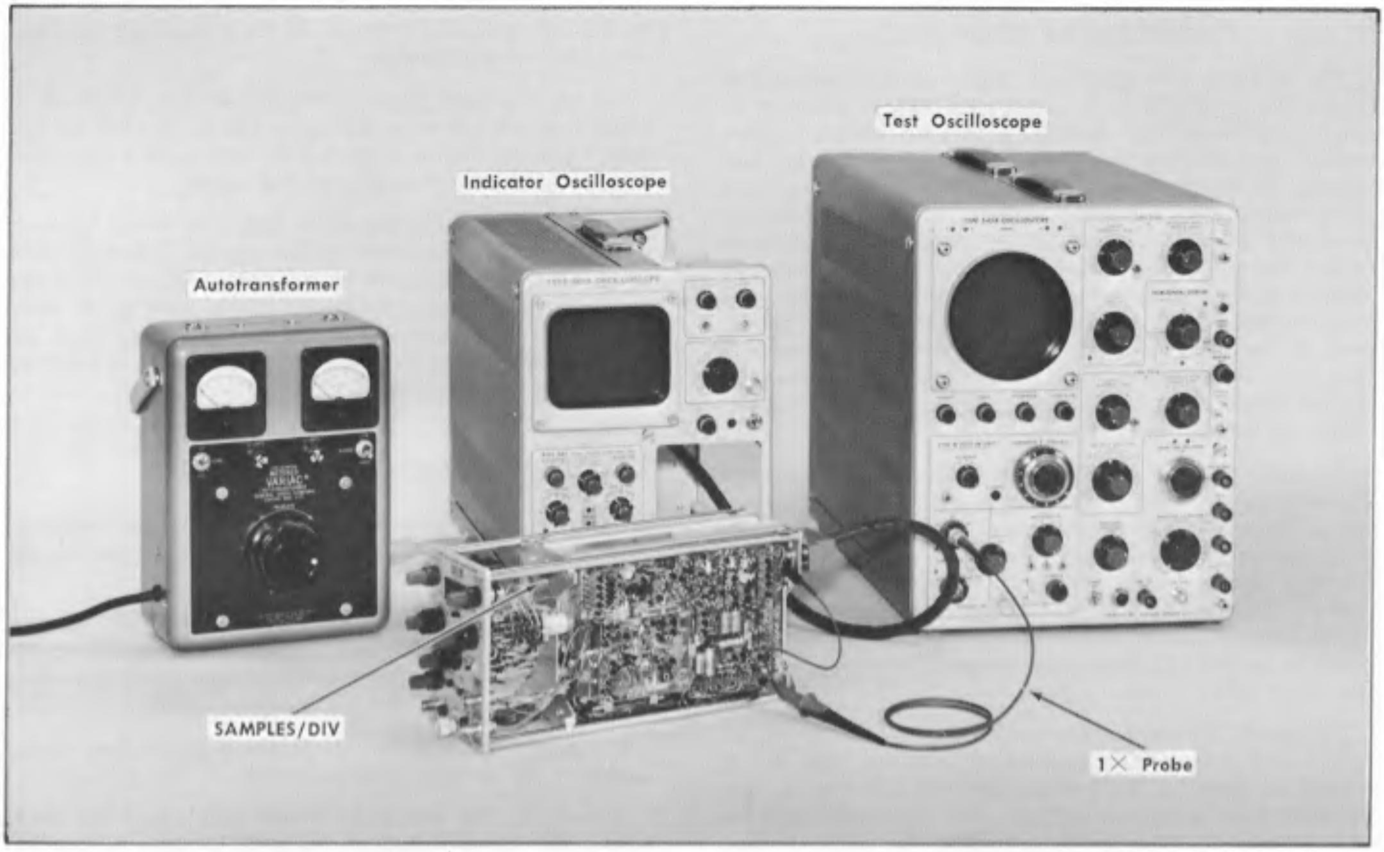


Fig. 7-3. Initial test equipment setup for steps 2 through 5.

Control Settings

Indicator Oscilloscope

Intensity	Counterclockwise
Calibrator	Off
CRT Cathode Selector	Chopped Blanking

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	10 μs
START POINT	WITH TRIGGER
DISPLAY	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
MANUAL SCAN	Midrange
TRIG SENSITIVITY	Fully clockwise
RECOVERY TIME	Midrange
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal SW 450)	100 (Up)

Vertical Sampling Unit

Vertical Mode	A Only
Smooth-Normal	Normal
Position	Centered
mV/div	100
mV/div Variable	Calib
Norm-Inv	Norm
DC Offset	Center of range
Internal Trigger	A

If a vertical unit without trigger takeoff is used, provide an external triggering signal and leave the SOURCE switch at EXT, POLARITY to +, except where instructed to set POLARITY to —.

Test Oscilloscope

Triggering	Auto + Line
Time/cm	5 ms

Type W Unit

Input Selector	GND
Input Atten	10
Millivolts/cm	10
Comparison Voltage	1900
Vc Range	0

1. Check Indicator Oscilloscope Power Supply

Consult the oscilloscope manual and check the power supply voltages applied to the Type 3T2 (—100, —12.2, +125, and + 300 V DC and 6.3 V AC) for regulation and ripple, adjusting if necessary.

2. Check or Adjust —19 Volts

a. Use the equipment setup as shown in Fig. 7-3. Connect the 1× probe to the —19 Volt test point shown in Fig. 7-4. Set the TRIG SENSITIVITY control fully counterclockwise after the Indicator oscilloscope trace is known to be present.

b. Measure the voltage using the Type W Unit as follows:

1. Establish zero reference at the center horizontal graticule line by setting the Type W Input Selector to GND. Adjust the DC BAL for no trace movement as the Millivolts/cm switch is changed, leave at the 10 mV/cm settings, and set the trace at the center graticule line with the Position control.

2. Set the A Input Selector switch to DC and the Vc Range switch to —11.

c. Check that the trace is within ±1.9 cm (1%) from the center graticule line. If the trace is more than 1.9 cm from the center graticule line, adjust R841, —19 VOLTS, to set the trace at the center graticule line.

d. Vary the Autotransformer output voltage from 105 volts to 125 volts AC RMS (or 210 volts to 250 volts for a 230-volt installation) and observe that the Test Oscilloscope display stays within 1.9 cm (1%) from the center graticule line.

e. Return the Autotransformer to the nominal operating voltage and disconnect the probe from the —19 Volt test point.

3. Check or Adjust +19 Volts

a. Connect the 1× probe to the +19 Volt test point shown in Fig. 7-4.

b. Use the method described in the preceding step, but set the Vc Range switch to +11.

c. Check that the trace is within ±1.9 cm (1%) from the center horizontal graticule line. If the trace is more than 1.9 cm from the graticule center line, adjust R821, +19 VOLTS, to set the trace at the center line.

d. Vary the Autotransformer output voltage from 105 volts to 125 volts AC RMS and observe that the Test Oscilloscope display stays within 1.9 cm (1%) from the center graticule line.

e. Return the Autotransformer to the nominal operating voltage and disconnect the probe from the +19 Volt test point.

4. Check —27 Volts

a. Connect the 1× probe to the —27 Volt test point shown in Fig. 7-4.

b. Set the Vc Range switch to —11 and the Input Selector to DC.

c. Set the Comparison Voltage knob and dial to center the trace.

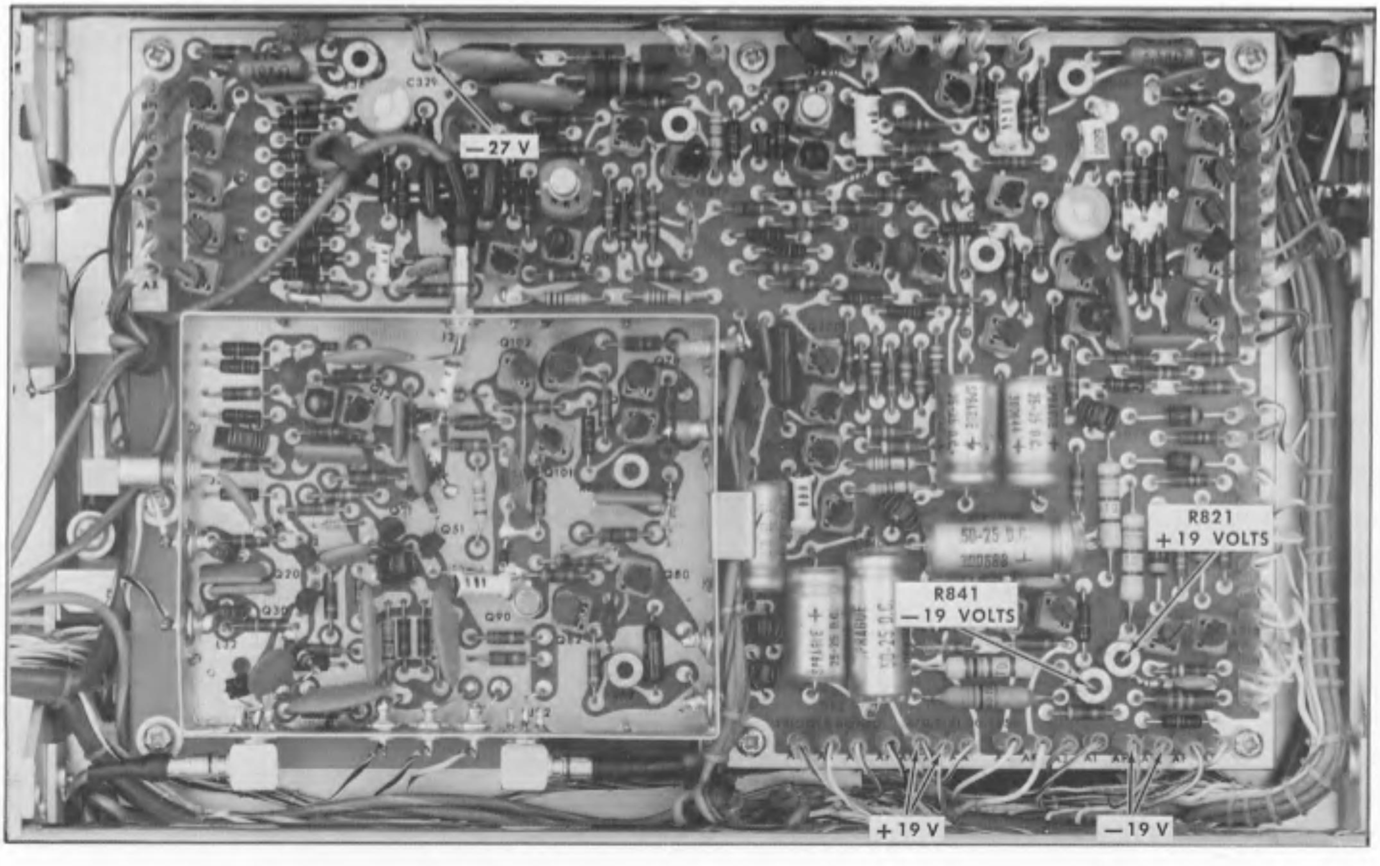


Fig. 7-4. Location of power supply test points and adjustments, right side of instrument, on Trigger Board Assembly.

d. Check that the dial reading is between 25.1 and 28.9 volts (27 volts ±7%).

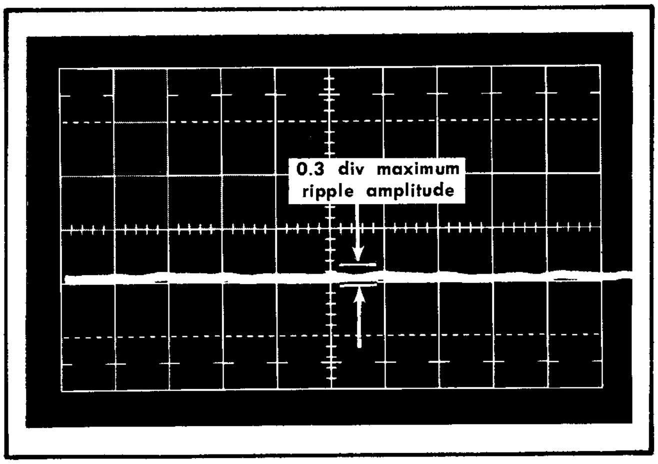


Fig. 7-5. Typical display of power supply ripple.

e. Disconnect the probe from the —27 Volt test point.

5. Check Ripple

a. Change the Type W Vc Range switch to 0, the Input Selector to AC and the Millivolts/cm switch to 1.

b. Set the TRIG SENSITIVITY control fully counterclockwise.

c. Connect the 1X probe to the —19 Volt test point and observe the Test Oscilloscope display for not more than 3 mV of ripple (.3 div); see Fig. 7-5.

d. Remove the probe from the —19 Volt test point and connect it to the +19 Volt test point.

e. Check the Test Oscilloscope display for not more than 3 mV of ripple (.3 div).

f. Disconnect the probe. Set the Autotransformer to the nominal operating voltage of the Indicator Oscilloscope or disconnect the Autotransformer and connect the Indicator Oscilloscope to the power line.

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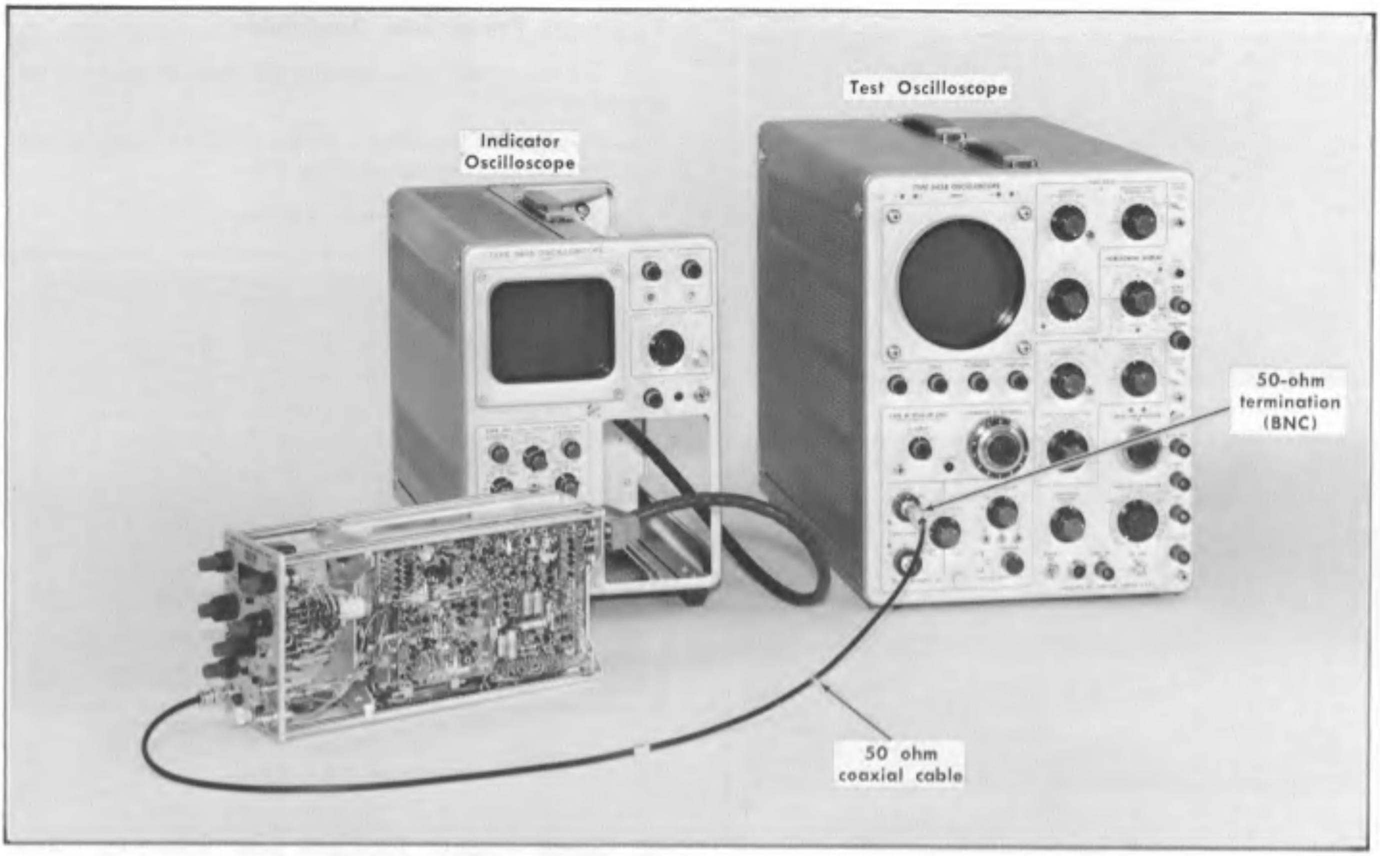

Fig. 7-6. Initial test equipment setup for steps 6 through 11.

Control Settings

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	10 μs
START POINT	WITH TRIGGER
DISPLAY MAG	$\times$1
TIME MAGNIFIER	$\times$1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
MANUAL SCAN	Midrange
TRIG SENSITIVITY	Fully counterclockwise
RECOVERY TIME	Midrange
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal)	100 (Up)

Vertical Sampling Unit

Channel A mV/Div	100

Test Oscilloscope

Triggering	**—Int, AC**
Time/cm	**.1 μs**

Type W

Millivolts/cm	**5**
Input Atten	10
Input Selector	DC
Vc Range	0

6. Adjust Trigger Recognizer

a. Connect the Type 3T2 PULSE OUT signal to the Type W Input A connector through a 50 Ω coaxial cable and a 50 Ω termination. The initial test equipment setup is shown in Fig. 7-6.

b. Turn the TRIG SENSITIVITY control fully clockwise and observe the Test Oscilloscope display.

c. Check that the Test Oscilloscope display changes from no signal to a negative pulse display, Fig. 7-7, with 8 to 12 cycles preceding the negative step. If the negative step first appears with no cycles preceding, at the center (12 o'clock) position of the TRIG SENSITIVITY control, the Trigger Recognizer circuit is operating correctly and requires no adjustment. Proceed to part e.

d. Adjust R82, OUTPUT TD BIAS, for 8 to 12 cycles ahead of the negative step as in Fig. 7-7B with the TRIG SENSITIVITY control fully clockwise and for no display with the TRIG SENSITIVITY control fully counterclockwise. Adjust R72, TRIG SENS BAL, for the appearance of the negative step as in Fig. 7-7A at the 12 o'clock position of the TRIG SENSITIVITY control. Location of the adjustment is shown in Fig. 7-8.

e. Set the Test Oscilloscope Time/cm switch to 50 μs and the Type 3T2 TRIG SENSITIVITY and RECOVERY TIME controls fully clockwise.

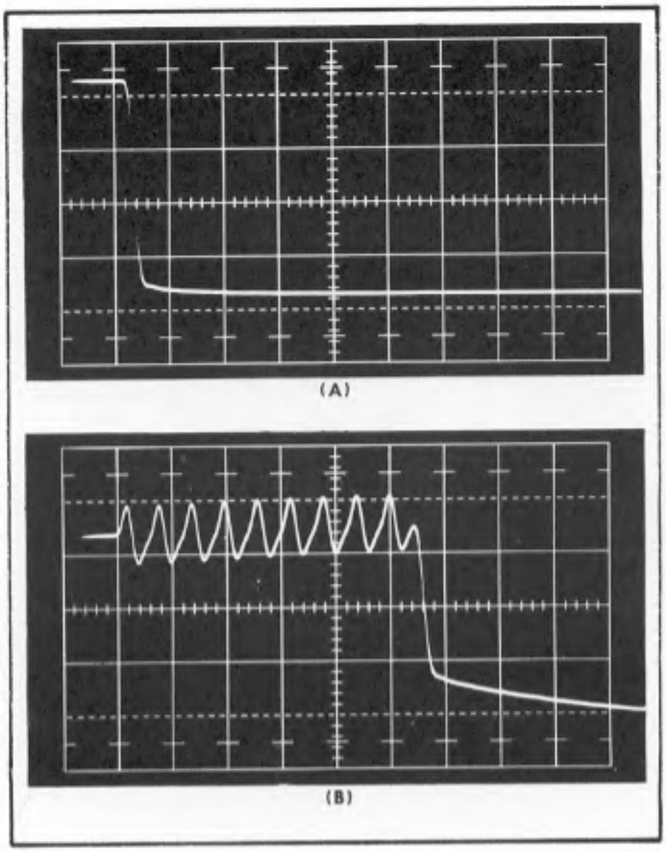

Fig. 7-7. Typical displays of correct Trigger Recognizer circuit operation. TRIG SENSITIVITY control (A) at 12 o'clock and (B) fully clockwise.

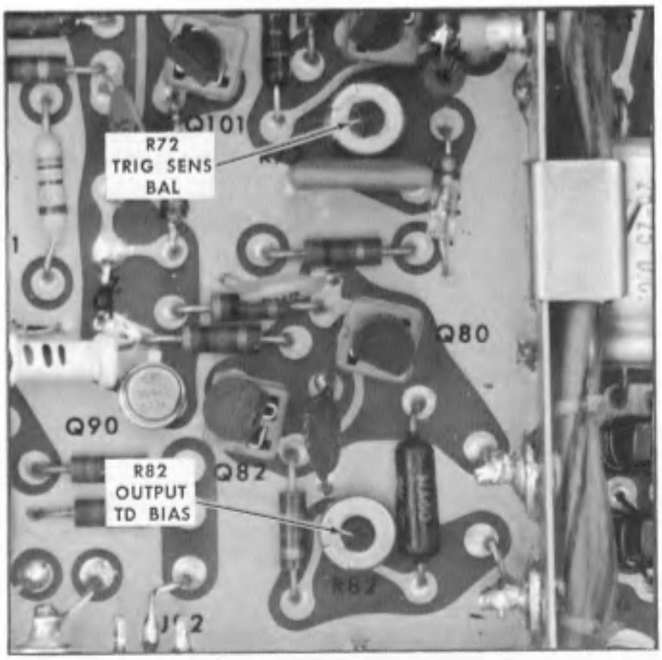

Fig. 7-8. Location of Trigger Recognizer circuit adjustments, right side of instrument, on the Trigger Board Assembly.

7. Check Pulse Out Amplitude

a. The equipment setup remains the same as given in the preceding step.

b. Measure the amplitude of the negative pulse on the Test Oscilloscope display; see Fig. 7-9.

c. Check that the amplitude is at least 150 mV.

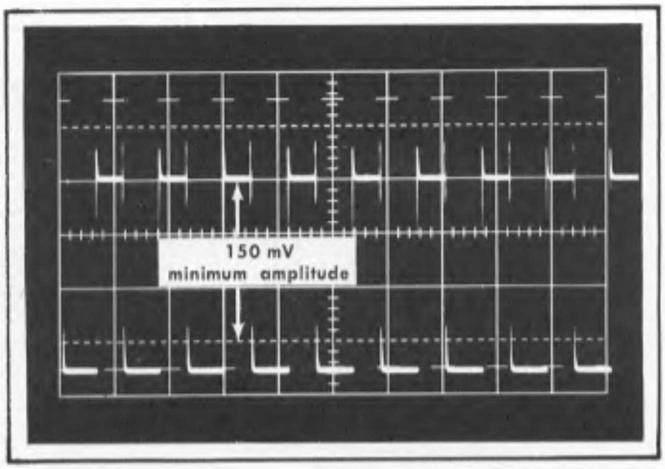

Fig. 7-9. Measurement of Pulse Out amplitude.

8. Check Trigger Holdoff and Recovery Time Range

a. Set the RANGE switch to 100 ns and the Test Oscilloscope Time/cm switch to 10 μs.

b. Check the Test Oscilloscope display for the trigger holdoff times as given in Table 7-1. Holdoff is the time between the leading negative-going portions of adjacent trigger pulses (see Fig. 7-10A). Reset the Test Oscilloscope Time/cm switch as required.

TABLE 7-1

RANGE	Minimum Trigger Holdoff	Test Oscilloscope Time/cm
100 ns	20 μs	10 μs
1 μs	20 μs	10 μs
10 μs	40 μs	20 μs
100 μs	400 μs	.2 ms
1 ms	4 ms	2 ms

c. Set the RANGE switch to 1 μs and the Test Oscilloscope Time/cm switch to 5 μs. Use the Test Oscilloscope Variable Time/cm control to obtain a display of exactly 1 pulse per 4 cm (see Fig. 7-10B) between the leading negative-going edges of the trigger pulses.

d. Turn the RECOVERY TIME control fully counterclockwise.

e. Check that the Test Oscilloscope display is 5 cm or more between the leading negative-going edges of the pulse; see Fig. 7-10C.

f. Disconnect the coaxial cable..

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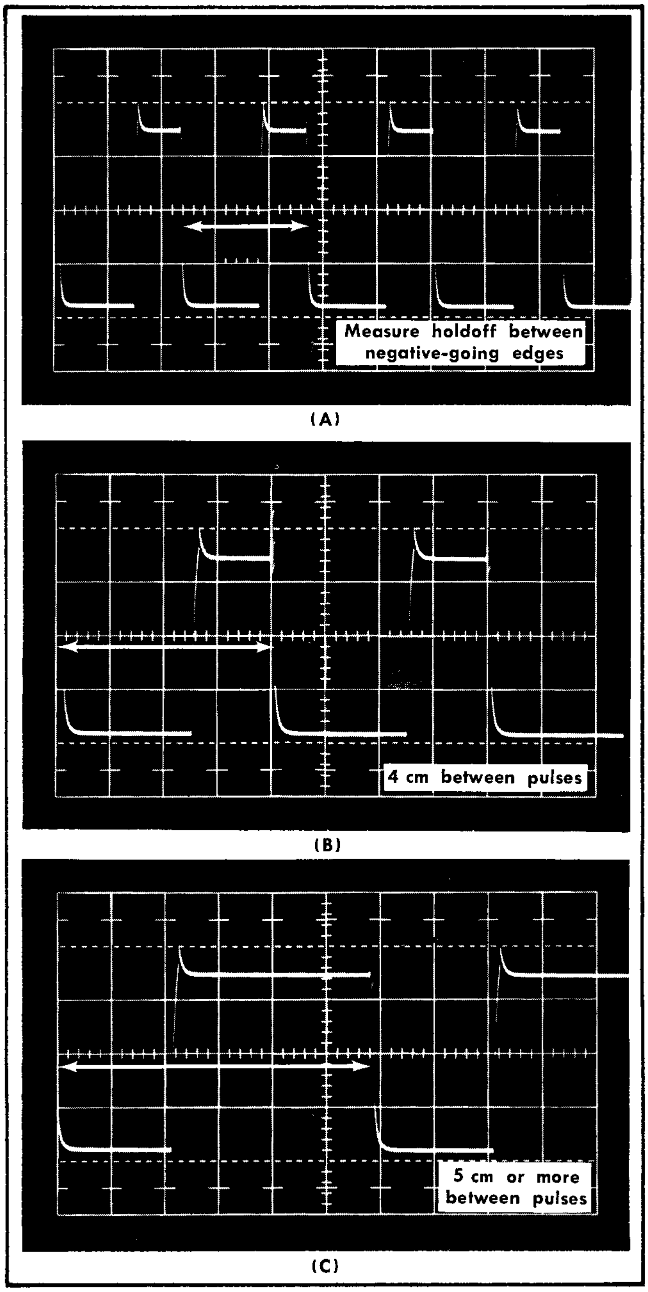

Fig. 7-10. Test Oscilloscope displays of (A) measurement of holdoff, (B) Recovery Time control fully clockwise and (C) Recovery Time control fully counterclockwise.

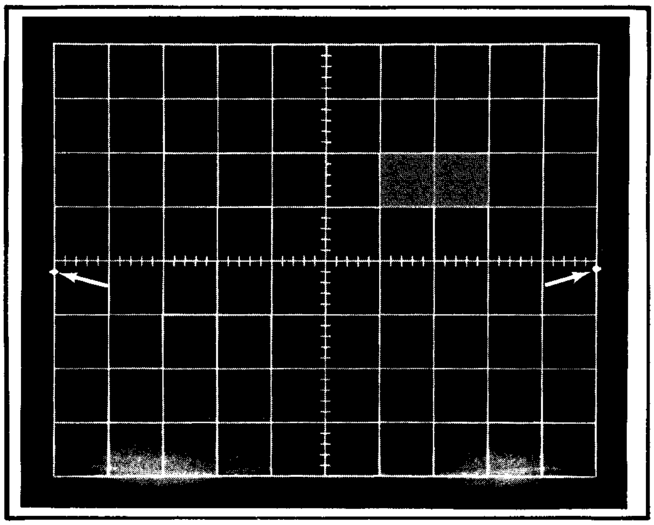

Fig. 7-11. Double exposure of Indicator Oscilloscope display of Manual Scan control range for Horiz Gain adjustment.

9. Check Manual Scan Range and Adjust Horiz Gain

a. Set the DISPLAY MODE switch to MANUAL, turn the MANUAL SCAN control fully clockwise. Connect a precision non-loading voltmeter between ground (—) and R474 (Man Scan Cal control) terminal to which a white with black tracer wire is connected. Adjust R474 for exactly +15 V. Disconnect the meter. Set the MANUAL SCAN control fully counterclockwise. With the HORIZ POSITION control, set the CRT spot carefully to the zero vertical graticule line; see Fig. 7-11.

b. Turn the MANUAL SCAN control fully clockwise and check that the spot is exactly at the tenth graticule line; see Fig. 7-11.

c. Adjust the HORIZ GAIN (front panel) control until the MANUAL SCAN control moves the spot exactly 10 divisions. It may be necessary to repeat for proper adjustment.

10. Check Spot Position Indicators

a. Turn the MANUAL SCAN control counterclockwise so the spot is more than 5 divisions to the left of the graticule center vertical line.

b. Check that only the left Spot Position Indicator is on.

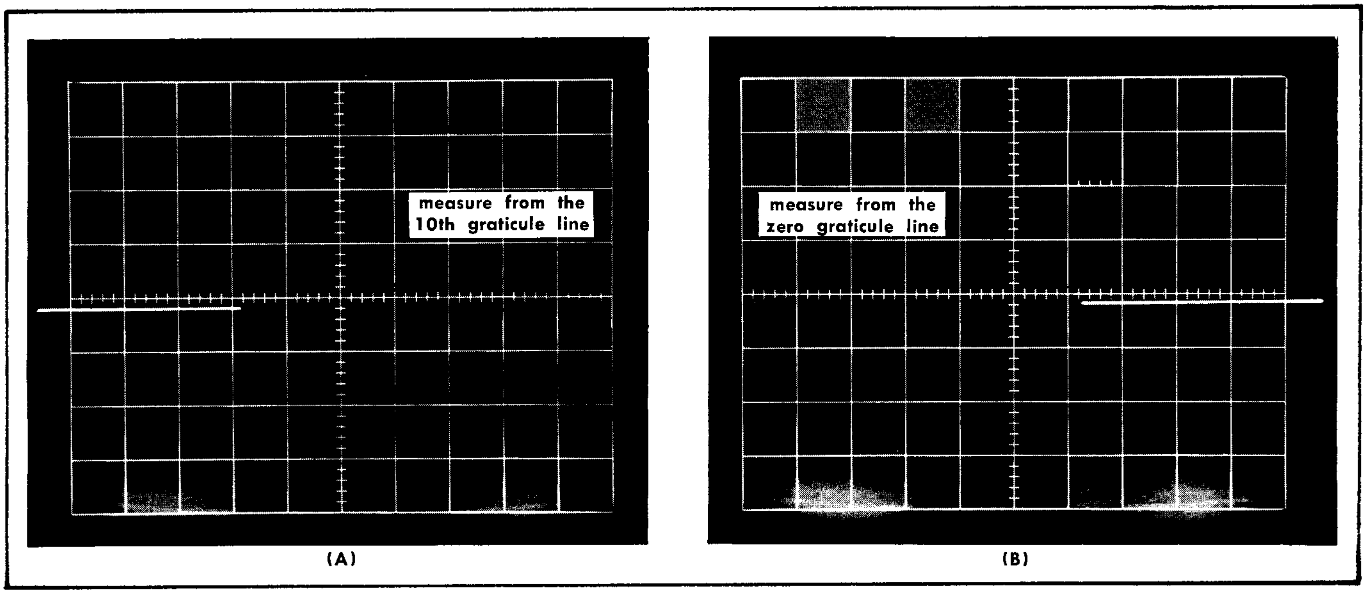

Fig. 7-12. Indicator Oscilloscope displays of Horiz Position control (A) fully counterclockwise and (B) fully clockwise.

c. Turn the MANUAL SCAN control clockwise so the spot is more than 5 divisions to the right of the graticule center line.

d. Check that only the right Spot Position Indicator is on.

11. Check Horiz Position Range

a. Set the DISPLAY MODE switch to NORMAL and turn the HORIZ POSITION control fully counterclockwise. Note the displacement from the tenth graticule line; see Fig. 7-12A.

b. Turn the HORIZ POSITION control fully clockwise and note the displacement from the zero graticule line; see Fig. 7-12B.

c. Add the two displacements together and check that the total displacement is at least 10 divisions.

d. Reset the HORIZ POSITION control to center the trace.

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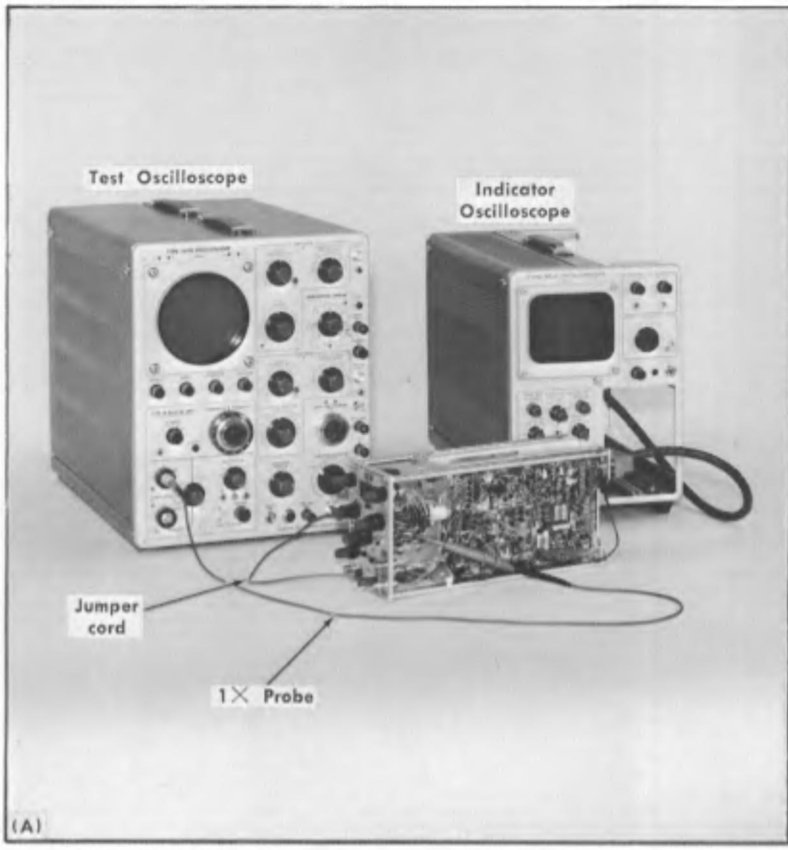

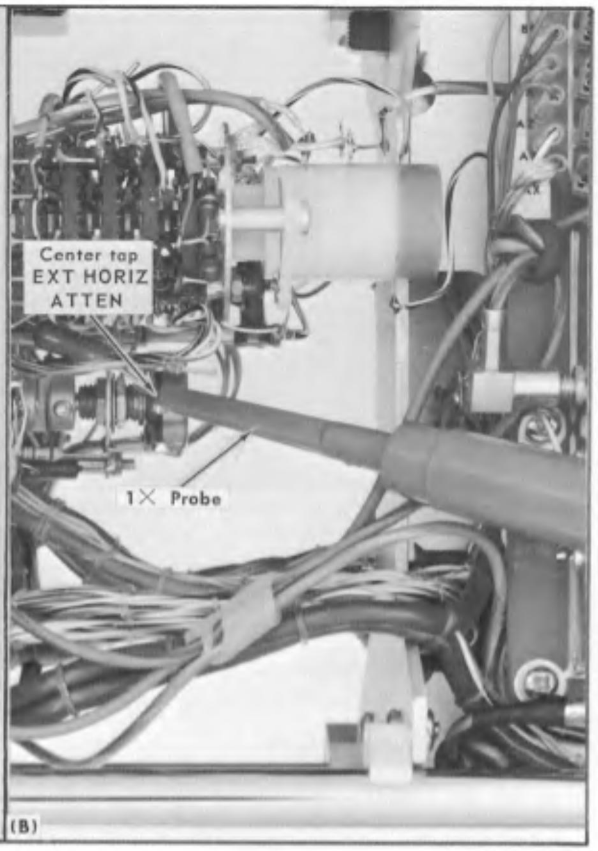

Fig. 7-13. (A) Test equipment setup for step 12 and (B) 1× probe connection.

Control Settings

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	1 μs
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	**EXT HORIZ**
EXT HORIZ ATTEN	Midrange
TRIG SENSITIVITY	Fully clockwise
RECOVERY TIME	As desired
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal)	100 (Up)

Vertical Sampling Unit

Channel A mV/Div	100

Test Oscilloscope

Triggering	—Int, AC
Time/cm	1 ms
Amplitude Calibrator	**20 Volts**

Type W

Millivolts/cm	50
Input Atten	10
Input Selector	GND
Vc Range	0
Comparison Voltage	1200

12. Check External Horizontal Deflection Factor

a. Connect the BNC to Banana plug jumper cord from the Test Oscilloscope Cal Out connector to the EXT HORIZ INPUT jack on the Type 3T2. Connect the 1× probe to the center tap of the EXT HORIZ ATTEN control as shown in Fig. 7-13B.

b. Adjust the EXT HORIZ ATTEN control for exactly 8 divisions of deflection on the Indicator Oscilloscope CRT; see Fig. 7-14.

c. Set the Type W Input Selector to DC and position the bottom of the test oscilloscope display at the center horizontal graticule line with the Position control; see Fig. 7-15A. Disregard any change in the Indicator Oscilloscope display deflection caused by loading of the probe.

d. Set the Vc Range switch to +11 and position the top of the Test Oscilloscope display at the center horizontal graticule line with the Comparison Voltage control; see Fig. 7-15B.

e. Check that the Comparison Voltage dial reads between 11.64 and 12.36 (12 volts ±3%).

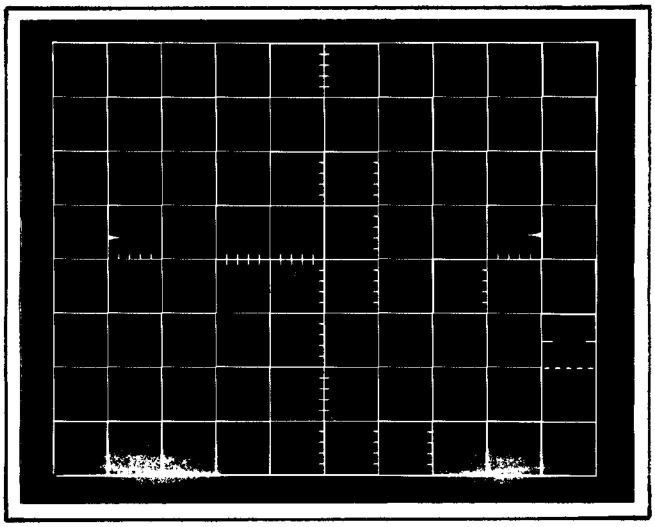

Fig. 7-14. Indicator Oscilloscope display of EXT HORIZ ATTEN control settings.

f. Disconnect the probe and jumper cord.

13. Check Sweep Out

a. Set the Type W Comparison Voltage to 0000 and the Vc Range switch to 0. Set the Test Oscilloscope Triggering controls for a free-running trace.

b. Connect the 1× probe to the SWP OUT jack.

c. Set the DISPLAY MODE to MANUAL and the MANUAL SCAN control fully counterclockwise. Set the spot at the zero graticule line with the HORIZ POSITION control.

d. Set the Test Oscilloscope trace at the center graticule line with the Type W Position control.

e. Set the Type W Vc Range switch to +11.

f. Manually position the spot on the indicator oscilloscope 1 division to the right with the Type 3T2 MANUAL SCAN control.

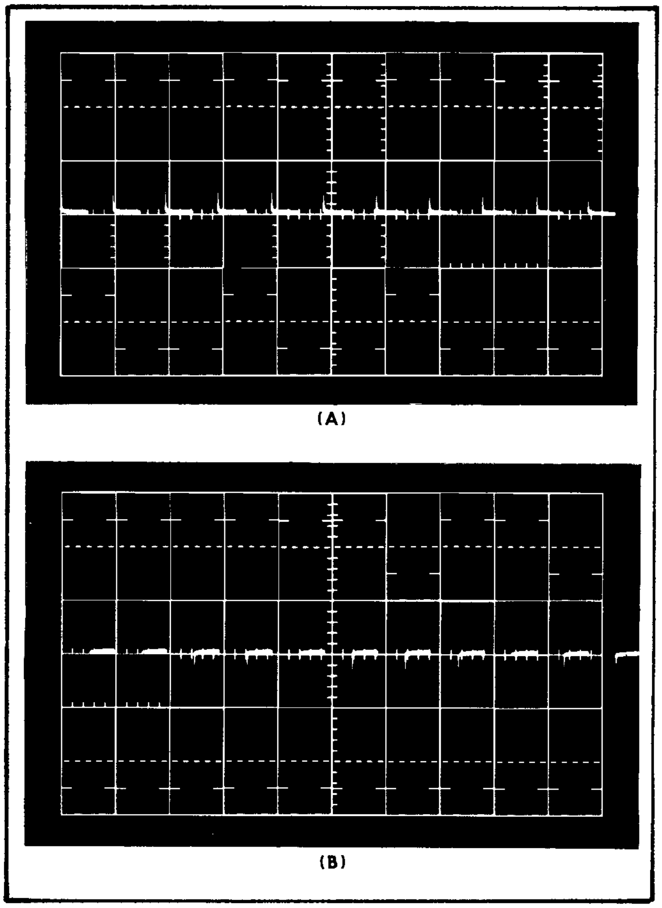

Fig. 7-15. Test Oscilloscope displays of voltage measurement; (A) reference setting and (B) Comparison Voltage setting.

g. With the Type W Comparison Voltage control, position the test oscilloscope trace back to the graticule centerline.

h. Check that the Comparison Voltage dial is between 0.95 and 1.05 indicating 1 volt per division ±5%. Repeat steps (f) and (g) once or twice as a further check.

i. Disconnect the probe.

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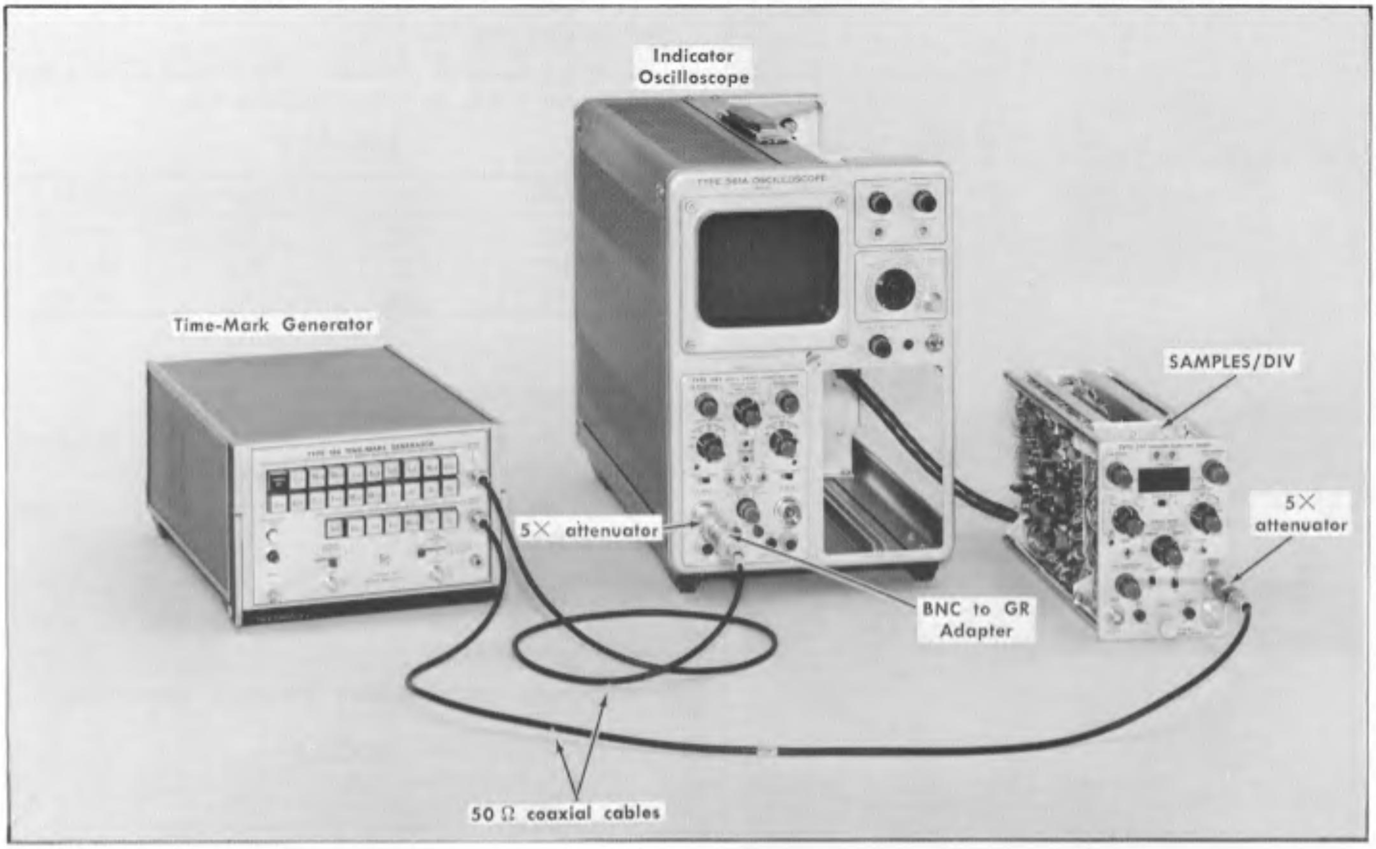


Fig. 7-16. Test equipment setup for steps 14 and 15.

Control Settings

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	**10 μs**
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	**NORMAL**
MANUAL SCAN	Midrange
TRIGGER SENSITIVITY	Stable display
RECOVERY TIME	As desired
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal)	100 (up)

Vertical Sampling Unit

Channel A mV/div	100

14. Adjust Start WITH TRIGGER Timing

a. Connect the Time Mark Generator Marker Output through a 50 Ω coaxial cable, a BNC to GR adapter and a 5× attenuator to the Vertical Input A connector and connect the Trigger Output through a 50 Ω coaxial cable and 5× attenuator to the 50 Ω TRIGGER INPUT connector. The equipment setup is shown in Fig. 7-16.

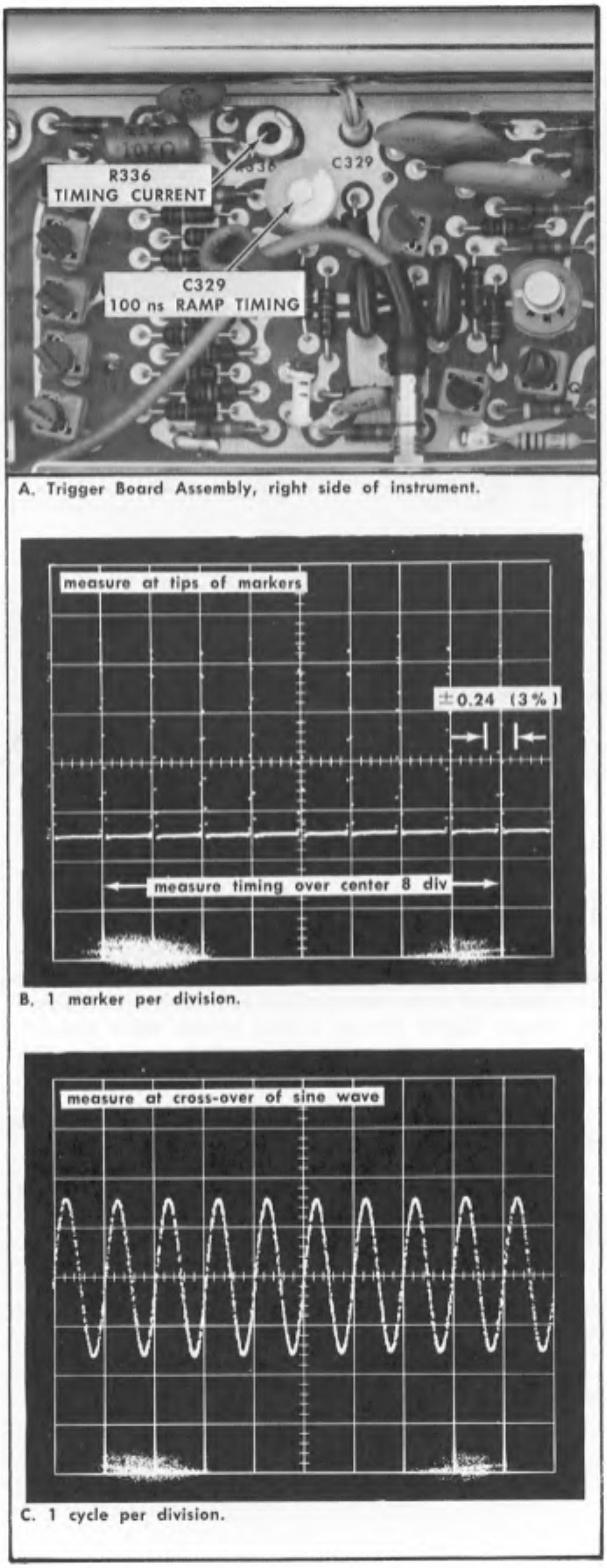
b. Set the Time-Mark Generator for 1 μs markers and triggers.

c. Set the TIME POSITION control for alignment of markers with the graticule. Check the Indicator Oscilloscope display for 1 marker per division.

d. Adjust R336, TIMING CURRENT, for exactly 1 marker per division between the 2nd and 10th graticule lines. See Fig. 7-17.

e. Set the RANGE switch to 100 ns and the Time Mark Generator to 10 ns.

f. Check that the display is one cycle per division.



A. Trigger Board Assembly, right side of instrument.

B. 1 marker per division.

C. 1 cycle per division.

Fig. 7-17. Location and typical displays of timing adjustments.

g. Adjust C329, 100 ns RAMP TIMING, for exactly 1 cycle per division. See Fig. 7-17.

h. Check the other positions of the RANGE switch within ±0.24 div, ±3%, as follows in Table 7-2.

TABLE 7-2

RANGE	Markers	Trigger	Display
1 μs	.1 μs	1 μs	1 per div
100 μs	10 μs	10 μs	1 per div
1 ms	.1 ms	.1 ms	1 per div

15. Check Single Sweep Operation

a. Set the RANGE switch to 10 μs and the Time-Mark Generator for 1 μs markers and trigger signals.

b. Set the DISPLAY MODE switch to SINGLE SWP and observe that the sweep is off.

c. Press the START button, then release it.

d. Check that one sweep occurs each time the START button is pressed.

e. Remove the Time-Mark Generator connections.

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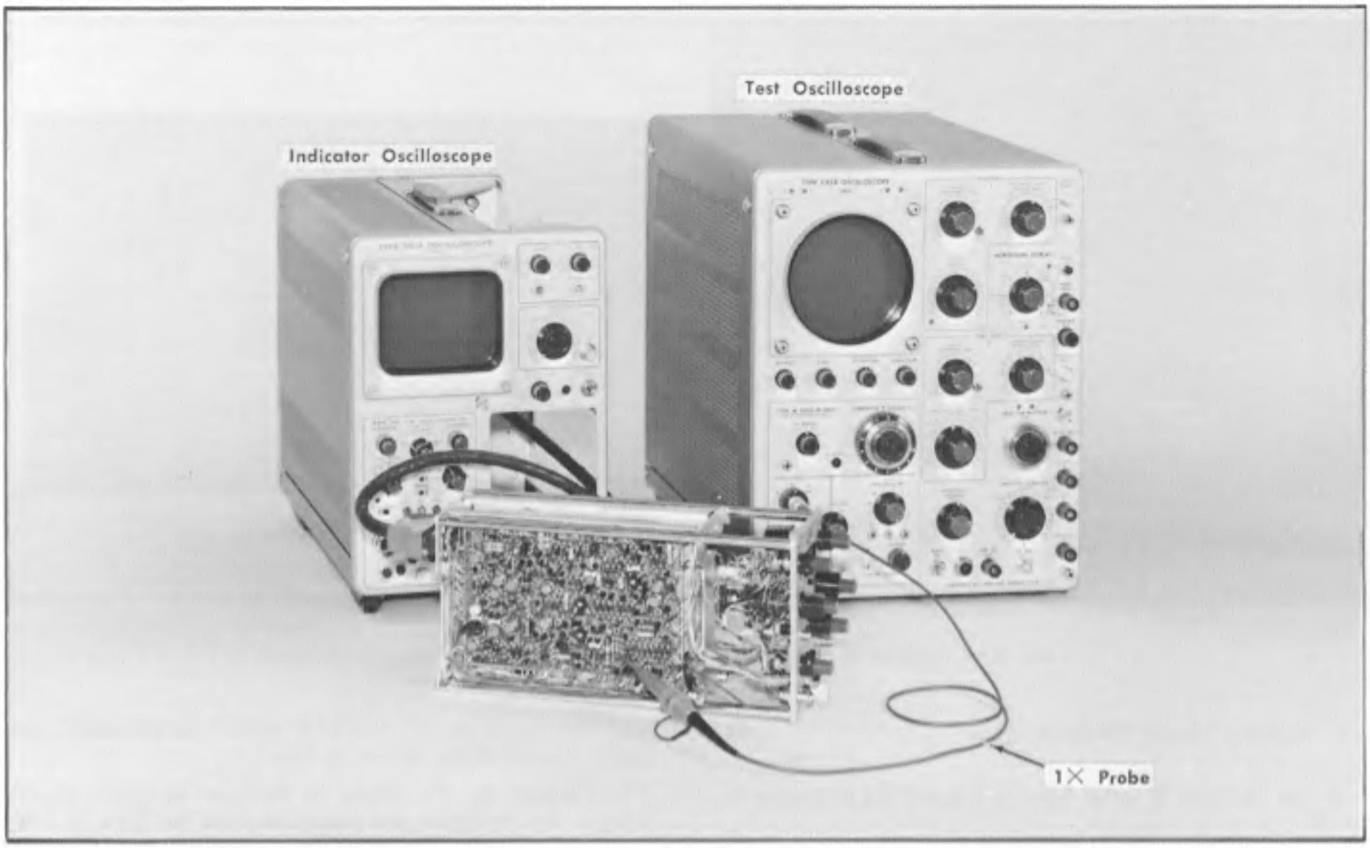


Fig. 7-18. Initial equipment setup for steps 16 through 19.

Control Settings

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	**10 μs**
START POINT	**BEFORE TRIGGER**
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	**NORMAL**
MANUAL SCAN	Midrange
TRIG SENSITIVITY	**Fully clockwise**
RECOVERY TIME	Midrange
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal)	100 (up)

Vertical Sampling Unit

Channel A mV/div	100

Test Oscilloscope

Triggering	—Int, AC
Time/cm	**20 μs**

Type W

Millivolts/cm	**20**
Input Atten	10
Input Selector	DC
Vc Range	0

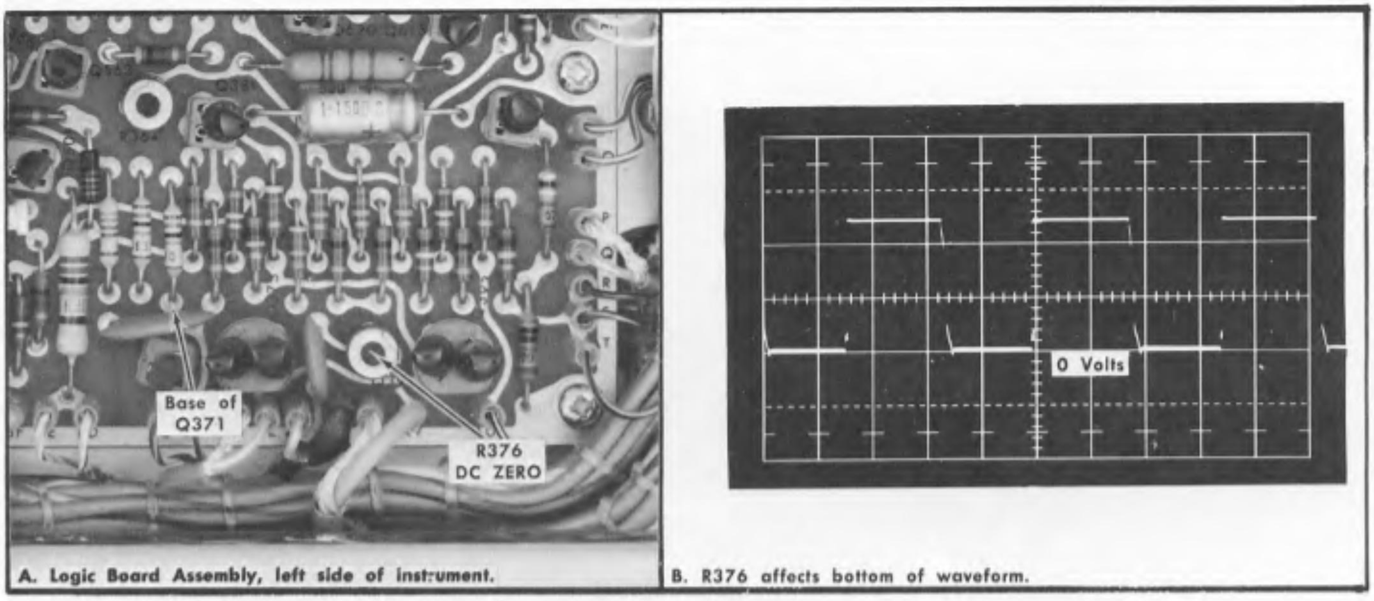
16. Adjust DC Zero

a. Connect the 1× probe from the Test Oscilloscope to the base of Q371, shown in Fig. 7-19. Test equipment setup is shown in Fig. 7-18.

b. Set the Test Oscilloscope zero reference and check that the Type 3T2 waveform at the base of Q371 starts at the zero reference. The amplitude of the waveform is set by the TIME POSITION controls.

c. Adjust R376, DC ZERO, to set the bottom of the waveform at zero volts; see Fig. 7-19.

d. Remove the probe.



A. Logic Board Assembly, left side of instrument.

B. R376 affects bottom of waveform.

Fig. 7-19. Location and Test Oscilloscope display of DC ZERO adjustment.

17. Adjust Horiz Output Zero

a. Set the Type W Input Atten to 100 and the Millivolts/cm to 10.

b. Set the Type 3T2 DISPLAY MODE to MANUAL and center the MANUAL SCAN control.

c. Connect the 1× probe to the base of Q531, pin BL using a straight tip on the probe, and use the Type W Posi-

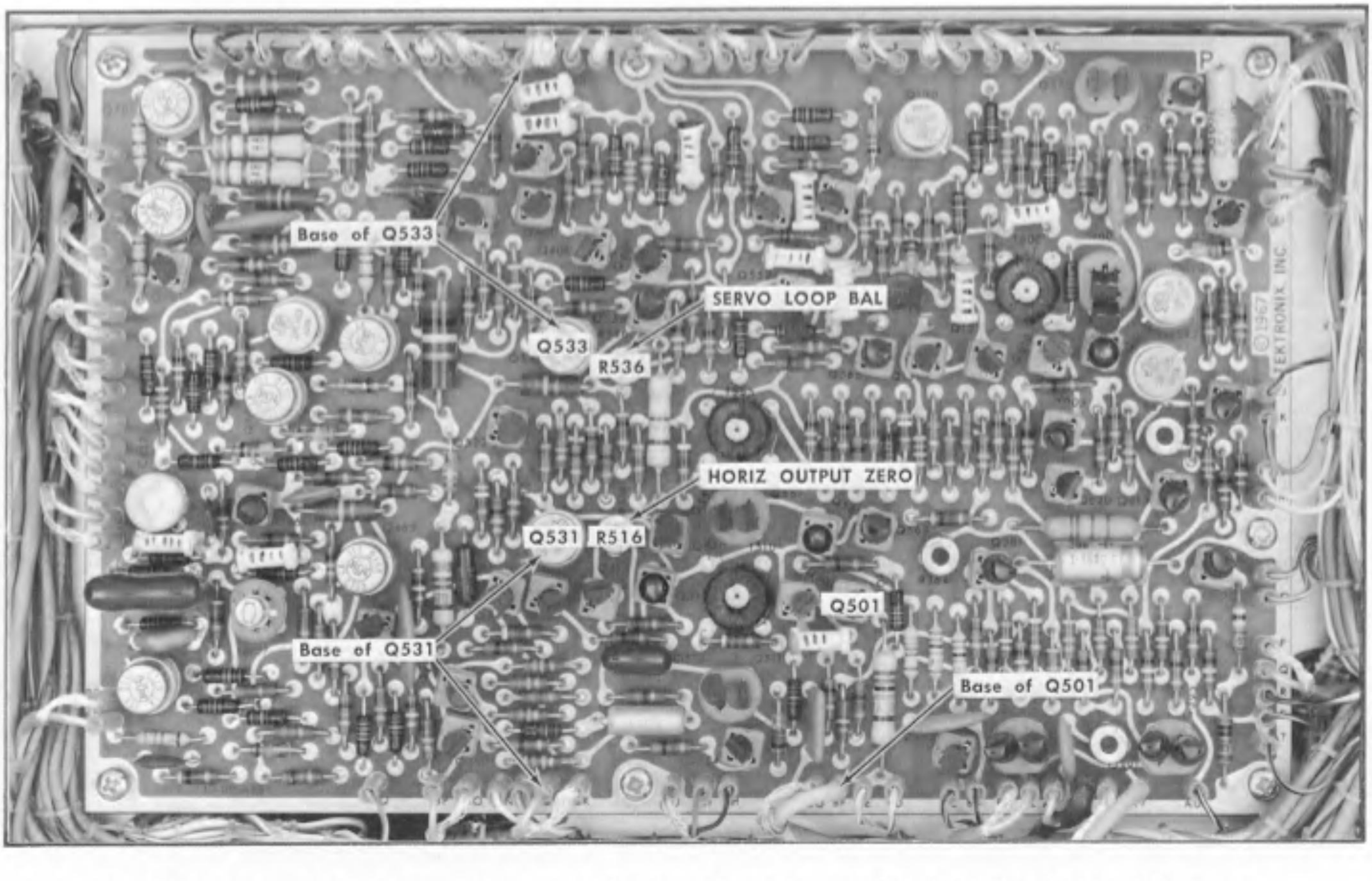
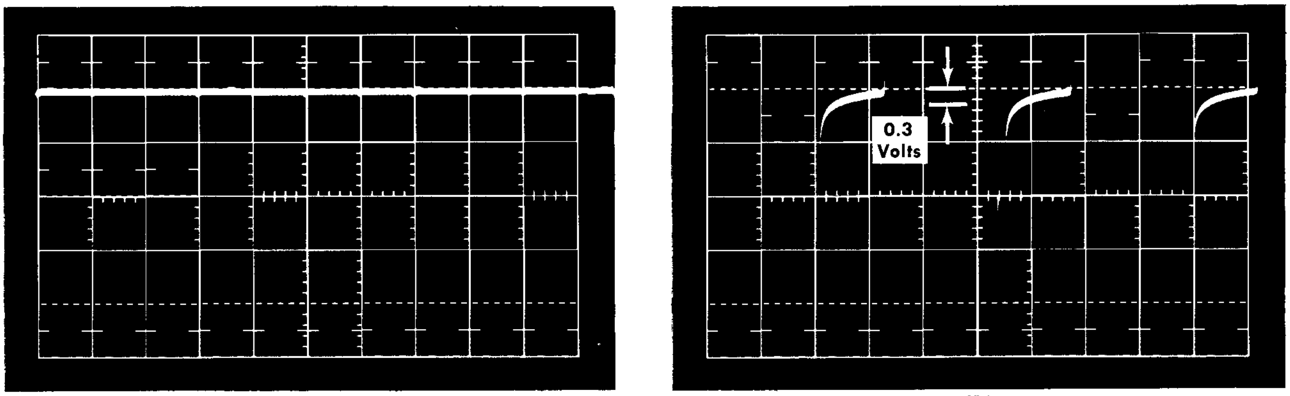


Fig. 7-20. Location of test points and adjustments for steps 17 and 18. Logic Board Assembly, left side of instrument.



(A) (B)

Fig. 7-21. Test Oscilloscope displays of (A) DC level at Q531 base and (B) Waveform level at Q501 base.

tion control to set the display on a reference graticule line of the Test Oscilloscope. See Fig. 7-20.

d. Connect the 1× probe to the base of Q501, pin BF, and check that the top of the waveform is within about 0.3 volts (0.3 div), less positive from the reference level.

e. Adjust R516, HORIZ OUTPUT ZERO, to set the top of the waveform about 0.3 volts (0.3 div) below the reference DC level.

f. Remove the probe.

18. Adjust Servo Loop Bal

a. Connect the 1× probe to the base of Q533, pin M or the transistor case, and note the DC level on the Test Oscilloscope.

b. Move the probe to the base of Q531, Pin BL or the case of the transistor, and check that the DC level is equal to that on the base of Q533.

c. Adjust R536, SERVO LOOP BAL, to set the DC level on the base of Q531 to the same DC level as at the base of Q533.

d. Remove the probe.

e. Alternate method: Change the START POINT switch from BEFORE TRIGGER to WITH TRIGGER and check that the spot does not move.

f. Set the START POINT switch to BEFORE TRIGGER.

NOTES

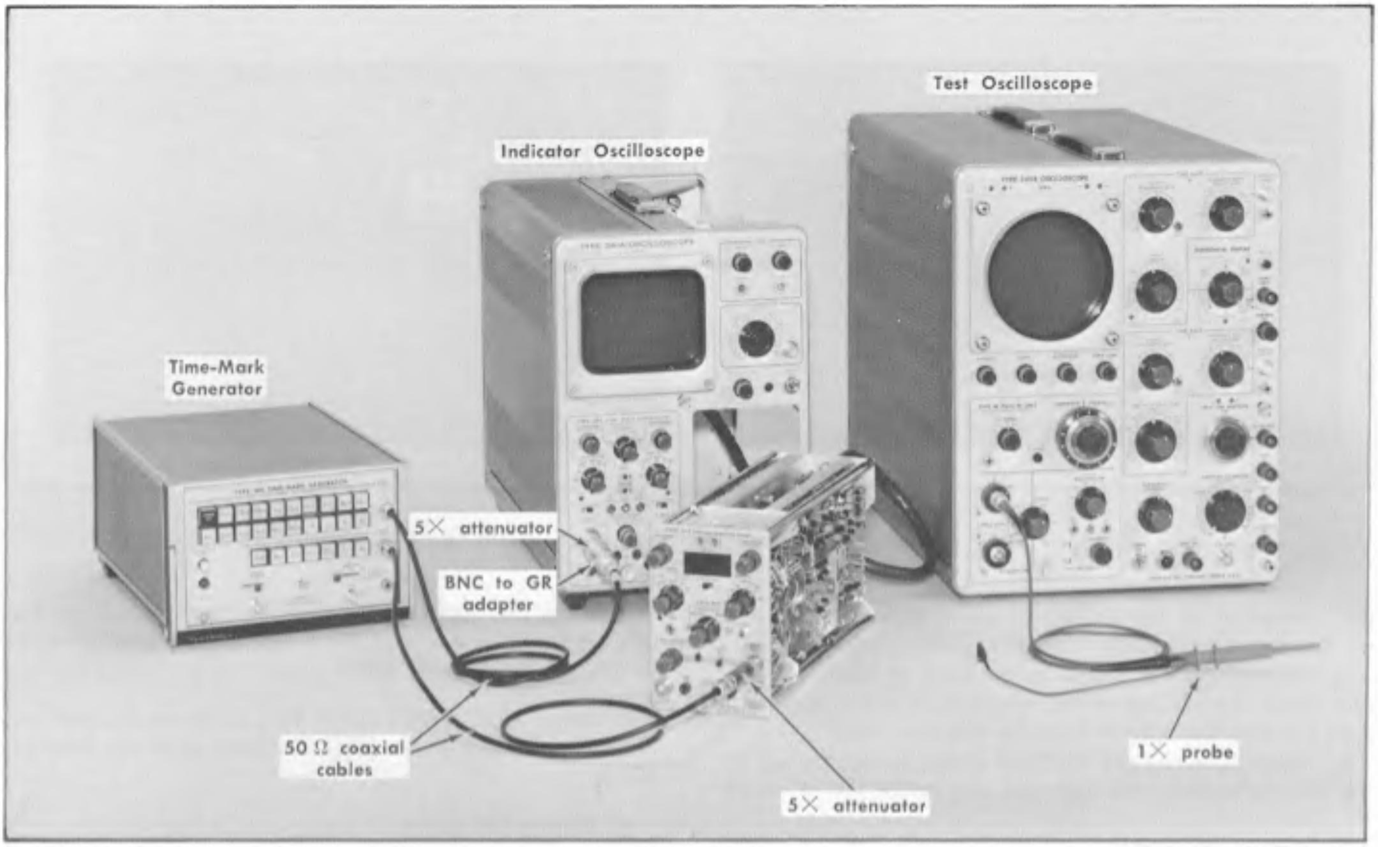


Fig. 7-22. Initial test equipment setup for steps 19 through 25.

Control Settings

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	10 μs
START POINT	BEFORE TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	**NORMAL**
MANUAL SCAN	Midrange
TRIG SENSITIVITY	**Stable display**
RECOVERY TIME	As desired
POLARITY	+
SOURCE	EXT
SAMPLES/DIV (Internal)	**VARIABLE (Down)**

Vertical Sampling Unit

Channel A mV/div	100

19. Adjust Start BEFORE TRIGGER Timing

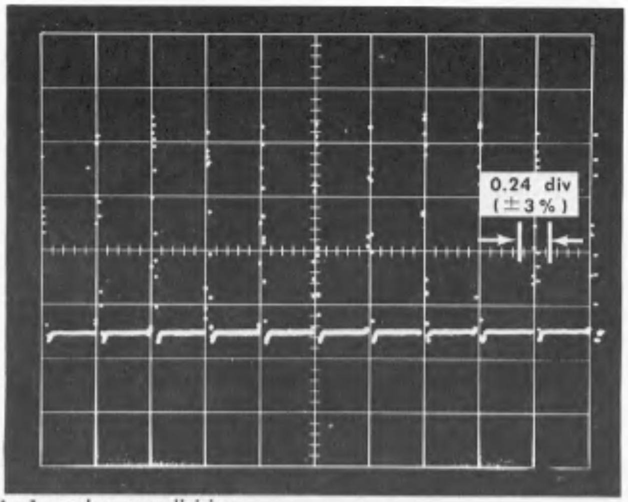
a. Connect the Time Mark Generator Marker Output through a 50 Ω coaxial cable, a BNC to GR adapter and a 5× attenuator to the Vertical Input A connector and connect the Trigger Output through a 50 Ω coaxial cable and 5× attenuator to the 50 Ω TRIGGER INPUT connector. The equipment setup is shown in Fig. 7-22.

b. Set the Time Mark Generator for 1 μs markers and triggers.

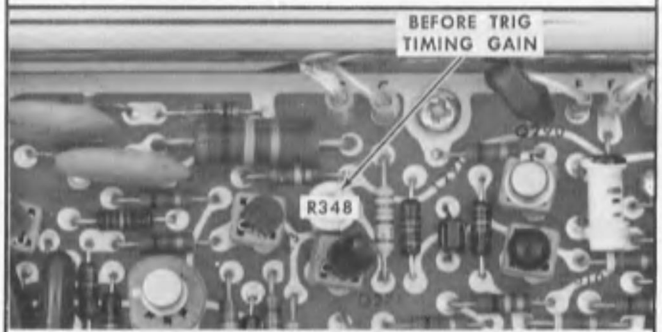
c. Align the markers with the TIME POSITION control to the graticule and check the display for 1 marker per division between the 2nd and 10th graticule lines.

d. Adjust R348, BEFORE TRIG TIMING GAIN, for exactly 1 marker per division; see Fig. 7-23.

e. Check the other positions of the RANGE switch for a display of 1 per div over the center 8 divisions on the graticule within ±0.24 div (±3%), as given in Table 7-3. Measure markers at the tips and the sine wave at the cross-over point. The 1 ms position will require a storage oscilloscope.



A. 1 marker per division.



B. Trigger Board Assembly, right side of instrument.

Fig. 7-23. BEFORE TRIGGER Timing display and location of adjustment.

TABLE 7-3

RANGE	Markers	Trigger
1 μs	.1 μs	1 μs
100 ns	10 ns	1 μs
100 μs	10 μs	10 μs
1 ms	.1 ms	.1 ms

f. Remove the Time Mark Generator connections.

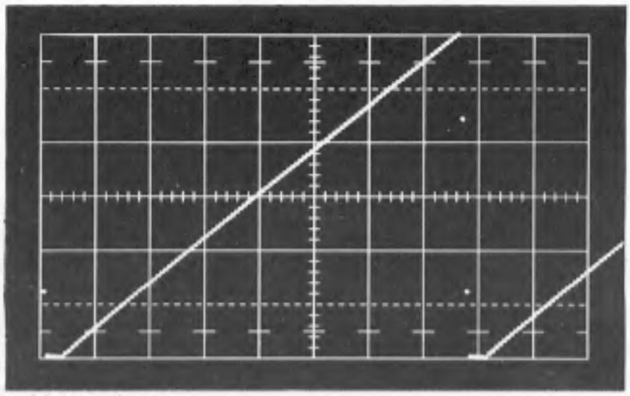
20. Adjust Slewing Ramps

a. Set the RANGE switch to 10 μs.

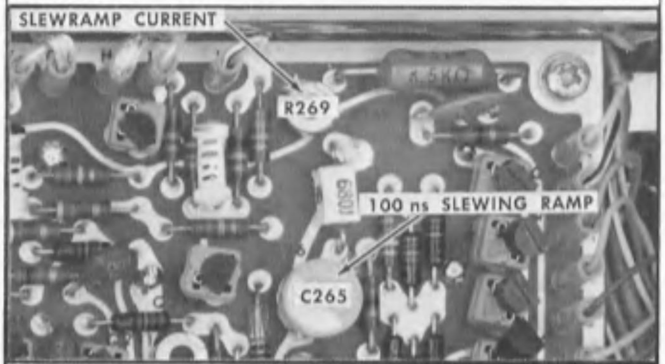
b. Connect the 1× probe to the base of Q533. Set the Test Oscilloscope Time/cm switch to 1 ms and the Type W Millivolts/cm switch to 20. Set the Variable control for a Test Oscilloscope display amplitude of 6 cm; see Fig. 7-24.

c. Connect the 1× probe to the base of Q531 and check that the staircase is also 6 cm in amplitude.

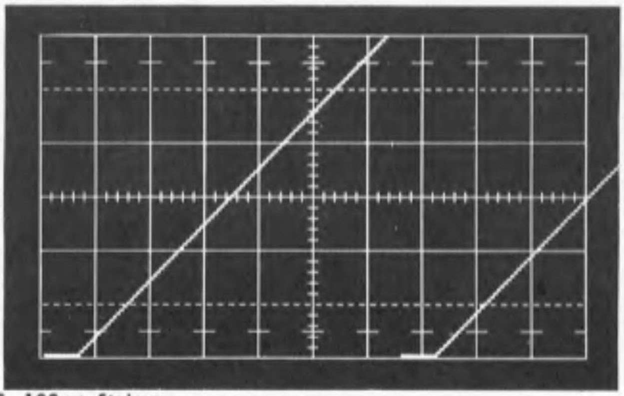
d. Adjust R269, SLEWRAMP CURRENT, for a 6 cm staircase on the base of Q531, equal to the staircase on the base of Q533.



A. 10 μs staircase.



B.



C. 100 ns Staircase.

Fig. 7-24. Waveforms at bases of Q533/Q531 and the location of adjustments, Trigger Board Assembly, right side of instrument.

e. Change the RANGE switch to 100 ns and the Test Oscilloscope Time/cm switch to .5 ms.

f. Connect the 1× probe to the base of Q533 and check that the amplitude of the staircase is 6 cm, set by the Type W Variable control.

g. Move the probe to the base of Q531 and check that the amplitude of the staircase is 6 cm.

h. Adjust C265, 100 ns SLEWING RAMP, for the 6 cm staircase on the base of Q531, equal to the staircase on the base of Q533.

i. Remove the probe.

21. Adjust Time Position Zero

a. Set the Type 3T2 Controls as follows:

TIME POSITION	Fully counterclockwise
Time Position FINE	Fully clockwise
RANGE	100 μs
TRIG SENSITIVITY	Fully clockwise

b. Set the start of the sweep to the left edge of the graticule with the HORIZ POSITION control.

c. Set the TIME POSITION control fully clockwise and check that the start of the sweep remains at the left edge of the graticule.

d. Adjust R364, TIME POSITION ZERO, (Fig. 7-25 shows the location) for the most counterclockwise setting possible with the TIME POSITION control fully clockwise and the start of the sweep at the left edge of the graticule.

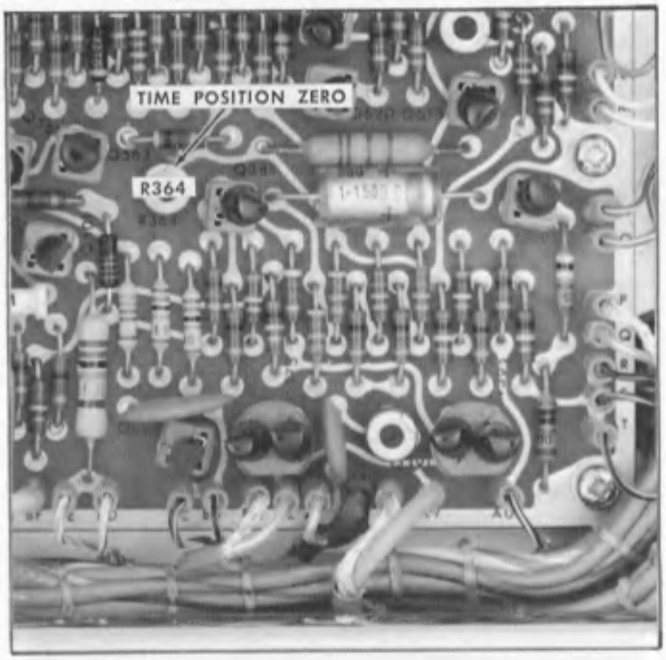


Fig. 7-25. Location of Time Position Zero adjustment, Logic Board Assembly, left side of instrument.

22. Adjust Lead Time

a. Connect the 50 Ω coaxial cable and BNC to GR adapter from the Type 3T2 PULSE OUT connector to the Vertical Input A connector and set the Channel A mV/div switch to 50.

b. Set the RANGE switch to 10 μs and the START POINT switch to WITH TRIGGER. Set the HORIZ POSITION control so that the trace starts at the edge of the graticule.

c. Set the START POINT switch to BEFORE TRIGGER and check that the falling edge of the waveform is at the sixth graticule line, see Fig. 7-26(A).

d. Adjust R231, LEAD TIME (Fig. 7-26B shows the location) to place the falling edge of the waveform at the sixth graticule line.

e. Disconnect the coaxial cable.

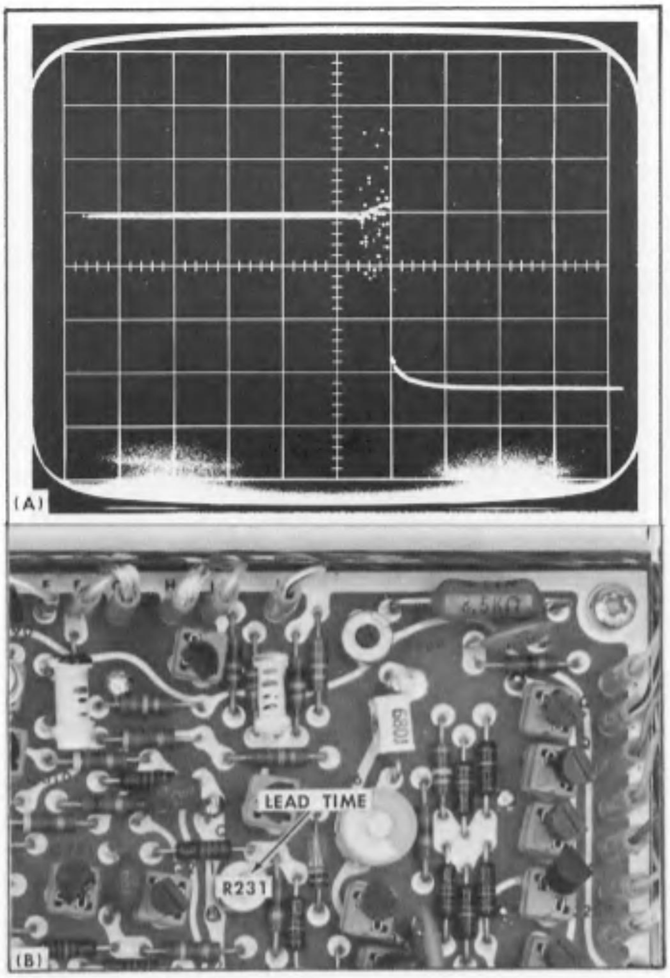


Fig. 7-26. Adjustment of Lead Time (A) Display and (B) Location on Trigger Board Assembly, right side of instrument.

23. Adjust 1 ms Correction

a. Set the DISPLAY MODE switch to MANUAL and center both the MANUAL SCAN and TIME POSITION controls.

b. Set the RANGE switch to 100 μs and to 1 ms while observing the spot on the CRT for a shift in position, then a slow recovery drift.

c. Check that there is no shift in position as the RANGE switch is changed from 100 μs to 1 ms.

d. Adjust R622, 1 ms CORRECTION (shown in Fig. 7-27) to eliminate the shift in position of the spot as the RANGE switch is changed from 100 μs to 1 ms.

24. Check Random Mode Minimum Triggering Rates

a. Connect the RG213/U 5 ns coaxial cable to the Type 111 Charge Line connector and the RG58C/U 5 ns coaxial cable to the Pulse Output connector. Connect the other end of the RG58C/U cable to the 10X and 2X 50 Ω attenuators in series. Connect the output attenuator to the sampling unit Input A connector. Set the Type 111 Pulse Generator controls: Repetition rate about 10 o'clock, Range 10 KC and Output Polarity to +.

b. Set the sampling unit for 200 mV/Div deflection factor and for internal triggering from channel A.

c. Type 3T2 control settings:

RANGE	100 ns
START POINT	BEFORE TRIGGER
DISPLAY MAG	X1
TIME MAGNIFIER	X1
Triggering	Internal +

d. Place the 10X probe onto the test oscilloscope input and set the vertical deflection factor to 5 V/div including probe attenuation (Type W: Input Atten 10, Millivolts/Cm 50). Attach the probe ground clip to the frame and the tip to pin AE of the Logic Board. Set the sweep rate at 20 μs/div and triggering for internal minus, AC coupled.

e. Adjust the Type 3T2 TRIG SENSITIVITY control for a stable display like Fig. 7-28A and the test oscilloscope triggering controls for a display similar to Fig. 7-29. Now adjust the Type 111 Repetition Rate control until the rate meter ramp knee (shown in Fig. 7-29) is at least 100 μs after the ramp starts. This gives a triggering rate of 10 kHz or lower.

Check that the indicator oscilloscope display is proper and that the LOW REP RATE lamp does not glow, even dimly.

f. Disconnect the signal input to the sampling unit and note that the CRT display stops and that the LOW REP RATE lamp glows. To determine the true useable low frequency trigger rate for the instrument being checked reconnect the signal cable and turn the Type 111 Repetition Rate control farther counterclockwise until the LOW REP RATE lamp begins to flicker dimly (the CRT display will appear normal). Check the rate meter ramp time from its start to the knee; the reciprocal of that time is the minimum trigger repetition rate.

g. Repeat the above procedure for each Type 3T2 RANGE, using the data of Table 7-4. In each case, the rate meter ramp knee must occur at or later than the time listed.

Should all ramps run short and the instrument not meet minimum triggering limits on any range, check the values of R587 and R588 and check that D588 is not conducting in the reverse direction. If any one range rate meter ramp is short, check the rate meter ramp capacitor as listed in Table 7-4.

h. With the Type 3T2 RANGE switch at 10 μS and the Type 111 Range switch at 100 CPS, the indicator oscilloscope display will be similar to Fig. 7-28C. Here, a storage oscilloscope was used to show that the pulse is still displayed. For this RANGE, and the other longer ranges, do not adjust the Type 3T2 TRIG SENSITIVITY control. The Type 111 pulse was chosen for this check because the triggering circuits respond well to such a pulse regardless of repetition rate. In addition, the indicator oscilloscope display will appear as just an occasional dot even when the system is performing correctly at the lowest trigger repetition rate of 10 Hz.

Disconnect the 10X probe and the Type 111 signal cable.

25. Check Variable Samples/Div (SN B080970 and up)

a. Set the DISPLAY MODE switch to NORMAL, the START POINT switch to WITH TRIGGER the RANGE switch to 10 μs and the SAMPLES/DIV control fullly clockwise.

b. Check that the trace consists of 12 dots/div or less. See Fig. 7-30.

c. Set the SAMPLES/DIV control counterclockwise and adjust R453, located on X10 Magnifier board, so the spot requires one second to cross the graticule. This adjustment is on the X10 Magnifier board, which is mounted just behind the bottom portion of the 3T2 front panel.

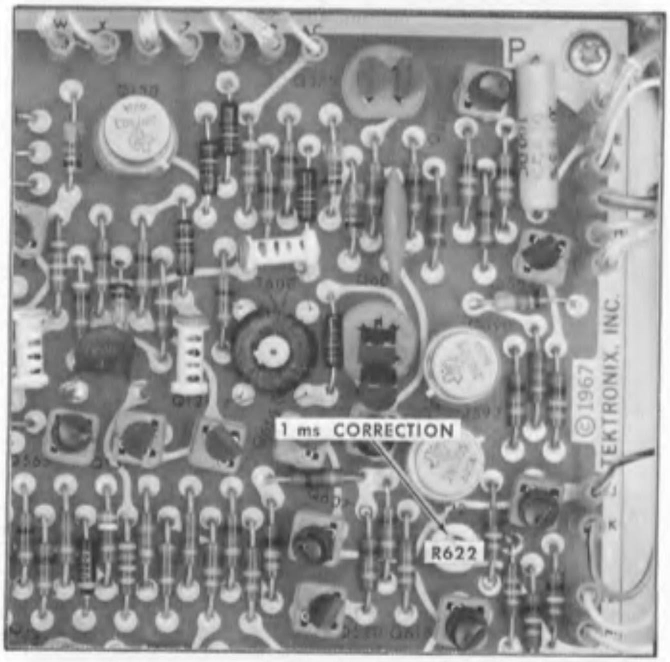
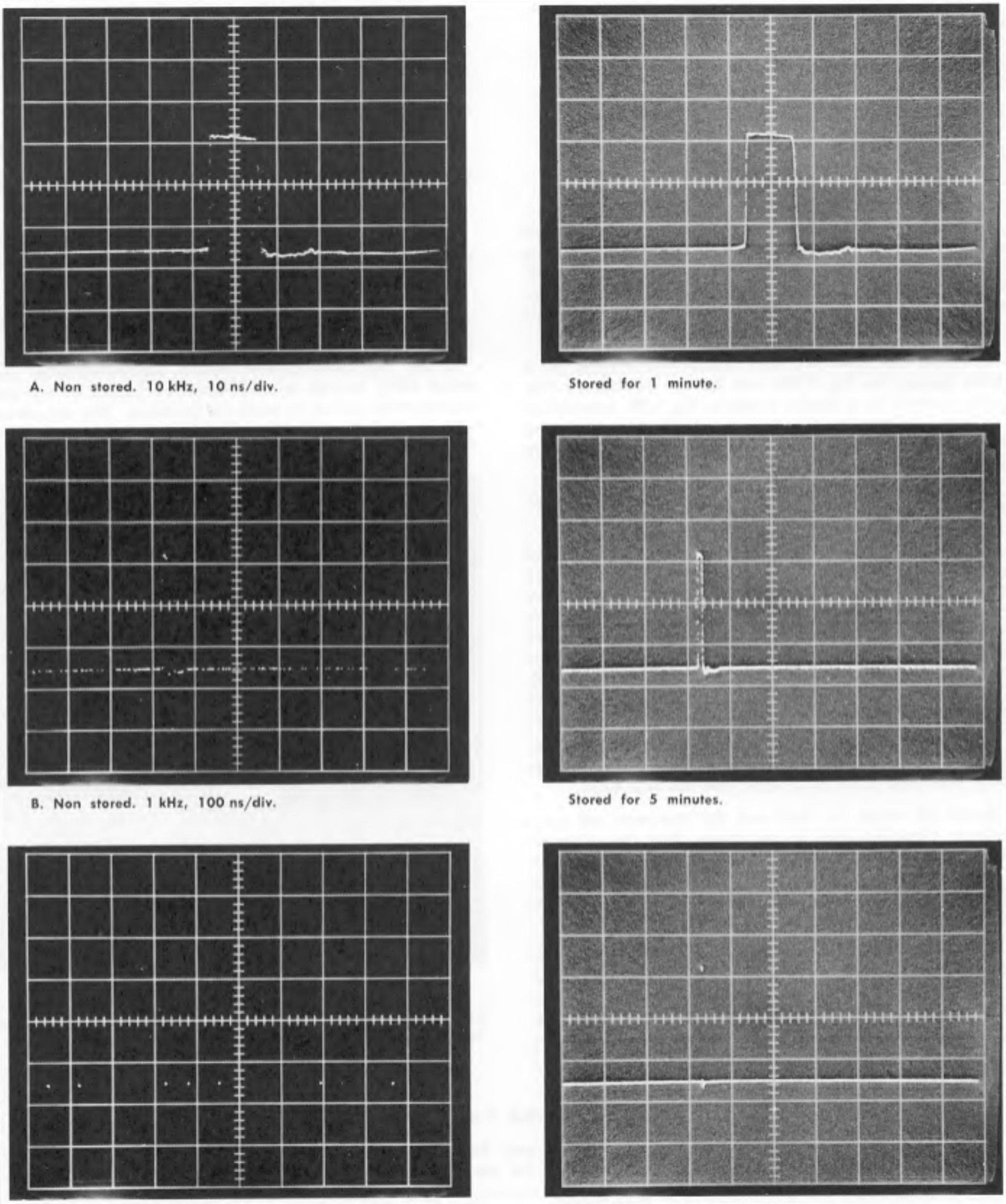


Fig. 7-27. Location of 1 ms Correction adjustment, Logic Board Assembly, left side of instrument.

TABLE 7-4

Triggering Rates and Test Oscilloscope Sweep Rates for part h below.

Range	Min. Freq.	Test 'scope sweep rate	Min. Time of one ramp	Rate Meter Ramp capacitor
100 ns	10 kHz	20 μs/div	100 μs	C594
1 μs	1 kHz	0.2 ms/div	1 ms	C593
10 μs	100 Hz	2 ms/div	10 ms	C592
100 μs & 1 ms	10 Hz	20 ms/div	100 ms	C591



A. Non stored. 10 kHz, 10 ns/div.

Stored for 1 minute.

B. Non stored. 1 kHz, 100 ns/div.

Stored for 5 minutes.

C. Non stored. 100 Hz, 1 μs/div.

Stored for 5 minutes.

Fig. 7-28. Indicator oscilloscope displays for step 24.

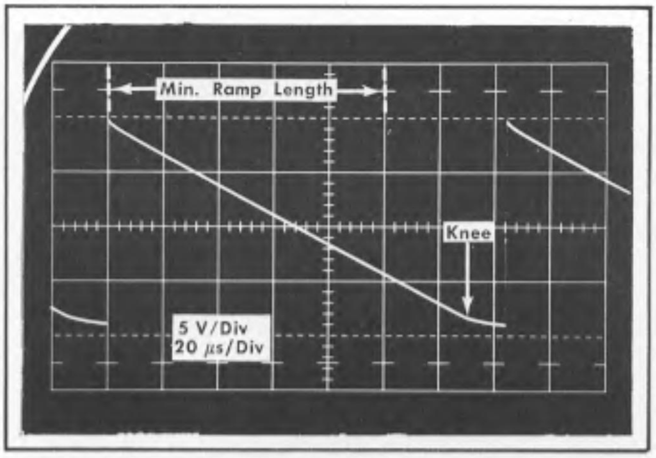


Fig. 7-29. Rate meter ramp showing BEFORE TRIGGER minimum rate limit is acceptable; step 24 (e).

26. Adjust Calibrated Samples/Div To 100 For Digital Use

a. Set the RANGE switch to 10 μs and the internal SAMPLES/DIV switch to 100.

b. Connect the Time-Mark Generator, set for 10 ns output, Marker Output through a 50 Ω coaxial cable, a BNC to GR

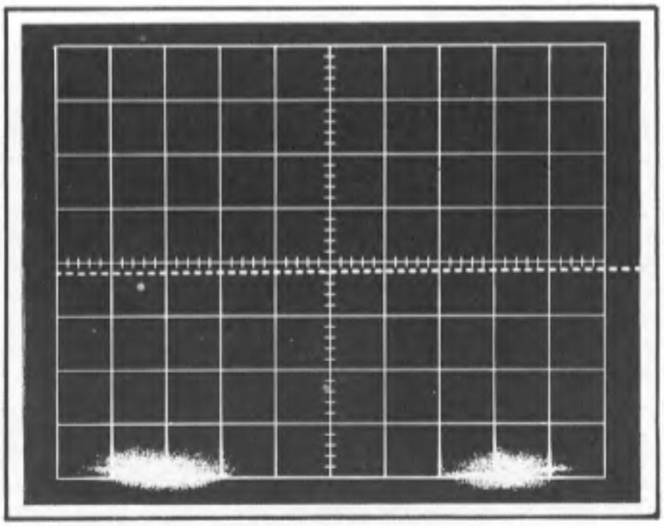


Fig. 7-30. Typical display of 12 dots/div with Samples/Div control turned fully clockwise.

d. Check for a display of 5 cycles or less; see Fig. 7-31A. Each cycle corresponds to 0.1% tolerance.

e. Adjust C452, see Fig. 7-31B, for the minimum number of cycles possible.

f. Disconnect the Time-Mark Generator and turn off the Indicator Oscilloscope; disconnect the plug-in extension cable and insert the Type 3T2 into the Indicator Oscilloscope plug-in compartment. Secure the Type 3T2 with the securing screw.

g. Turn on the Indicator Oscilloscope and allow about 3 minutes for the instrument to warm up.

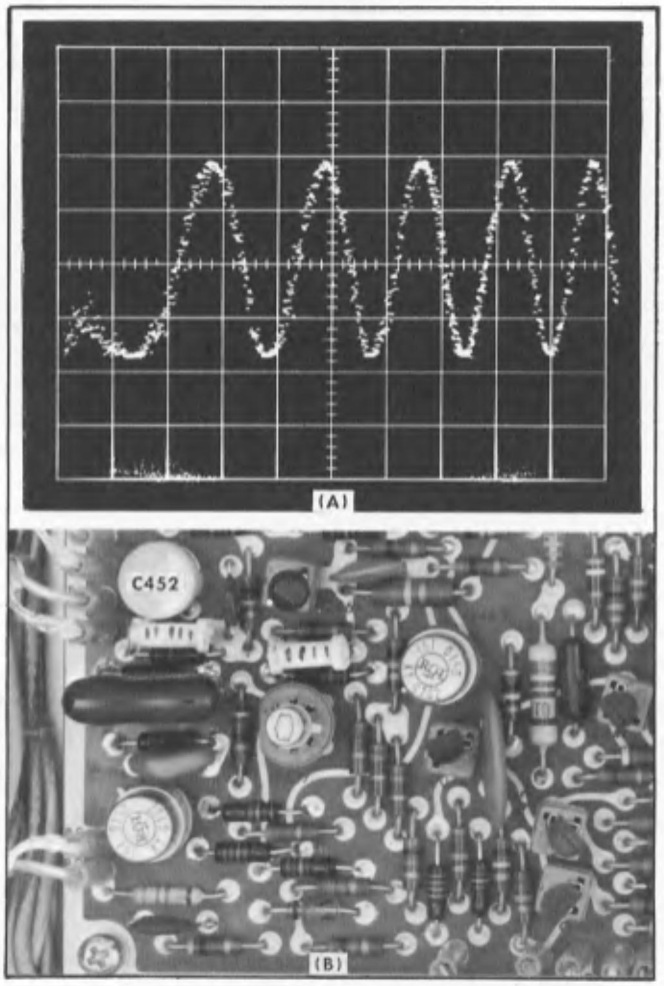


Fig. 7-31. (A) Typical display for checking 100 dots/div, calibrated, and (B) Location of C452, Logic Board Assembly, left side of instrument.

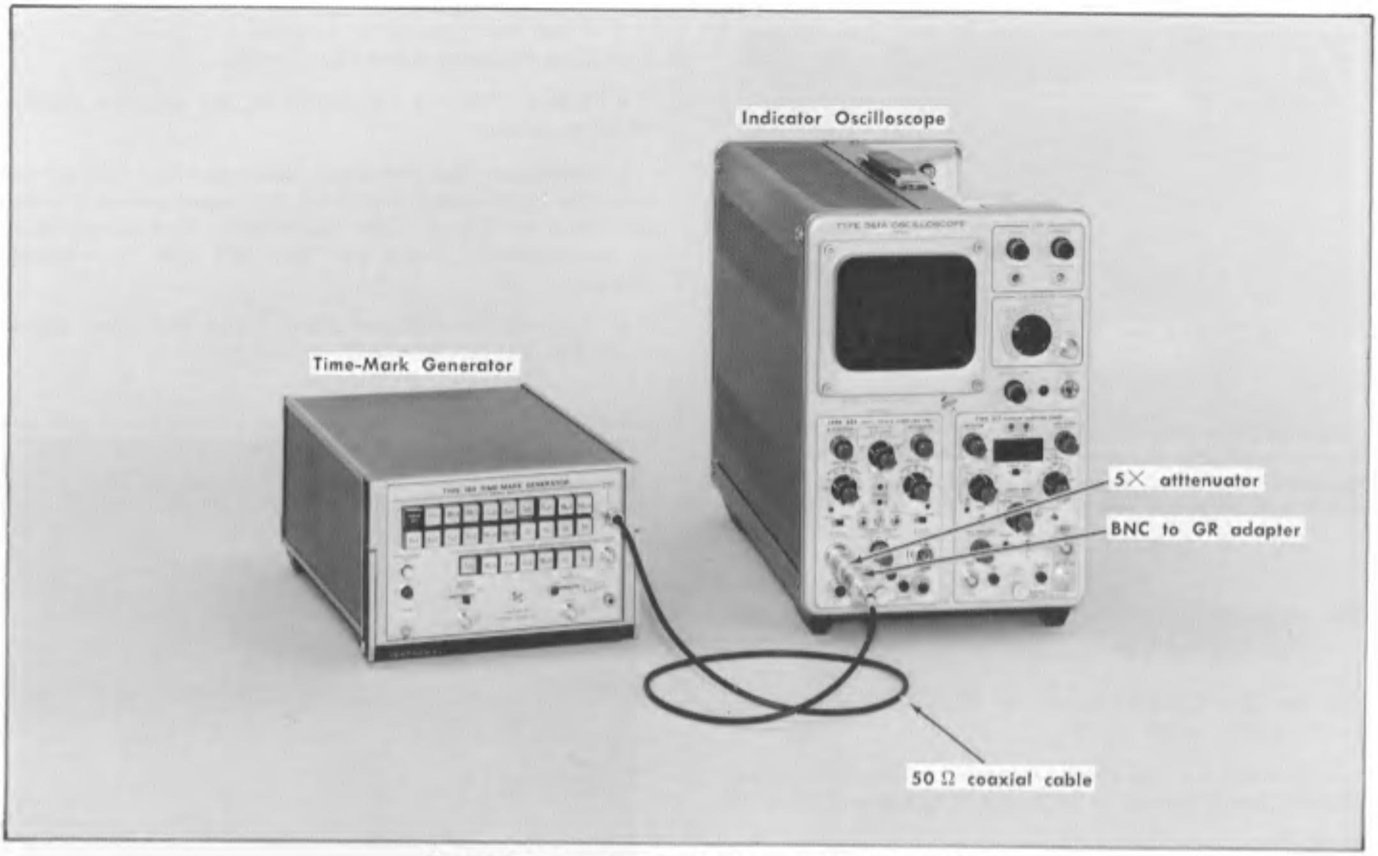


Fig. 7-32. Test equipment setup for steps 26 through 28.

Control Settings:

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	10 μs
START POINT	**WITH TRIGGER**
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
MANUAL SCAN	Midrange
TRIG SENSITIVITY	Stable display
RECOVERY TIME	As desired
POLARITY	+
SOURCE	**INT**
SAMPLES/DIV (Internal)	**100 (Up)**

Vertical Sampling Unit

Channel A mV/div	100

27. Check Timing Accuracy

a. Connect the Time-Mark Generator to the Vertical Input A connector through a 50 Ω coaxial cable, a BNC to GR adapter and a 5× attenuator.

b. Check the timing accuracy of the Type 3T2 according to Table 7-5. See Fig. 7-33. Make a note of tolerance of the DISPLAY MAG and TIME MAGNIFIER positions and compare to the RANGE position tolerance. Check the timing with the TIME POSITION control clockwise, centered and counterclockwise with the first part off the sweep excluded as listed in Table 7-5.

c. Check that the algebraic addition of the tolerances at various combinations of settings of the TIME MAGNIFIER and the RANGE switches are within ±3%, (0.24 div measured over 8 div) with the DISPLAY MAG switch at ×1 and within ±5%, (0.4 div over 8 div) with the DISPLAY MAG switch at ×10.

d. Set the START POINT switch to WITH TRIGGER.

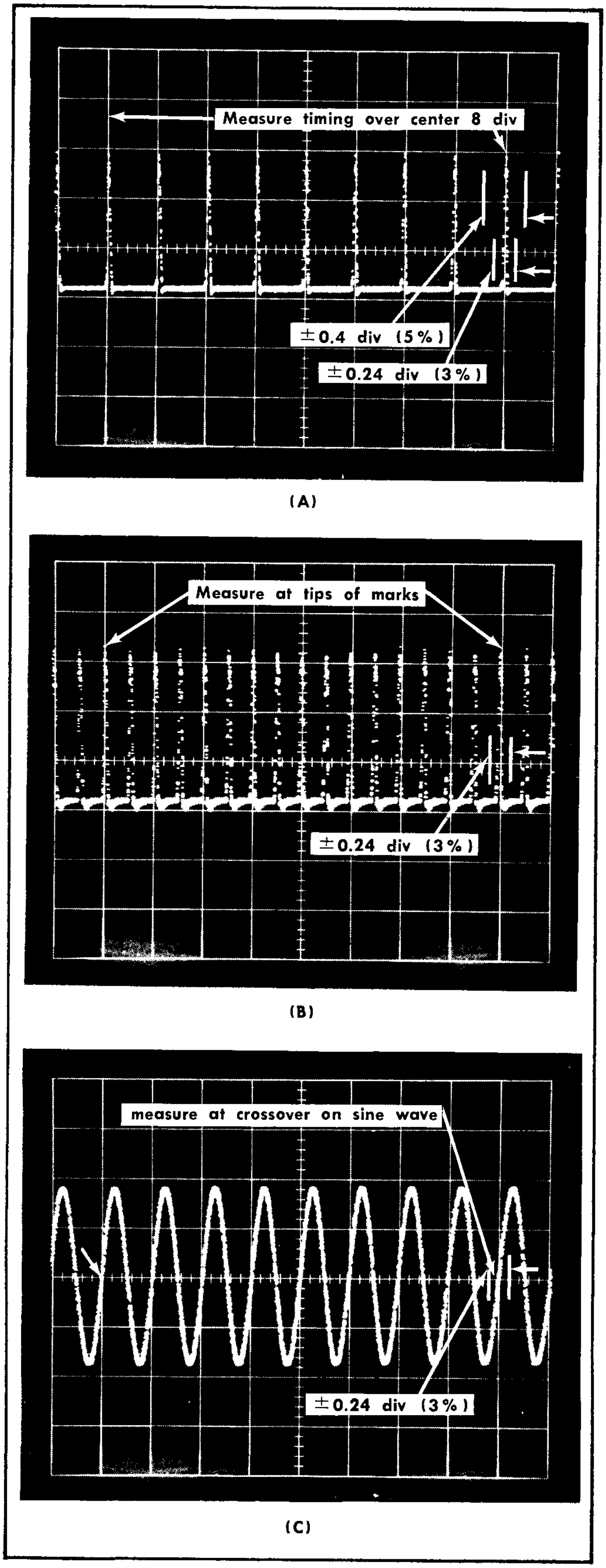


Fig. 7-33. Typical Indicator Oscilloscope displays for checking the timing accuracy.

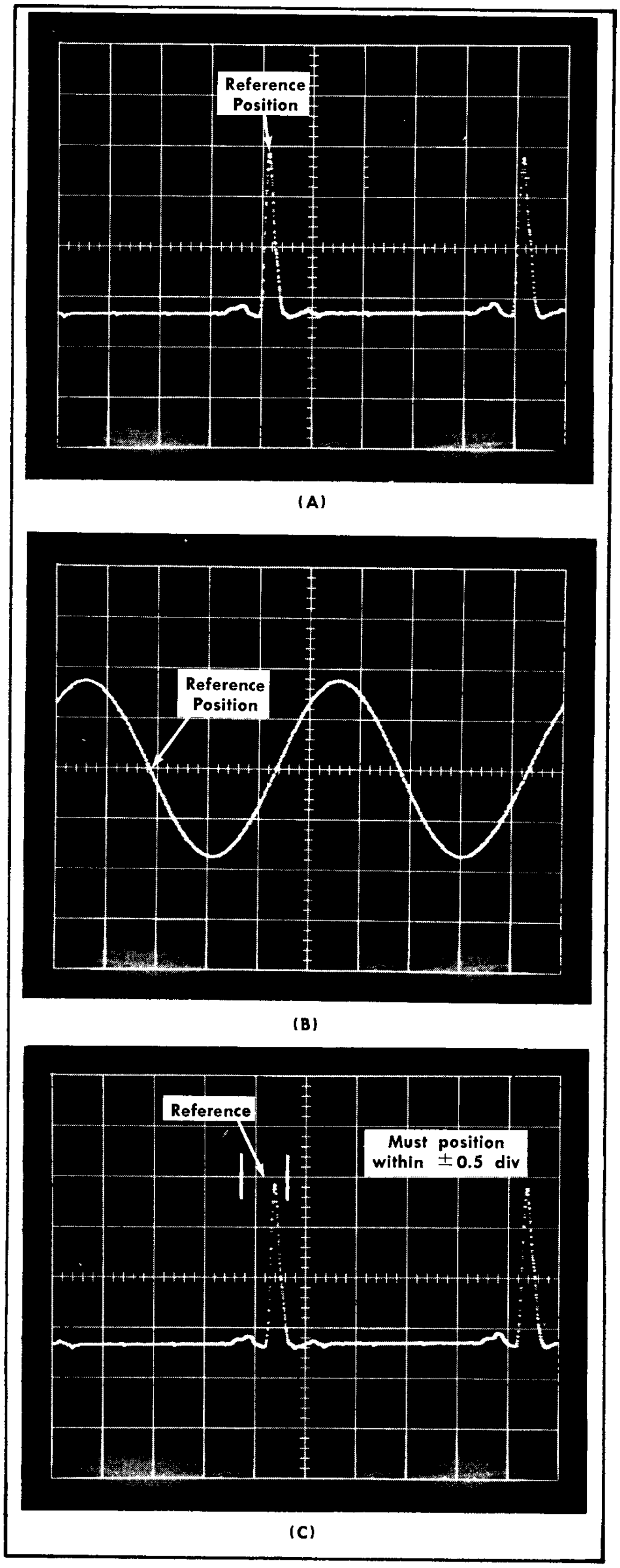
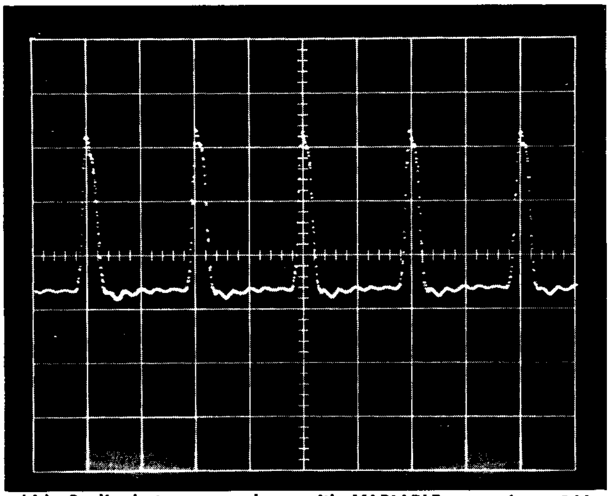


Fig. 7-34. Typical Indicator Oscilloscope displays for checking the Time Position control ranges. (A) and (B) Show reference position and (C) Display after Time Position control is turned fully counterclockwise.

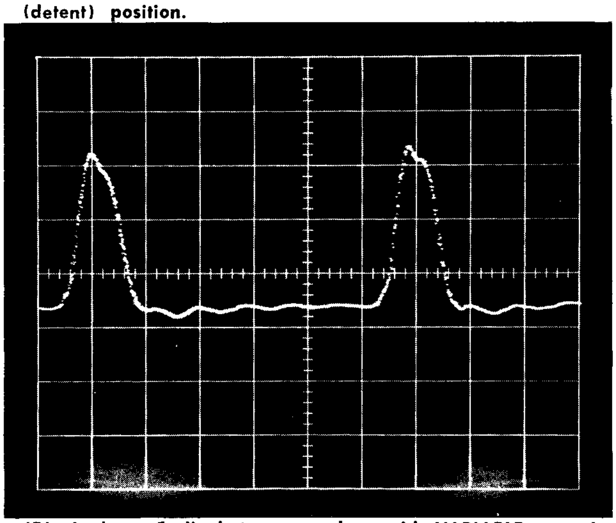
TABLE 7-5

Switch	Setting	Input Signal	Display	Exclude from start of sweep with TIME POSITION control	Noted Tolerance
DISPLAY MAG	×10 Reset to ×1	10 μs	1 marker/div	150 ns	
TIME MAGNIFIER	×2	.5 μs	1 marker/div	150 ns	
	×5	.1 μs	2 markers/div		
	×10	.1 μs	1 marker/div		
	×20	50 ns	1 cycle/div		
	×50	20 ns	1 cycle/div		
	Reset to ×1				
RANGE[1]	10 μs	1 μs	1 marker/div	150 ns	
	1 ms	100 μs	1 marker/div	15 μs	
	100 μs	10 μs	1 marker/div	1.5 μs	
	1 μs	.1 μs	1 marker/div	15 ns	
	100 ns	10 ns	1 cycle/div	10 ns	

[1]Check with the START POINT switch at WITH TRIGGER and BEFORE TRIGGER settings. The 1 ms position, BEFORE TRIGGER mode, requires use of a storage oscilloscope.



(A) 2 div between markers with VARIABLE control at CAL (detent) position.



(B) At least 5 div between markers with VARIABLE control turned fully clockwise.

Fig. 7-35. Indicator Oscilloscope displays for checking the Time Magnifier VARIABLE control range.

28. Check Time Position Ranges

a. Refer to Table 7-6 and check the positioning range of the TIME POSITION control on each RANGE switch setting.

b. Set the RANGE switch and the Time Mark Generator as given in Table 7-6 and set the TIME POSITION and FINE controls fully clockwise.

c. Observe the location of the marker near the left edge of the CRT screen; see Fig. 7-34A or B. This will be the reference marker position; see Fig. 7-34C.

d. Turn the TIME POSITION control slowly counterclockwise and count the number of markers that pass through the reference-marker position; see Fig. 7-34C.

TABLE 7-6

TIME POSITION Range Check

RANGE	Input Signal	Number of markers to move through reference position
100 ns	50 ns	2 cycles
1 μs	.5 μs	2 markers
10 μs	5 μs	2 markers
100 μs	50 μs	2 markers
1 ms	.5 ms	2 markers

e. Check that the Indicator Oscilloscope display in which the number of markers passing the reference-marker position equals the number listed in the last column of the Table within 0.5 div.

29. Check Time Magnifier Variable Range

a. Set the RANGE switch to 1 μs and the TIME MAGNIFIER switch to ×2.

b. Apply .1 μs markers from the Time Mark Generator and observe 1 marker per two divisions on the CRT, see Fig. 7-35A.

c. Turn the Time Magnifier VARIABLE control fully clockwise and observe the marker display.

d. Check that the markers are at least 5 divisions apart; see Fig. 7-35B.

e. Return the Time Magnifier VARIABLE control to CAL position and set the TIME MAGNIFIER switch to ×1.

NOTES

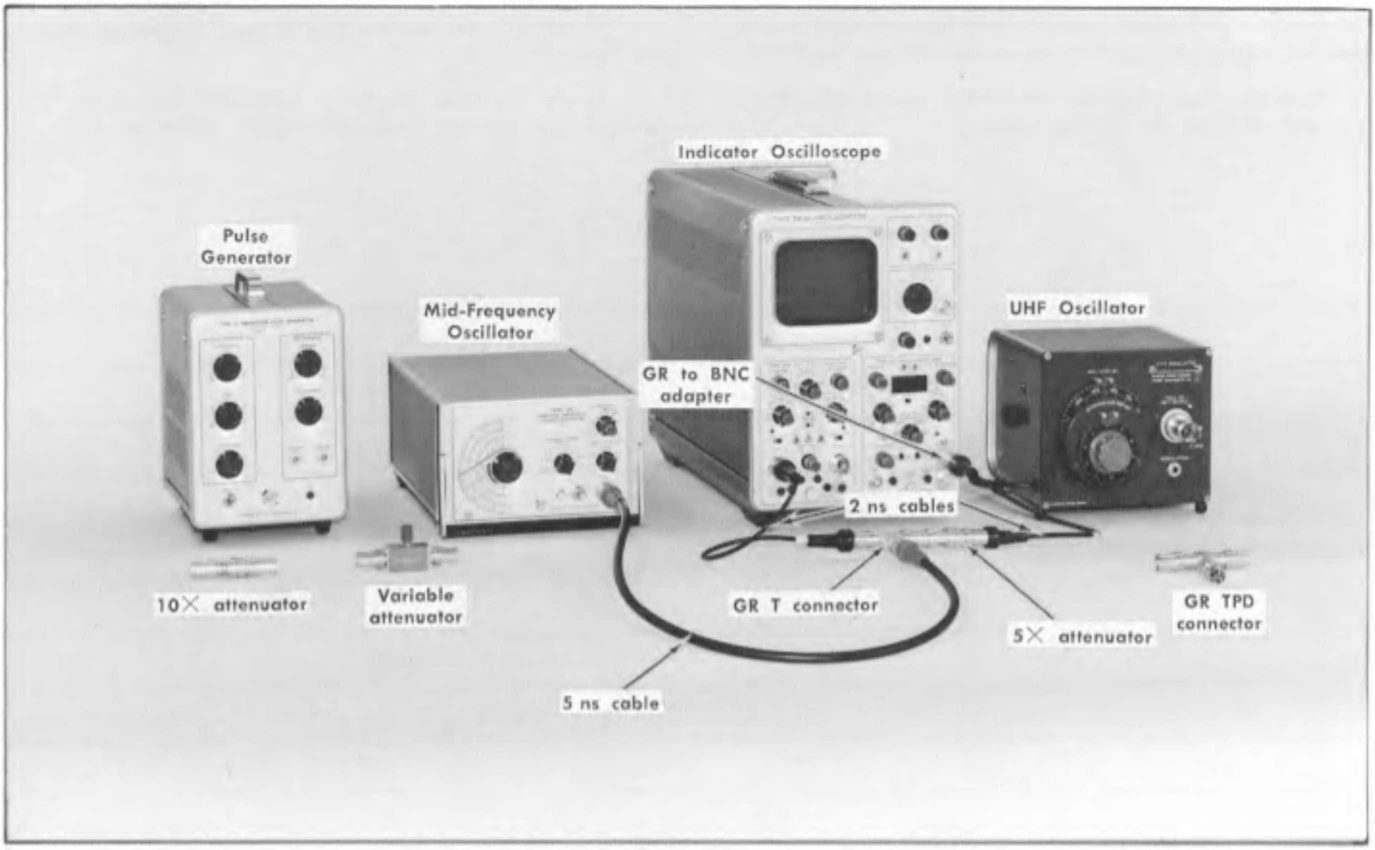


Fig. 7-36. Initial test equipment setup for step 29.

Control Settings:

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	**100 ns**
START POINT	WITH TRIGGER
DISPLAY MAG	×1
TIME MAGNIFIER	×1
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
MANUAL SCAN	Midrange
TRIG SENSITIVITY	Stable display
RECOVERY TIME	As desired
POLARITY	+
SOURCE	INT
SAMPLES/DIV (Internal)	100 (Up)

Vertical Sampling Unit

Channel A mV/div	100

30. Check Trigger Jitter

The trigger jitter is checked at sine wave frequencies of 30 MHz and 1 GHz and at a 100 kHz repetition rate of 2 ns pulses.

30 MHz Sine Wave

a-1. Initial test equipment setup is shown in Fig. 7-36. Connect the Type 191 to the GR Tee connector through a 5 ns cable, one side of the Tee connector to the Vertical Input A connector through a 2 ns cable and connect the other side of the Tee connector to the Type 3T2 50 Ω TRIGGER INPUT connector through a 5× attenuator, a 2 ns cable and a GR to BNC adapter.

a-2. Set the Type 191 for an output signal of 30 MHz and the amplitude for 5 divisions of display; see Fig. 7-37A. Use 8 divisions for the display amplitude if the Vertical Sampling Unit is a Type 3S1.

a-3. Obtain a stable display with the TRIG SENSITIVITY control clockwise into free-run operation. Center the display with the DC Offset control.

a-4. Set the TIME MAGNIFIER switch to ×50 and center the rising portion of the display with the TIME POSITION control (Fig. 7-37B).

a-5. Set the Vertical mV/div switch to 2 and recenter the display with the TIME POSITION control. Readjust the TRIG SENSITIVITY and RECOVERY TIME controls for a stable display.

a-6. Check that the trigger jitter is not greater than 1 div (200 ps). See Fig. 7-37C.

a-7. Change the SOURCE Switch to EXT and again check that the jitter is within 200 ps. Use 5 divisions display amplitude with a Type 3S1.

a-8. Set the POLARITY switch to — and check that the jitter is not greater than 200 ps, see Fig. 7-37D.

a-9. Set the POLARITY switch to + and check that the jitter is within 200 ps.

a-10. Disconnect the signal cable from the Type 191.

1 GHz Sine Wave

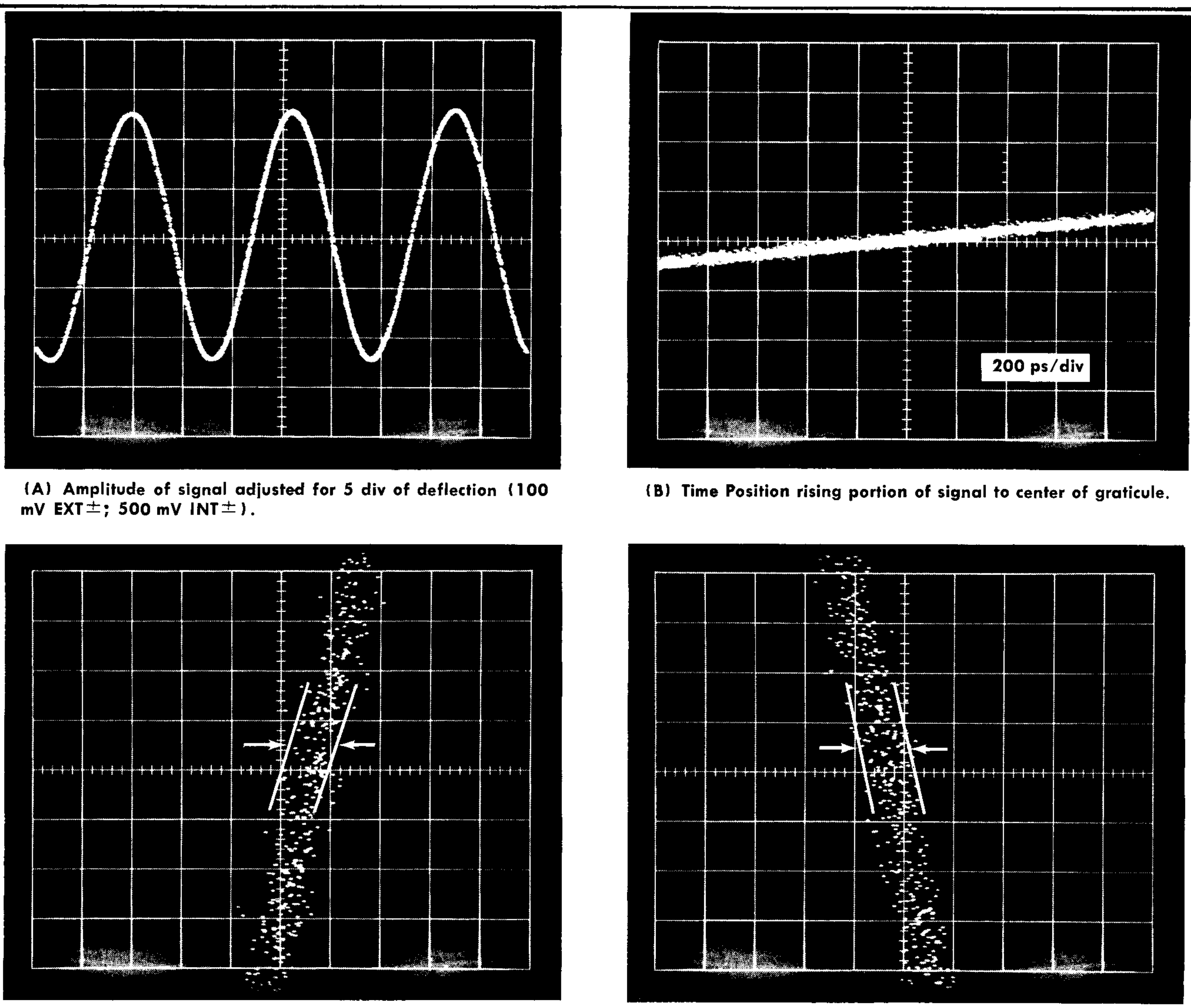
b-1. Set the Vertical mV/div switch to 100 and the Type 3T2 SOURCE switch to EXT.

b-2. Connect the 1-GHz Oscillator to the variable attenuator, 5 ns cable, 2× attenuator, GR TPD connector, one side of the TPD connector to the Vertical Input A connector through a 2 ns cable and connect the other side of the TPD connector to a 5× attenuator, a 2 ns cable and a GR to BNC adapter to the 1 MΩ/UHF SYNC TRIGGER INPUT connector.

b-3. Set the variable attenuator for an amplitude of 3.5 div; see Fig. 7-38A.

b-4. Obtain a stable display with the TRIG SENSITIVITY control in free-run operation, nearly at full clockwise setting.

b-5. Set the Type 3T2 DISPLAY MAG switch to ×10 and the TIME MAGNIFIER switch to ×50. Use the TIME POSITION control to center the rising portion of the sine wave.



(A) Amplitude of signal adjusted for 5 div of deflection (100 mV EXT±; 500 mV INT±).

(B) Time Position rising portion of signal to center of graticule.

(C) Trigger jitter should be 1 div (200 ps) or less (INT+ or EXT+).

(D) Trigger jitter should be 1 div (200 ps) or less (INT— or EXT—).

Fig. 7-37. Typical displays for checking 30 MHz trigger jitter.

b-6. Set the Vertical mV/div switch to 10 and use the DC Offset control to center the rising portion of the signal.

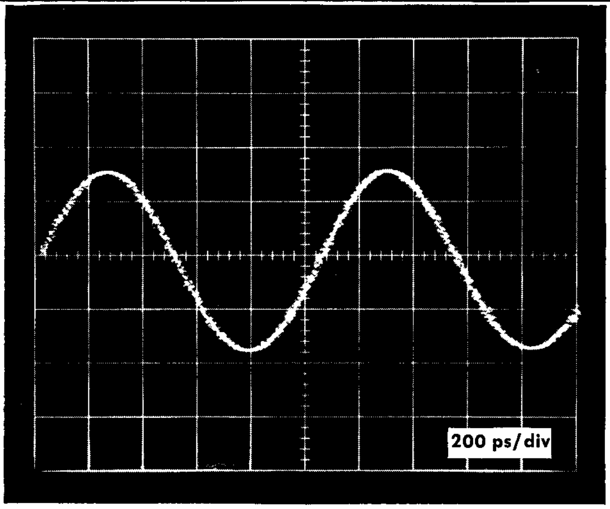
b-7. Check that the trigger jitter is not more than 50 ps, see Fig. 7-38B. (Set the POLARITY switch to — and check for best synchronizing.)

b-8. Disconnect the Oscillator.

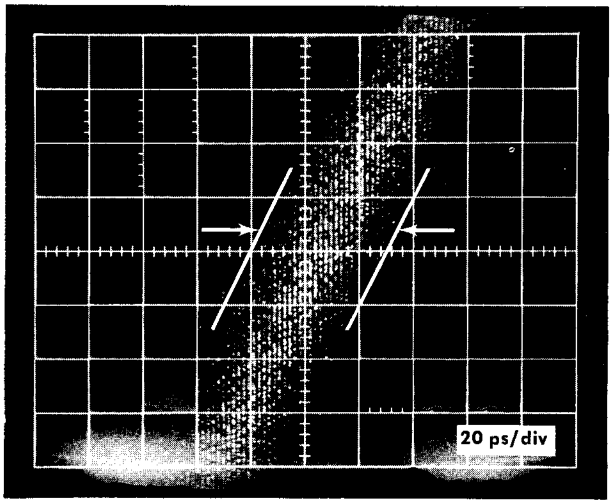
2 ns ± Pulse

c-1. Set the Type 3T2 controls as follows:

START POINT	WITH TRIGGER
TIME POSITION	Fully clockwise
DISPLAY MAG	×1
TIME MAGNIFIER	×10
SOURCE	INT
POLARITY	+

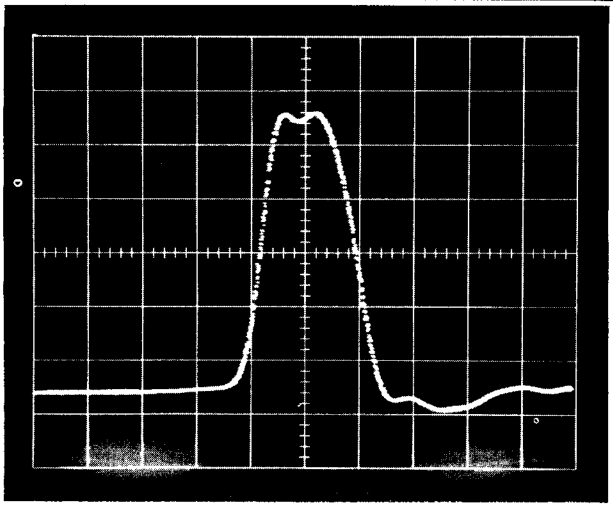


(A) Signal amplitude adjusted for 3.5 div (100 mV applied to 1 MΩ/UHF SYNC TRIGGER INPUT) vertical deflection.

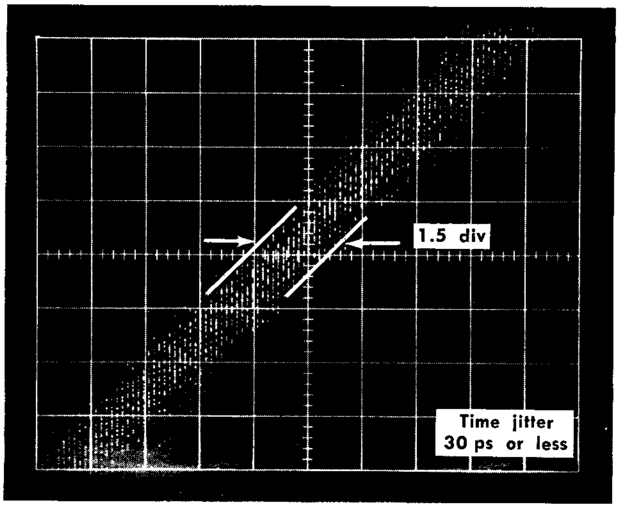


(B) Trigger jitter should be 2.5 div (50 ps) or less (EXT±).

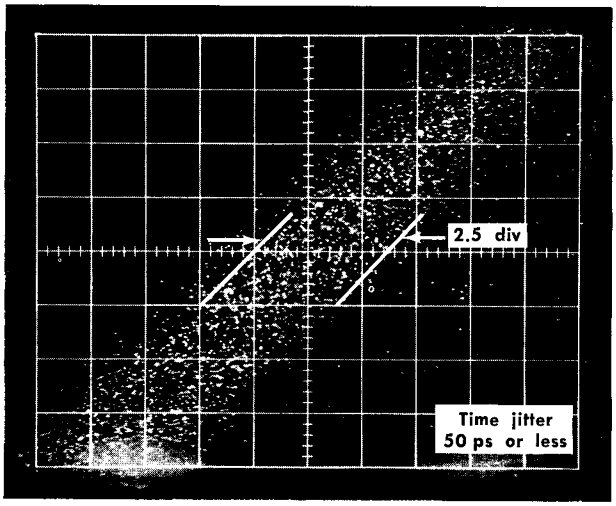
Fig. 7-38. Typical displays of 1 GHz trigger jitter. (B) is a 2 s exposure.



(A) 250 mV pulse at 1 ns/div, 50 mV/div.



(B) With Trigger, 20 ps/div, 10 mV/div.



(C) Before Trigger, 20 ps/div, 10 mV/div.

Fig. 7-39. Typical displays of 2 ns pulse trigger jitter. (B) and (C) are 2 s exposures.

c-2. Connect the Pulse Generator, set for 100 kHz and + Output, through a 10× attenuator, variable atenuator, 5 ns cable, GR Tee connector, one side of the Tee connector to the Vertical Input A through a 2 ns cable. Connect the other side of the Tee connector to a 5× attenuator, a 2 ns cable and a GR to BNC adapter to the 50 Ω TRIGGER INPUT connector.

c-3. Center the 2 ns pulse with the TIME POSITION control, set the TRIG SENSITIVITY control for a stable display and set the variable attenuator for a display amplitude of 5 div (with Type 3S76), see Fig. 7-39A, or for a display amplitude of 8 div (with Type 3S1).

c-4. Set the DISPLAY MAG switch to 10 and the TIME MAGNIFIER switch to ×50. Use the TIME POSITION control to set the rising portion of the pulse at the center of the graticule.

c-5. Set the Vertical mV/div switch to 10 and use the DC Offset control to center the rising portion of the pulse on the graticule.

c-6. Check the display for 30 ps or less of time jitter; see Fig. 7-39B. Change signal amplitude so the trigger circuit receives a 150 mV peak pulse and check for 20 ps or less time jitter.

c-7. Check the 2 ns pulse trigger jitter as listed in Table 7-7. In all cases, the trigger jitter should not exceed 30 ps with the START POINT switch at WITH TRIGGER, and 50 ps with the START POINT switch at BEFORE TRIGGER.

TABLE 7-7

START POINT	SOURCE	POLARITY	2 ns Pulse Output
WITH TRIGGER Fig. 7-37B	INT	+	+
		−	−
	EXT	−	−
		+	+
BEFORE TRIGGER Fig. 7-37C	EXT	+	+
		−	−
	INT	−	−
		+	+

NOTE

A Type 3S76 may not permit a jitter free display with greater than 5 division display amplitude. The Type 3S1 may require adjustment of the Dot Response control for low jitter.

c-8. Disconnect the Pulse Generator.

NOTES

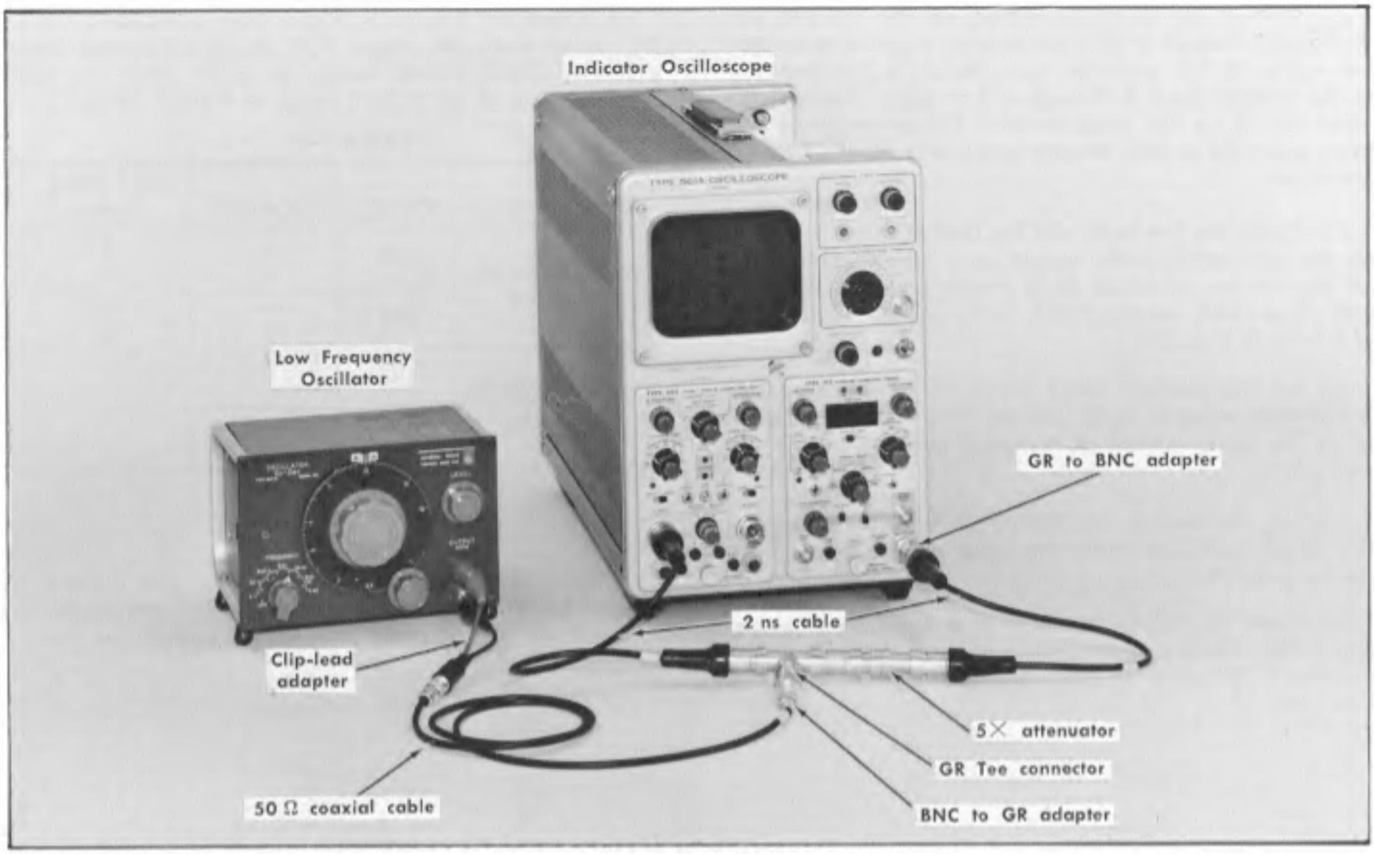


Fig. 7-40. Initial test equipment setup for steps 30 and 31.

Type 3T2

TIME POSITION	Midrange
Time Position FINE	Midrange
HORIZ POSITION	Midrange
SAMPLES/DIV	Midrange
RANGE	**1 ms**
START POINT	**WITH TRIGGER**
DISPLAY MAG	**×1**
TIME MAGNIFIER	**×1**
Time Magnifier VARIABLE	CAL
DISPLAY MODE	NORMAL
MANUAL SCAN	Midrange
TRIG SENSITIVITY	Stable display
RECOVERY TIME	As desired
POLARITY	+
SOURCE	**EXT**
SAMPLES/DIV (Internal)	100 (Up)

Vertical Sampling Unit

Channel A mV/div	**100**

31. Check Triggering Frequency Range

a. Connect the Low Frequency Oscillator through a clip-lead adapter, a 50 Ω coaxial cable, a BNC to GR adapter and GR Tee-connector. Connect one side of the Tee-connector through a 2 ns cable to the Vertical Input A connector, and the other side through a 5× attenuator, 2 ns cable and GR to BNC adapter to the 1 MΩ/UHF SYNC TRIGGER INPUT connector. Test equipment setup is shown in Fig. 7-40.

b. Adjust the Oscillator for a display amplitude of 5 div at 10 kHz.

c. Check that a stable display is obtained with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls; see Fig. 7-41A. Set the POLARITY switch to — and check for a stable display with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls.

d. Set the Oscillator for 100 kHz and set the RANGE switch to 100 μs. Set the amplitude for 5 divisions.

e. Check that a stable display is obtained with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls, (see Fig. 7-41B), then set the POLARITY switch to + and check for a stable display with adjustment of the TRIG SENSITIVITY and RECOVERY TIME controls.

f. Change the TRIGGER INPUT connection to the 50 Ω TRIGGER INPUT connector and check for stable triggering in both + and — POLARITY of the 100 kHz sine wave.

g. Disconnect the Oscillator. Set the RANGE switch to 100 ns.

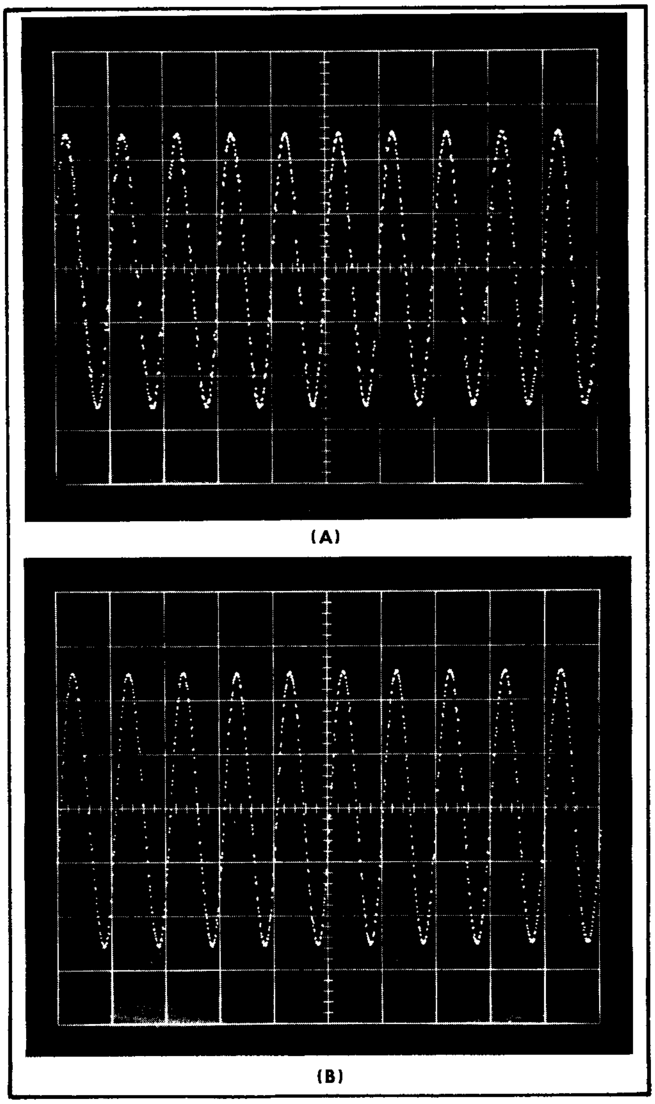


Fig. 7-41. Typical trigger displays of (A) 10 kHz and (B) 100 kHz sine waves.

32. Check Trigger Kickout

a. Connect a 2 ns cable and a GR to BNC adapter from the Vertical Input A connector to the Type 3T2 50 Ω TRIGGER INPUT connector.

b. Set the POLARITY switch to +, the SOURCE switch to EXT and set the TIME POSITION controls fully clockwise.

c. Set the TRIG SENSITIVITY control for a free-running trace and measure the amplitude of the pulse on the Indicator Oscilloscope, Fig. 7-42.

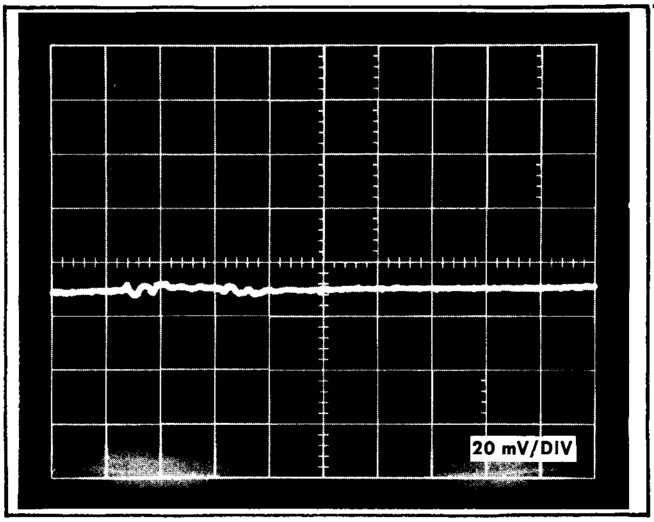


Fig. 7-42. Typical display of Trigger Kickout.

d. Check that the Trigger Kickout Pulse is within ±20 mV or less.

e. Disconnect the 2 ns cable.

This completes the calibration procedure for all systems except digital readout. Test instruments and equipment may now be disconnected. If the Type 3T2 is used with a Type 6R1A or Type 230 and a Type 567 or Type 568 Oscilloscope, step 32 should be performed to assure correct operation.

33. Operational Check With Digital Readout System

The SAMPLES/DIV (internal) switch must be at 100. The Decimal and Units lamps go out when the Time Magnifier VARIABLE is moved from the CAL position or when the DISPLAY MODE switch is at MANUAL or EXT HORIZ.

Table 7-8 lists the Units and Decimal lamps to be lit with the Type 3T2 RANGE and TIME MAGNIFIER switch settings.

TABLE 7-8

RANGE	TIME MAGNIFIER	Decimal	Units
1 ms	×1 ×2 ×5	0 X 0 0 0	ms
	×10 ×20 ×50	0 0 0 X 0	μs
100 μs	×1 ×2 ×5	0 0 0 X 0	μs
	×10 ×20 ×50	0 0 X 0 0	μs
10 μs	×1 ×2 ×5	0 0 0 X 0	μs
	×10 ×20 ×50	0 0 0 X 0	μs
1 μs	×1 ×2 ×5	0 X 0 0 0	μs
	×10 ×20 ×50	0 0 0 X 0	ns
100 ns	×1 ×2 ×5	0 0 0 X 0	ns
	×10 ×20 ×50	0 0 X 0 0	ns

NOTES

PARTS ORDERING INFORMATION

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

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

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

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound

SECTION 8

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Bulbs			
B580	150-0035-00			Neon	A1D T2		
B791	150-0035-00			Neon	A1D T2		
B793	150-0035-00			Neon	A1D T2		
B900	150-0057-00			Incandescent	w/1.5 lg timed leads		
B901	150-0057-00			Incandescent	w/1.5 lg timed leads		
B902	150-0057-00			Incandescent	w/1.5 lg timed leads		
B910	150-0057-00			Incandescent	w/1.5 lg timed leads		
B911	150-0057-00			Incandescent	w/1.5 lg timed leads		
B912	150-0057-00			Incandescent	w/1.5 lg timed leads		
B913	150-0057-00			Incandescent	w/1.5 lg timed leads		
B914	150-0057-00			Incandescent	w/1.5 lg timed leads		
B915	150-0057-00			Incandescent	w/1.5 lg timed leads		
B920	150-0057-00			Incandescent	w/1.5 lg timed leads		
B921	150-0057-00			Incandescent	w/1.5 lg timed leads		
B922	150-0057-00			Incandescent	w/1.5 lg timed leads		

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C1	281-0610-00			2.2 pF	Cer	200 V	
C2	283-0079-00			0.01 μF	Cer	250 V	
C5	283-0000-00			0.001 μF	Cer	500 V	
C13	283-0059-00			1 μF	Cer	25 V	+80%—20%
C17	283-0026-00			0.2 μF	Cer	25 V	
C24	283-0080-00			0.022 μF	Cer	25 V	+80%—20%
C26	283-0026-00			0.2 μF	Cer	25 V	
C27	283-0039-00			0.001 μF	Cer	500 V	
C34	283-0023-00			0.1 μF	Cer	10 V	
C36	283-0026-00			0.2 μF	Cer	25 V	
C37	283-0039-00			0.001 μF	Cer	500 V	
C43	283-0080-00			0.022 μF	Cer	25 V	+80%—20%
C45	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C48	283-0039-00			0.001 μF	Cer	500 V	
C55	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C58	283-0039-00			0.001 μF	Cer	500 V	
C59	283-0080-00			0.022 μF	Cer	25 V	+80%—20%
C62	283-0060-00			100 pF	Cer	200 V	5%
C66	283-0039-00			0.001 μF	Cer	500 V	
C74	283-0059-00			1 μF	Cer	25 V	+80%—20%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C76	281-0636-00			100 pF	Cer	500 V	
C80	283-0000-00			0.001 μF	Cer	500 V	
C85	283-0000-00			0.001 μF	Cer	500 V	
C90	281-0504-00			10 pF	Cer	500 V	10%
C100	281-0636-00			100 pF	Cer	500 V	
C140	283-0114-00			0.0015 μF	Cer	200 V	
C142	281-0523-00			100 pF	Cer	350 V	
C146	281-0518-00			47 pF	Cer	500 V	
C148	281-0523-00			100 pF	Cer	350 V	
C207	281-0613-00			10 pF	Cer	200 V	10%
C220	281-0504-00			10 pF	Cer	500 V	10%
C223	283-0003-00			0.01 μF	Cer	150 V	
C231	283-0000-00			0.001 μF	Cer	500 V	
C240	283-0079-00			0.01 μF	Cer	250 V	
C253	281-0510-00			22 pF	Cer	500 V	
C260 [1]	*295-0106-00			1 μF	Timing Capacitor Assembly		
C261				0.1 μF			
C262				0.0099 μF			
C263				900 pF			
C264	285-0006-00			68 pF	Glass	500 V	5%
C265	281-0092-00			9-35 pF, Var	Cer		
C266	283-0026-00			0.2 μF	Cer	25 V	
C267	283-0060-00			100 pF	Cer	200 V	5%
C271	283-0000-00			0.001 μF	Cer	500 V	
C280	283-0000-00			0.001 μF	Cer	500 V	
C295	281-0622-00			47 pF	Cer	500 V	1%
C300	283-0000-00			0.001 μF	Cer	500 V	
C308	283-0597-00			470 pF	Mica	300 V	10%
C314	281-0613-00			10 pF	Cer	200 V	10%
C320 [1]	*295-0106-00			1 μF	Timing Capacitor Assembly		
C322				0.1 μF			
C324				0.0099 μF			
C326				900 pF			
C328	283-0602-00			53 pF	Mica	300 V	5%
C329	281-0092-00			9-35 pF, Var	Cer		
C332	283-0026-00			0.2 μF	Cer	25 V	
C333	283-0060-00			100 pF	Cer	200 V	5%
C358	283-0079-00			0.01 μF	Cer	250 V	
C370	283-0136-00	XB070000		10 pF	Cer	50 V	5%
C372	290-0164-00			1 μF	Elect.	150 V	
C376	283-0004-00			0.02 μF	Cer	150 V	
C398	283-0059-00	XB070000		1 μF	Cer	25 V	+80%—20%
C401	281-0525-00	B010100	B029999	470 pF	Cer	500 V	
C401	281-0516-00	B030000		39 pF	Cer	500 V	
C404	281-0504-00			10 pF	Cer	500 V	10%
C415	283-0000-00			0.001 μF	Cer	500 V	
C424	283-0041-00			0.0033 μF	Cer	500 V	5%

[1] C260, C261, C262, C263 and C320, C322, C324, C326 furnished as a unit.

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C448	283-0593-00	B010100	B019999	0.01 μF	Mica	100 V	1%
C448	285-0596-00	B020000		0.01 μF	PTM	100 V	1%
C452	281-0091-00			2-8 pF, Var	Cer		
C453	283-0149-00	B010100	B099999	25 pF	Cer	200 V	2%
C453	283-0144-00	B100000		33 pF	Cer	500 V	1%
C454	281-0623-00			650 pF	Cer	500 V	5%
C455	283-0068-00			0.01 μF	Cer	500 V	
C461	281-0523-00			100 pF	Cer	350 V	
C465	283-0060-00			100 pF	Cer	200 V	5%
C469	283-0115-00			47 pF	Cer	200 V	5%
C480	281-0523-00			100 pF	Cer	350 V	
C487	281-0513-00			27 pF	Cer	500 V	
C502	281-0509-00			15 pF	Cer	500 V	10%
C512	283-0594-00			0.001 μF	Mica	100 V	1%
C559	283-0059-00			1 μF	Cer	25 V	+80%—20%
C594	285-0598-00			0.01 μF	PTM	100 V	5%
C600	281-0523-00			100 pF	Cer	350 V	
C602	283-0079-00			0.01 μF	Cer	250 V	
C748	283-0000-00			0.001 μF	Cer	500 V	
C774	283-0054-00			150 pF	Cer	200 V	5%
C784	283-0079-00			0.01 μF	Cer	250 V	
C805	290-0317-00			1000 μF	Elect.	40 V	+100%—10%
C810	283-0000-00			0.001 μF	Cer	500 V	
C820	290-0209-00			50 μF	Elect.	25 V	+75%—10%
C825	290-0317-00			1000 μF	Elect.	40 V	+100%—10%
C830	283-0000-00			0.001 μF	Cer	500 V	
C842	290-0209-00			50 μF	Elect.	25 V	+75%—10%
C852	283-0111-00			0.1 μF	Cer	50 V	
C854	283-0111-00			0.1 μF	Cer	50 V	
C880	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C882	283-0039-00			0.001 μF	Cer	500 V	
C883	290-0107-00			25 μF	Elect.	25 V	
C885	283-0039-00			0.001 μF	Cer	500 V	
C886	290-0107-00			25 μF	Elect.	25 V	
C892	290-0107-00			25 μF	Elect.	25 V	
C894	290-0107-00			25 μF	Elect.	25 V	
C898	290-0135-00	B010100	B039999	15 μF	Elect.	20 V	
C898	290-0391-00	B040000		15 μF	Elect.	30 V	10%

Diodes

D2	*152-0185-00	Silicon	Replaceable by 1N4152
D3	*152-0185-00	Silicon	Replaceable by 1N4152
D10	*152-0185-00	Silicon	Replaceable by 1N4152
D24	*152-0185-00	Silicon	Replaceable by 1N4152
D34	*152-0185-00	Silicon	Replaceable by 1N4152

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D43	*152-0322-00			Silicon	Tek Spec
D53	*152-0322-00			Silicon	Tek Spec
D62	152-0177-00			Tunnel	TD253B 10 mA
D66	152-0070-00			Back	BD4 0.1 mA
D68	*152-0185-00			Silicon	Replaceable by 1N4152
D74	152-0055-00			Zener	1N962B 0.4 W, 11 V, 5%
D76	152-0008-00			Germanium	
D90	152-0177-00			Tunnel	TD253B 10 mA
D120	*152-0185-00			Silicon	Replaceable by 1N4152
D122	*152-0185-00			Silicon	Replaceable by 1N4152
D124	152-0071-00			Germanium	ED2007
D132	*152-0185-00			Silicon	Replaceable by 1N4152
D134	152-0008-00			Germanium	
D140	*152-0185-00			Silicon	Replaceable by 1N4152
D141	152-0071-00			Germanium	ED2007
D144	*152-0185-00			Silicon	Replaceable by 1N4152
D225	*152-0185-00			Silicon	Replaceable by 1N4152
D228	*152-0185-00			Silicon	Replaceable by 1N4152
D236	*152-0185-00			Silicon	Replaceable by 1N4152
D240	152-0034-00	B010100	B029999	Zener	1N753 0.4 W, 6.2 V, 10%
D240	152-0280-00	B030000		Zener	1N753A 0.4 W, 6.2 V, 5%
D256	152-0071-00			Germanium	ED2007
D258	*152-0185-00			Silicon	Replaceable by 1N4152
D259	*152-0185-00			Silicon	Replaceable by 1N4152
D260	*152-0185-00			Silicon	Replaceable by 1N4152
D261	*152-0185-00			Silicon	Replaceable by 1N4152
D262	*152-0185-00			Silicon	Replaceable by 1N4152
D263	*152-0185-00			Silicon	Replaceable by 1N4152
D264	*152-0185-00			Silicon	Replaceable by 1N4152
D277	*152-0185-00			Silicon	Replaceable by 1N4152
D282	*152-0185-00			Silicon	Replaceable by 1N4152
D284	*152-0185-00			Silicon	Replaceable by 1N4152
D306	*152-0185-00			Silicon	Replaceable by 1N4152
D307	*152-0185-00			Silicon	Replaceable by 1N4152
D308	*152-0185-00			Silicon	Replaceable by 1N4152
D309	*152-0185-00			Silicon	Replaceable by 1N4152
D311	*152-0185-00			Silicon	Replaceable by 1N4152
D314	*152-0185-00			Silicon	Replaceable by 1N4152
D320	*152-0185-00			Silicon	Replaceable by 1N4152
D321	*152-0185-00			Silicon	Replaceable by 1N4152
D322	*152-0185-00			Silicon	Replaceable by 1N4152
D323	*152-0185-00			Silicon	Replaceable by 1N4152
D324	*152-0185-00			Silicon	Replaceable by 1N4152
D325	*152-0185-00			Silicon	Replaceable by 1N4152
D326	*152-0185-00			Silicon	Replaceable by 1N4152
D327	*152-0185-00			Silicon	Replaceable by 1N4152

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D328	*152-0185-00			Silicon	Replaceable by 1N4152
D329	*152-0185-00			Silicon	Replaceable by 1N4152
D330	*152-0185-00			Silicon	Replaceable by 1N4152
D340	152-0139-00	B010100	B029999	Zener	1N751 0.4 W, 5.1 V, 10%
D340	152-0279-00	B030000		Zener	1N751A 0.4 W, 5.1 V, 5%
D343	*152-0185-00			Silicon	Replaceable by 1N4152
D349	*152-0185-00			Silicon	Replaceable by 1N4152
D402	*152-0185-00			Silicon	Replaceable by 1N4152
D404	*152-0185-00			Silicon	Replaceable by 1N4152
D405	*152-0185-00			Silicon	Replaceable by 1N4152
D423	*152-0233-00			Silicon	Tek Spec
D424	*152-0185-00			Silicon	Replaceable by 1N4152
D434	*152-0185-00			Silicon	Replaceable by 1N4152
D447	152-0025-00			Germanium	1N634
D448	*152-0165-00			Silicon	Selected from 1N3579
D454	*152-0185-00	B010100	B099999	Silicon	Replaceable by 1N4152
D454	*152-0324-00	B100000		Silicon	Tek Spec
D455	*152-0185-00			Silicon	Replaceable by 1N4152
D456	*152-0165-00	B010100	B099999	Silicon	Selected from 1N3579
D456	*152-0324-00	B100000		Silicon	Tek Spec
D459	*152-0185-00			Silicon	Replaceable by 1N4152
D463	*152-0185-00			Silicon	Replaceable by 1N4152
D464	*152-0185-00			Silicon	Replaceable by 1N4152
D476	*152-0185-00			Silicon	Replaceable by 1N4152
D501	*152-0185-00			Silicon	Replaceable by 1N4152
D505	152-0008-00			Germanium	
D510	*152-0185-00			Silicon	Replaceable by 1N4152
D550	*152-0185-00			Silicon	Replaceable by 1N4152
D553	*152-0185-00			Silicon	Replaceable by 1N4152
D554	*152-0185-00			Silicon	Replaceable by 1N4152
D558	*152-0185-00			Silicon	Replaceable by 1N4152
D562	152-0139-00	B010100	B029999	Zener	1N751 0.4 W, 5.1 V, 10%
D562	152-0279-00	B030000		Zener	1N751A 0.4 W, 5.1 V, 5%
D571	*152-0185-00			Silicon	Replaceable by 1N4152
D572	152-0008-00			Germanium	
D574	152-0008-00			Germanium	
D588	152-0008-00			Germanium	
D600	*152-0185-00			Silicon	Replaceable by 1N4152
D700	*152-0185-00			Silicon	Replaceable by 1N4152
D701	*152-0185-00			Silicon	Replaceable by 1N4152
D703	*152-0185-00			Silicon	Replaceable by 1N4152
D704	152-0008-00			Germanium	
D705	*152-0185-00			Silicon	Replaceable by 1N4152
D706	152-0025-00	B010100	B029999	Germanium	1N634
D706	*152-0185-00	B030000	B049999	Silicon	Replaceable by 1N4152
D706	*152-0233-00	B050000		Silicon	Tek Spec
D708	*152-0185-00			Silicon	Replaceable by 1N4152
D709	*152-0185-00			Silicon	Replaceable by 1N4152
D712	152-0234-00	B010100	B029999	Zener	1N976A 0.4 W, 43 V, 10%
D712	152-0283-00	B030000		Zener	1N976B 0.4 W, 43 V, 5%
D713	*152-0185-00			Silicon	Replaceable by 1N4152
D715	152-0025-00			Germanium	1N634

Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D740	*152-0185-00			Silicon	Replaceable by 1N4152
D741	*152-0185-00	XB080000		Silicon	Replaceable by 1N4152
D743	*152-0185-00			Silicon	Replaceable by 1N4152
D744	*152-0185-00			Silicon	Replaceable by 1N4152
D746	*152-0185-00			Silicon	Replaceable by 1N4152
D753	152-0123-00			Zener	1N935A 0.4 W, 9.1 V, 5% TC
D754	*152-0185-00			Silicon	Replaceable by 1N4152
D805	152-0066-00			Silicon	1N3194
D807	152-0066-00			Silicon	1N3194
D814	*152-0185-00			Silicon	Replaceable by 1N4152
D825	152-0066-00			Silicon	1N3194
D827	152-0066-00			Silicon	1N3194
D832	*152-0185-00			Silicon	Replaceable by 1N4152
D834	152-0195-00			Zener	1N751A 0.4 W, 5.1 V, 5%
D944	*152-0185-00	XB080000		Silicon	Replaceable by 1N4152
D850	152-0147-00			Zener	1N971B 0.4 W, 27 V, 5%
D950	*152-0107-00			Silicon	Replaceable by 1N647
D952	*152-0107-00			Silicon	Replaceable by 1N647

Connectors

J1	131-0390-00			BNC, female
J2[2]				
J21	131-0390-00			BNC, female
J22[2]				
J24	136-0156-00			Socket, 44 pin
J92[2]				
J95	131-0390-00			BNC, female
J470	*136-0140-00			Socket, Banana Jack Assembly
J720	*136-0140-00			Socket, Banana Jack Assembly

Inductors

L1[2]				
L21[2]				
L22	*108-0406-00			80 μH
L31	276-0554-00			Core, Toroid Ferrite
L32	*108-0447-00			20 μH
L62	*108-0262-01			0.6 μH
L76	276-0554-00			Core, Toroid Ferrite
L95[2]				
L100	276-0554-00			Core, Toroid Ferrite
L102	*120-0402-00			Toroid, 3 turns, single

[2]See Mechanical Parts List.

Inductors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
L104	*108-0260-00			0.1 μH	
L291	*120-0402-00			Toroid, 3 turns, single	
L295	276-0554-00			Core, Toroid Ferrite	
L309	276-0507-00			Core, Ferramic Suppressor	
L882	*120-0382-00			Toroid, 14 turns, single	
L886	*120-0382-00			Toroid, 14 turns, single	
L892	*120-0382-00			Toroid, 14 turns, single	
L894	*120-0382-00			Toroid, 14 turns, single	

Plugs

P21	131-0149-00			24 contact, male	
P22	131-0149-00			24 contact, male	

Transistors

Q11	*153-0549-00			Silicon	Selected FET
Q12	*151-0199-00	B010100	B079999	Silicon	Replaceable by MPS-3640
Q12	151-0221-00	B080000		Silicon	2N4258
Q20	*151-0199-01	B010100	B079999	Silicon	Replaceable by MPS-3640
Q20	*151-0271-00	B080000		Silicon	Tek Spec
Q30	*151-0199-01	B010100	B079999	Silicon	Replaceable by MPS-3640
Q30	*151-0271-00	B080000		Silicon	Tek Spec
Q41	*151-0198-00	B010100	B079999	Silicon	Replaceable by MPS-918
Q41	151-0269-00	B080000		Silicon	High Frequency
Q51	*151-0198-00	B010100	B079999	Silicon	Replaceable by MPS-918
Q51	151-0269-00	B080000		Silicon	High Frequency
Q70	151-0164-00			Silicon	2N3702
Q72	151-0164-00			Silicon	2N3702
Q74	151-0188-00	B010100	B079999	Silicon	2N3906
Q74	151-0220-00	B080000		Silicon	2N4122
Q80	151-0164-00			Silicon	2N3702
Q82	151-0164-00			Silicon	2N3702
Q90	151-0089-00			Germanium	2N962
Q101	151-0190-00			Silicon	2N3904
Q102	*151-0199-00	B010100	B079999	Silicon	Replaceable by MPS-3640
Q102	*151-0271-00	B080000		Silicon	Tek Spec
Q121	151-0190-00			Silicon	2N3904
Q130	151-0041-00			Germanium	2N1303
Q131	151-0190-00			Silicon	2N3904
Q141	151-0190-00			Silicon	2N3904
Q143	151-0190-00			Silicon	2N3904
Q210	151-0188-00	B010100	B019999	Silicon	2N3906
Q210	151-0164-00	B020000		Silicon	2N3702
Q212	151-0188-00	B010100	B019999	Silicon	2N3906
Q212	151-0164-00	B020000		Silicon	2N3702
Q214	151-0188-00	B010100	B019999	Silicon	2N3906
Q214	151-0164-00	B020000		Silicon	2N3702
Q220	151-0188-00	B010100	B019999	Silicon	2N3906

Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q220	151-0164-00	B020000		Silicon	2N3702
Q231	151-0190-00			Silicon	2N3904
Q235	151-0166-00			Silicon	2N2923
Q251	151-0190-00			Silicon	2N3904
Q252	151-0188-00			Silicon	2N3906
Q254	151-0188-00			Silicon	2N3906
Q261	151-0190-00			Silicon	2N3904
Q263	151-0190-00			Silicon	2N3904
Q265	151-0190-00			Silicon	2N3904
Q267	151-0190-00			Silicon	2N3904
Q269	151-0190-00			Silicon	2N3904
Q271	151-0166-00			Silicon	2N2923
Q281	151-0190-00			Silicon	2N3904
Q283	151-0190-00			Silicon	2N3904
Q290	*151-0083-00	B010100	B069999	Germanium	Tek Spec
Q290	*153-0560-00	B070000		Silicon	Selected 2N930
Q301	151-0166-00			Silicon	2N2923
Q302	151-0188-00			Silicon	2N3906
Q306	151-0188-00			Silicon	2N3906
Q310	151-0220-00			Silicon	2N4122
Q321	151-0190-00			Silicon	2N3904
Q323	151-0190-00			Silicon	2N3904
Q325	151-0190-00			Silicon	2N3904
Q327	151-0190-00			Silicon	2N3904
Q329	151-0190-00			Silicon	2N3904
Q341	151-1003-00			Silicon	Dual FET
Q344	151-0188-00			Silicon	2N3906
Q360	151-0188-00			Silicon	2N3906
Q371	151-0166-00	B010100	B069999	Silicon	2N2923
Q371A,B	151-0249-00	B070000	B099999	Silicon	Dual
Q371A,B	*151-0236-00	B100000		Silicon	Dual, Tek Spec
Q373	151-0166-00	B010100	B069999X	Silicon	2N2923
Q381	151-0166-00			Silicon	2N2923
Q391	151-0166-00	B010100	B069999	Silicon	2N2923
Q391A,B	151-0249-00	B070000	B099999	Silicon	Dual
Q391A,B	*151-0236-00	B100000		Silicon	Dual, Tek Spec
Q393	151-0166-00	B010100	B069999X	Silicon	2N2923
Q395	151-0166-00			Silicon	2N2923
Q401	151-0190-00			Silicon	2N3904
Q406	151-0188-00			Silicon	2N3906
Q420	151-0188-00			Silicon	2N3906
Q430	151-0188-00			Silicon	2N3906
Q431	151-0190-00			Silicon	2N3904
Q441	151-0190-00			Silicon	2N3904
Q457A,B	151-1007-00			Silicon	Dual FET
Q461	151-0179-00			Silicon	2N3877A
Q465	151-0150-00			Silicon	2N3440
Q467	151-0150-00			Silicon	2N3440
Q480	151-0188-00			Silicon	2N3906
Q481	151-0190-00			Silicon	2N3904
Q494	151-0190-01	XB080000		Silicon	Tek Spec
Q501	151-0190-00			Silicon	2N3904

Transistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Q502	151-0188-00			Silicon	2N3906
Q504	151-0188-00			Silicon	2N3906
Q511	151-0190-00			Silicon	2N3904
Q513	151-0190-00			Silicon	2N3904
Q515	*153-0549-00			Silicon	Selected FET
Q517	151-0190-00			Silicon	2N3904
Q520	151-0188-00			Silicon	2N3906
Q522	151-0164-00			Silicon	2N3702
Q531	151-0072-00			Germanium	2N1308
Q533	151-0072-00			Germanium	2N1308
Q535	151-0166-00			Silicon	2N2923
Q540	151-0164-00			Silicon	2N3702
Q552	151-0188-00			Silicon	2N3906
Q555	151-0190-00			Silicon	2N3904
Q557	151-0190-00			Silicon	2N3904
Q561	*153-0549-00			Silicon	Selected FET
Q563	151-0166-00			Silicon	2N2923
Q565	151-0166-00			Silicon	2N2923
Q572	151-0188-00			Silicon	2N3906
Q573	151-0190-00			Silicon	2N3904
Q575	151-0166-00			Silicon	2N2923
Q581	151-0179-00			Silicon	2N3877A
Q584	151-0188-00			Silicon	2N3906
Q590	151-0071-00			Germanium	2N1305
Q592	151-0071-00			Germanium	2N1305
Q601	151-0190-00			Silicon	2N3904
Q603	151-0190-00			Silicon	2N3904
Q605	*153-0549-00			Silicon	Dual FET
Q607	151-0166-00			Silicon	2N2923
Q610	151-0188-00			Silicon	2N3906
Q615	151-0166-00			Silicon	2N2923
Q620	151-0188-00			Silicon	2N3906
Q705	151-0150-00			Silicon	2N3440
Q710	151-0150-00			Silicon	2N3440
Q722	151-0041-00			Germanium	2N1303
Q741	151-0166-00			Silicon	2N2923
Q751	151-0190-00			Silicon	2N3904
Q761	*151-0192-00			Silicon	Replaceable by MPS-6521
Q771	151-0150-00			Silicon	2N3440
Q781	151-0150-00			Silicon	2N3440
Q791	151-0179-00			Silicon	2N3877A
Q793	151-0179-00			Silicon	2N3877A
Q811	151-0190-00			Silicon	2N3904
Q815	151-0190-00			Silicon	2N3904
Q831	151-0190-00			Silicon	2N3904
Q835	151-0190-00			Silicon	2N3904
Q944	151-0190-01	XB080000		Silicon	Tek Spec
Q948	*151-0150-00	XB080000		Silicon	Selected from 2N3440

Resistors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

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

R1	315-0101-00			100 Ω	¼ W		5%
R2	317-0101-00			100 Ω	⅛ W		5%
R5	315-0205-00			2 MΩ	¼ W		5%
R7	315-0205-00			2 MΩ	¼ W		5%
R10	315-0183-00			18 kΩ	¼ W		5%
R13	315-0101-00			100 Ω	¼ W		5%
R15	315-0512-00			5.1 kΩ	¼ W		5%
R17	315-0102-00			1 kΩ	¼ W		5%
R18	315-0102-00			1 kΩ	¼ W		5%
R22	315-0510-00			51 Ω	¼ W		5%
R24	315-0390-00			39 Ω	¼ W		5%
R26	315-0132-00			1.3 kΩ	¼ W		5%
R27	315-0132-00			1.3 kΩ	¼ W		5%
R34	315-0390-00			39 Ω	¼ W		5%
R35	315-0512-00			5.1 kΩ	¼ W		5%
R36	315-0132-00			1.3 kΩ	¼ W		5%
R37	315-0132-00			1.3 kΩ	¼ W		5%
R39	315-0272-00			2.7 kΩ	¼ W		5%
R41	317-0470-00			47 Ω	⅛ W		5%
R45	317-0101-00			100 Ω	⅛ W		5%
R46	315-0512-00			5.1 kΩ	¼ W		5%
R48	321-0230-00			2.43 kΩ	⅛ W	Prec	1%
R51	317-0470-00			47 Ω	⅛ W		5%
R56	315-0512-00			5.1 kΩ	¼ W		5%
R58	321-0230-00			2.43 kΩ	⅛ W	Prec	1%
R59	315-0272-00			2.7 kΩ	¼ W		5%
R62	315-0101-00			100 Ω	¼ W		5%
R64[3]	311-0678-00			50 kΩ, Var			
R66	321-0268-00	B010100	B079999	6.04 kΩ	⅛ W	Prec	1%
R66	321-0256-00	B080000		4.53 kΩ	⅛ W	Prec	1%
R68	315-0391-00			390 Ω	¼ W		5%
R70	315-0101-00			100 Ω	¼ W		5%
R72	311-0634-00			500 Ω, Var			
R73	315-0561-00			560 Ω	¼ W		5%
R75	321-0222-00			2 kΩ	⅛ W	Prec	1%
R77	315-0102-00			1 kΩ	¼ W		5%
R78	315-0303-00			30 kΩ	¼ W		5%
R80	315-0301-00			300 Ω	¼ W		5%
R82	311-0635-00			1 kΩ, Var			
R83	315-0561-00			560 Ω	¼ W		5%
R85	315-0301-00			300 Ω	¼ W		5%

[3]Furnished as a unit with R130.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R92	315-0182-00			1.8 kΩ	¼ W		5%
R94	315-0510-00			51 Ω	¼ W		5%
R120	315-0242-00			2.4 kΩ	¼ W		5%
R124	315-0102-00			1 kΩ	¼ W		5%
R126	315-0752-00			7.5 kΩ	¼ W		5%
R130[4]	311-0678-00			50 kΩ, Var			
R131	315-0473-00			47 kΩ	¼ W		5%
R134	315-0363-00			36 kΩ	¼ W		5%
R135	315-0102-00			1 kΩ	¼ W		5%
R137	315-0363-00			36 kΩ	¼ W		5%
R140	315-0511-00			510 Ω	¼ W		5%
R142	315-0202-00			2 kΩ	¼ W		5%
R144	315-0103-00			10 kΩ	¼ W		5%
R146	315-0302-00			3 kΩ	¼ W		5%
R200A, R200B[5]	*311-0661-00	B010100	B079999	2x10 kΩ, Var			
R200A, R200B[5]	*311-0962-00	B080000		2x10 kΩ, Var			
R202	321-0352-00			45.3 kΩ	⅛ W	Prec	1%
R203	321-0264-00			5.49 kΩ	⅛ W	Prec	1%
R205	321-0260-01			4.99 kΩ	⅛ W	Prec	½%
R206	321-0289-01			10 kΩ	⅛ W	Prec	½%
R207	321-0689-00			24.9 kΩ	⅛ W	Prec	½%
R208	321-0269-00			6.19 kΩ	⅛ W	Prec	1%
R209	321-0289-01			10 kΩ	⅛ W	Prec	½%
R211	321-0265-00			5.62 kΩ	⅛ W	Prec	1%
R213	321-0330-00			26.7 kΩ	⅛ W	Prec	1%
R214	322-0603-00			2.51 kΩ	¼ W	Prec	1%
R216	315-0912-00			9.1 kΩ	¼ W		5%
R218	315-0101-00			100 Ω	¼ W		5%
R220	315-0101-00			100 Ω	¼ W		5%
R222	315-0913-00			91 kΩ	¼ W		5%
R223	315-0102-00			1 kΩ	¼ W		5%
R225	315-0101-00			100 Ω	¼ W		5%
R230	315-0242-00			2.4 kΩ	¼ W		5%
R231	311-0609-00			2 kΩ, Var			
R233	315-0101-00			100 Ω	¼ W		5%
R236	315-0124-00			120 kΩ	¼ W		5%
R238	315-0753-00			75 kΩ	¼ W		5%
R240	315-0101-00			100 Ω	¼ W		5%
R242	315-0753-00			75 kΩ	¼ W		5%
R251	315-0103-00			10 kΩ	¼ W		5%
R253	315-0243-00			24 kΩ	¼ W		5%

[4]Furnished as a unit with R64.

[5]Furnished as a unit with SW200A,B.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R254	315-0103-00			10 kΩ	¼ W		5%
R256	315-0183-00			18 kΩ	¼ W		5%
R257	315-0183-00			18 kΩ	¼ W		5%
R259	315-0183-00			18 kΩ	¼ W		5%
R264	315-0510-00			51 Ω	¼ W		5%
R266	315-0101-00			100 Ω	¼ W		5%
R267	315-0510-00			51 Ω	¼ W		5%
R268	308-0403-00			8.5 kΩ	3 W	WW	1%
R269	311-0609-00			2 kΩ, Var			
R271	315-0103-00			10 kΩ	¼ W		5%
R273	315-0103-00			10 kΩ	¼ W		5%
R275	315-0104-00			100 kΩ	¼ W		5%
R277	315-0124-00			120 kΩ	¼ W		5%
R281	315-0912-00			9.1 kΩ	¼ W		5%
R282	315-0101-00			100 Ω	¼ W		5%
R284	315-0124-00			120 kΩ	¼ W		5%
R285	315-0393-00			39 kΩ	¼ W		5%
R287	315-0101-00			100 Ω	¼ W		5%
R288	315-0510-00			51 Ω	¼ W		5%
R289	315-0624-00			620 kΩ	¼ W		5%
R292	315-0101-00			100 Ω	¼ W		5%
R294	315-0184-00			180 kΩ	¼ W		5%
R295	315-0472-00			4.7 kΩ	¼ W		5%
R296	315-0393-00			39 kΩ	¼ W		5%
R300	315-0101-00			100 Ω	¼ W		5%
R301	315-0471-00			470 Ω	¼ W		5%
R303	321-0193-00			1 kΩ	⅛ W	Prec	1%
R304	321-0314-00			18.2 kΩ	⅛ W	Prec	1%
R306	315-0183-00			18 kΩ	¼ W		5%
R308	315-0101-00			100 Ω	¼ W		5%
R311	315-0912-00			9.1 kΩ	¼ W		5%
R313	315-0103-00			10 kΩ	¼ W		5%
R314	315-0102-00			1 kΩ	¼ W		5%
R329	315-0105-00			1 MΩ	¼ W		5%
R330	315-0105-00			1 MΩ	¼ W		5%
R332	315-0101-00			100 Ω	¼ W		5%
R333	315-0510-00			51 Ω	¼ W		5%
R335	308-0301-00			10 kΩ	3 W	WW	1%
R336	311-0609-00			2 kΩ, Var			
R340	315-0242-00			2.4 kΩ	¼ W		5%
R342	315-0102-00			1 kΩ	¼ W		5%
R343	315-0102-00			1 kΩ	¼ W		5%
R345	315-0101-00			100 Ω	¼ W		5%
R347	315-0303-00			30 kΩ	¼ W		5%
R348	311-0634-00			500 Ω, Var			

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R349	321-0227-00			2.26 kΩ	1/8 W	Prec	1%
R354 } R355 }	311-0679-00	B010100	B079999	2x10 kΩ, Var			
R354 } R355 }	*311-0965-00	B080000		2x10 kΩ, Var			
R360	321-0265-00	B010100	B029999	5.62 kΩ	1/8 W	Prec	1%
R360	321-0263-00	B030000		5.36 kΩ	1/8 W	Prec	1%
R362	321-0402-00			150 kΩ	1/8 W	Prec	1%
R363	321-0402-00			150 kΩ	1/8 W	Prec	1%
R364	311-0606-00			500 kΩ, Var			
R365	321-0260-01			4.99 kΩ	1/8 W	Prec	1/2%
R366	321-0289-01			10 kΩ	1/8 W	Prec	1/2%
R367	321-0689-00			24.9 kΩ	1/8 W	Prec	1/2%
R368	321-0269-00			6.19 kΩ	1/8 W	Prec	1%
R369	321-0289-01			10 kΩ	1/8 W	Prec	1/2%
R370	315-0624-00			620 kΩ	1/4 W		5%
R372	315-0473-00			47 kΩ	1/4 W		5%
R373	315-0473-00			47 kΩ	1/4 W		5%
R375	315-0183-00			18 kΩ	1/4 W		5%
R376	311-0635-00			1 kΩ, Var			
R377	315-0183-00			18 kΩ	1/4 W		5%
R378	315-0102-00			1 kΩ	1/4 W		5%
R379	315-0102-00			1 kΩ	1/4 W		5%
R381	315-0102-00			1 kΩ	1/4 W		5%
R383	315-0101-00			100 Ω	1/4 W		5%
R386	315-0471-00			470 Ω	1/4 W		5%
R388	315-0104-00			100 kΩ	1/4 W		5%
R390	315-0624-00			620 kΩ	1/4 W		5%
R391	315-0102-00			1 kΩ	1/4 W		5%
R393	315-0104-00			100 kΩ	1/4 W		5%
R395	321-0285-01			9.09 kΩ	1/8 W	Prec	1/2%
R396	321-0193-01			1 kΩ	1/8 W	Prec	1/2%
R397	315-0104-00			100 kΩ	1/4 W		5%
R399	315-0101-00			100 Ω	1/4 W		5%
R401	315-0102-00			1 kΩ	1/4 W		5%
R402	315-0103-00	B010100	B029999	10 kΩ	1/4 W		5%
R402	315-0512-00	B030000		5.1 kΩ	1/4 W		5%
R404	315-0510-00			51 Ω	1/4 W		5%
R405	315-0104-00			100 kΩ	1/4 W		5%
R406	315-0103-00			10 kΩ	1/4 W		5%
R408	315-0103-00			10 kΩ	1/4 W		5%
R409	315-0102-00			1 kΩ	1/4 W		5%
R410	315-0363-00			36 kΩ	1/4 W		5%
R413	315-0363-00			36 kΩ	1/4 W		5%
R415	315-0105-00			1 MΩ	1/4 W		5%
R417	315-0363-00			36 kΩ	1/4 W		5%
R418	315-0823-00			82 kΩ	1/4 W		5%
R420	322-0361-00			56.2 kΩ	1/4 W	Prec	1%
R421	321-0326-00			24.3 kΩ	1/8 W	Prec	1%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R423	315-0304-00			300 kΩ	¼ W		5%
R424	315-0104-00			100 kΩ	¼ W		5%
R426	315-0271-00			270 Ω	¼ W		5%
R427	315-0101-00			100 Ω	¼ W		5%
R430	315-0102-00			1 kΩ	¼ W		5%
R431	315-0512-00			5.1 kΩ	¼ W		5%
R432	315-0183-00			18 kΩ	¼ W		5%
R434	315-0183-00			18 kΩ	¼ W		5%
R436	315-0182-00			1.8 kΩ	¼ W		5%
R437	315-0103-00			10 kΩ	¼ W		5%
R438	315-0182-00			1.8 kΩ	¼ W		5%
R440	315-0163-00			16 kΩ	¼ W		5%
R441	315-0203-00			20 kΩ	¼ W		5%
R443	315-0912-00			9.1 kΩ	¼ W		5%
R444	315-0102-00			1 kΩ	¼ W		5%
R445	315-0183-00			18 kΩ	¼ W		5%
R447	315-0101-00			100 Ω	¼ W		5%
R448	315-0102-00	XB100000		1 kΩ	¼ W		5%
R449	315-0104-00			100 kΩ	¼ W		5%
R450[6]	311-0679-00			10 kΩ, Var			
R451	315-0132-00	B010100	B079999X	1.3 kΩ	¼ W		5%
R452	315-0102-00			1 kΩ	¼ W		5%
R453	311-0940-00	XB080000		2.5 kΩ, Var			
R454	315-0104-00			100 kΩ	¼ W		5%
R455	315-0470-00			47 Ω	¼ W		5%
R457	315-0152-00			1.5 kΩ	¼ W		5%
R459	315-0152-00			1.5 kΩ	¼ W		5%
R461	315-0101-00			100 Ω	¼ W		5%
R462	301-0274-00			270 kΩ	½ W		5%
R463	315-0102-00			1 kΩ	¼ W		5%
R465	315-0102-00			1 kΩ	¼ W		5%
R467	315-0302-00			3 kΩ	¼ W		5%
R469	321-0341-00			34.8 kΩ	⅛ W	Prec	1%
R472	321-0222-00			2 kΩ	⅛ W	Prec	1%
R473	321-0280-00	B010100	B019999	8.06 kΩ	⅛ W	Prec	1%
R473	315-0682-00	B020000		6.8 kΩ	¼ W		5%
R474	311-0086-00	XB020000	B079999	2.5 kΩ, Var			
R474	311-0940-00	B080000		2.5 kΩ, Var			
R475	311-0347-00			100 kΩ, Var			
R476	308-0301-00			10 kΩ	3 W	WW	
R477	321-0306-00			15 kΩ	⅛ W	Prec	1%
R478	315-0102-00			1 kΩ	¼ W		5%
R480	315-0474-00			470 kΩ	¼ W		5%
R482	315-0101-00			100 Ω	¼ W		5%
R485	315-0101-00			100 Ω	¼ W		5%
R487	315-0103-00			10 kΩ	¼ W		5%
R490	315-0393-00	XB080000		39 kΩ	¼ W		5%
R491	315-0133-00	XB080000		13 kΩ	¼ W		5%
R494	321-0199-00	XB080000		1.15 kΩ	⅛ W	Prec	1%
R501	323-0428-00			280 kΩ	½ W	Prec	1%

[6]Furnished as a unit with R735.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R502	315-0102-00			1 kΩ	¼ W		5%
R504	315-0101-00			100 Ω	¼ W		5%
R505	315-0102-00			1 kΩ	¼ W		5%
R506	315-0114-00			110 kΩ	¼ W		5%
R508	315-0102-00			1 kΩ	¼ W		5%
R510	315-0471-00			470 Ω	¼ W		5%
R514	315-0101-00			100 Ω	¼ W		5%
R516	311-0607-00			10 kΩ, Var			
R518	315-0362-00			3.6 kΩ	¼ W		5%
R520	315-0102-00			1 kΩ	¼ W		5%
R522	315-0392-00			3.9 kΩ	¼ W		5%
R523	315-0153-00			15 kΩ	¼ W		5%
R525	315-0621-00			620 Ω	¼ W		5%
R527	315-0102-00			1 kΩ	¼ W		5%
R530	315-0101-00			100 Ω	¼ W		5%
R532	315-0183-00			18 kΩ	¼ W		5%
R533	315-0302-00			3 kΩ	¼ W		5%
R535	315-0103-00			10 kΩ	¼ W		5%
R536	311-0614-00			30 kΩ, Var			
R538	301-0274-00			270 kΩ	½ W		5%
R540	315-0302-00			3 kΩ	¼ W		5%
R541	323-0356-00			49.9 kΩ	½ W	Prec	1%
R543	315-0912-00			9.1 kΩ	¼ W		5%
R545	315-0105-00			1 MΩ	¼ W		5%
R546	315-0104-00			100 kΩ	¼ W		5%
R550	315-0102-00			1 kΩ	¼ W		5%
R552	315-0105-00			1 MΩ	¼ W		5%
R553	315-0103-00			10 kΩ	¼ W		5%
R554	315-0912-00			9.1 kΩ	¼ W		5%
R555	315-0103-00			10 kΩ	¼ W		5%
R560	315-0102-00			1 kΩ	¼ W		5%
R562	315-0512-00			5.1 kΩ	¼ W		5%
R563	315-0302-00			3 kΩ	¼ W		5%
R564	315-0102-00			1 kΩ	¼ W		5%
R566	315-0153-00			15 kΩ	¼ W		5%
R567	315-0392-00			3.9 kΩ	¼ W		5%
R569	315-0561-00			560 Ω	¼ W		5%
R571	315-0102-00			1 kΩ	¼ W		5%
R572	315-0102-00			1 kΩ	¼ W		5%
R574	315-0682-00			6.8 kΩ	¼ W		5%
R576	315-0102-00			1 kΩ	¼ W		5%
R577	315-0101-00			100 Ω	¼ W		5%
R579	315-0563-00			56 kΩ	¼ W		5%
R581	315-0104-00			100 kΩ	¼ W		5%
R582	315-0204-00			200 kΩ	¼ W		5%
R584	315-0103-00			10 kΩ	¼ W		5%
R585	315-0103-00			10 kΩ	¼ W		5%
R587	315-0562-00			5.6 kΩ	¼ W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R588	315-0511-00			510 Ω	¼ W		5%
R589	315-0103-00			10 kΩ	¼ W		5%
R595	315-0124-00			120 kΩ	¼ W		5%
R597	315-0102-00			1 kΩ	¼ W		5%
R600	315-0102-00			1 kΩ	¼ W		5%
R604	315-0153-00			15 kΩ	¼ W		5%
R607	315-0823-00			82 kΩ	¼ W		5%
R610	315-0101-00			100 Ω	¼ W		5%
R612	315-0103-00			10 kΩ	¼ W		5%
R614	315-0102-00			1 kΩ	¼ W		5%
R616	315-0101-00			100 Ω	¼ W		5%
R618	323-0331-00			27.4 kΩ	½ W	Prec	1%
R620	315-0622-00			6.2 kΩ	¼ W		5%
R622	311-0613-00			100 kΩ, Var			
R623	315-0513-00			51 kΩ	¼ W		5%
R626	315-0101-00			100 Ω	¼ W		5%
R700	315-0433-00			43 kΩ	¼ W		5%
R703	315-0103-00			10 kΩ	¼ W		5%
R704	315-0242-00			2.4 kΩ	¼ W		5%
R708	315-0104-00			100 kΩ	¼ W		5%
R715	303-0104-00			100 kΩ	1 W		5%
R717	315-0102-00			1 kΩ	¼ W		5%
R721	321-0306-00			15 kΩ	⅛ W	Prec	1%
R722	321-0335-00			30.1 kΩ	⅛ W	Prec	1%
R724	315-0103-00			10 kΩ	¼ W		5%
R726	315-0392-00			3.9 kΩ	¼ W		5%
R727	315-0153-00			15 kΩ	¼ W		5%
R730	321-0268-00	B010100	B079999X	6.04 kΩ	⅛ W	Prec	1%
R731	315-0153-00	B010100	B079999	15 kΩ	¼ W		5%
R731	315-0114-00	B080000		110 kΩ	¼ W		5%
R733	315-0103-00	B010100	B079999	10 kΩ	¼ W		5%
R733	315-0104-00	B080000		100 kΩ	¼ W		5%
R735[7]	311-0679-00			10 kΩ, Var			
R737	321-0347-00	B010100	B079999	40.2 kΩ	⅛ W	Prec	1%
R737	321-0251-00	B080000		4.02 kΩ	⅛ W	Prec	1%
R738	321-0251-00	B010100	B079999	4.02 kΩ	⅛ W	Prec	1%
R738	321-0347-00	B080000		40.2 kΩ	⅛ W	Prec	1%
R740	315-0121-00			120 Ω	¼ W		5%
R742	315-0204-00			200 kΩ	¼ W		5%
R745	315-0203-00			20 kΩ	¼ W		5%
R746	315-0101-00			100 Ω	¼ W		5%
R747	301-0473-00			47 kΩ	½ W		5%
R748	301-0473-00			47 kΩ	½ W		5%
R751	315-0101-00			100 Ω	¼ W		5%
R754	321-0330-00	XB080000		26.7 kΩ	⅛ W	Prec	1%

[7]Furnished as a unit with R450.

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R755	301-0472-00			4.7 kΩ	½ W		5%
R760	315-0101-00			100 Ω	¼ W		5%
R765	315-0103-00			10 kΩ	¼ W		5%
R770	323-0365-00			61.9 kΩ	½ W	Prec	1%
R772	321-0235-00			2.74 kΩ	⅛ W	Prec	1%
R774	301-0513-00			51 kΩ	½ W		5%
R780	323-0365-00			61.9 kΩ	½ W	Prec	1%
R782	321-0235-00			2.74 kΩ	⅛ W	Prec	1%
R784	301-0513-00			51 kΩ	½ W		5%
R785	311-0629-00			3 kΩ, Var			
R790	317-0473-00			47 kΩ	⅛ W		5%
R792	317-0473-00			47 kΩ	⅛ W		5%
R794	317-0274-00			270 kΩ	⅛ W		5%
R796	317-0106-00			10 MΩ	⅛ W		5%
R801	308-0293-00			4 kΩ	3 W	WW	
R802	308-0258-00			6 kΩ	3 W	WW	
R803	308-0023-00			10 kΩ	10 W	WW	
R805	307-0103-00			2.7 Ω	¼ W		5%
R807	307-0103-00			2.7 Ω	¼ W		5%
R810	301-0563-00			56 kΩ	½ W		5%
R814	315-0472-00			4.7 kΩ	¼ W		5%
R816	315-0392-00			3.9 kΩ	¼ W		5%
R820	323-0216-00			1.74 kΩ	½ W	Prec	1%
R821	311-0622-00			100 Ω, Var			
R822	323-0216-00			1.74 kΩ	½ W	Prec	1%
R825	307-0103-00			2.7 Ω	¼ W		5%
R827	307-0103-00			2.7 Ω	¼ W		5%
R830	315-0183-00			18 kΩ	¼ W		5%
R832	315-0153-00			15 kΩ	¼ W		5%
R834	315-0152-00			1.5 kΩ	¼ W		5%
R836	315-0132-00			1.3 kΩ	¼ W		5%
R838	315-0392-00			3.9 kΩ	¼ W		5%
R840	323-0195-00			1.05 kΩ	½ W	Prec	1%
R841	311-0605-00			200 Ω, Var			
R842	323-0151-00			365 Ω	½ W	Prec	1%
R850	303-0103-00			10 kΩ	1 W		5%
R852	315-0101-00			100 Ω	¼ W		5%
R854	315-0101-00			100 Ω	¼ W		5%
R880	315-0101-00			100 Ω	¼ W		5%
R898	315-0270-00			27 Ω	¼ W		5%
R940	315-0513-00	XB080000		51 kΩ	¼ W		5%
R941	315-0104-00	XB080000		100 kΩ	¼ W		5%
R942	315-0513-00	XB080000		51 kΩ	¼ W		5%
R943	315-0124-00	XB080000		120 kΩ	¼ W		5%
R944	315-0393-00	XB080000		39 kΩ	¼ W		5%
R947	315-0133-00	XB080000		13 kΩ	¼ W		5%

Switches

Ckt. No.		Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
	Wired or Unwired					
SW30		260-0816-00			Slide	SOURCE
SW40		260-0816-00			Slide	POLARITY
SW125[8]		260-0856-00			Rotary	RANGE
SW205	Wired	*262-0803-00	B010100	B079999	Rotary	TIME MAGNIFIER
SW205	Wired	*262-0803-01	B080000		Rotary	TIME MAGNIFIER
SW205		260-0854-00			Rotary	TIME MAGNIFIER
SW200A, SW200B [9]		*311-0661-00	B010100	B079999		
SW200A, SW200B [9]		*311-0962-00	B080000			
SW270[8]		260-0856-00			Rotary	START POINT
SW410	Wired	*262-0804-00	B010100	B019999	Rotary	DISPLAY MODE
SW410	Wired	*262-0804-01	B020000		Rotary	DISPLAY MODE
SW410		260-0855-00			Rotary	DISPLAY MODE
SW415		260-0689-00			Push-Button	START
SW450		260-0878-00			Slide	
SW735		260-0816-00			Slide	DISPLAY MAG

Transformers

T55	*120-0487-00	Toroid, 5 turns, bifilar
T510	*120-0486-00	Toroid, 40 turns, bifilar
T555	*120-0486-00	Toroid, 40 turns, bifilar
T600	*120-0486-00	Toroid, 40 turns, bifilar
T801	*120-0485-00	Power

READOUT RESISTOR CARD

	*670-0142-00	Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C128A	290-0276-00	1		0.68 μF	Elect.	35 V	10%
C128A	283-0179-00	2		0.68 μF	Cer	100 V	10%
C128B	285-0686-00			0.068 μF	PTM	100 V	10%
C128C	285-0685-00			0.0068 μF	PTM	100 V	10%
C128D	283-0119-00			2200 pF	Cer	200 V	5%
C591	290-0301-00			10 μF	Elect.	20 V	10%
C592	290-0267-00			1 μF	Elect.	35 V	
C593	290-0188-00			0.1 μF	Elect.	35 V	10%

[8]SW125 and SW270 furnished as a unit.

[9]SW200A,B and R200A,B furnished as a unit.

Diodes

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D355	*152-0185-00			Silicon	Replaceable by 1N3605
D900	*152-0107-00			Silicon	Replaceable by 1N647
D904	*152-0107-00			Silicon	Replaceable by 1N647
D908	*152-0107-00			Silicon	Replaceable by 1N647
D910	*152-0107-00			Silicon	Replaceable by 1N647
D911	*152-0107-00			Silicon	Replaceable by 1N647
D912	*152-0107-00			Silicon	Replaceable by 1N647
D913	*152-0107-00			Silicon	Replaceable by 1N647
D914	*152-0107-00			Silicon	Replaceable by 1N647
D915	*152-0107-00			Silicon	Replaceable by 1N647

Fuse

F801	159-0053-00			5A Fast-Blo w/pig tail	

Transistors

Q821	*151-0217-00			Silicon	Tek Spec
Q841	*151-0217-00			Silicon	Tek Spec

Resistors

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

R351	315-0303-00	1	2	30 kΩ	1/4 W		5%
R351	315-0304-00	3		300 kΩ	1/4 W		5%
R353	315-0302-00			3 kΩ	1/4 W		5%
R356	323-0086-00			76.8 Ω	1/2 W	Prec	1%
R357	323-0193-00			1 kΩ	1/2 W	Prec	1%
R591	315-0200-00			20 Ω	1/4 W		5%
R592	315-0200-00			20 Ω	1/4 W		5%
R900	308-0405-00			70 Ω	3 W	WW	
R904	308-0405-00			70 Ω	3 W	WW	
R908	308-0405-00			70 Ω	3 W	WW	
R910	303-0330-00			33 Ω	1 W		5%
R914	308-0405-00			70 Ω	3 W	WW	
R920	305-0750-00			75 Ω	2 W		5%
R921	305-0750-00			75 Ω	2 W		5%
R922	305-0750-00			75 Ω	2 W		5%

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
  Detail Part of Assembly and/or Component
  mounting hardware for Detail Part
    Parts of Detail Part
    mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specificed.

PARTS ORDERING INFORMATION

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

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

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

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

SECTION 9
MECHANICAL PARTS LIST

FIG. 1 FRONT & SWITCHES

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-1	333-0971-02			1	PANEL, front
-2	386-1174-00			1	PLATE, front sub-panel
-3	366-0189-00			1	KNOB, red—EXT HORIZ ATTEN MANUAL SCAN
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-4	366-0322-00			1	KNOB, charcoal—DISPLAY MODE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-5	262-0804-00	B010100	B019999	1	SWITCH, wired—DISPLAY MODE
	262-0804-01	B020000		1	SWITCH, wired—DISPLAY MODE
	- - - - - -			-	switch includes:
	260-0855-00			1	SWITCH, unwired
	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-6	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-7	210-0583-00			2	NUT, hex., 1/4-32 x 5/16 inch
-8	384-0666-00			1	ROD, extension, 2.591 inches long
-9	376-0050-00			1	ASSEMBLY, coupling
	- - - - - -			-	assembly includes:
-10	354-0251-00			2	RING, coupling, 3/8 diameter x 0.172 inches long
-11	376-0046-00			1	COUPLING, plastic
	213-0022-00			4	SCREW, set, 4-40 x 3/16 inch, HSS
	- - - - - -			-	mounting hardware: (not included w/switch)
-12	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-13	366-0189-00			1	KNOB, red—CAL VARIABLE
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-14	366-0322-00			1	KNOB, charcoal—TIME MAGNIFIER
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-15	262-0803-00			1	SWITCH, wired—TIME MAGNIFIER
	- - - - - -			-	switch includes:
	260-0854-00			1	SWITCH, unwired
-16	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-17	361-0154-00			2	SPACER, sleeve, 0.312 inch long
-18	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-19	384-0667-00	B010100	B039999	1	ROD, extension, 3.956 inches long
	384-0667-01	B040000		1	ROD, extension, 3.877 inches long
	- - - - - -			-	mounting hardware: (not included w/switch)
-20	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & No. Index	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-21	366-0189-00			1	KNOB, red—START POINT
	- - - - - -			-	knob includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS
-22	366-0332-00			1	KNOB, charcoal—RANGE
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-23	260-0856-00			1	SWITCH, unwired—TIME/DIV
	- - - - - -			-	mounting hardware: (not included w/switch)
-24	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-25	384-0615-00			4	ROD, spacer, 12 1/4 inches long
-26	162-0579-00			ft	TUBING, plastic, spiral (3/4 inch)
-27	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
	210-0406-00			1	NUT, hex., 4-40 x 3/16 inch
-28	366-0265-00			1	KNOB, red—RECOVERY TIME
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-29	366-0264-00			1	KNOB, charcoal—TRIG SENSITIVITY
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-30	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-31	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-32	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-33	366-0265-00			1	KNOB, red—FINE
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-34	366-0264-00			1	KNOB, charcoal—TIME POSITION
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-35	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-36	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-37	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-38	366-0265-00			1	KNOB, red—SAMPLES/DIV
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-39	366-0264-00			1	KNOB, charcoal—HORIZ POSITION
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-40	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-41	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-42	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & No. Index	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-43	366-0109-00			1	KNOB, alum.—plug-in securing
	- - - - - -			-	knob includes:
	213-0005-00			1	SCREW, set, 8-32 x 1/8 inch, HSS
-44	214-0052-00			1	FASTENER, plug-in, pawl right
	- - - - - -			-	mounting hardware: (not included w/fastener)
-45	210-0004-00			2	LOCKWASHER, internal, #4
-46	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-47	136-0140-00			2	SOCKET, banana jack, charcoal cap
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-48	210-0895-00			1	WASHER, plastic, insulating
-49	210-0465-00			2	NUT, hex., 1/4-32 x 3/8 inch
-50	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-51	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-52	210-0471-00			1	NUT, hex., alum., 1/4-32 x 5/16 x 19/32 inch long
-53	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-54	136-0137-00			1	SOCKET, banana jack sleeve
-55	358-0075-00			1	BUSHING, variable resistor mounting
-56	260-0689-00			1	SWITCH, push button—START
	- - - - - -			-	mounting hardware: (not included w/switch)
-57	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-58	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-59	210-0583-00			2	NUT, hex., 1/4-32 x 5/16 inch
-60	352-0084-00			1	HOLDER, bulb, neon single
-61	200-0609-00			1	COVER, single neon bulb holder
-62	352-0064-01			1	HOLDER, bulb, neon double
	- - - - - -			-	mounting hardware: (not included w/holder)
-63	211-0109-00			1	SCREW, 4-40 x 7/8 inch, FHS
-64	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-65	378-0541-00			3	FILTER, lens, neon
-66	260-0816-00			3	SWITCH, slide
	- - - - - -			-	mounting hardware for each: (not included w/switch)
	210-0001-00			2	LOCKWASHER, internal, #2
-67	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-68	386-1225-00			1	PLATE, readout
-69	214-0891-00			1	HEAT SINK, readout
-70	214-0889-00			1	LIGHT DIVIDER, readout
-71	214-0890-00			1	INSULATOR, readout
-72	670-0144-00			1	ASSEMBLY, circuit board—READOUT
	- - - - - -			-	assembly includes:
	388-0843-00			1	BOARD, circuit
	- - - - - -			-	mounting hardware: (not included w/assembly)
73	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
1-74	670-0143-00			1	ASSEMBLY, circuit board, neon
	- - - - - -			-	assembly includes:
	388-0842-00			1	BOARD, circuit
-75	136-0252-00	B010100	B030369	6	SOCKET, connector
	136-0252-01	B030370		6	SOCKET, connector
-76	175-0438-00			1	ASSEMBLY, cable, 1 MΩ/UHF SYNC
	- - - - - -			-	assembly includes:
	- - - - - -			1	CONNECTOR, coaxial, 50 Ω, female
-77	131-0390-00			1	CONNECTOR, coaxial, 1 contact, female
-78	175-0440-00			1	ASSEMBLY, cable, TRIGGER INPUTS 50 Ω
	- - - - - -			-	assembly includes:
	- - - - - -			1	CONNECTOR, right angle, 50 Ω, female
-79	131-0390-00			1	CONNECTOR, coaxial, 1 contact, female
-80	175-0439-00			1	ASSEMBLY, cable, 150 MV INTO 50 Ω
	- - - - - -			-	assembly includes:
	- - - - - -			1	CONNECTOR, coaxial, 50 Ω, female
-81	131-0390-00			1	CONNECTOR, coaxial, 1 contact, female
-82	200-0534-00			1	COVER, neon holder
-83	179-1176-00			1	CABLE HARNESS, switch
	- - - - - -			-	cable harness includes:
	131-0371-00			23	CONNECTOR, single contact, female

FIG. 2 CIRCUIT BOARDS, CHASSIS & REAR

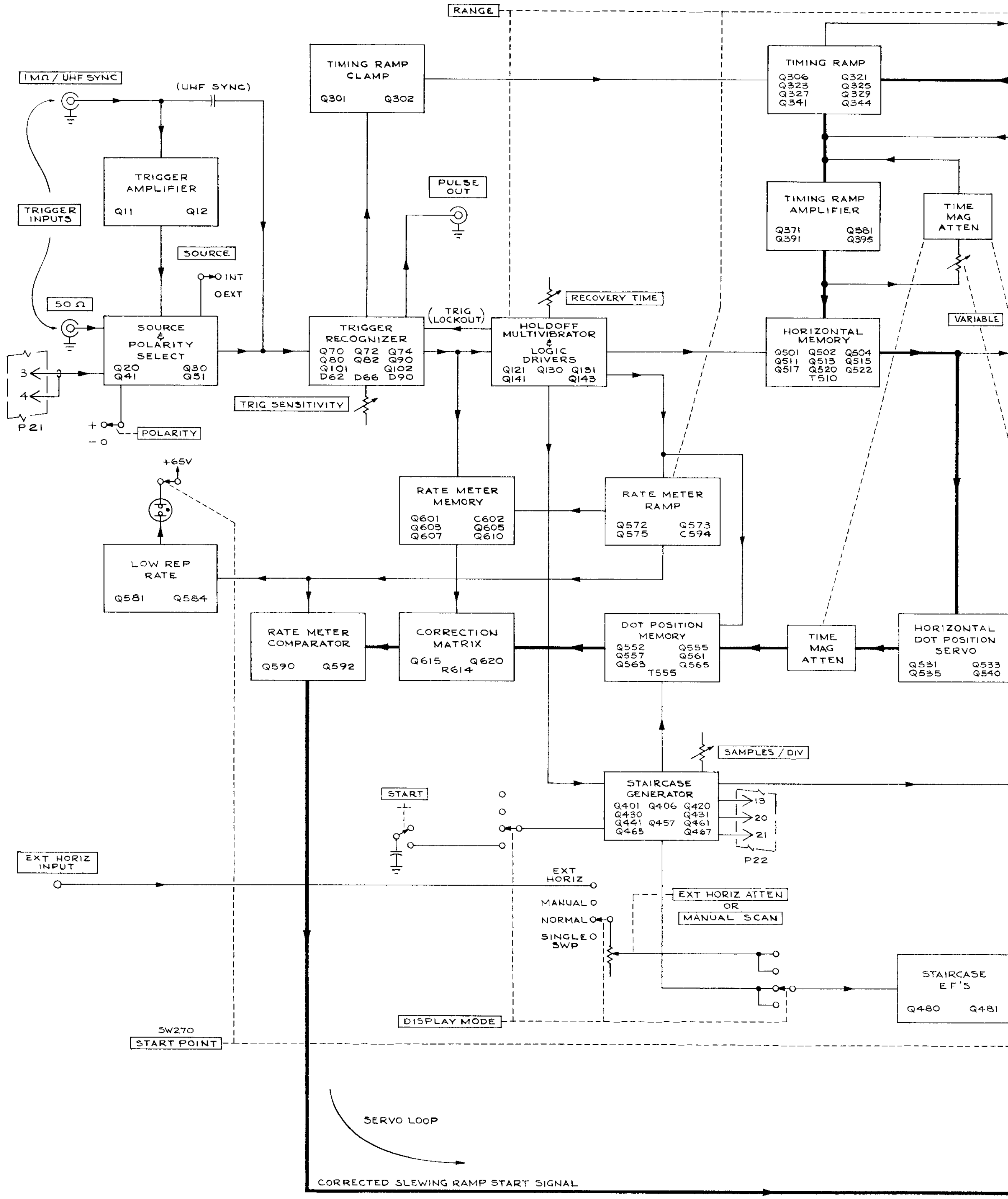
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-1	441-0714-00			1	CHASSIS, trigger
	- - - - - -			-	mounting hardware: (not included w/chassis)
-2	211-0504-00			5	SCREW, 6-32 x 1/4 inch, PHS
-3	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
-4	670-0141-00			1	ASSEMBLY, circuit board—TRIGGER
	- - - - - -			-	assembly includes:
	388-0838-00			1	BOARD circuit
-5	214-0506-00			63	PIN, connector, straight male
-6	136-0220-00			41	SOCKET, transistor, 3 pin
-7	136-0235-00			1	SOCKET, transistor, 6 pin
-8	136-0252-00	B010100	B030369	13	SOCKET, connector
	136-0252-01	B030370		13	SOCKET, connector
-9	426-0121-00			1	HOLDER, plastic, toroid
-10	337-0897-00			1	SHIELD, electrical, wrap around
-11	131-0265-00			2	CONNECTOR, coaxial, right angle, male
-12	131-0156-00			2	CONNECTOR, coaxial, straight, male, w/hardware
	- - - - - -			-	mounting hardware: (not included w/assembly)
-13	211-0116-00			7	SCREW, sems, 4-40 x 5/16 inch, PHS
-14	- - - - - -			1	TRANSFORMER
	- - - - - -			-	mounting hardware: (not included w/transformer)
-15	211-0131-00			2	SCREW, 4-40 x 1.875 inches, PHS
-16	214-0843-00			1	NUT, bar, transformer
-17	358-0215-00			1	BUSHING, plastic, horse shoe
-18	136-0156-01			1	SOCKET, circuit card, 22 contact
	- - - - - -			-	mounting hardware: (not included w/socket)
-19	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-20	670-0142-00			1	ASSEMBLY, circuit card, — READOUT RESISTOR
	- - - - - -			-	assembly includes:
	388-0841-00			1	CARD, circuit
-21	361-0142-00			1	SPACER, stepped
-22	213-0172-00			1	SCREW, thumb
	354-0311-00			1	RING, rubber
-23	- - - - - -			2	TRANSISTOR, w/heat sink
	- - - - - -			-	mounting hardware for each: (not included w/transistor)
-24	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-25	166-0024-00			4	SPACER, tube
-26	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-27	351-0059-00			2	GUIDE, circuit card
	- - - - - -			-	mounting hardware for each: (not included w/guide)
-28	211-0511-00			1	SCREW, 6-32 x 1/2 inch, PHS
-29	129-0111-00			2	POST, chassis separator
	- - - - - -			-	mounting hardware for each: (not included w/post)
-30	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS

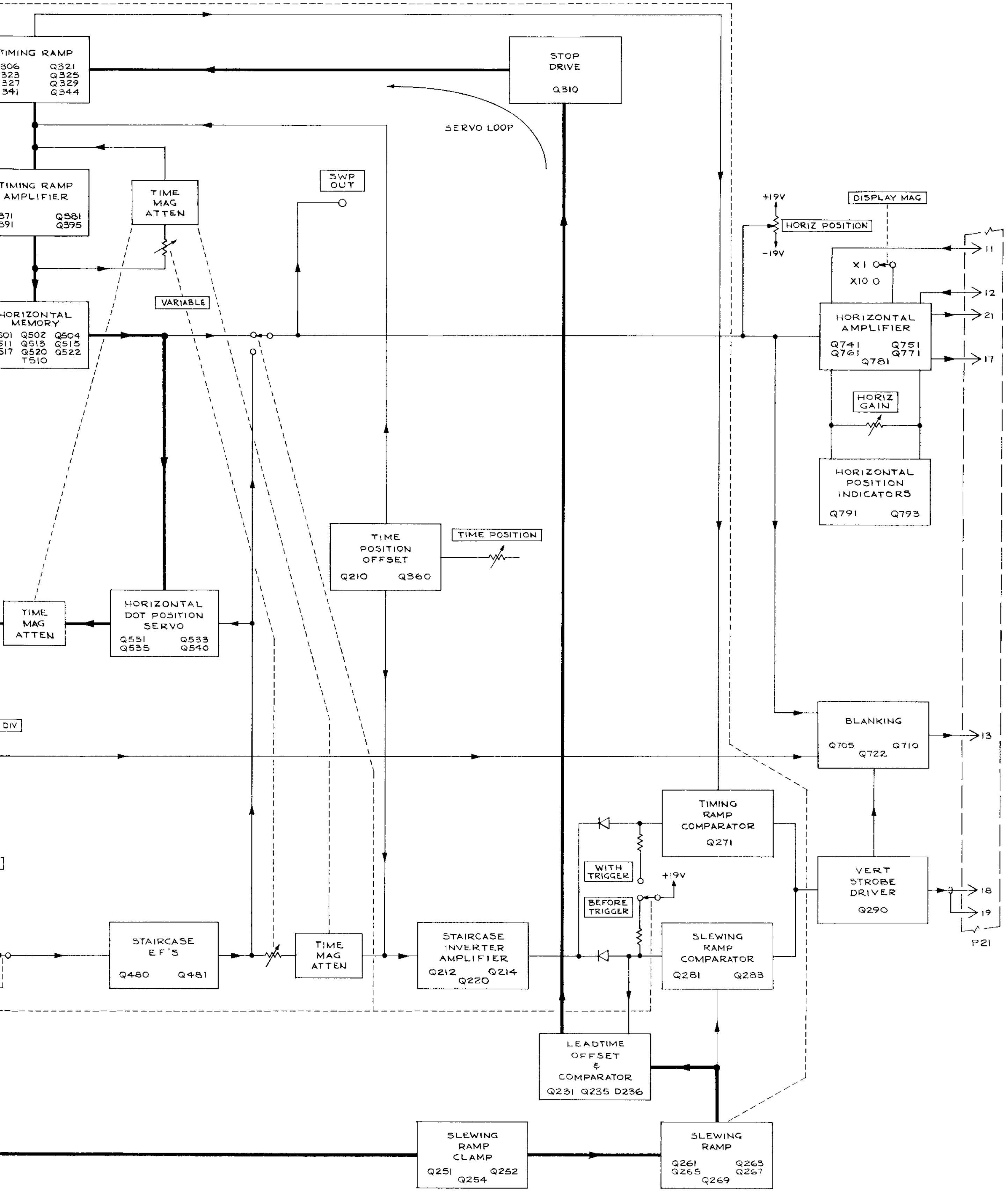
FIG. 2 CIRCUIT BOARDS, CHASSIS & REAR *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-31	386-1175-00			1	PLATE, support chassis
	- - - - - -	XB020000		1	RESISTOR, variable (not shown)
	- - - - - -			-	mounting hardware: (not included w/resistor)
	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
	407-0042-00			1	BRACKET, resistor
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-32	260-0878-00			1	SWITCH, slide—SAMPLE
	- - - - - -			-	mounting hardware: (not included w/switch)
-33	211-0101-00			2	SCREW, 4-40 x 1/4 inch, FHS
-34	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-35	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
-36	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, RHS
-37	210-0601-00			1	EYELET, brass, tapered barrel
-38	210-0478-00			1	NUT, hex., alum., 6-32 x 5/16 x 21/32 inch long
-39	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-40	343-0048-00			1	CLAMP, cable (half)
	- - - - - -			-	mounting hardware: (not included w/clamp)
-41	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-42	210-0863-00			1	WASHER, D type
-43	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-44	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	mounting hardware: (not included w/lug)
-45	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-46	344-0118-00			2	CLIP, capacitor mounting
	- - - - - -			-	mounting hardware for each: (not included w/clip)
-47	213-0044-00			1	SCREW, thread forming, 5/32 x 3/16 inch, PHS
-48	200-0256-00			2	COVER, plastic, 1 inch diameter x 2 1/32 inches long
-49	441-0713-00			1	CHASSIS, logic
	- - - - - -			-	mounting hardware: (not included w/chassis)
-50	211-0504-00			5	SCREW, 6-32 x 1/4 inch, PHS
	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
-51	670-0140-00			1	ASSEMBLY, circuit board—LOGIC
	- - - - - -			-	assembly includes:
	388-0837-00			1	BOARD, circuit
-52	214-0506-00			88	PIN, connector, straight male
-53	136-0183-00			12	SOCKET, transistor, 3 pin, round
-54	136-0220-00			40	SOCKET, transistor, 3 pin, square
-55	135-0235-00			7	SOCKET, transistor, 6 pin, round
-56	214-0565-00			3	FASTENER, plastic, coil form
	- - - - - -			-	mounting hardware: (not included w/assembly)
-57	211-0116-00			7	SCREW, sems, 4-40 x 5/16 inch, PHB
-58	387-0595-00			1	PLATE, rear panel
	- - - - - -			-	mounting hardware: (not included w/plate)
-59	212-0044-00			4	SCREW, 8-32 x 1/2 inch, RHS

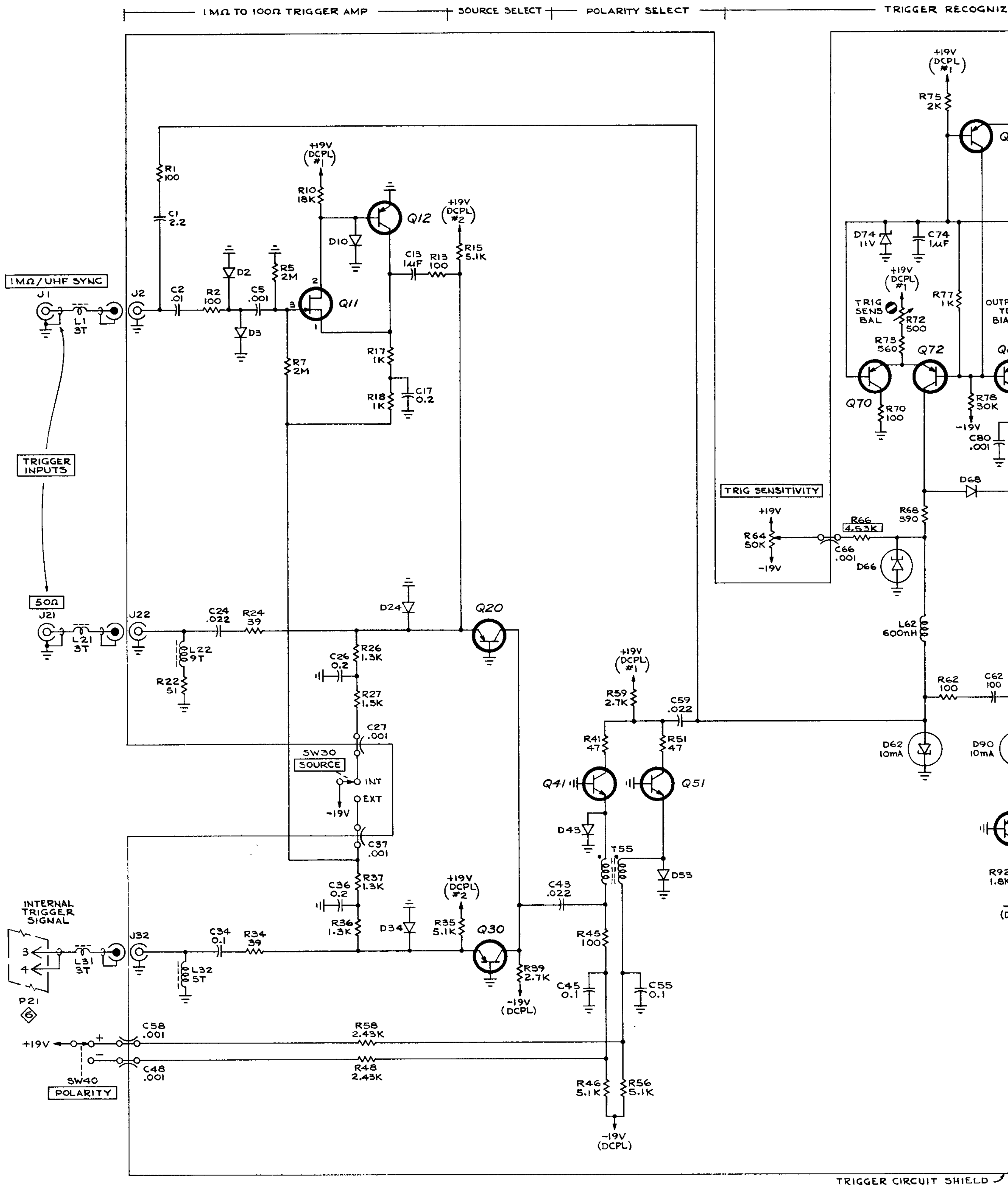
FIG. 2 CIRCUIT BOARDS, CHASSIS & REAR *(cont)*

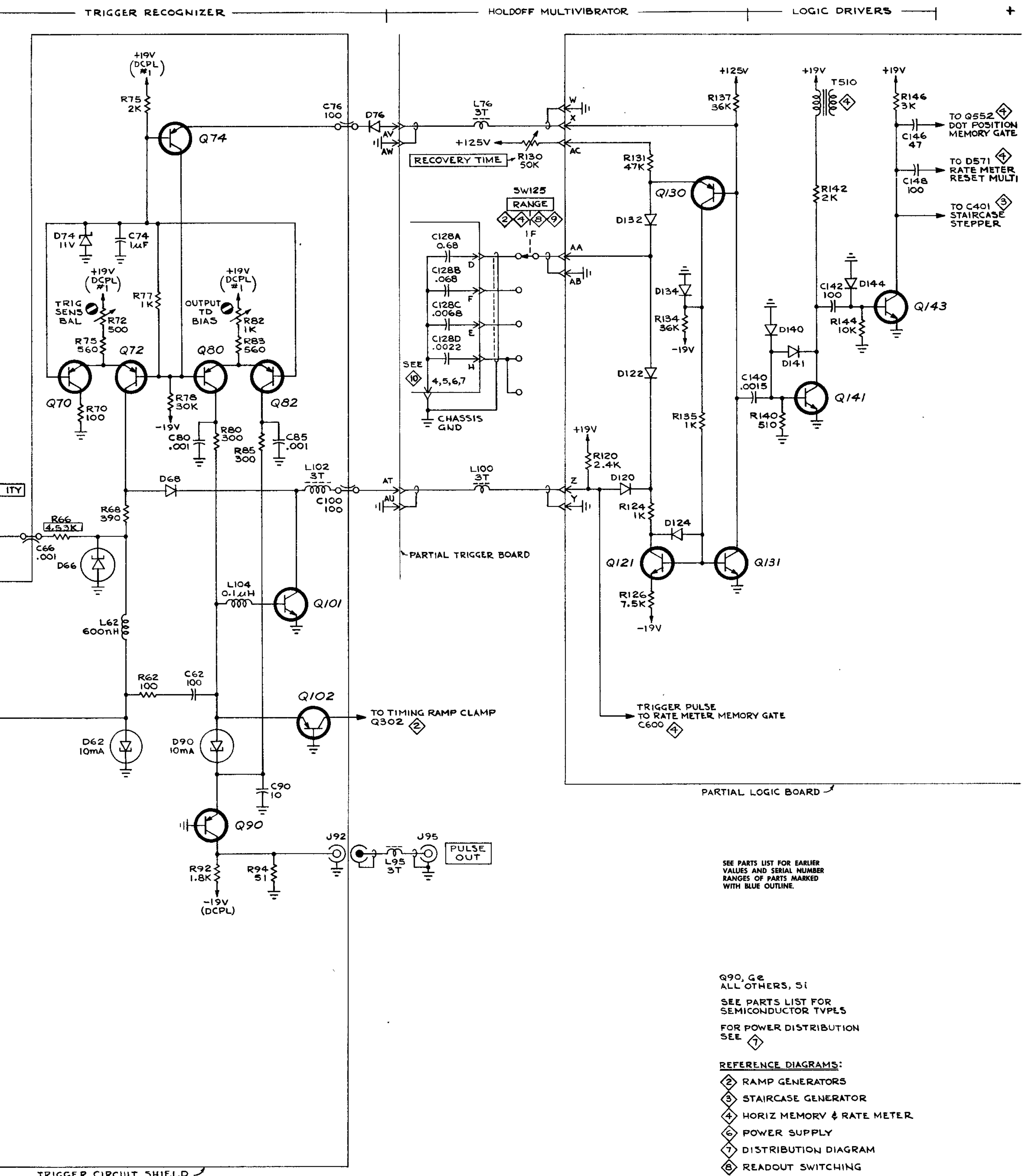
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-60	131-0149-00			1	CONNECTOR, 24 pin
	- - - - - -			-	mounting hardware: (not included w/connector)
-61	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-62	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-63	131-0149-00			1	CONNECTOR, 24 contact
	- - - - - -			-	mounting hardware: (not included w/connector)
-64	211-0116-00			2	SCREW, 4-40 x 5/8 inch, RHS
-65	166-0032-00			2	SPACER, alum., 0.180 ID x 1/4 OD x 5/16 inch long
-66	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-67	210-0202-00			1	LUG, solder, SE #6
	- - - - - -			-	mounting hardware: (not included w/lug)
-68	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-69	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-70	351-0037-00			1	GUIDE, plastic, plug-in
	- - - - - -			-	mounting hardware: (not included w/guide)
-71	211-0013-00			1	SCREW, 4-40 x 3/8 inch, RHS
-72	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-73	179-1175-00			1	CABLE HARNESS, connector
	- - - - - -			-	cable harness includes:
	131-0371-00			41	CONNECTOR, single contact, female
-74	179-1174-00			1	CABLE HARNESS, power
	- - - - - -			-	cable harness includes:
	131-0371-00			75	CONNECTOR, single contact, female
-75	348-0065-00			2	GROMMET, plastic, split


RANGE
1 MΩ / UHF SYNC
(UHF SYNC)
TRIGGER INPUTS
50 Ω
P21
TIMING RAMP CLAMP
Q301 Q302
TRIGGER AMPLIFIER
Q11 Q12
PULSE OUT
SOURCE
INT
EXT
SOURCE & POLARITY SELECT
Q20 Q30
Q41 Q51
POLARITY
TRIGGER RECOGNIZER
Q70 Q72 Q74
Q80 Q82 Q90
Q101 Q102
D62 D66 D90
TRIG SENSITIVITY
(TRIG LOCKOUT)
RECOVERY TIME
HOLDOFF MULTIVIBRATOR & LOGIC DRIVERS
Q121 Q130 Q151
Q141 Q143
TIMING RAMP
Q306 Q321
Q323 Q325
Q327 Q329
Q341 Q344
TIMING RAMP AMPLIFIER
Q371 Q381
Q391 Q395
TIME MAG ATTEN
VARIABLE
HORIZONTAL MEMORY
Q501 Q502 Q504
Q511 Q513 Q515
Q517 Q520 Q522
T510
+65V
RATE METER MEMORY
Q601 C602
Q603 Q605
Q607 Q610
RATE METER RAMP
Q572 Q573
Q575 C594
LOW REP RATE
Q581 Q584
RATE METER COMPARATOR
Q590 Q592
CORRECTION MATRIX
Q615 Q620
R614
DOT POSITION MEMORY
Q552 Q555
Q557 Q561
Q563 Q565
T555
TIME MAG ATTEN
HORIZONTAL DOT POSITION SERVO
Q531 Q533
Q535 Q540
SAMPLES / DIV
START
STAIRCASE GENERATOR
Q401 Q406 Q420
Q430 Q431
Q441 Q457 Q461
Q465 Q467
13
20
21
P22
EXT HORIZ INPUT
EXT HORIZ
MANUAL
NORMAL
SINGLE SWP
EXT HORIZ ATTEN OR MANUAL SCAN
STAIRCASE EF'S
Q480 Q481
DISPLAY MODE
SW270
START POINT
SERVO LOOP
CORRECTED SLEWING RAMP START SIGNAL



TIMING RAMP
306 Q321
323 Q325
327 Q329
341 Q344
STOP DRIVE
Q310
SERVO LOOP
TIMING RAMP AMPLIFIER
371 Q581
391 Q395
TIME MAG ATTEN
SWP OUT
+19V
-19V
DISPLAY MAG
HORIZ POSITION
X1
X10
11
12
21
17
VARIABLE
HORIZONTAL MEMORY
Q501 Q502 Q504
Q511 Q513 Q515
Q517 Q520 Q522
T510
HORIZONTAL AMPLIFIER
Q741 Q751
Q761 Q771
Q781
HORIZ GAIN
HORIZONTAL POSITION INDICATORS
Q791 Q793
TIME POSITION OFFSET
Q210 Q360
TIME POSITION
TIME MAG ATTEN
HORIZONTAL DOT POSITION SERVO
Q531 Q533
Q535 Q540
DIV
BLANKING
Q705 Q710
Q722
13
TIMING RAMP COMPARATOR
Q271
WITH TRIGGER
BEFORE TRIGGER
+19V
VERT STROBE DRIVER
Q290
18
19
P21
STAIRCASE EF'S
Q480 Q481
TIME MAG ATTEN
STAIRCASE INVERTER AMPLIFIER
Q212 Q214
Q220
SLEWING RAMP COMPARATOR
Q281 Q283
LEADTIME OFFSET & COMPARATOR
Q231 Q235 D236
SLEWING RAMP CLAMP
Q251 Q252
Q254
SLEWING RAMP
Q261 Q263
Q265 Q267
Q269


1MΩ TO 100Ω TRIGGER AMP
SOURCE SELECT
POLARITY SELECT
TRIGGER RECOGNIZ
1MΩ/UHF SYNC
TRIGGER INPUTS
50Ω
INTERNAL TRIGGER SIGNAL
TRIG SENSITIVITY
TRIG SENS BAL
SW30 SOURCE
INT
EXT
SW40 POLARITY
TRIGGER CIRCUIT SHIELD
Q11
Q12
Q20
Q30
Q41
Q51
Q70
Q72
T55
P21



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

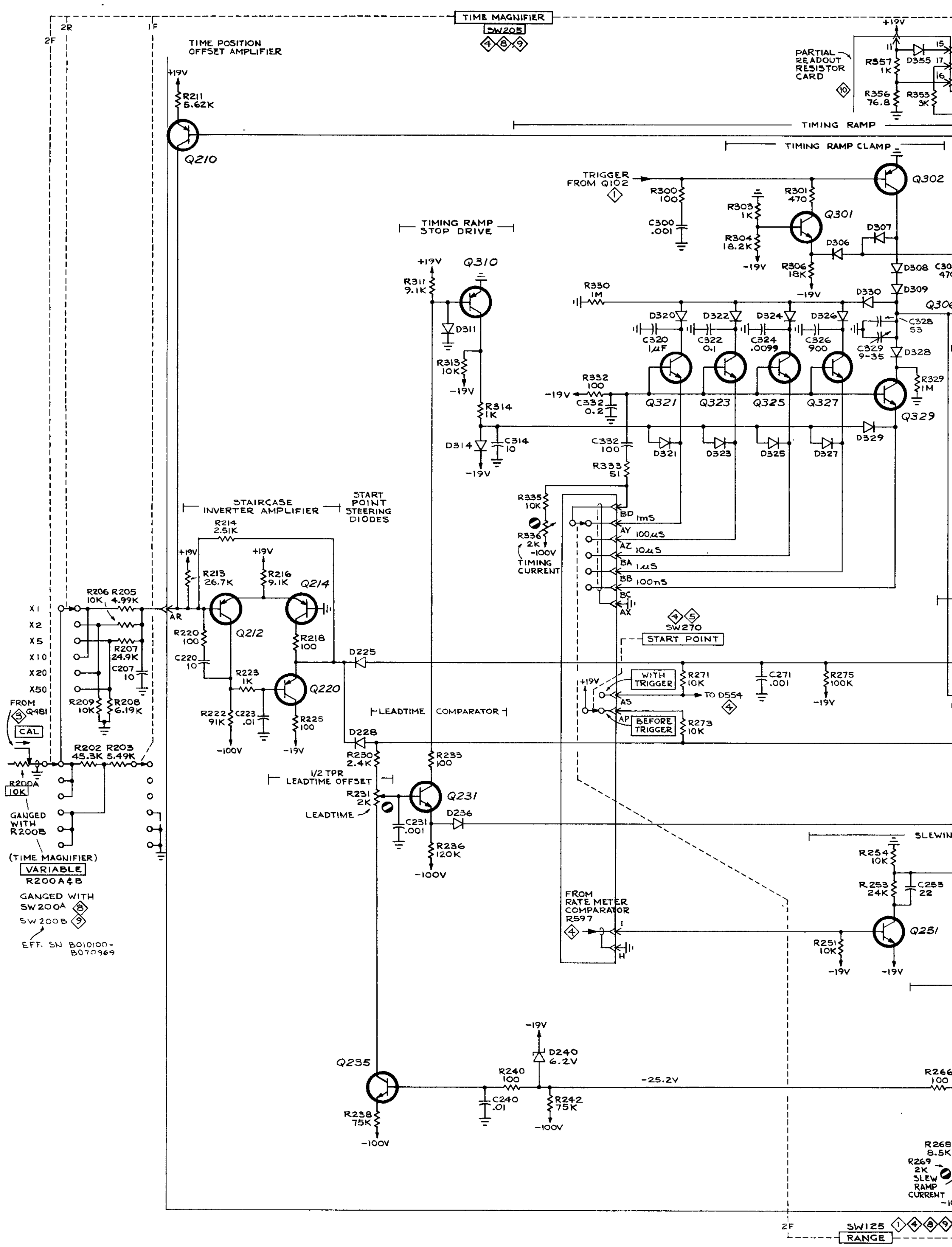
Q90, Ge
ALL OTHERS, Si

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

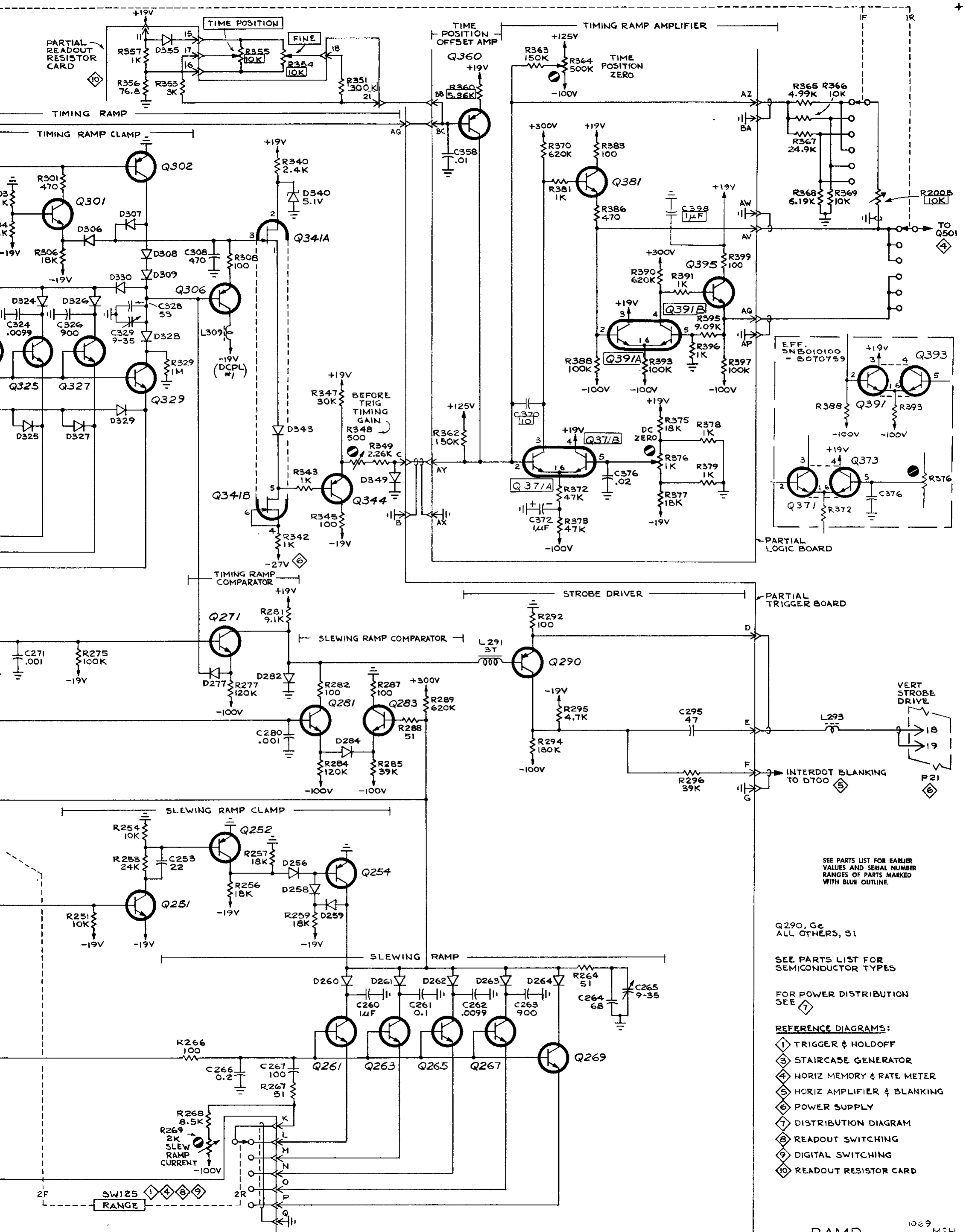
FOR POWER DISTRIBUTION SEE 7

REFERENCE DIAGRAMS:

- 2 RAMP GENERATORS
- 3 STAIRCASE GENERATOR
- 4 HORIZ MEMORY & RATE METER
- 6 POWER SUPPLY
- 7 DISTRIBUTION DIAGRAM
- 8 READOUT SWITCHING
- 9 DIGITAL SWITCHING
- 10 READOUT RESISTOR CARD



TYPE 3T2 RANDOM SAMPLING SWEEP



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

Q290, Ge
ALL OTHERS, Si

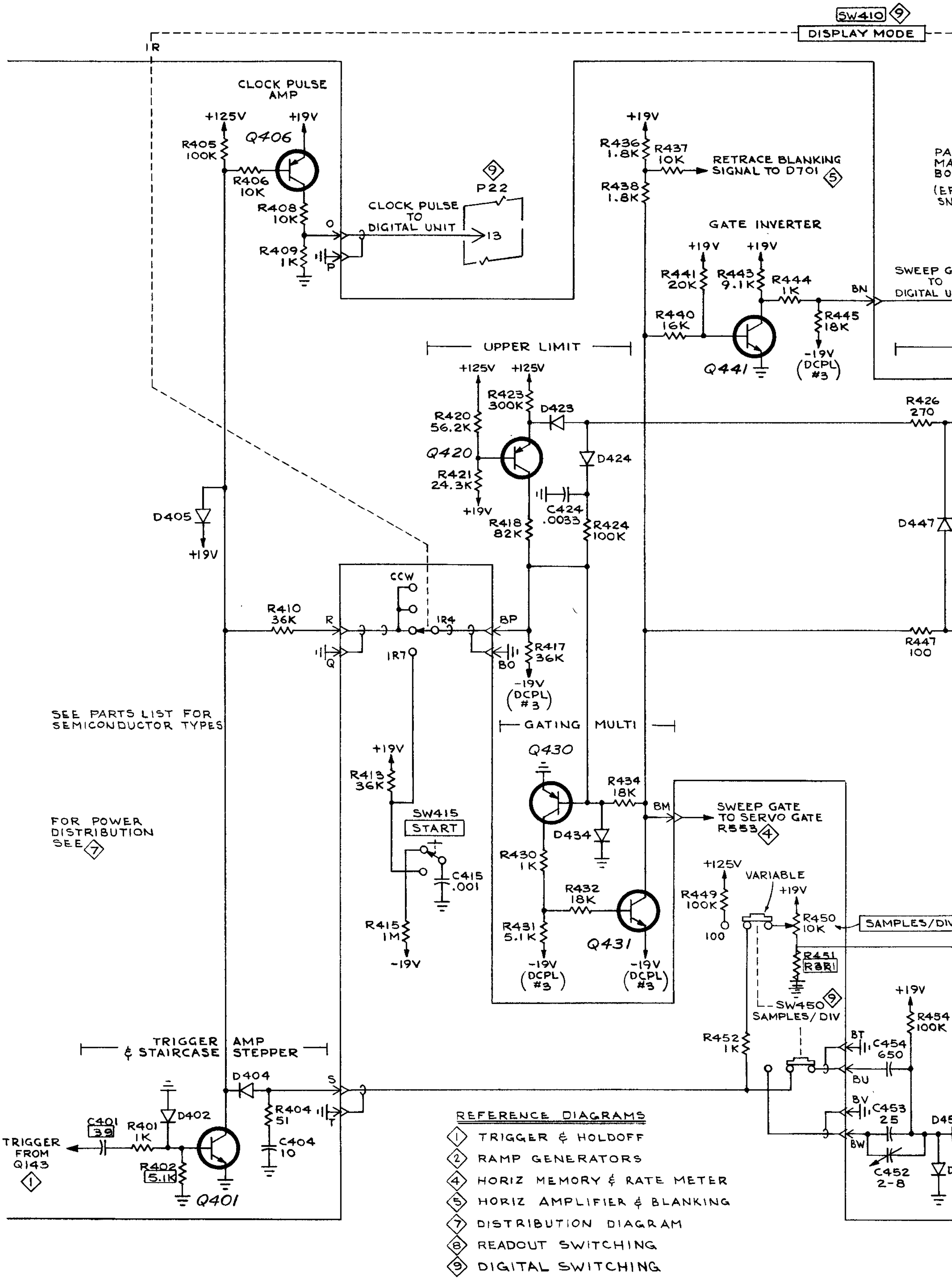
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

FOR POWER DISTRIBUTION SEE ⑦

REFERENCE DIAGRAMS:
① TRIGGER & HOLDOFF
③ STAIRCASE GENERATOR
④ HORIZ MEMORY & RATE METER
⑤ HORIZ AMPLIFIER & BLANKING
⑥ POWER SUPPLY
⑦ DISTRIBUTION DIAGRAM
⑧ READOUT SWITCHING
⑨ DIGITAL SWITCHING
⑩ READOUT RESISTOR CARD

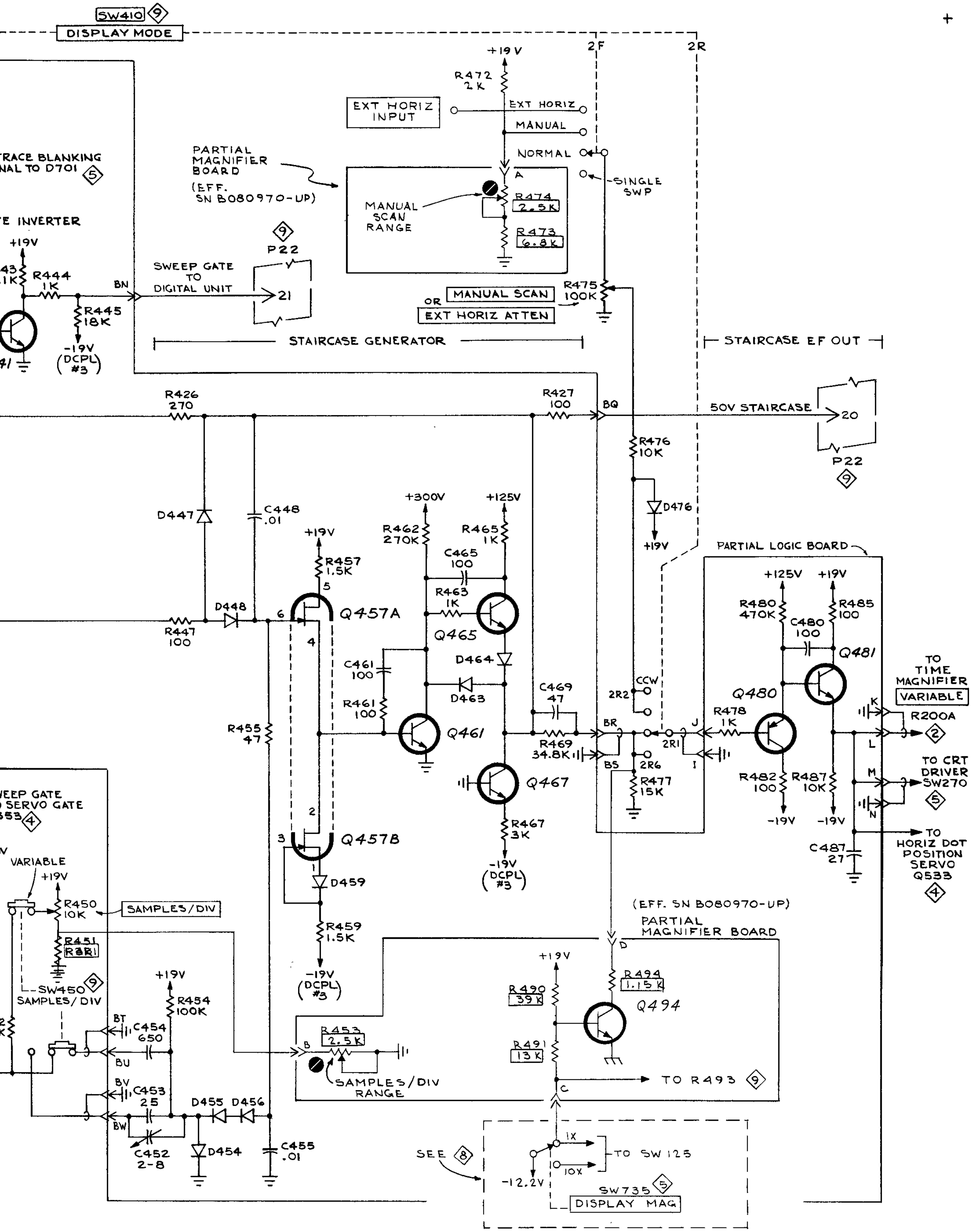
1069 MAH

RAMP GENERATORS ②



TYPE 3T2 RANDOM SAMPLING SWEEP

D

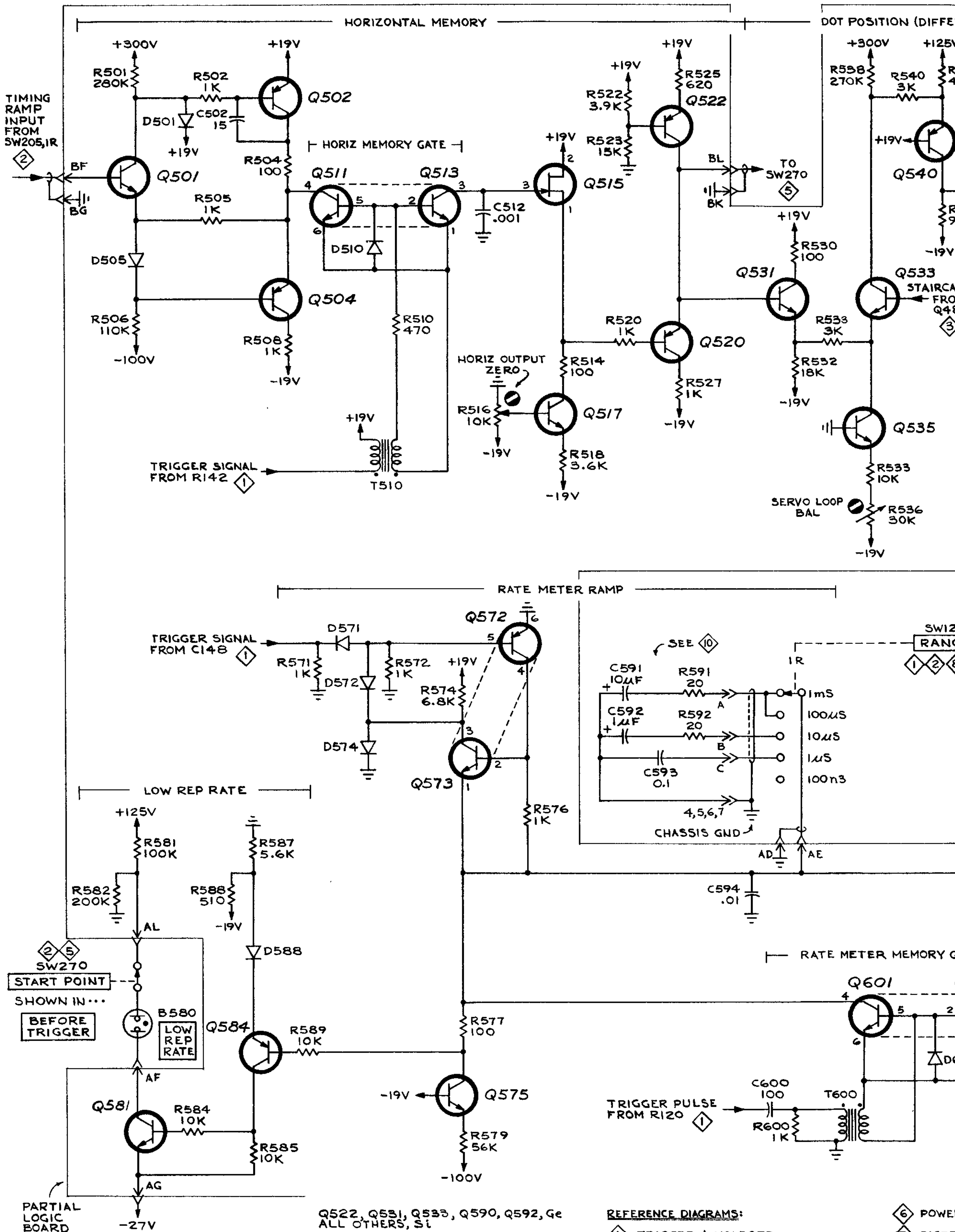


SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

D

STAIRCASE GENERATOR ③

MRH 1069

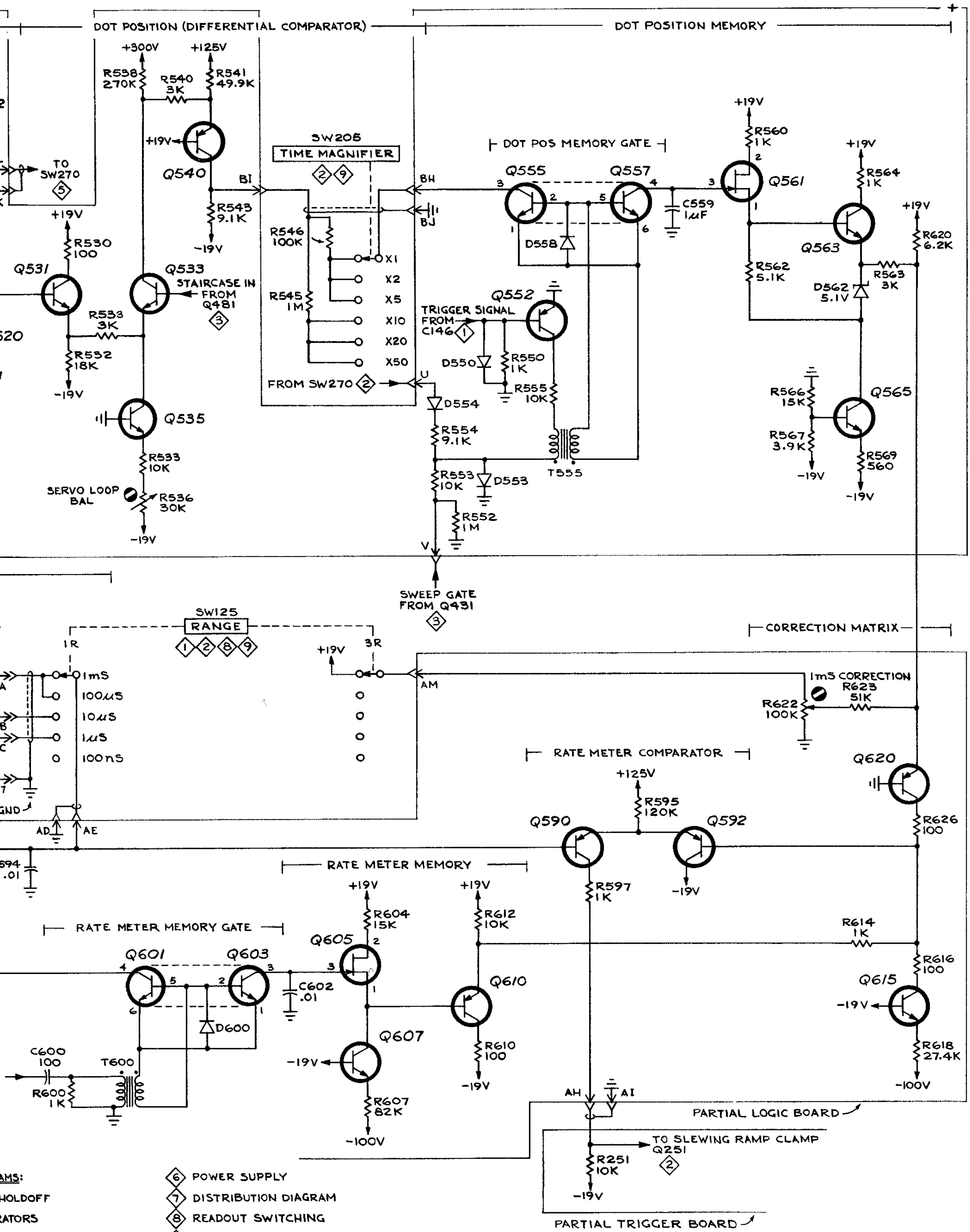


Q522, Q531, Q533, Q590, Q592, Ge
ALL OTHERS, Si

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

FOR POWER DISTRIBUTION SEE 7

REFERENCE DIAGRAMS:
1 TRIGGER & HOLDOFF
2 RAMP GENERATORS
3 STAIRCASE GENERATOR
5 HORIZ AMPLIFIER & BLANKING
6 POWE
7 DISTR
8 READO
9 DIGIT
10 READO



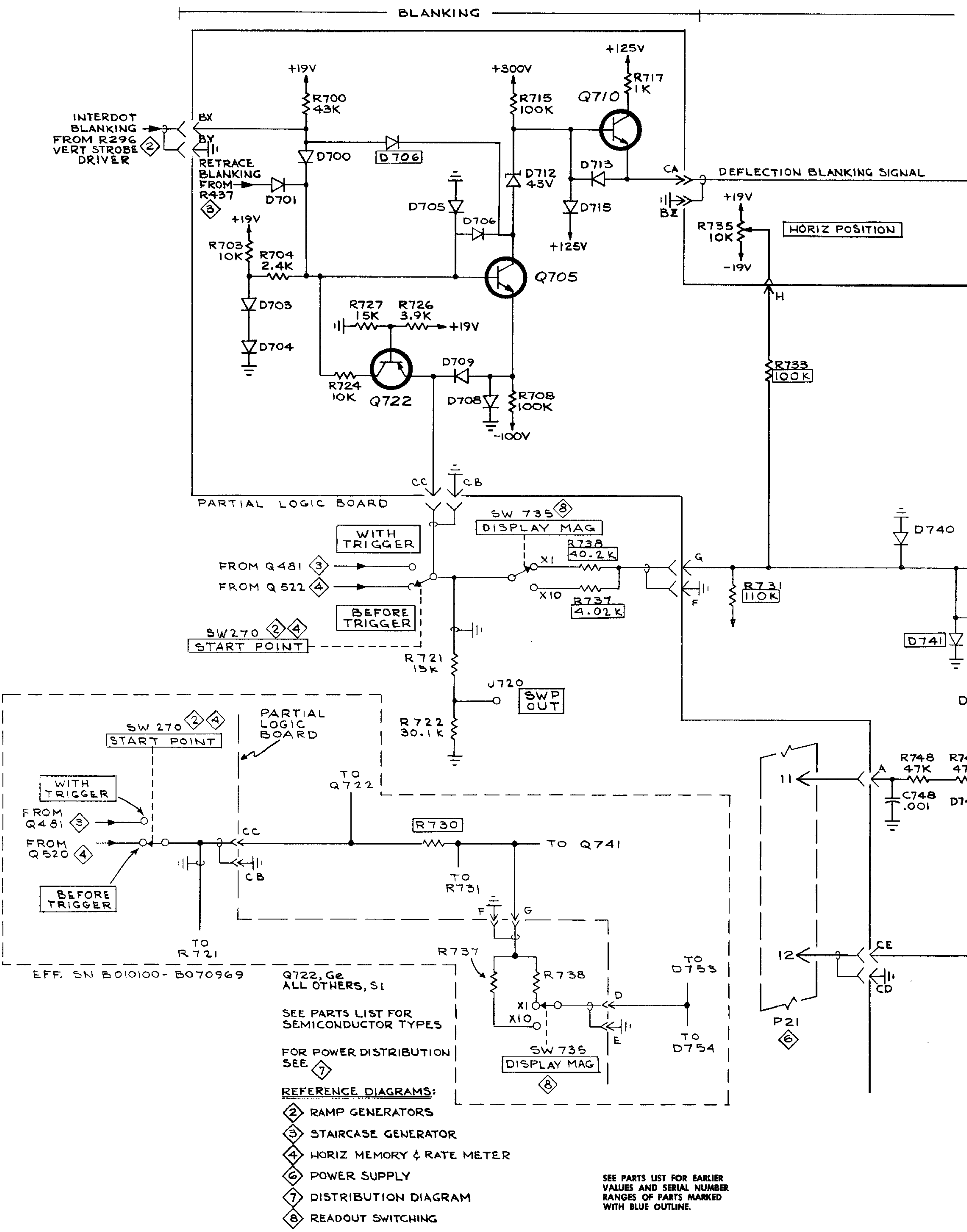
AMS:
HOLDOFF
RATORS
GENERATOR
IFIER & BLANKING

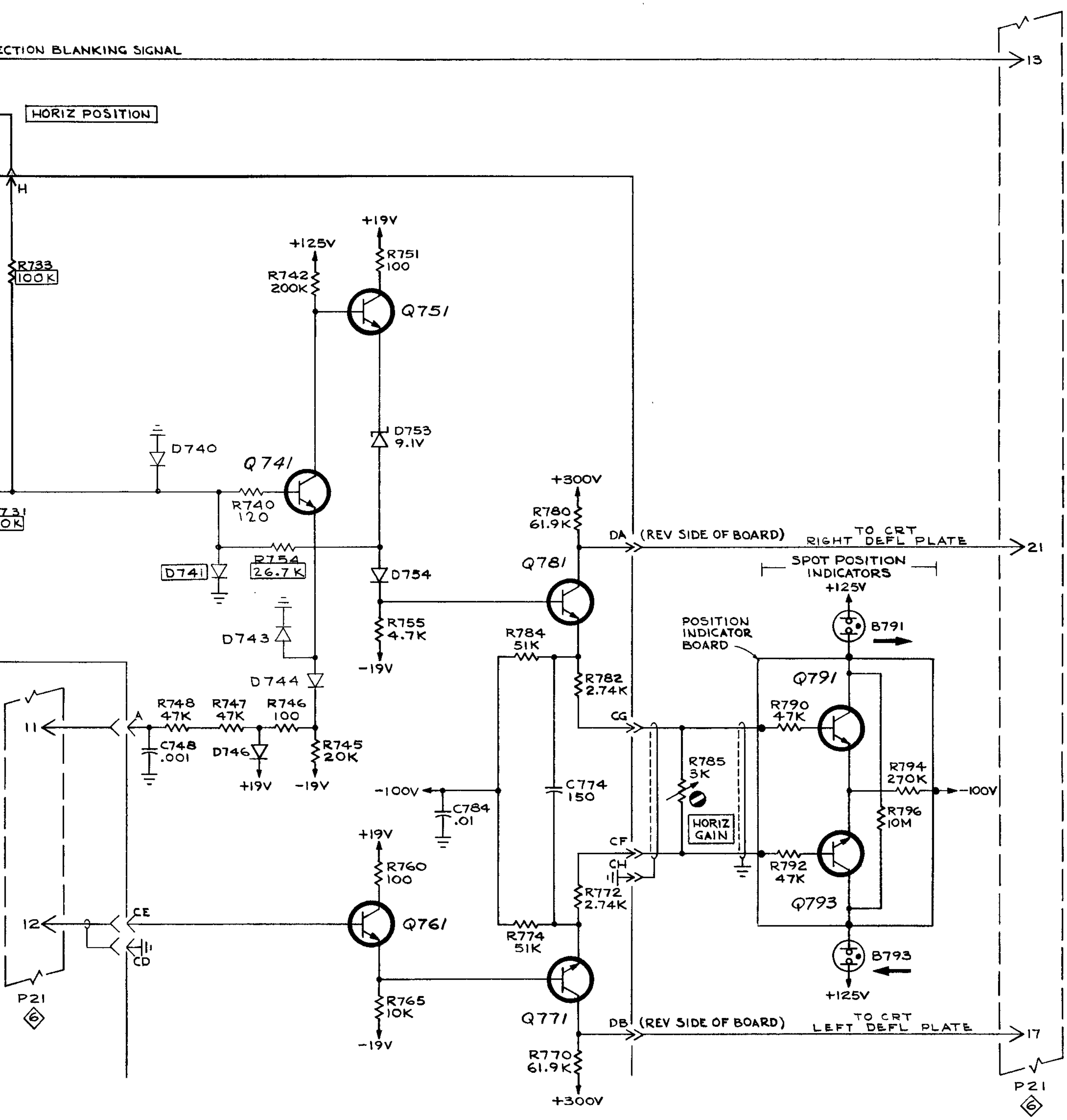
6 POWER SUPPLY
7 DISTRIBUTION DIAGRAM
8 READOUT SWITCHING
9 DIGITAL SWITCHING
10 READOUT RESISTOR CARD

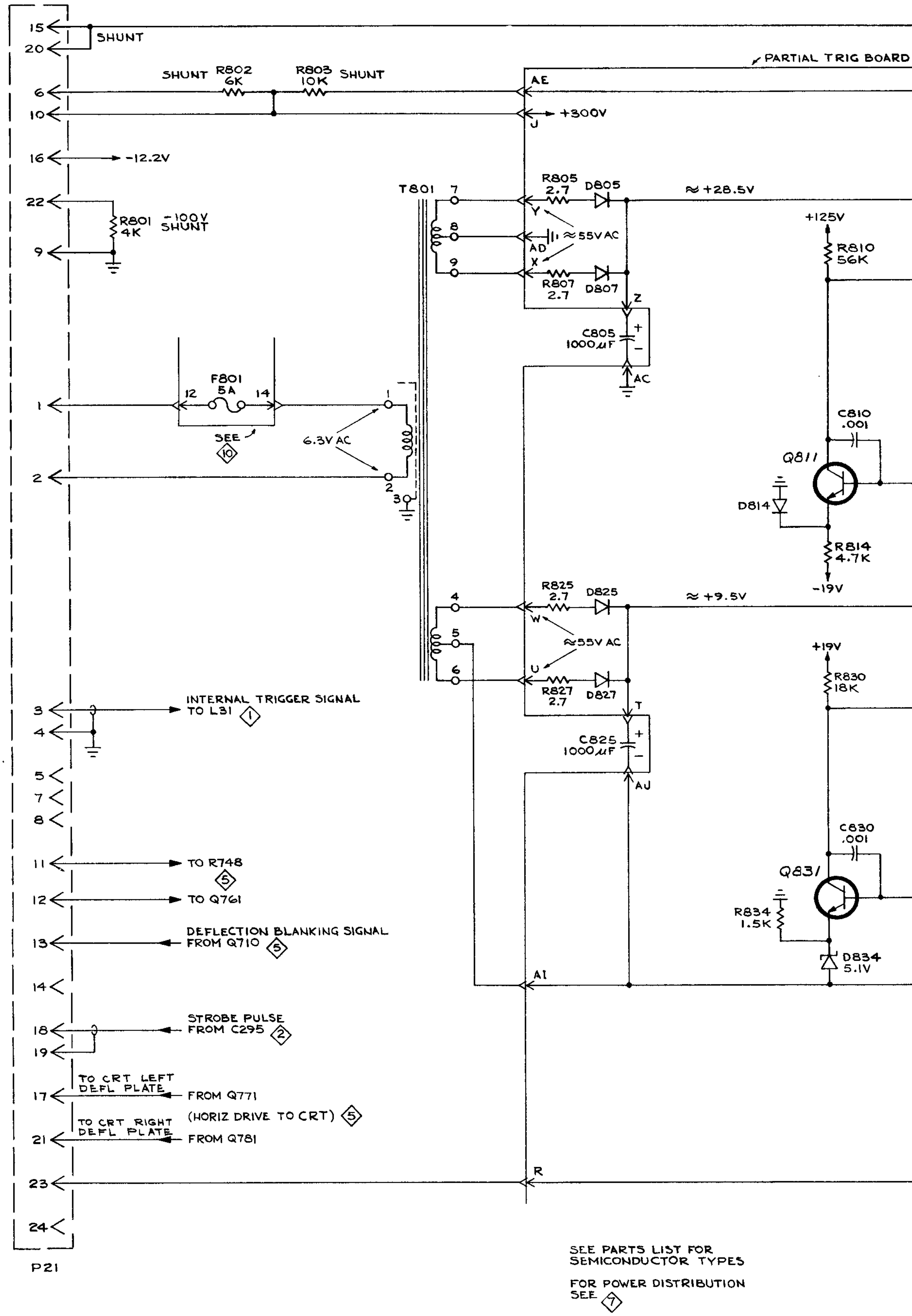
A1

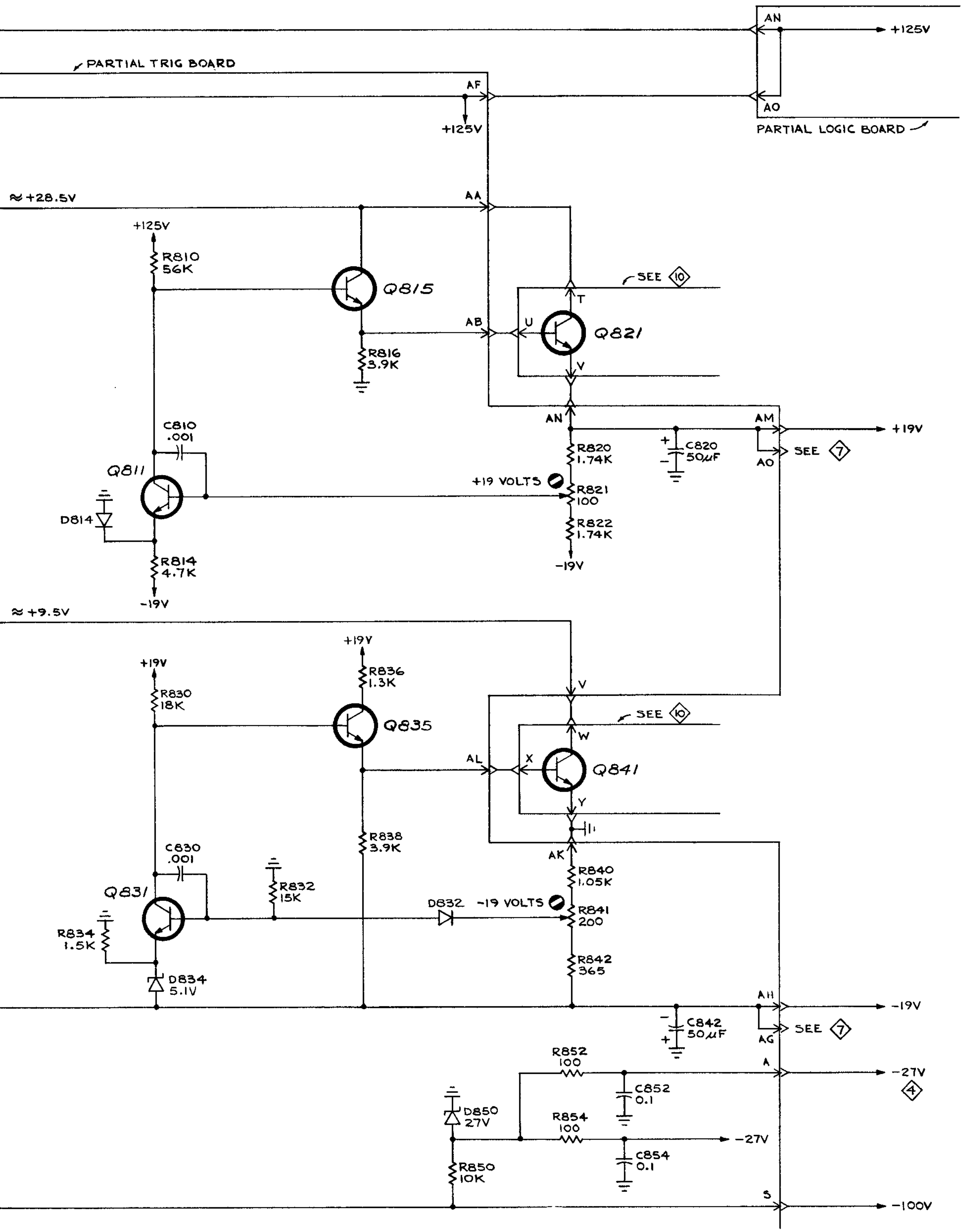
HORIZ MEMORY & RATE METER 4

MRH 467


BLANKING
INTERDOT BLANKING FROM R296 VERT STROBE DRIVER 2
BX
BY
RETRACE BLANKING FROM R437 3
+19V
R700 43K
D700
D701
D706
+300V
R715 100K
D712 43V
+125V
R717 1K
Q710
D713
D715
+125V
D705
D706
+19V
R703 10K
R704 2.4K
D703
D704
Q705
R727 15K
R726 3.9K
+19V
D709
R724 10K
Q722
D708
R708 100K
-100V
CA
DEFLECTION BLANKING SIGNAL
BZ
+19V
R735 10K
HORIZ POSITION
-19V
H
R733 100K
CC
CB
PARTIAL LOGIC BOARD
SW 735 8
DISPLAY MAG
WITH TRIGGER
R738 40.2K
X1
X10
R737 4.02K
G
F
R731 110K
D740
D741
FROM Q481 3
FROM Q 522 4
BEFORE TRIGGER
SW270 2 4
START POINT
R721 15K
J720
SWP OUT
R722 30.1K
SW 270 2 4
START POINT
PARTIAL LOGIC BOARD
WITH TRIGGER
FROM Q481 3
FROM Q520 4
BEFORE TRIGGER
TO Q722
CC
CB
R730
TO Q741
TO R731
TO R721
F
G
R737
R738
X1
X10
D
E
TO D753
TO D754
SW 735
DISPLAY MAG
8
EFF. SN B010100-B070969
R748 47K
C748 .001
A
11
12
CE
CD
P21
6
Q722, Ge
ALL OTHERS, Si
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
FOR POWER DISTRIBUTION SEE 7
REFERENCE DIAGRAMS:
2 RAMP GENERATORS
3 STAIRCASE GENERATOR
4 HORIZ MEMORY & RATE METER
6 POWER SUPPLY
7 DISTRIBUTION DIAGRAM
8 READOUT SWITCHING
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.


ECTION BLANKING SIGNAL
HORIZ POSITION
R733
100K
R731
OK
+125V
+19V
R742
200K
R751
100
Q751
D740
Q741
D753
9.1V
R740
120
R754
26.7K
D741
D754
D743
R755
4.7K
-19V
D744
R748
47K
R747
47K
R746
100
C748
.001
D746
R745
20K
+19V
-19V
11
12
CE
CD
P21
6
+300V
R780
61.9K
DA
(REV SIDE OF BOARD)
TO CRT
RIGHT DEFL PLATE
21
Q781
SPOT POSITION
INDICATORS
+125V
B791
POSITION
INDICATOR
BOARD
R784
51K
R782
2.74K
CG
Q791
R790
47K
R785
3K
HORIZ
GAIN
-100V
C784
.01
C774
150
R794
270K
R796
10M
-100V
CF
CH
R792
47K
Q793
+19V
R760
100
Q761
R772
2.74K
R774
51K
B793
+125V
R765
10K
-19V
Q771
DB
(REV SIDE OF BOARD)
TO CRT
LEFT DEFL PLATE
17
R770
61.9K
+300V
13
P21
6


SHUNT
PARTIAL TRIG BOARD
SHUNT R802 6K
R803 10K SHUNT
AE
+300V
J
-12.2V
T801
R805 2.7
D805
≈ +28.5V
+125V
R801 4K
-100V SHUNT
≈ 55V AC
R807 2.7
D807
R810 56K
C805 1000µF
F801 5A
SEE 10
6.3V AC
C810 .001
Q811
D814
R814 4.7K
-19V
R825 2.7
D825
≈ +9.5V
≈ 55V AC
+19V
R830 18K
R827 2.7
D827
INTERNAL TRIGGER SIGNAL TO L31 1
C825 1000µF
C830 .001
TO R748 5
TO Q761
Q831
R834 1.5K
DEFLECTION BLANKING SIGNAL FROM Q710 5
D834 5.1V
STROBE PULSE FROM C295 2
TO CRT LEFT DEFL PLATE
FROM Q771
(HORIZ DRIVE TO CRT) 5
TO CRT RIGHT DEFL PLATE
FROM Q781
P21
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
FOR POWER DISTRIBUTION SEE 7



T FOR
OR TYPES

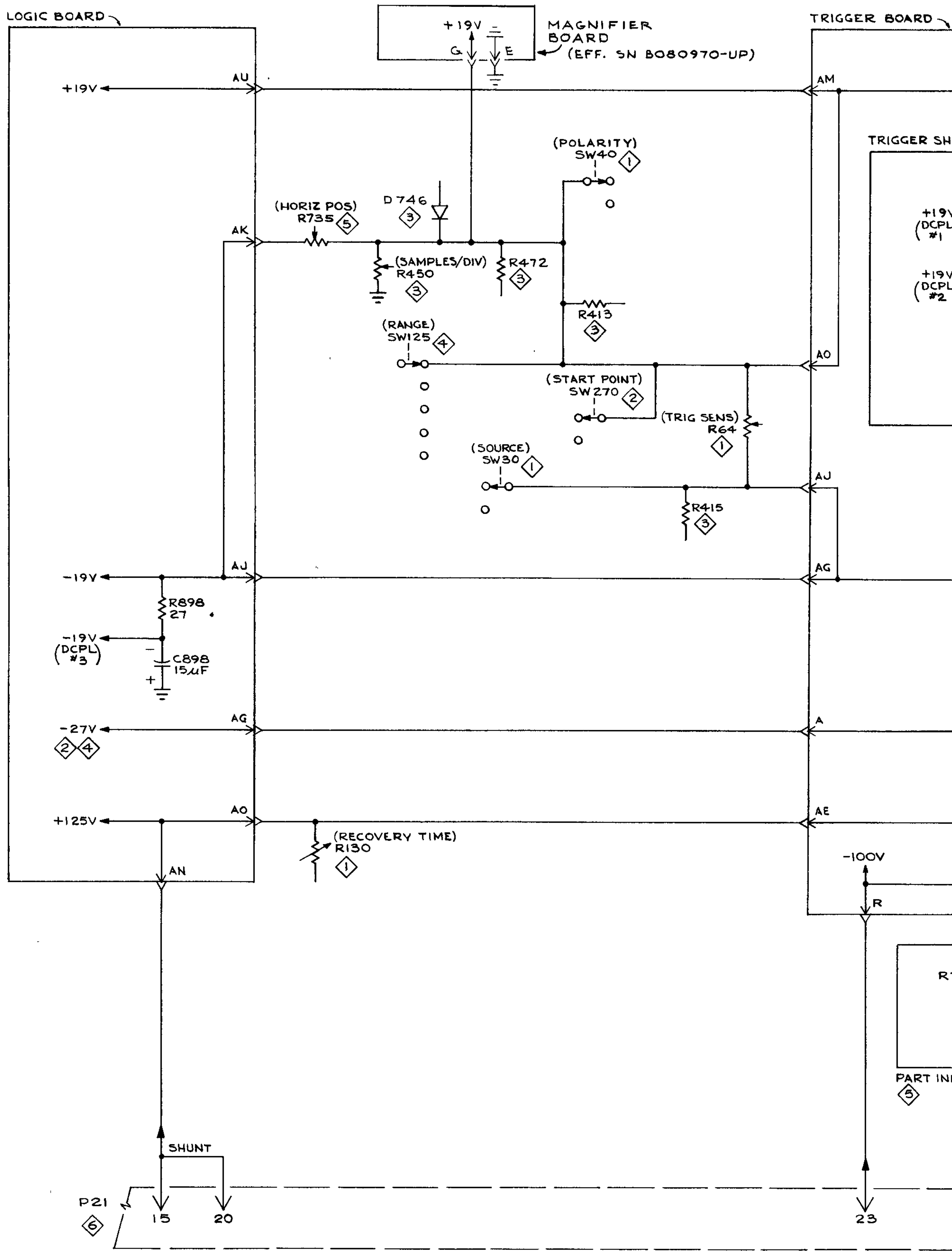
RIBUTION

REFERENCE DIAGRAMS:

① TRIGGER & HOLDOFF
② RAMP GENERATORS
④ HORIZ MEMORY & RATE METER
⑤ HORIZ AMPLIFIER & BLANKING
⑦ DISTRIBUTION DIAGRAM
⑩ READOUT RESISTOR CARD

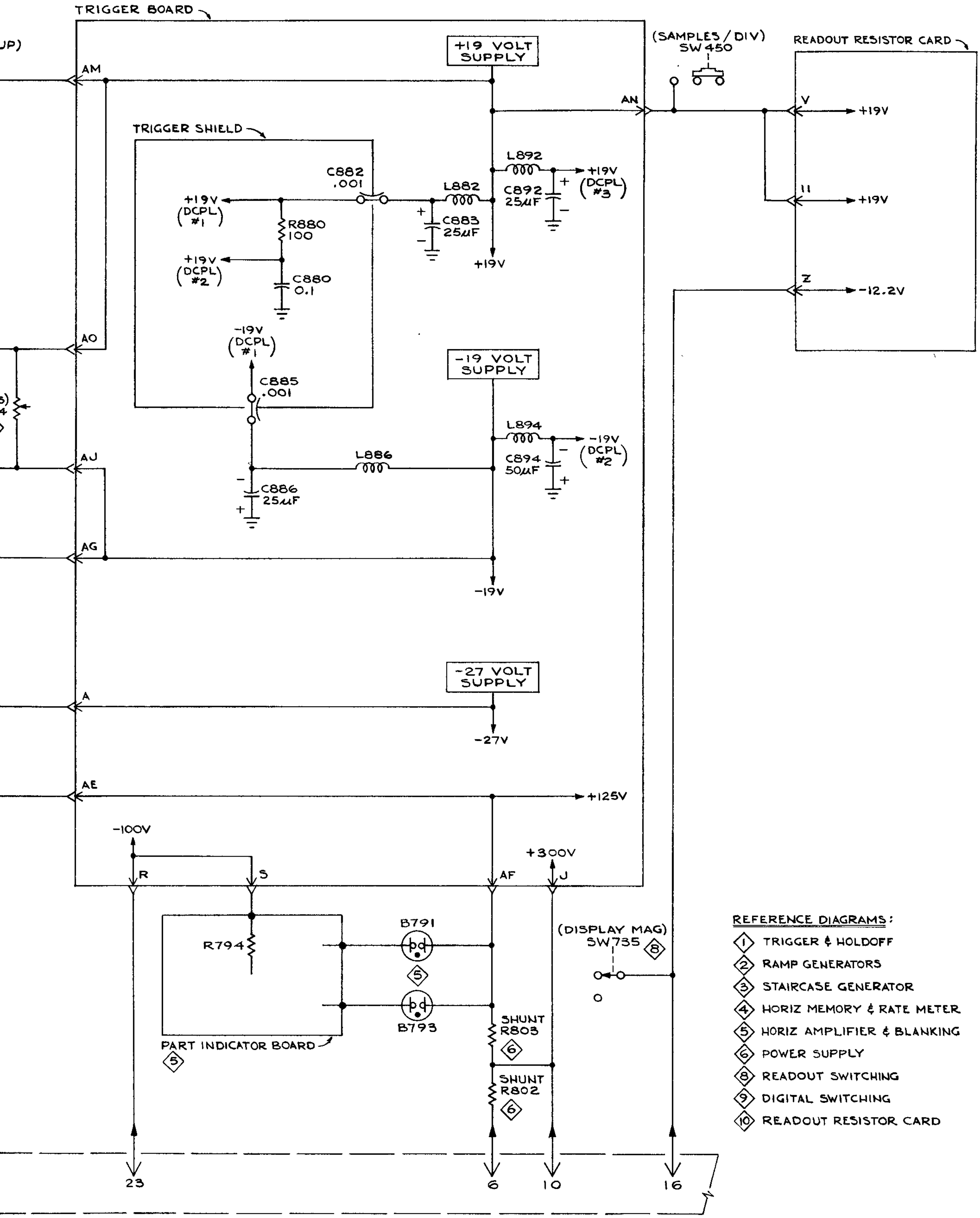
A2

POWER SUPPLY ⑥ 467



TYPE 3T2 RANDOM SAMPLING SWEEP

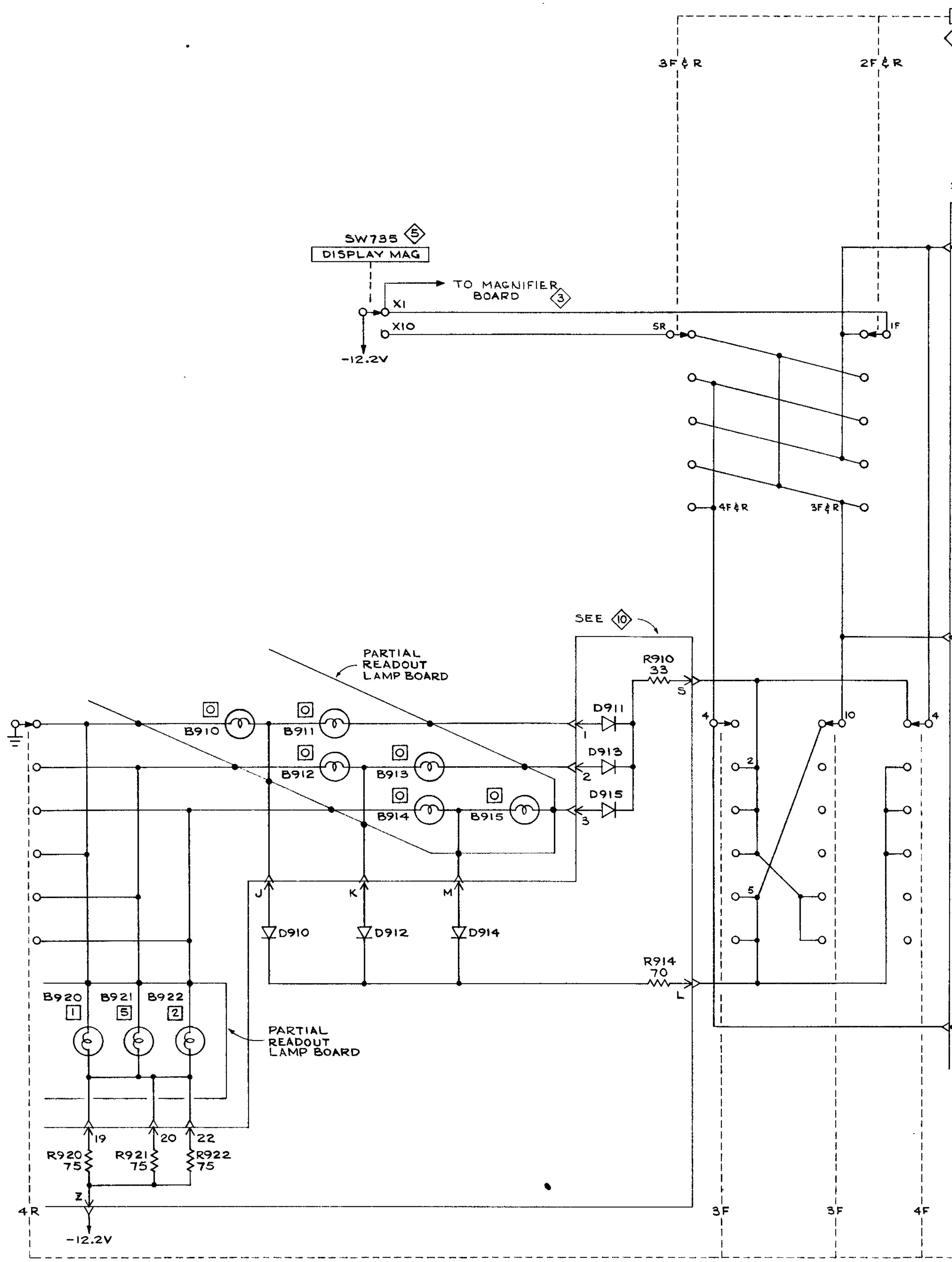
B

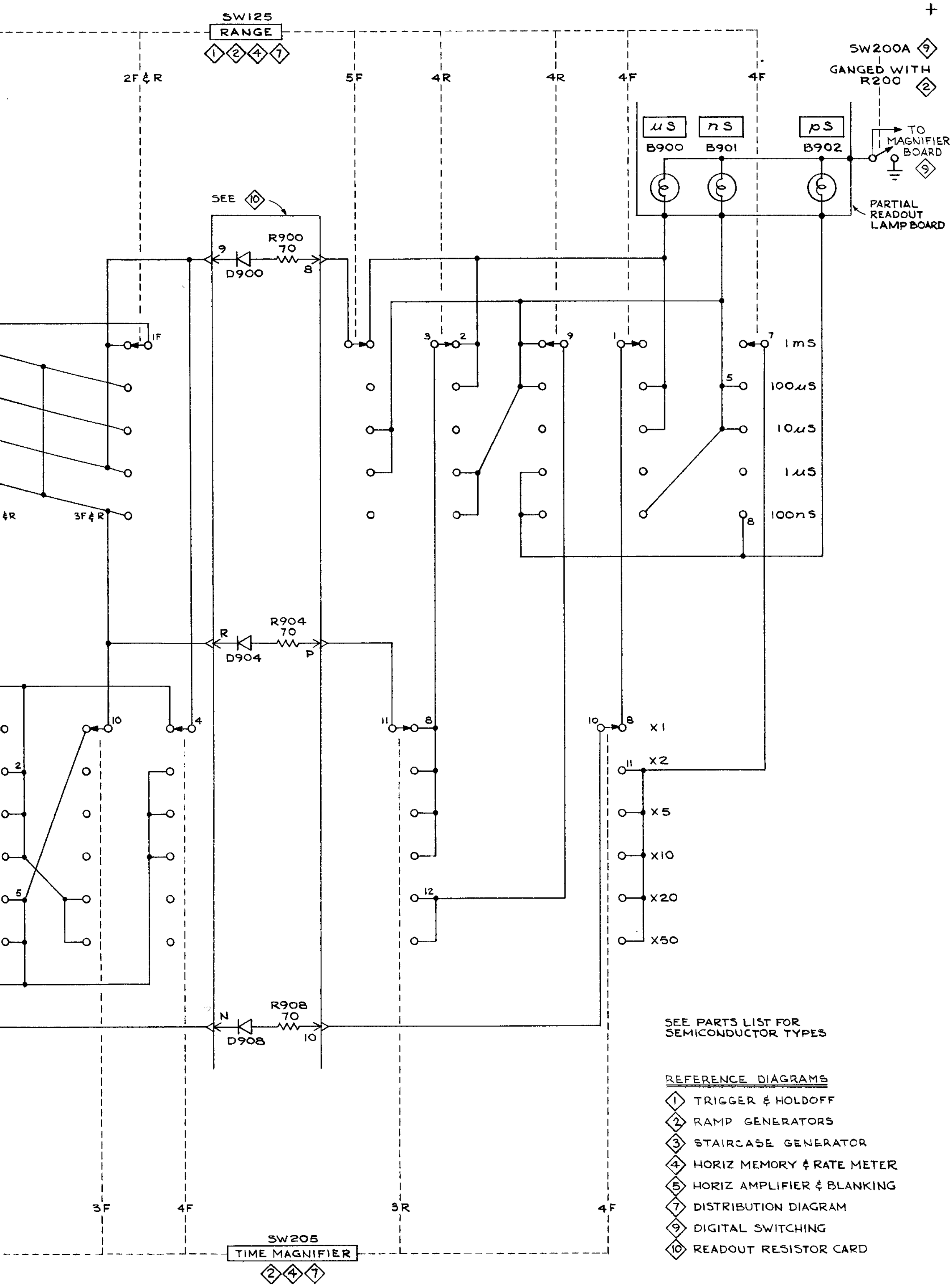


B

DISTRIBUTION DIAGRAM 7

MRH 1069


3F & R
2F & R
SW735
DISPLAY MAG
TO MAGNIFIER BOARD
X1
X10
-12.2V
5R
1F
4F & R
3F & R
SEE
PARTIAL READOUT LAMP BOARD
R910
33
S
D911
D913
D915
B910
B911
B912
B913
B914
B915
J
K
M
D910
D912
D914
R914
70
L
B920
B921
B922
R920
75
R921
75
R922
75
Z
4R
3F
3F
4F



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS

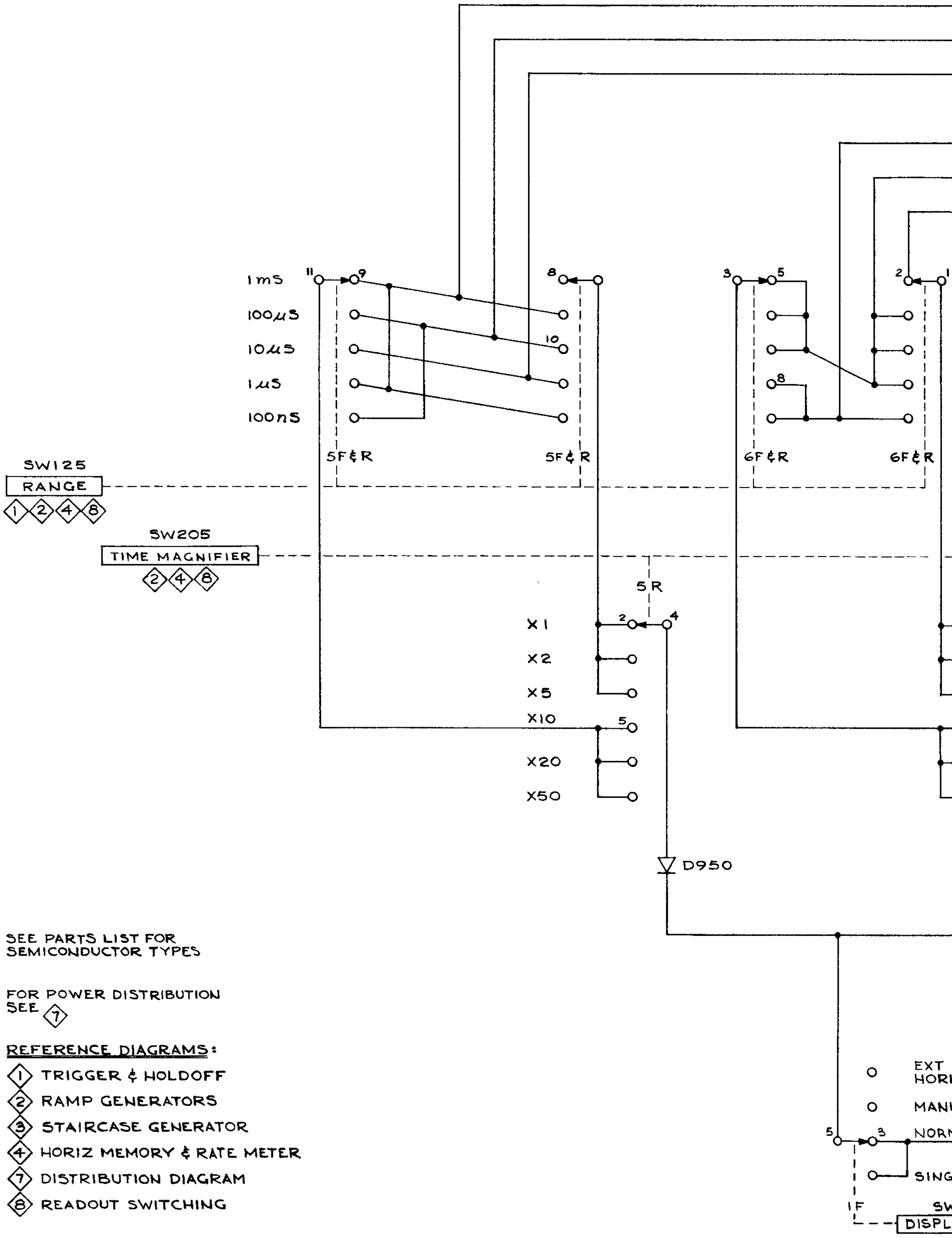
1 TRIGGER & HOLDOFF
2 RAMP GENERATORS
3 STAIRCASE GENERATOR
4 HORIZ MEMORY & RATE METER
5 HORIZ AMPLIFIER & BLANKING
7 DISTRIBUTION DIAGRAM
9 DIGITAL SWITCHING
10 READOUT RESISTOR CARD

FOR POWER DISTRIBUTION SEE 7

B

READOUT SWITCHING 8

MRH 1069



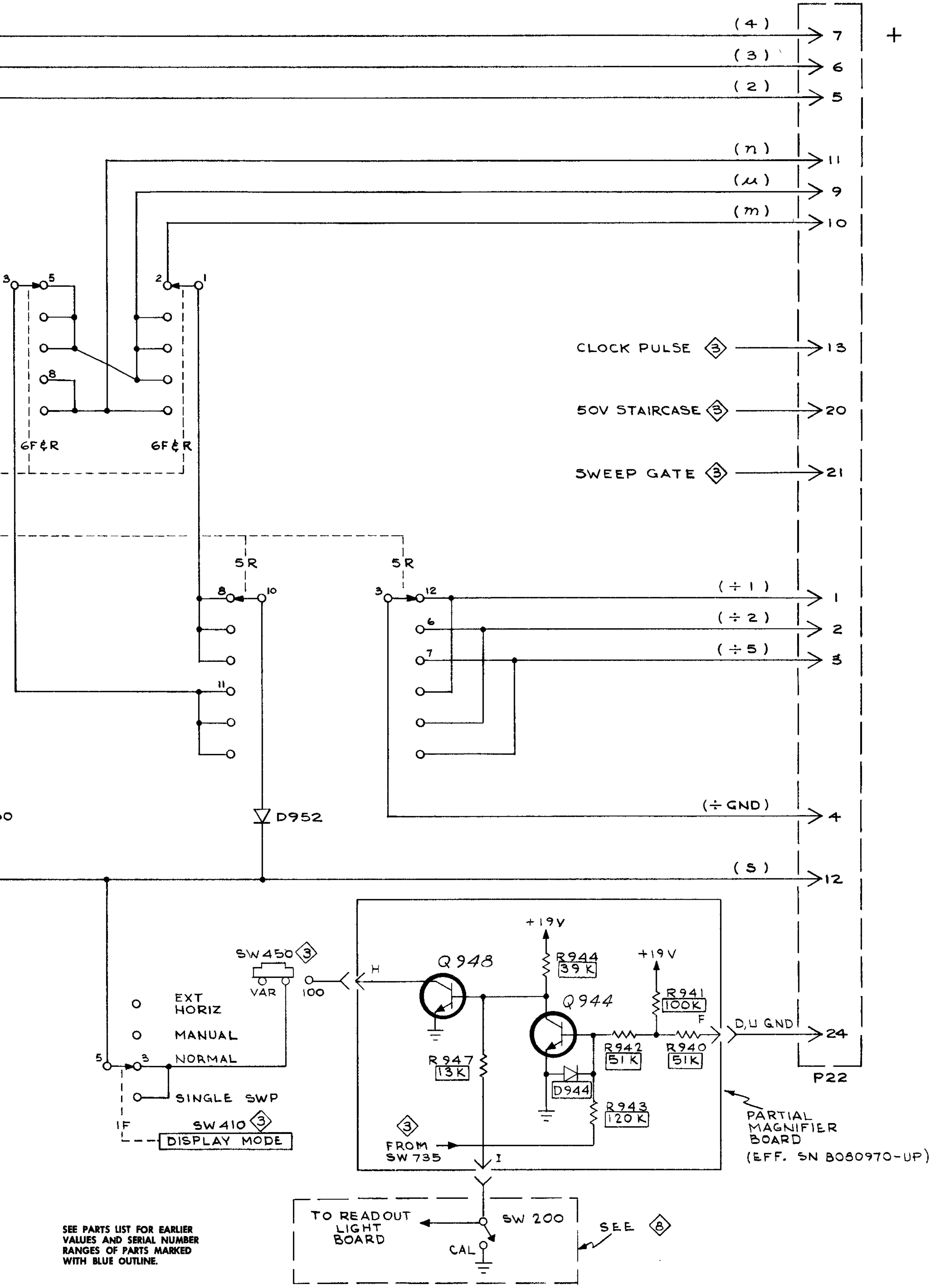
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

FOR POWER DISTRIBUTION SEE 7

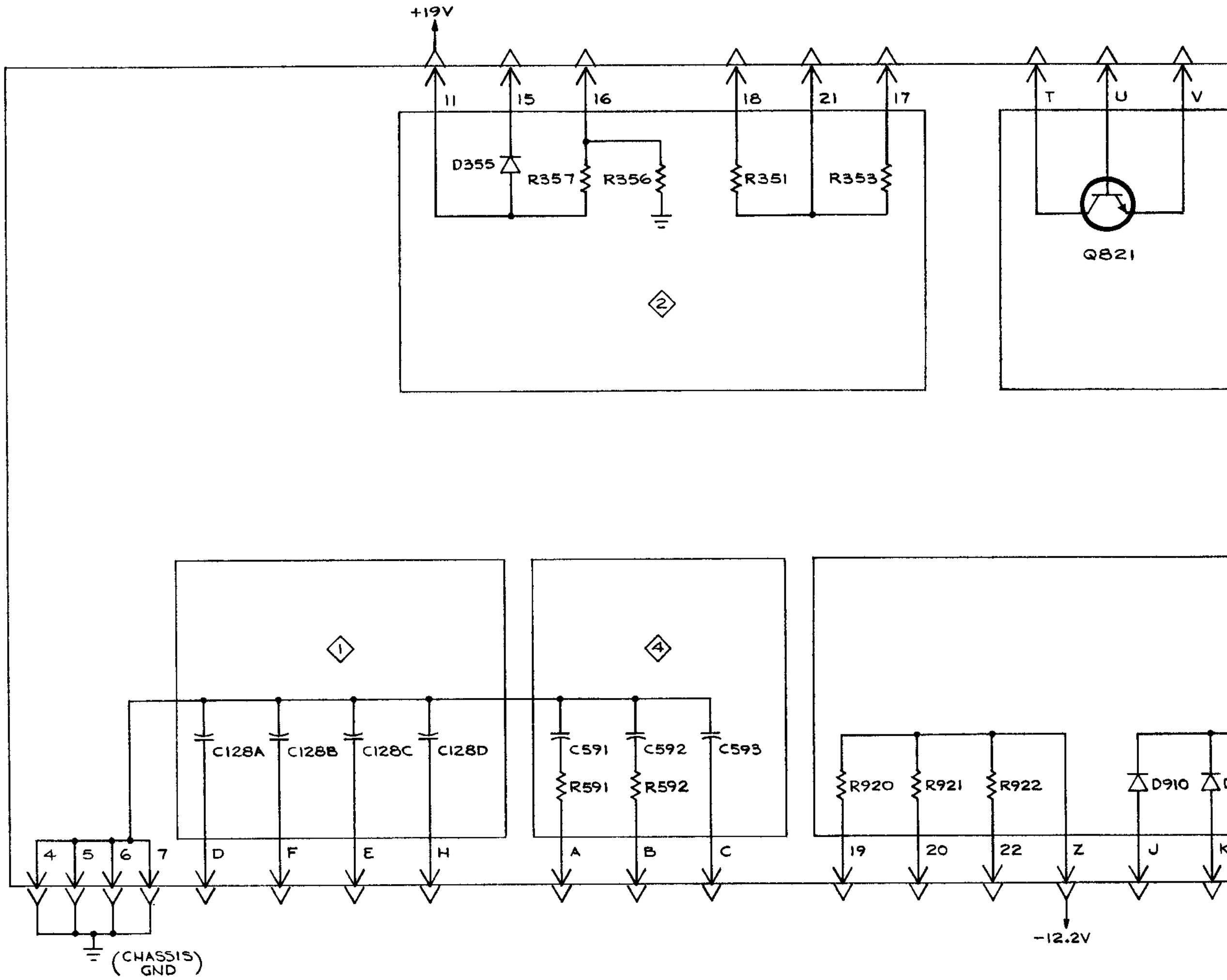
REFERENCE DIAGRAMS:

1 TRIGGER & HOLDOFF
2 RAMP GENERATORS
3 STAIRCASE GENERATOR
4 HORIZ MEMORY & RATE METER
7 DISTRIBUTION DIAGRAM
8 READOUT SWITCHING

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



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

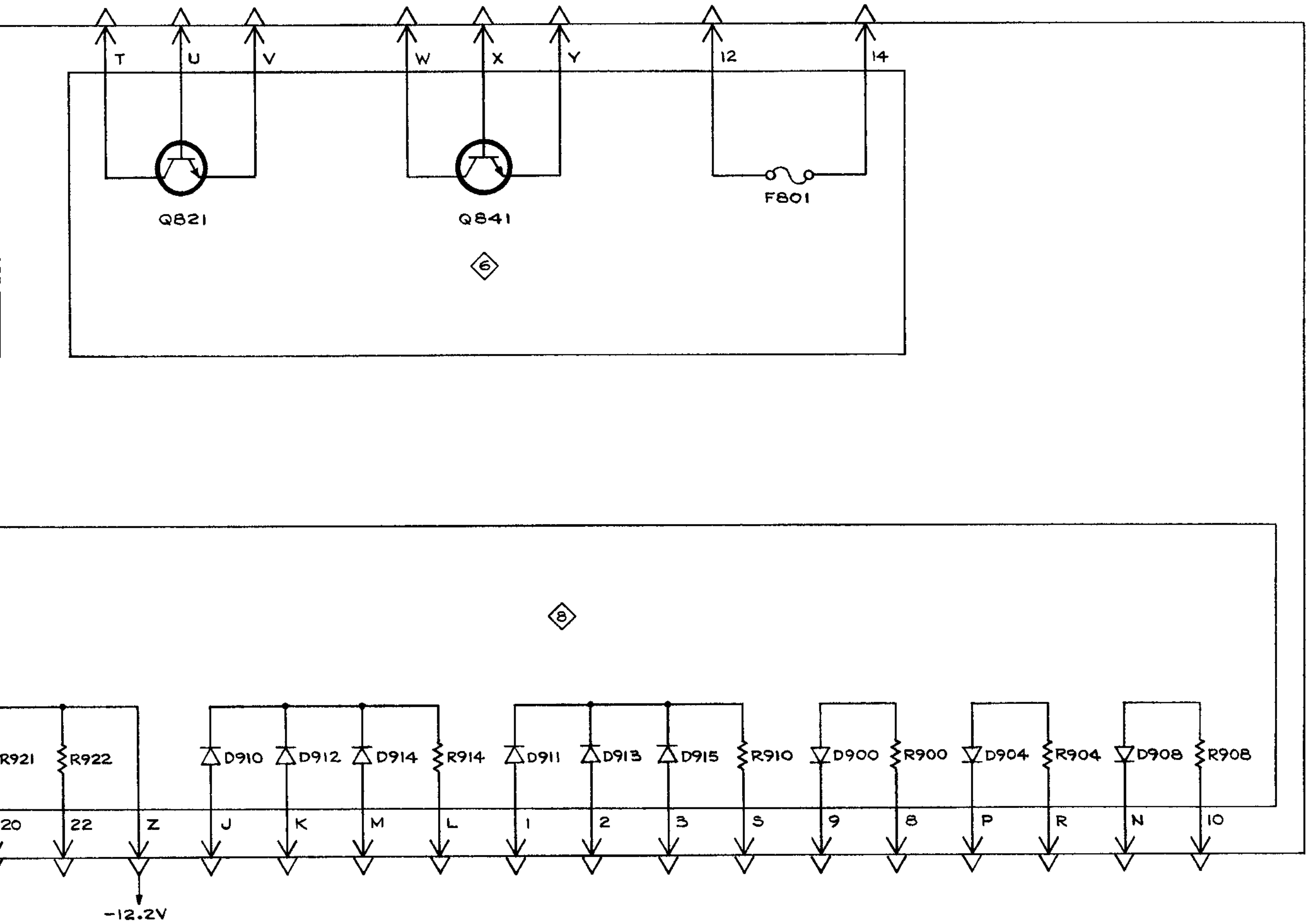


1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	B	C	D	E	F	H	J	K	L	M	N	P	R

J24

TYPE 3T2 RANDOM SAMPLING SWEEP

A



7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
H	J	K	L	M	N	P	R	S	T	U	V	W	X	Y	Z

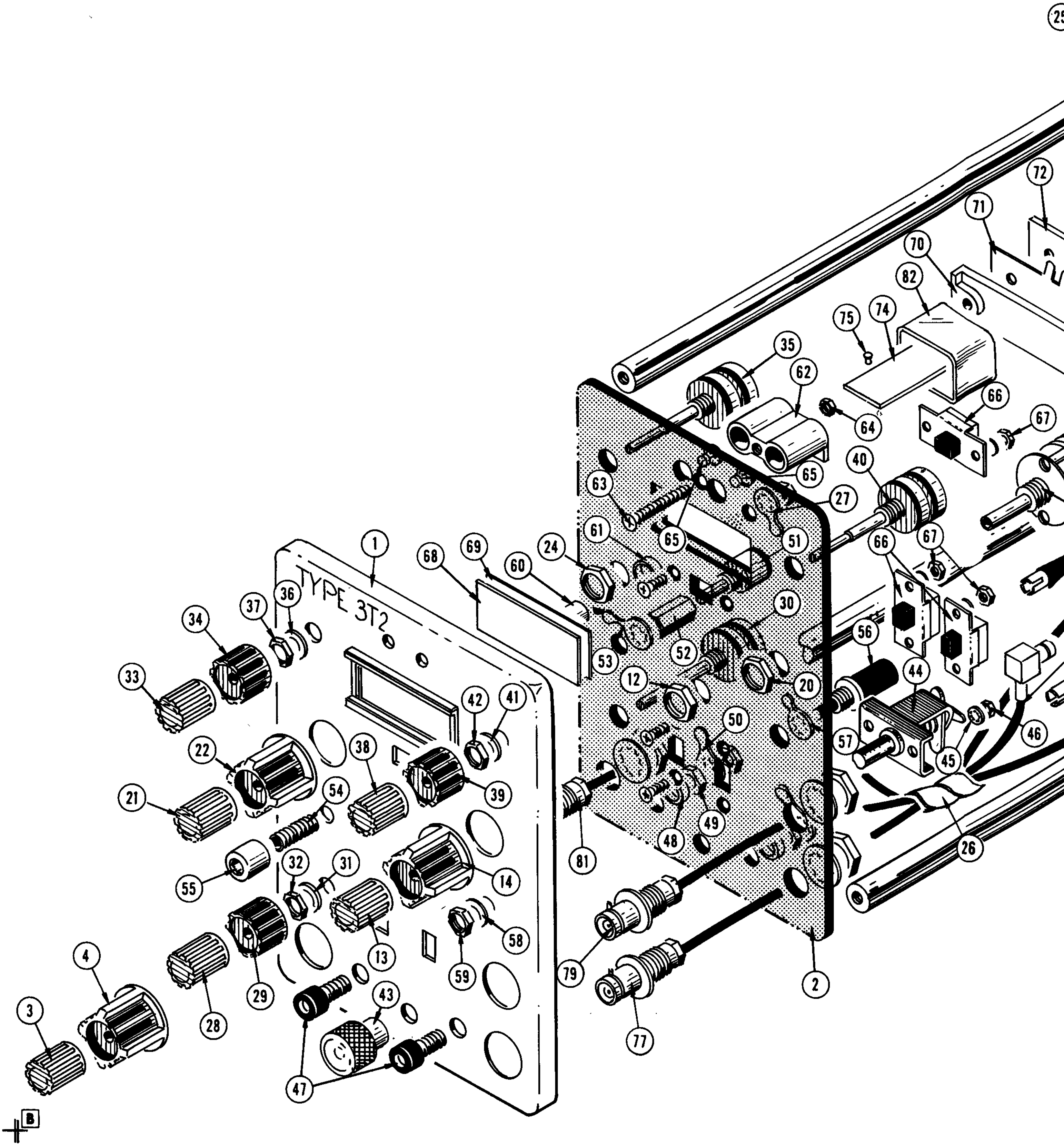
J24

REFERENCE DIAGRAMS:

1. TRIGGER & HOLDOFF
2. RAMP GENERATORS
4. HORIZ MEMORY & RATE METER
6. POWER SUPPLY
8. READOUT SWITCHING

A

READOUT RESISTOR CARD 10 MRH 567


TYPE 3T2
1
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75
77
79
81
82
B

FIG. 1 FRONT & SWITCHES

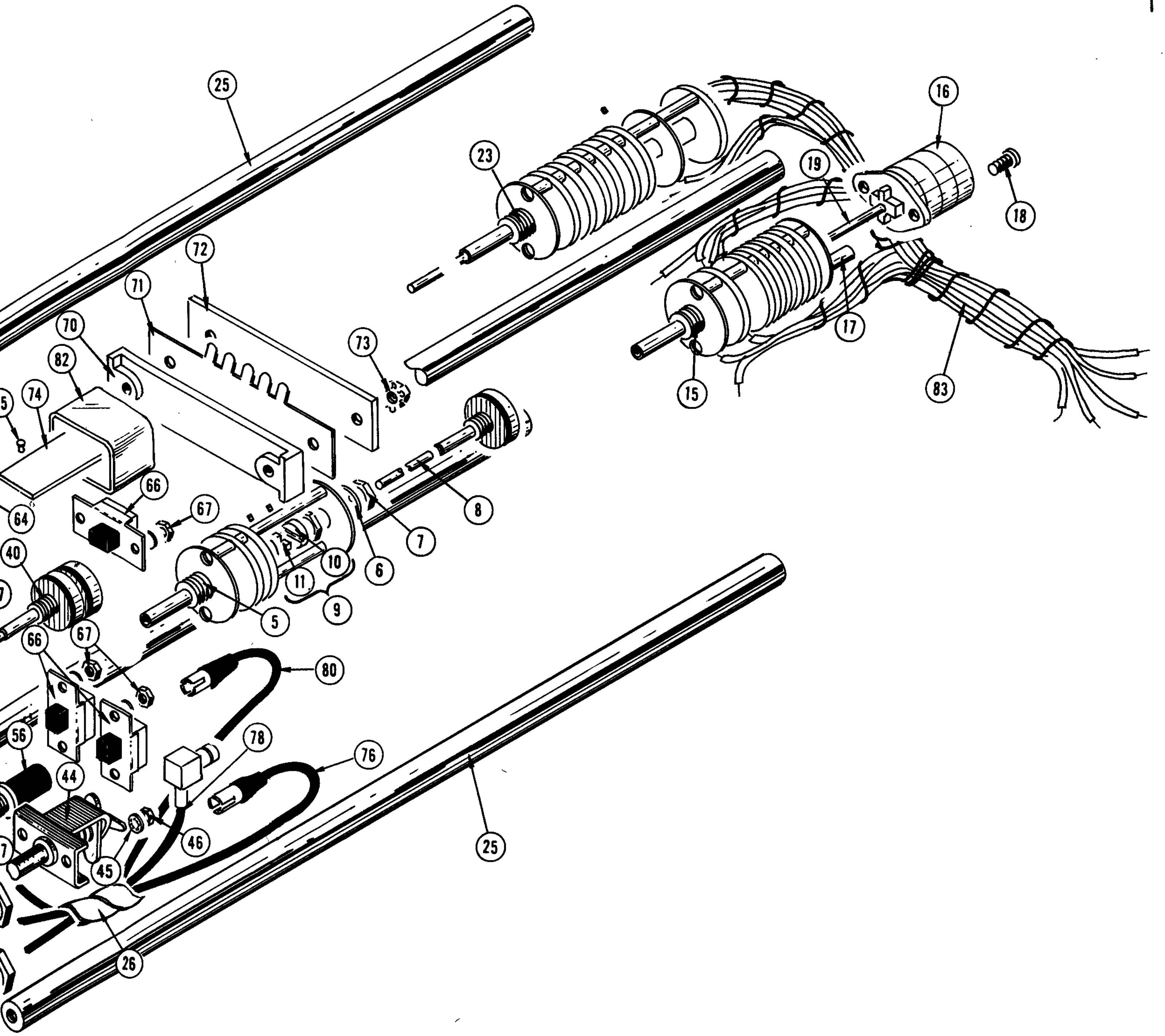
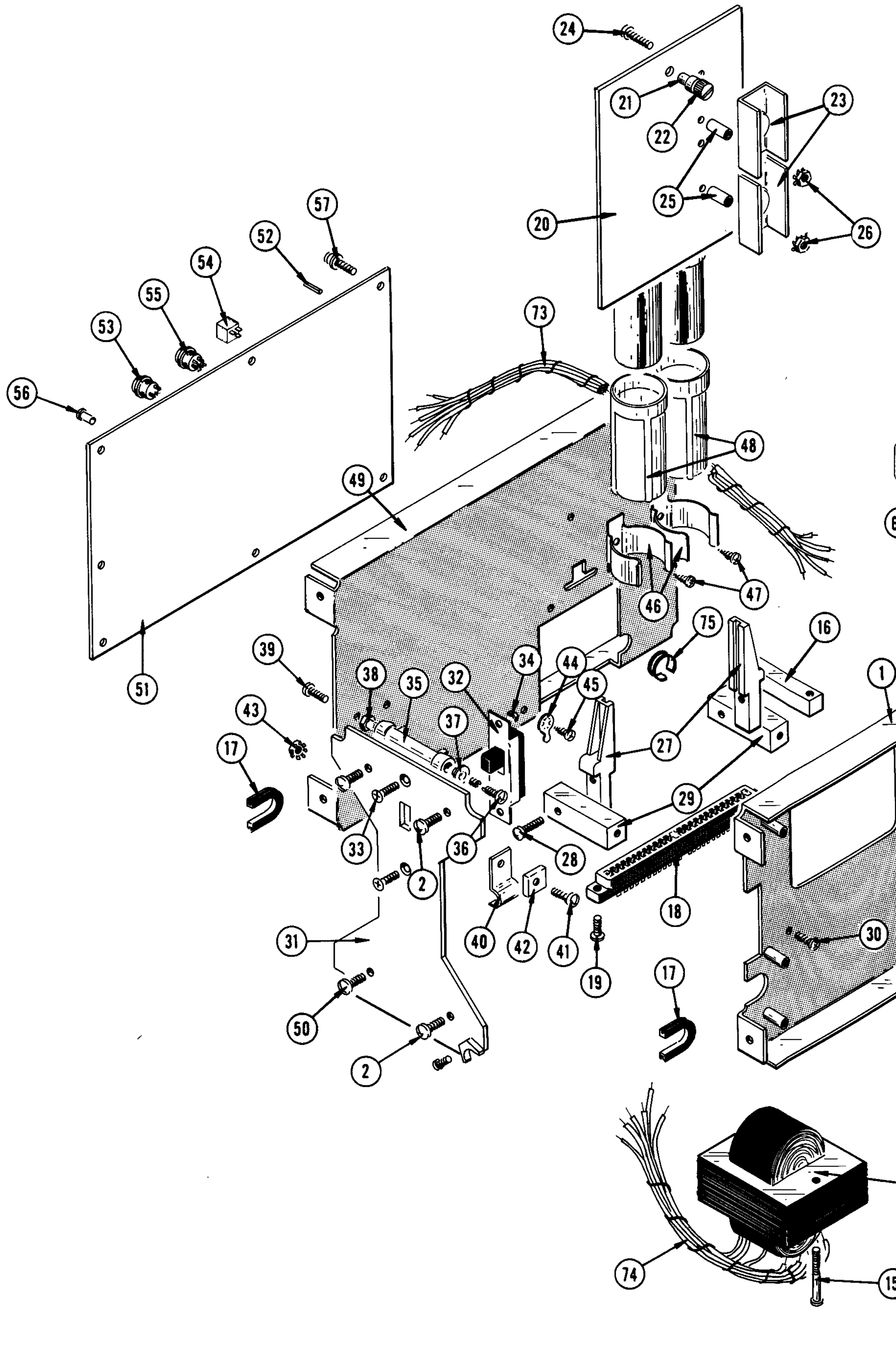
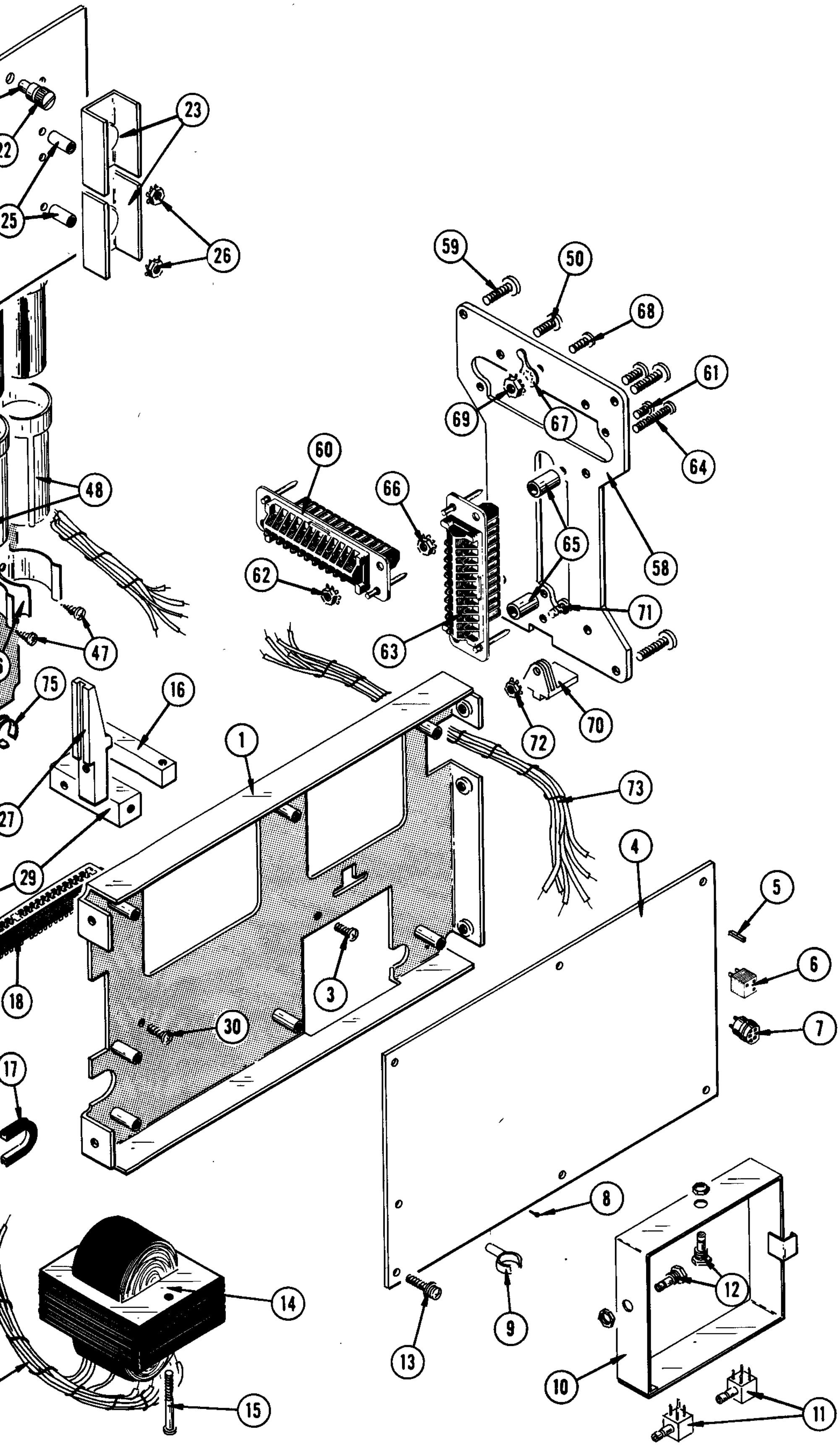


FIG. 2 CIRCUIT BOARDS, CHASS



4A


22
23
25
26
59
50
68
61
69
67
64
60
66
48
65
58
62
71
63
47
75
16
72
70
1
73
27
29
4
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6
18
3
30
7
17
8
9
12
14
13
10
11
15

FIG. 3 STANDARD ACCESSORIES

+

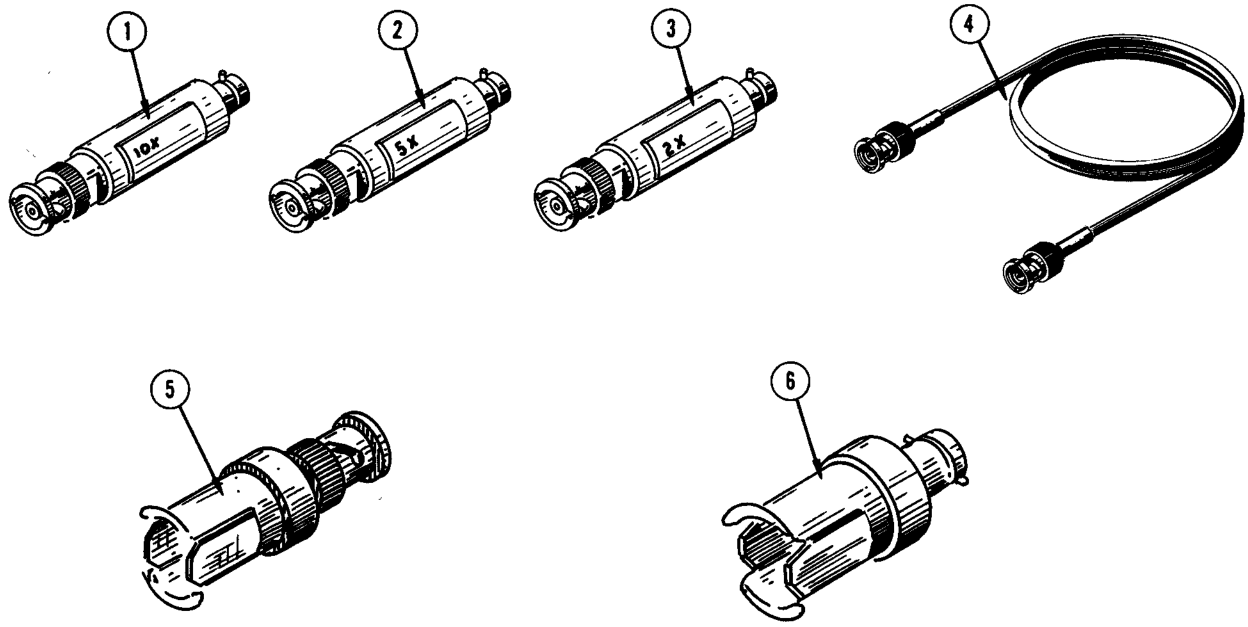


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-1	011-0059-00			1	50 Ω 10X attenuator BNC
-2	011-0060-00	B010100	B019999X	1	50 Ω 5X attenuator BNC
-3	011-0069-00	B010100	B019999X	1	50 Ω 2X attenuator BNC
-4	012-0057-01	B010100	B019999X	2	CABLE, 50 Ω coaxial w/BNC
-5	017-0063-00			1	ADAPTER, BNC to G.R. female
-6	017-0064-00			1	ADAPTER, BNC to G.R. male
	070-0631-00			2	MANUAL, instruction (not shown)

Ⓑ I

+A

MANUAL CHANGE INFORMATION

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

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

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

TEXT CORRECTION

Section 1 Characteristics

Page 1-3 Horizontal Deflection System

CHANGE: SWP OUT connector signal to read:

SWP OUT Connector signal (SN B080970-up)	1 V/Div, ±5% (through 10 kΩ) 1X MAG 0.1 V/Div, ±5% (through 10 kΩ) 10X MAG	
SWP OUT Connector signal (SN B010100-B070969)	1 V/Div, ±5%	Through 10 kΩ

Page 1-3 Electrical Characteristics

CHANGE: first Performance Requirement line under "Pulse, External (50 Ω Input)" to:

External (50 Ω Input)	
With Trigger	30 ps or less trigger jitter with 50 mV, 2 ns duration pulse. 20 ps or less trigger jitter with 150 mV, 2 ns duration pulse.
Before Trigger	50 ps or less trigger jitter with 50 mV, 2 ns duration pulse.

Diagrams Block Diagram

DELETE: Q373 and Q393 from the Timing Ramp Amplifier block.

C6/1169

TEXT CORRECTIONS

Section 3 Operating Instructions

Page 3-5 DISPLAY MAG Switch

DELETE: the last sentence.

Page 3-8 2nd column, 9th line from the bottom

ADD: a period after the word waveform, and DELETE: the remainder of the sentence.

Section 5 Maintenance

Page 5-12 Fig. 5-8A

REPLACE: the existing Figure with the one included in this insert.

ADD: a Figure 5-10 included in this insert.

Section 7 Calibration

ADD: the following between the present Step 25 and Step 26.

25. Check Variable Samples/Div (SN B080970 and up)

a. Set the DISPLAY MODE switch to NORMAL, the START POINT switch to WITH TRIGGER, the RANGE switch to 10 μs and the SAMPLES/DIV control fully clockwise.

b. Check that the trace consists of 12 dots/div or less. See Fig. 7-30.

c. Set the SAMPLES/DIV control counterclockwise and adjust R453, located on X10 Magnifier board, so the spot requires one second to cross the graticule. This adjustment is on the X10 Magnifier board, which is mounted just behind the bottom portion of the 3T2 front panel.

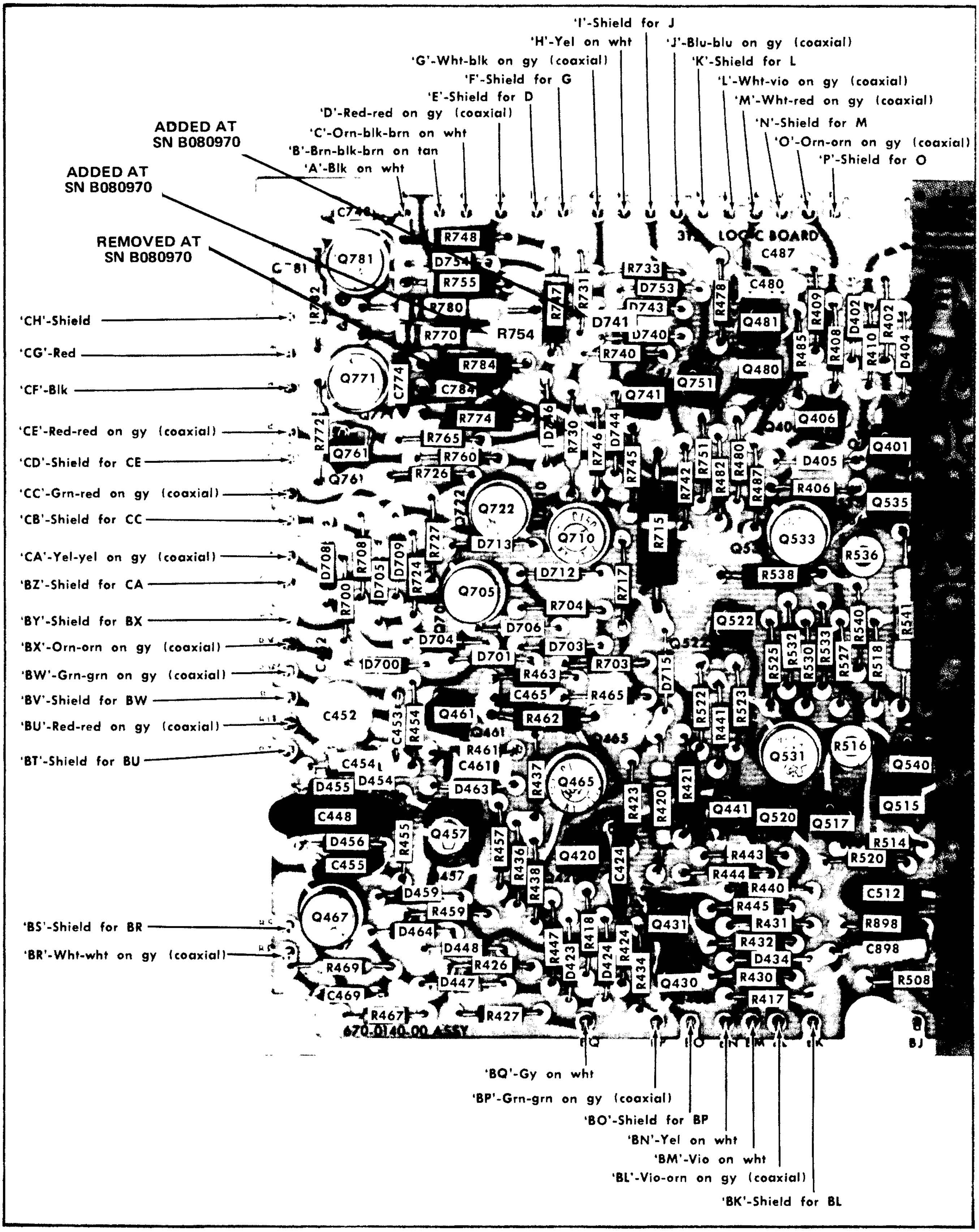


Fig. 5-8A. Logic Board, Left.

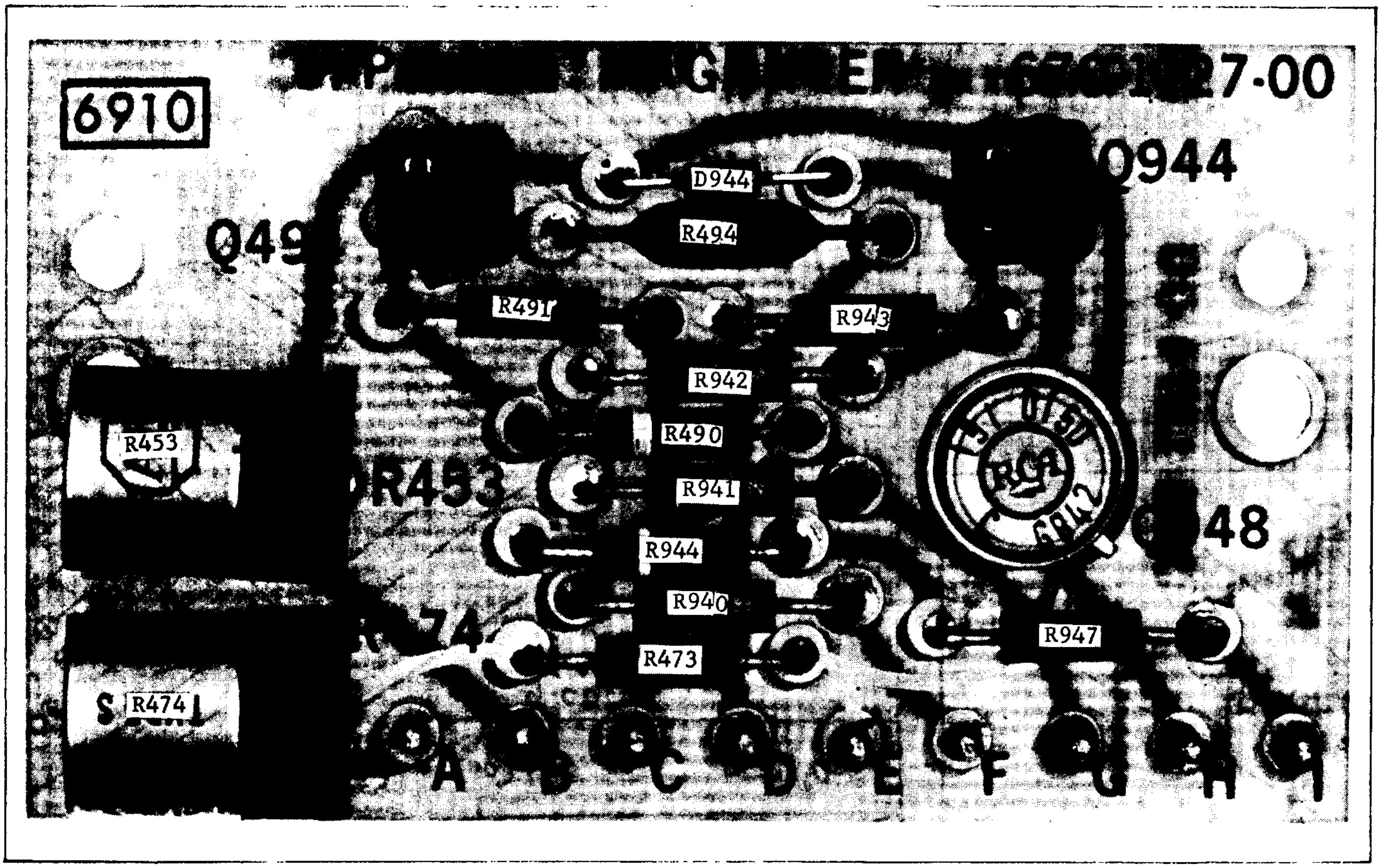


FIG. 5-10. X10 Magnifier Board.

The following are the connections for the Magnifier Board.

'A'- Orn on wht

'B'- Vio on wht

'C'- Blk on wht

'D'- Red on wht

'E'- Wht

'F'- Brn on wht

'G'- Blk-red on wht

'H'- Blk-brn on wht

'I'- Blk-orn on wht

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

REMOVE:

R451	315-0132-00	1.3 kΩ	1/4 W	5%
R730	321-0268-00	6.04 kΩ	1/8 W	1%

CHANGE TO:

Q12	151-0221-00	Silicon	2N4258	
Q20	151-0271-00	Silicon	Tek Spec	
Q30	151-0271-00	Silicon	Tek Spec	
Q41	151-0269-00	Silicon	Hi-Frequency	
Q51	151-0269-00	Silicon	Hi-Frequency	
Q74	151-0220-00	Silicon	2N4122	
Q102	151-0271-00	Silicon	Tek Spec	
R66	321-0256-00	4.53 kΩ	1/4 W	5%
R200A, R200B } 5	311-0962-00	2x10 kΩ, Var		
R351	315-0304-00	300 kΩ	1/4 W	5%
R354, R355 }	311-0965-00	2x10 kΩ, Var		
R474	311-0940-00	2.5 kΩ, Var		
R731	315-0114-00	110 kΩ	1/4 W	5%
R733	315-0104-00	100 kΩ	1/4 W	5%
R737	321-0251-00	4.02 kΩ	1/8 W	1%
R738	321-0347-00	40.2 kΩ	1/8 W	1%
SW200A, SW200B } 9	311-0962-00			
SW205	262-0803-01	Rotary	TIME MAGNIFIER	

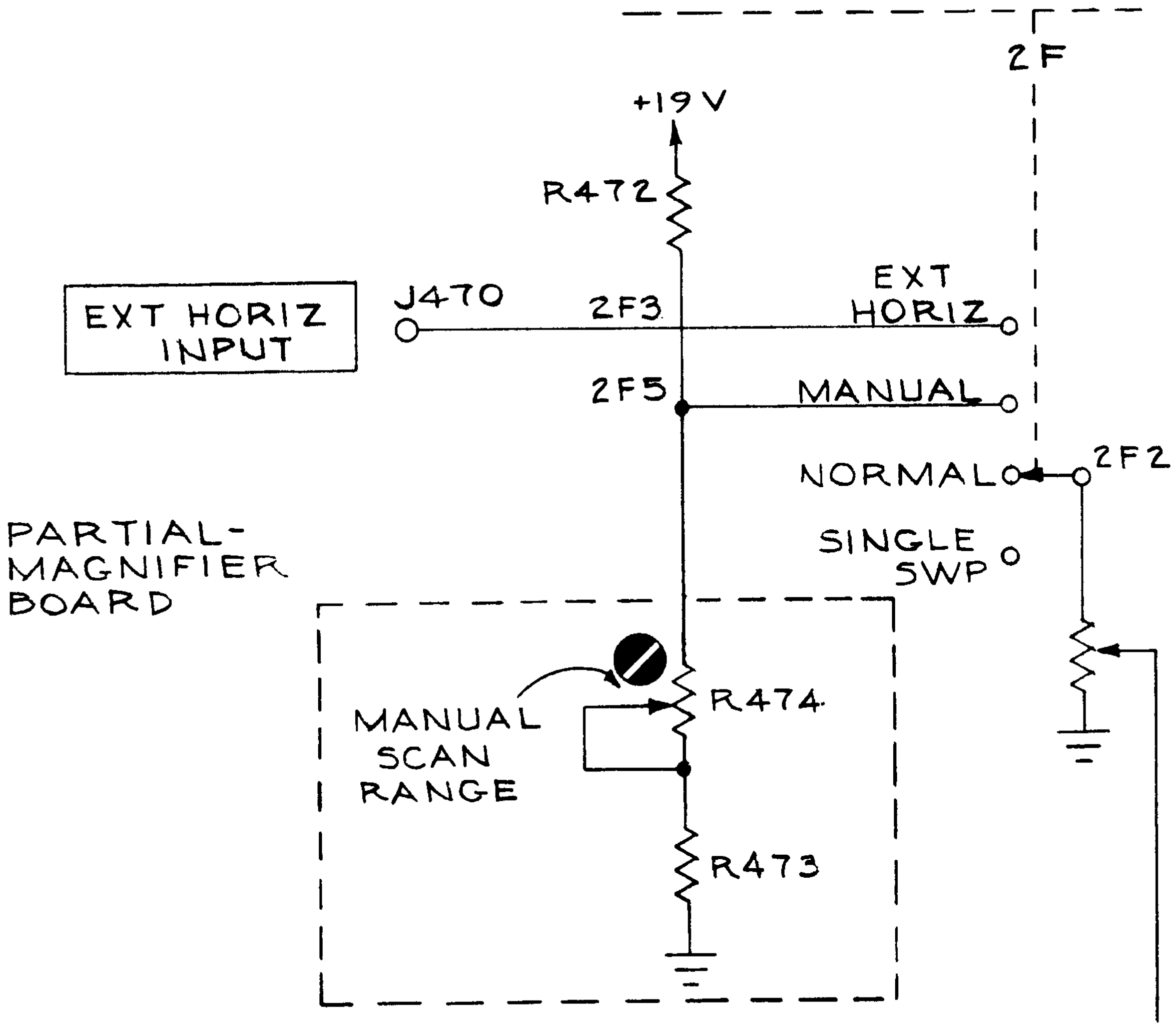
ADD:

D741	152-0185-00	Silicon	Replaceable by 1N4152
D944	152-0185-00	Silicon	Replaceable by 1N4152

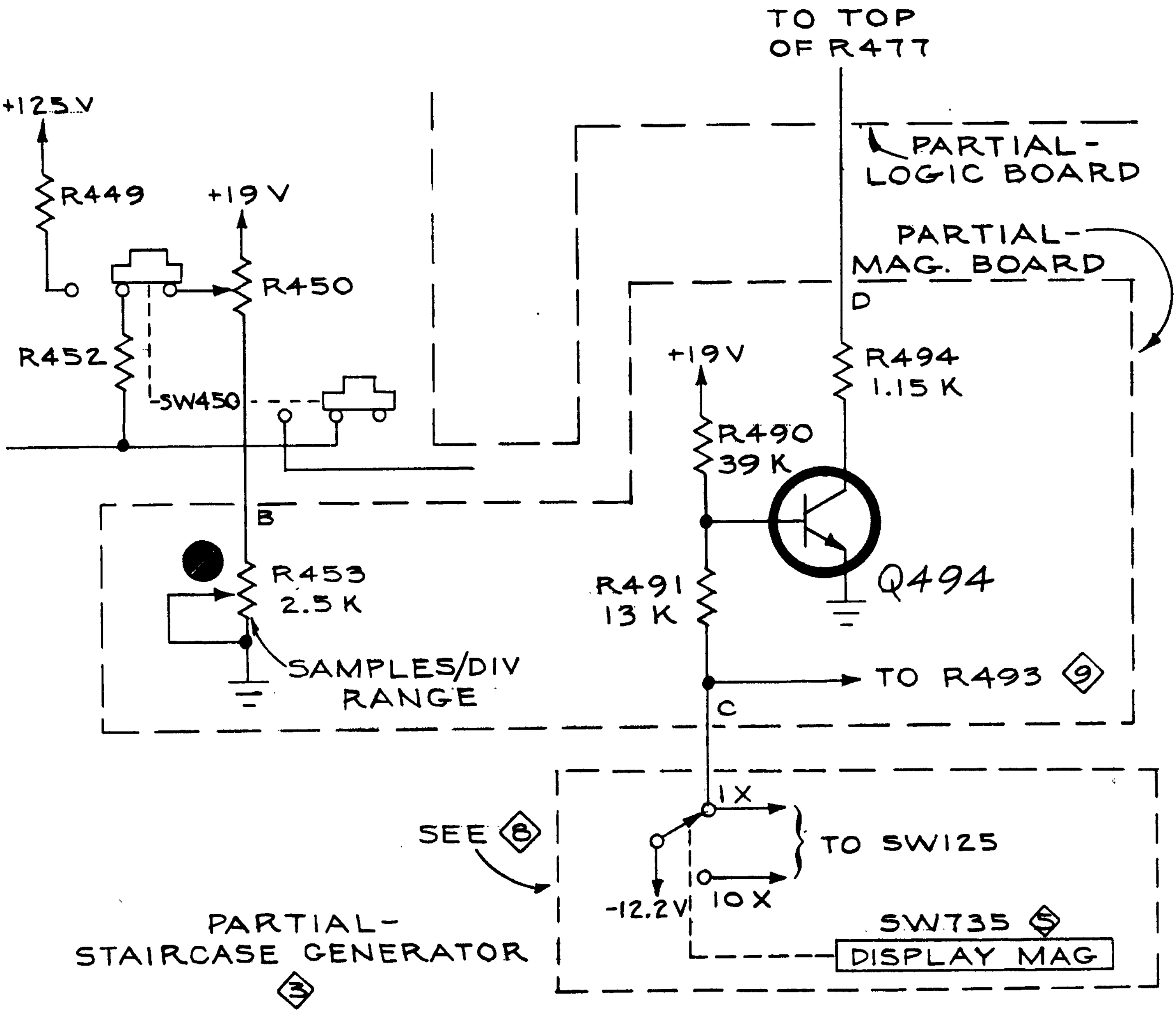
M14,843/969

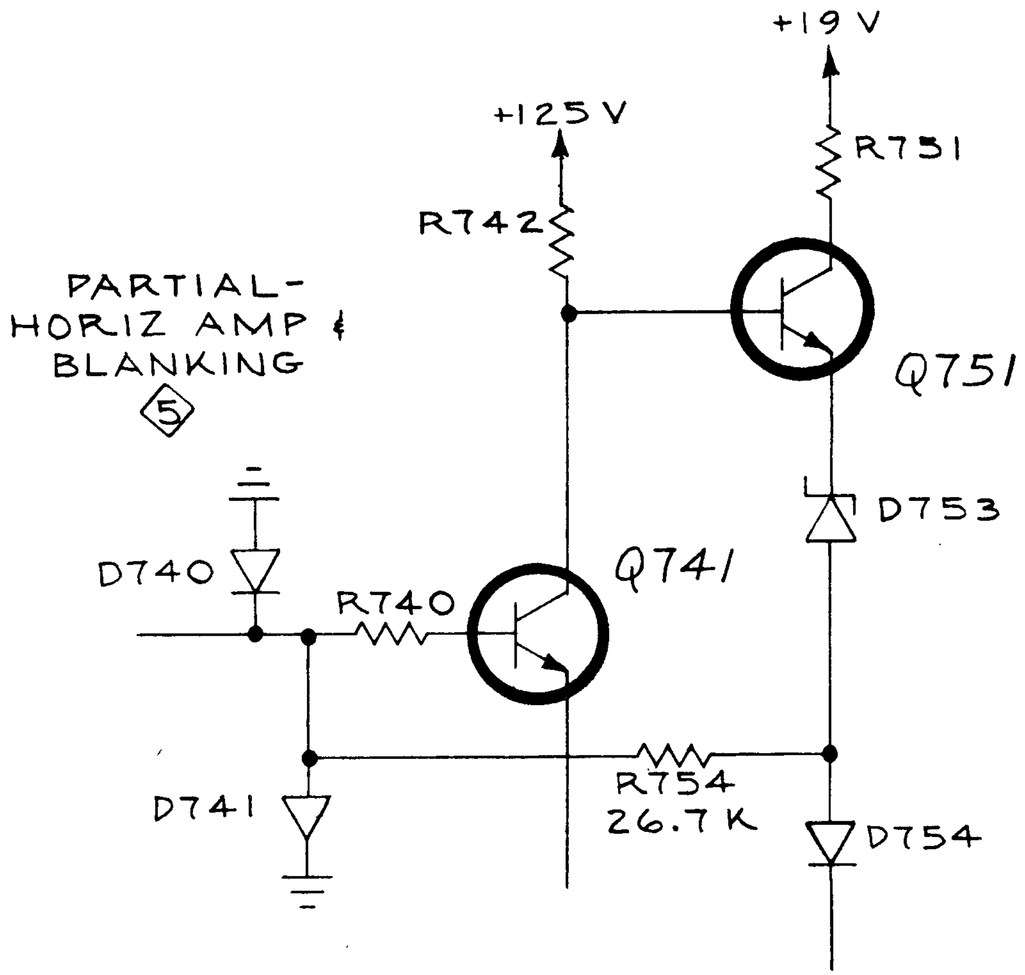
ADD (cont'd):

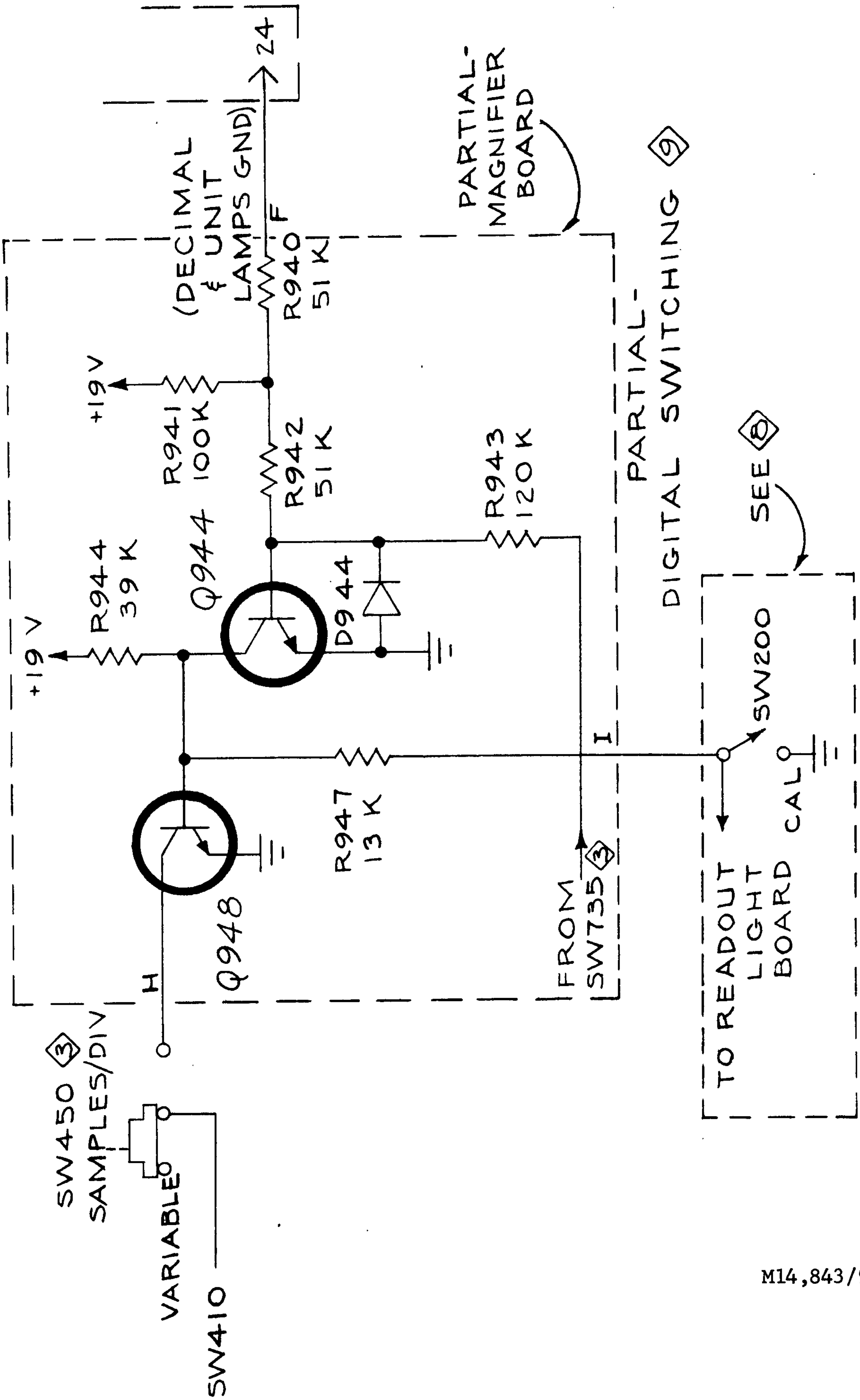
Q494	151-0190-01	Silicon	Tek Spec	
Q944	151-0190-01	Silicon	Tek Spec	
Q948	151-0150-00	Silicon	2N3440	
R453	311-0940-00	2.5 kΩ, Var		
R490	315-0393-00	39 kΩ	1/4 W	5%
R491	315-0133-00	13 kΩ	1/4 W	5%
R494	321-0199-00	1.15 kΩ	1/8 W	1%
R754	321-0330-00	26.7 kΩ	1/8 W	1%
R940	315-0513-00	51 kΩ	1/4 W	5%
R941	315-0104-00	100 kΩ	1/4 W	5%
R942	315-0513-00	51 kΩ	1/4 W	5%
R943	315-0124-00	120 kΩ	1/4 W	5%
R944	315-0393-00	39 kΩ	1/4 W	5%
R947	315-0133-00	13 kΩ	1/4 W	5%



PARTIAL-
STAIRCASE GENERATOR
3


TO TOP
OF R477
+125 V
R449
+19 V
R450
R452
SW450
PARTIAL-
LOGIC BOARD
PARTIAL-
MAG. BOARD
D
+19 V
R494
1.15 K
R490
39 K
B
R453
2.5 K
R491
13 K
Q494
SAMPLES/DIV
RANGE
TO R493 9
C
1X
SEE 8
TO SW125
-12.2V
10 X
SW735 5
DISPLAY MAG
PARTIAL-
STAIRCASE GENERATOR
3


+19 V
+125 V
R751
R742
PARTIAL-
HORIZ AMP &
BLANKING
5
Q751
D753
Q741
D740
R740
R754
26.7 K
D741
D754


24
(DECIMAL & UNIT LAMPS GND)
F
R940 51 K
PARTIAL-MAGNIFIER BOARD
PARTIAL-DIGITAL SWITCHING 9
+19V
R941 100K
R942 51 K
R943 120 K
R944 39 K
+19 V
Q944
D944
SEE 8
SW200
I
CAL
R947 13 K
Q948
FROM SW735 3
H
TO READOUT LIGHT BOARD
SW450 3 SAMPLES/DIV
VARIABLE
SW410

TYPE 3T2 TENT SN B060890

STANDARD ACCESSORIES CORRECTION

FIG. 3 ACCESSORIES

CHANGE and ADD to Fig. & Index No. 3-1:

3-1	011-0059-00	B010100	B059999	1 50 Ω 10X attenuator BNC
	011-0059-01	B060000		1 50 Ω 10X attenuator BNC

M14,919/469

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

D225	152-0141-02	Silicon	1N4152
D228	152-0141-02	Silicon	1N4152
D236	152-0141-02	Silicon	1N4152
D277	152-0233-00	Silicon	Tek Spec
D284	152-0141-02	Silicon	1N4152
D282	152-0141-02	Silicon	1N4152
D311	152-0141-02	Silicon	1N4152
D314	152-0141-02	Silicon	1N4152

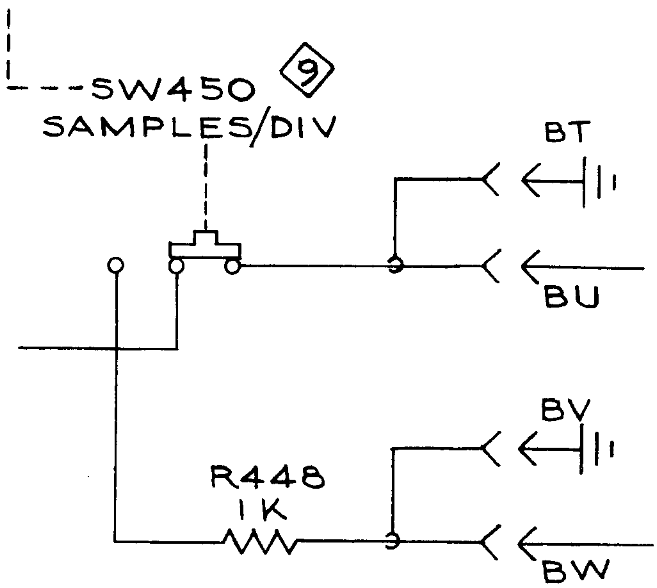
ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE TO:

C453	283-0144-00	33 pF	Cer	500 V	1%
D454	152-0324-00	Silicon	Tek Spec		
D456	152-0324-00	Silicon	Tek Spec		
Q371A,B	151-0236-00	Silicon	Dual, Tek Spec		
Q391A,B	151-0236-00	Silicon	Dual, Tek Spec		

ADD:

R448	315-0102-00	1 kΩ	1/4 W		5%



PARTIAL-
STAIRCASE GENERATOR
3

TYPE 3T2 TENT SN B101110

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

R213	321-0333-00	28.7 kΩ	1/8 W	1%

M15,651/1069

TYPE 3T2 TENT SN B121240

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

Q791	151-0292-00	Silicon	NPN
Q793	151-0292-00	Silicon	NPN

M15,783/1269

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTIONS

CHANGE TO:

D277	152-0246-00	Silicon	250 mW, 40 V, Low-leakage

ADD:

D271	152-0185-00	Silicon	Replaceable by 1N4152