INSTRUCTION MANUAL

Serial Number ____________

TYPE 11B2A TIME BASE PLUG-IN

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0640-00

267


TYPE 11B2A TIME BASE
HORIZ DISPLAY
A INTEN BY B
A
A INTEN BY B
B DLY'D BY A
B DLY'D BY A
EXT INPUT
X10
MAG
OFF
UNCAL
COUPLING
AC
DC
SOURCE
INT
EXT
TRIG LEVEL
B DLY'D SWEEP
SLOPE
TRIG IN
OR EXT INPUT
TIME/CM AND DELAY TIME
mSEC
µSEC
SEC
DELAYED SWEEP
VARIABLE
B
PULL TO UNLOCK
CALIB
TRIG MODE
FREE RUN
AUTO
NORM
SINGLE SWEEP
RESET
HF STABILITY
TRIG LEVEL
SLOPE
A
A
SWEEP
B
DELAY TIME MULT 1-10
COUPLING
AC
AC LF REJ
DC
SOURCE
INT
LINE
EXT
EXT ÷ 10
TRIG IN
A
+ GATE
B
SERIAL
TEKTRONIX
PORTLAND. OREGON. U.S.A.

SECTION 1
CHARACTERISTICS

Introduction

The Tektronix Type 11B2A Time Base plug-in unit provides calibrated sweep rate capabilities from five seconds to 0.1 microsecond/division for Tektronix 647-series oscilloscopes. A ×10 magnifier allows each sweep rate to be increased 10 times to provide a maximum sweep rate of 10 nanoseconds/division in the .1 μSEC position. The delayed sweep feature allows the B sweep to be delayed a selected amount from the start of A sweep to provide accurate relative-time measurements. X-Y measurements can be made by applying the external horizontal signal to the EXT INPUT connector (HORIZ DISPLAY switch set to EXT INPUT).

The trigger circuits of the Type 11B2A provide stable triggering over the full range of vertical frequency response. Separate trigger controls are provided to select the desired triggering for A and B sweeps. One of four trigger modes can be selected for A sweep; free run, automatic, normal or single sweep.

The electrical characteristics which follow are divided into two categories. Characteristics listed in the Performance Requirement column are checked in the Performance Check and Calibration sections of this manual. Items listed in the Supplemental Information column are provided for reference use and do not directly reflect the measurement capabilities of this instrument. The Performance Check procedure given in Section 5 of this manual provides a convenient method of checking the Performance Requirements listed in this section. The following characteristics apply over a calibration interval of 1000 hours at an ambient temperature range of −30°C to +65°C, except as otherwise indicated. Warm-up time for given accuracy is 20 minutes.

ELECTRICAL CHARACTERISTICS
Triggering (A and B Sweep)

Characteristic	Performance Requirement	Supplemental Information
Source	Internal from vertical plug-in unit. Internal from AC power source (A only). External from signal applied to TRIG IN connector. External signal applied to TRIG IN connector attenuated 10 times (A only).	
Coupling	AC AC low-frequency reject (A only) DC	
Polarity (slope)	Sweep can be triggered from positive-going or negative-going portion of trigger signal	
Trigger Mode (A sweep only)	Free run Automatic Normal Single sweep	Selected by A TRIG MODE switch
Internal Trigger Sensitivity-A sweep only (also see Fig. 1-2) AC	0.3 centimeter of deflection, minimum, 60 Hz to 20 MHz; increasing to 2 centimeters at 100 MHz	Typical lower —3 dB point, 16 Hz
AC LF REJ	0.3 centimeter of deflection, minimum, 50 kHz to 20 MHz; increasing to 2 centimeters at 100 MHz	Typical lower —3 dB point, 16 kHz
DC	0.3 centimeter of deflection, minimum, DC to 20 MHz; increasing to 2 centimeters at 100 MHz	
External Trigger Sensitivity-A sweep only (also see Fig. 1-3) AC	125 millivolts minimum, 60 Hz to 20 MHz; increasing to 250 millivolts at 100 MHz	Typical lower —3 dB point, 16 Hz
AC LF REJ	125 millivolts minimum, 50 kHz to 20 MHz; increasing to 250 millivolts at 100 MHz	Typical lower —3 dB point, 16 kHz

ELECTRICAL CHARACTERISTICS *(cont)*

Characteristic	Performance Requirement	Supplemental Information
DC	125 millivolts minimum, DC to 20 MHz; increasing to 250 millivolts at 100 MHz	
Internal Trigger Sensitivity-B sweep only (also see Fig. 1-2) AC	0.5 centimeter of deflection minimum, 60 Hz to 20 MHz; increasing to 3 centimeters at 100 MHz	Typical lower —3 dB point, 16 Hz
DC	0.5 centimeter of deflection minimum, DC to 20 MHz; increasing to 3 centimeters at 100 MHz	
External Trigger Sensitivity-B sweep only (also see Fig. 1-3) AC	200 millivolts minimum, 60 Hz to 20 MHz; increasing to 300 millivolts at 100 MHz	Typical lower —3 dB point, 16 Hz
DC	200 millivolts minimum, DC to 20 MHz; increasing to 300 millivolts at 100 MHz	
Auto Triggering (A Sweep only)	Provides triggering capability for trigger signals above 20 Hz and produces a free-running sweep for lower frequencies or in absence of trigger signal	
Single Sweep (A Sweep only)	Triggering capability same as normal trigger Performance Requirement	Resets manually by front-panel RESET push button. Remote resetting requires a positive-going step or pulse of at least 5 volts with a risetime of 10 μs or faster and a duration of 1.5 μs or greater applied to the connector located on rear panel of the indicator oscilloscope.
External Trigger Input Input RC characteristics		Approximately 1 Megohm paralleled by 20 pF (except in AC LF REJ, A sweep only)
Maximum Input Voltage		500 volts combined DC and peak AC
LEVEL control range (A sweep only) EXT EXT ÷ 10	 At least + and —5 volts At least + and —50 volts except AC LF REJ	
LEVEL control range (B sweep only) EXT	At least + and —10 volts	

HORIZONTAL DEFLECTION SYSTEM
A and B Sweep Generator

Characteristic	Performance Requirement		Supplemental Information
Sweep Rates A	5 seconds to 0.1 microsecond/centimeter in 25 calibrated steps		Steps in 1-2-5 sequence. A Sweep is main and delaying sweep. B Sweep is delayed sweep
B	5 seconds to 0.1 microsecond/centimeter		
Sweep Accuracy—A and B Sweep	0°C to +40°C	—30° C to +65° C	
5 SEC to 0.1 SEC/cm	Within 3%	Within +4%, —6%	A VARIABLE and B TIME/CM VARIABLE controls set to CALIB. MAG switch set to OFF
50 mSEC to 0.1 μSEC/cm	Within 1.5%	Within 2.5%	
Normal Sweep Linearity	Within 5%	Within 5%	Measured over any two division interval within center eight divisions
Variable Sweep Rate	Uncalibrated sweep rate to 2.5 times, or more, the TIME/CM switch setting		Slowest sweep rate 12.5 seconds/division, or slower, in the 5 SEC position.

HORIZONTAL DEFLECTION SYSTEM *(cont)*

Characteristic	Performance Requirement		Supplemental Information
Sweep Length			
A sweep	10.5 to 11.0 centimeters		
B sweep	10.2 to 11.0 centimeters		
Sweep Holdoff—A Sweep 5 SEC to 0.1 mSEC/CM			One time or less, the A TIME/CM switch setting
50 μSEC to 1 μSEC/CM			Two times, or less, the A TIME/CM switch setting
0.5 μSEC to 0.1 μSEC/CM			Two microseconds or less

Sweep Magnifier

Characteristic	Performance Requirement		Supplemental Information
Sweep Magnification	Each sweep rate can be increased 10 times the indicated sweep rate by horizontally expanding the center division of display		Extends fastest sweep rate to 10 nanoseconds/centimeter
Magnified Sweep Accuracy (equivalent magnified sweep rates given	0°C to +40°C	−30°C to +65°C	
0.5 second to 10 millisecond/centimeter	Within 4%	Within +5.5%, −7.5%	A VARIABLE and B TIME/CM VARIABLE controls set to CALIB
5 millisecond to 50 nanoseconds centimeter	Within 2.5%	Within 4%	
20 and 10 nanoseconds/centimeter	Within 3.5%	Within 5%	
Magnified Sweep Linearity	Within 5%	Within 10%	Measured over any two centimeter interval within center eight centimeters. Exclude first 100 nanoseconds and last 60 nanoseconds of total magnified sweep length
Normal/Magnified Registration (5 SEC to 1 μSEC/CM)	±0.2 centimeter or less trace shift from center screen when switching MAG switch from ×10 to OFF		

Sweep Delay

Characteristic	Performance Requirement		Supplemental Information
Calibrated Delay Time	Continuous from 50 seconds to one microsecond		A VARIABLE control set to CALIB
DELAY TIME MULT Dial Range	0.30 to 10.30		
Delay Time Accuracy	0°C to +40°C	−30°C to +65°C	
5 SEC to 0.1 SEC/CM	Within 2.5%	Within +3%, −6%	Includes incremental DELAY-TIME MULT linearity.
50 mSEC to 1 μSEC/CM	Within 1%	Within 2%	Accuracy of the difference between two DELAY-TIME MULT dial settings is expressed as a percent of 10× the A TIME/CM switch setting.
Incremental DELAY-TME MULT Linearity	Within 0.15%	Within 0.2%	
Delay Time Jitter	One part or less in 20,000 of the available delay interval (10 times the A TIME/CM switch setting)		Equal to 0.5 centimeter or less with A TIME/CM switch set to 1 mSEC and B TIME/CM switch set to 1 μSEC

External Horizontal Operation

Characteristic	Performance Requirement	Supplemental Information
Deflection Factor (X-axis only)		
No magnification	1 volt/centimeter	10-series volts/cm switch(s) controls the Y-axis deflection.
With 10 times magnification	0.1 volt/centimeter	
Accuracy	±10%	

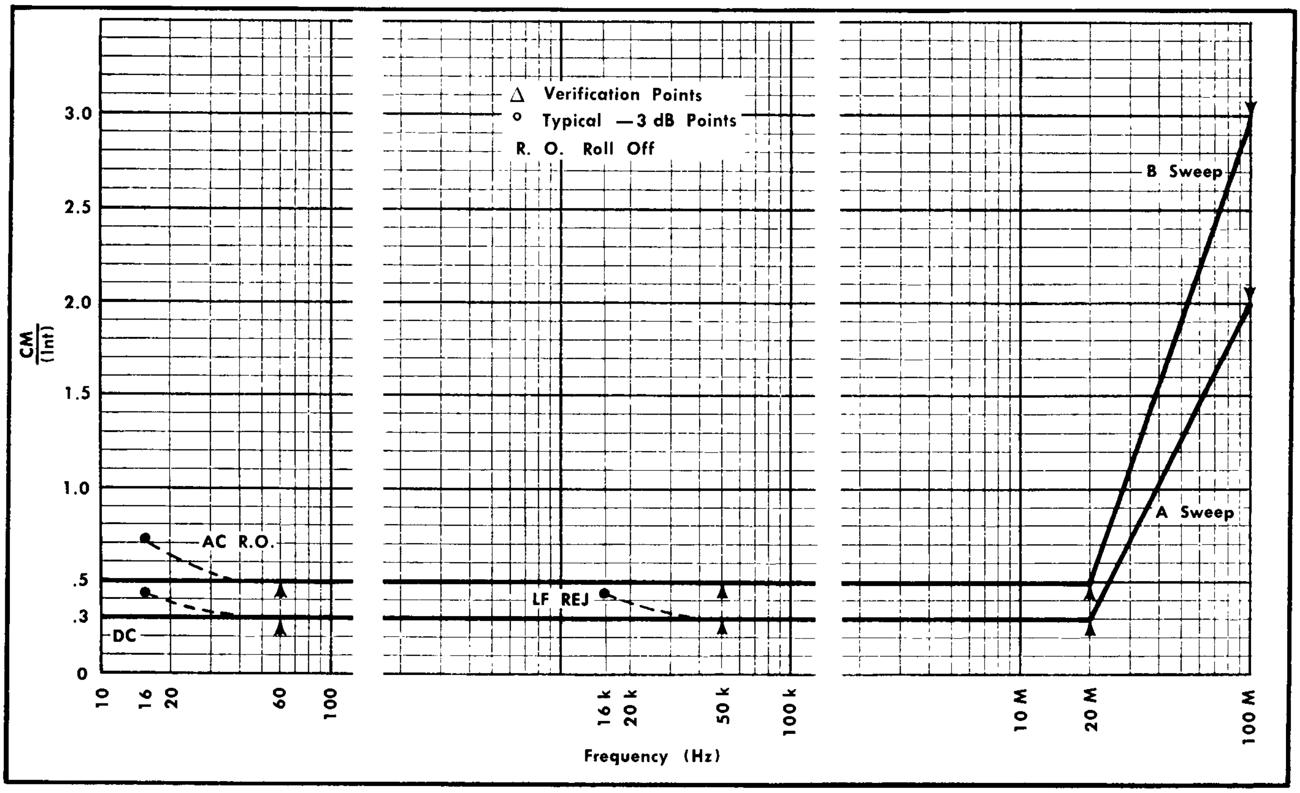


Fig. 1-2. A and B sweep internal trigger coupling and sensitivity.

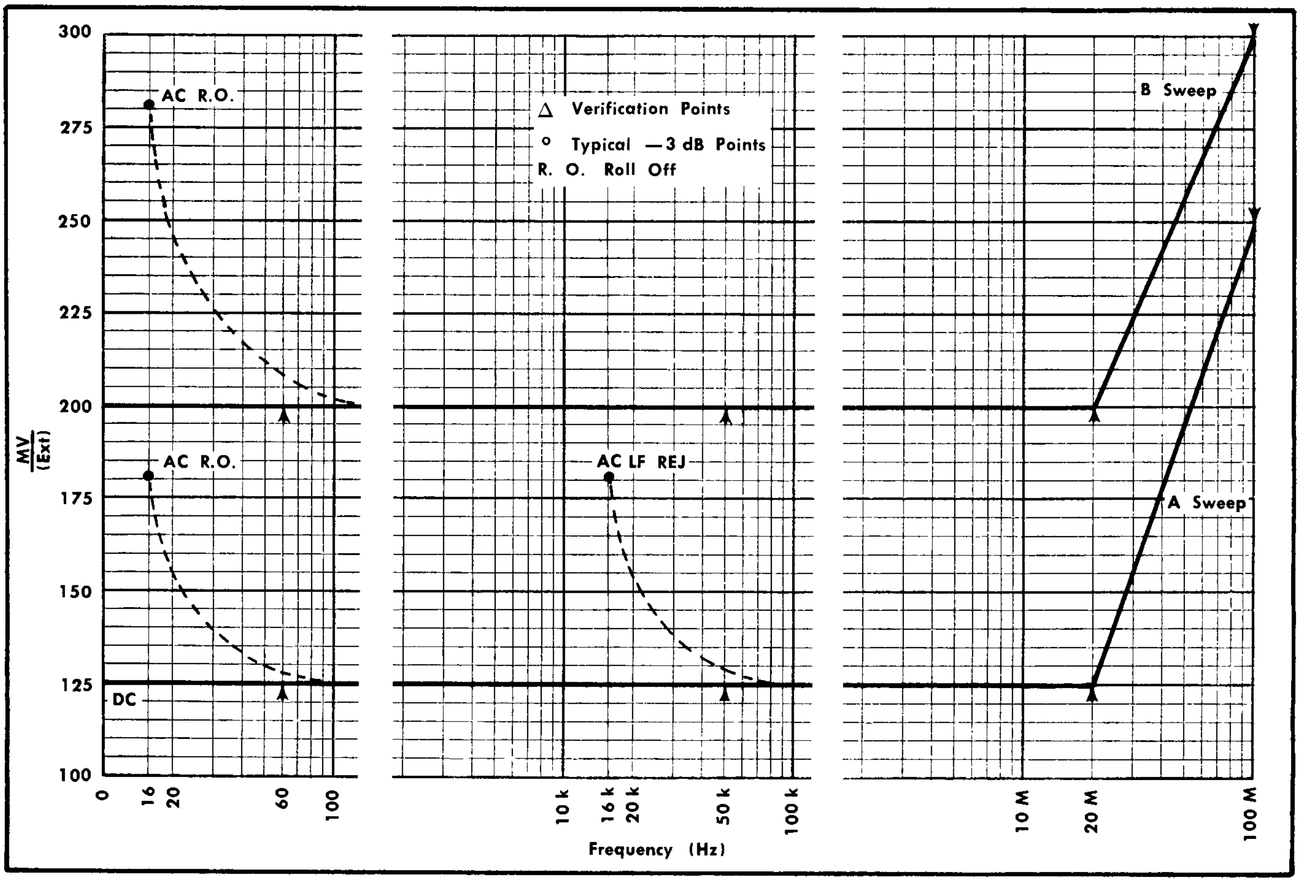


Fig. 1-3. A and B sweep external trigger coupling and sensitivity.

Bandwidth	DC to 3 MHz or greater at —3 dB point	B COUPLING switch effects the lower 3 dB point; see External Trigger Sensitivity (B sweep only) characteristic.
Input RC Characteristics		1 megohm paralleled by 30 pF

Output Signals

Characteristic	Performance Requirement	Supplemental Information
A and B Sweep		
Waveshape	Sawtooth pulse	
Amplitude	10 volts peak, ±10%	
Polarity	Positive-going with baseline near zero volts	
Duration	Same duration as the respective sweep	
Output resistance		Approximately 750 ohms
A and B + Gates		
Waveshape	Rectangular pulse	
Amplitude	15 volts peak, ±10%	
Polarity	Positive going with baseline at about —0.7 volts	
Duration	Same duration as the respective sweep	
Output resistance		Approximately 1.6 kilohm

ENVIRONMENTAL CHARACTERISTICS

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the electrical performance requirements given in this section following environmental test. Complete details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

Characteristic	Performance Requirement	Supplemental Information
Temperature		
Operating	—30°C to +65°C	
Non-operating	—55°C to +75°C	
Altitude		
Operating	15,000 feet maximum	Derate maximum operating temperature by 1°C/1000 feet change in altitude above 5000 feet.
Non-operating	50,000 feet maximum	May be tested during non-operating temperature test
Humidity Non-Operating	Five cycles (120 hours) of MIL-STD-202B, Method 106A	Exclude freezing and vibration
Vibration Operating and non-operating	15 minutes vibration along each of the three major axes at a total displacement of 0.025-inch peak to peak (4g at 55 c/s) with frequency varied from 10-55-10 c/s in one-minute cycles. Hold at 55 c/s for three minutes on each axis	Installed in indicator oscilloscope which is secured to vibration platform during test. Total vibration time, about 55 minutes.
Shock Operating and non-operating	Two shocks of 20 g, one-half sine, 11 millisecond duration each direction along each major axis	Guillotine-type chocks. Installed in indicator oscilloscope. Total of 12 shocks.
Transportation	Meets National Safe Transit type of test when correctly packaged	
Package vibration	One hour vibration slightly in excess of 1 g	Package should just leave vibration surface
Package drop	30 inch drop on any corner, edge or flat surface	

STANDARD ACCESSORIES

Standard accessories supplied with the Type 11B2A are listed on the last pullout page at the rear of this manual. For optional accessories available for use with this instrument, see the current Tektronix, Inc. catalog.

SECTION 3
CIRCUIT DESCRIPTION

Introduction

This section of the manual contains a description of the circuitry used in the Type 11B2A Time Base unit. The description begins with a discussion of the instrument using the basic block diagram shown in Fig. 3-1. Then each circuit is described in detail using a detailed block diagram to show the interconnections between the stages in each major circuit and the relationship of the front-panel controls to the individual stages.

A complete block diagram is located in the Diagrams section at the rear of this manual. This block diagram shows the overall relationship between all of the circuits in this instrument. Complete schematics of each circuit are also given in the Diagrams section. Refer to these diagrams throughout the following circuit description for electrical values and relationship.

BLOCK DIAGRAM

General

The following discussion is provided to aid in understanding the overall concept of the Type 11B2A before the individual circuits are discussed in detail. A basic block diagram of the Type 11B2A is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block represents a major circuit within the instrument. The number on each block refers to the complete circuit diagram which is located at the rear of this manual.

The internal trigger signal from the vertical plug-in unit is connected to the Internal Trigger Preamp stage in the A Trigger Generator circuit. Output of the Internal Trigger Preamp stage is connected to both the A and B Trigger Generator circuits. The A and B Trigger Generator circuits produce an output pulse which initiates the sweep signal produced by the A or B Sweep Generator circuits. The input signal to the A Trigger Generator circuit can be selected from the internal trigger signal, an external signal applied to the A TRIG IN connector, or a sample of the line voltage applied to the indicator oscilloscope. The B Trigger Generator input signal can be selected from the internal trigger signal or an external signal applied to the B TRIG IN connector. Each trigger circuit contains level, slope, coupling and source controls. The input signal applied to the B Trigger Generator is connected to the Horizontal Preamp circuit in the EXT INPUT position of the HORIZ DISPLAY switch to provide external horizontal deflection.

The A Sweep Generator circuit produces a linear sawtooth output signal when initiated by the A Trigger Generator circuit. The slope of the sawtooth produced by the A Sweep Generator circuit is controlled by the A TIME/CM switch. The operating mode of the A Sweep Generator circuit is determined by the TRIG MODE switch. In the FREE RUN position, the output sawtooth free runs independently of any applied trigger pulses. In the AUTO position the sweep can be triggered when an adequate trigger signal is available, but the absence of an adequate trigger signal causes the sweep to free run. In the NORM position, a sweep is produced only when correctly triggered by an adequate trigger signal. The SINGLE SWEEP position allows one (and only one) sweep to be initiated after the A Sweep Generator circuit is reset with the RESET button.

The B Sweep Generator circuit is basically the same as the A Sweep Generator circuit. However, this circuit only produces a sawtooth output signal after a delay time determined by the A TIME/CM switch and the DELAY TIME MULT dial. If the HORIZ DISPLAY switch is set to the not-triggered B DLY'D BY A and A INTEN BY B positions (to left of A), the B Sweep Generator begins to produce the sweep immediately following the selected delay time. If this switch is set to the triggered B DLY'D BY A and A INTEN BY B positions (to right of A), the B Sweep Generator circuit does not produce a sweep until it receives a trigger from the B Trigger Generator circuit after the selected delay time.

The output of either the A or B Sweep Generator circuit is amplified by the Horizontal Preamp circuit to produce the horizontal deflection for the indicator oscilloscope CRT in all positions of the HORIZ DISPLAY switch except EXT INPUT. Other horizontal deflection signals can be connected to the Horizontal Preamp through the B TRIG IN OR EXT INPUT connector.

CIRCUIT OPERATION

General

The following circuit analysis is written around the detailed block diagrams which are given for each major circuit. These detailed block diagrams give the names of the individual stages within the major circuits and show how they are connected together. The block diagrams also show the inputs and outputs for each major circuit and the relationship of the front-panel controls to the individual steps. The circuit diagrams from which the detailed block diagrams are derived are shown in the Diagrams section of this manual. The names assigned to the individual stages on the block diagrams are used throughout the following discussion.

This circuit analysis attempts to describe the electrical operation and relationship of all circuits in the Type 11B2A. The theory of operation for circuits which are commonly used in the electronics industry is not described in detail in this discussion. Instead, references are given to textbooks or other source material where more complete information on these circuits can be found. Circuits which are unusual, or peculiar to this instrument are described in detail.

A TRIGGER GENERATOR

General

The A Trigger Generator circuit produces trigger pulses to start the A Sweep Generator circuit. These trigger pulses are

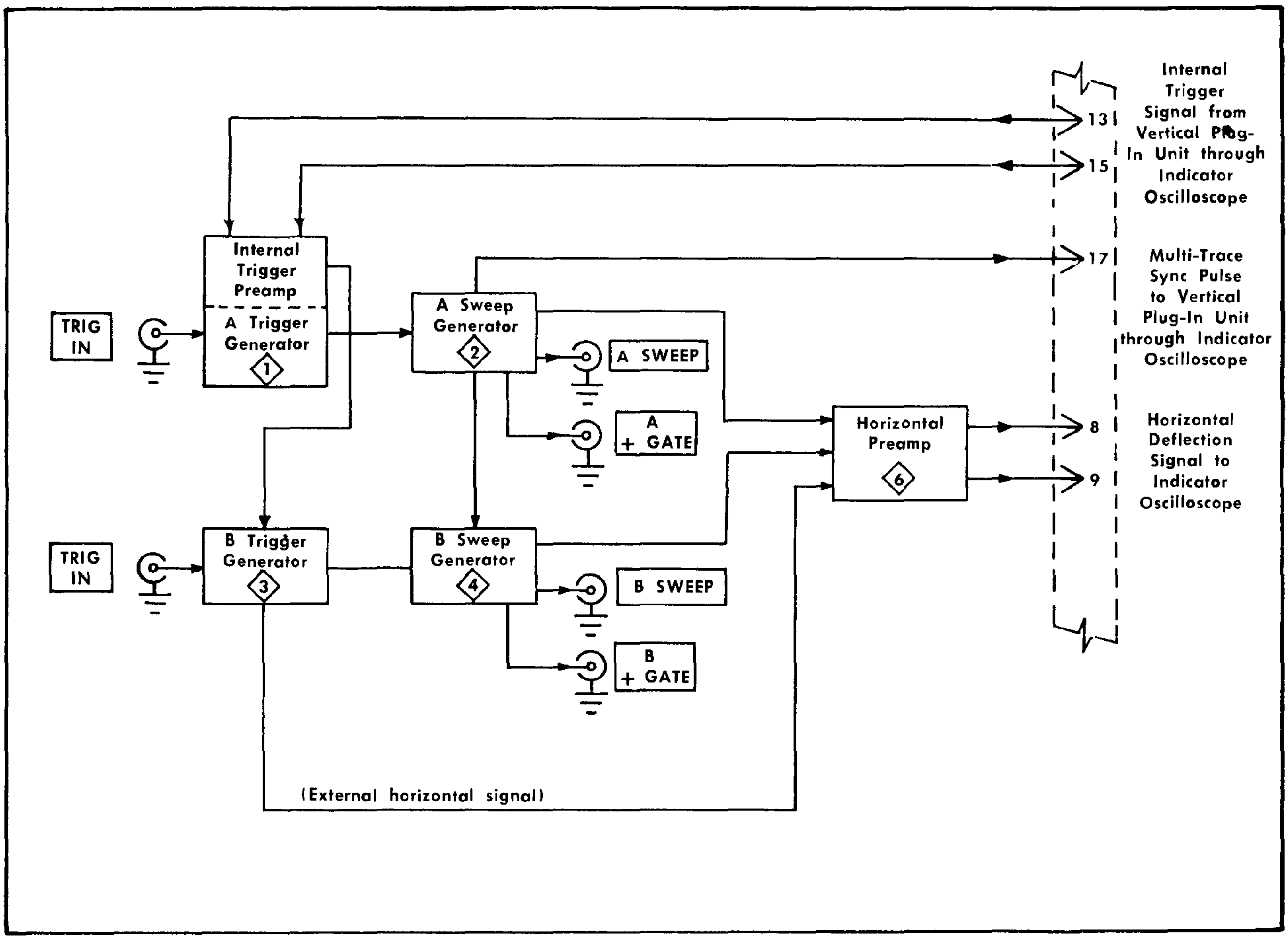


Fig. 3-1. Basic block diagram of Type 11B2A Time Base.

derived from the internal trigger signal from the vertical plug-in unit (through the Internal Trigger Preamp stage); from an external signal connected to the TRIG IN connector, or from a sample of the line voltage applied to the indicator oscilloscope. Controls are provided in this circuit to select trigger level, slope, coupling and source. The A Trigger Generator circuit also includes the Internal Trigger Preamp stage. The Internal Trigger Preamp stage amplifiers the internal trigger signal from the vertical plug-in unit to the level necessary to drive the A and B Trigger Generator circuits. Fig. 3-2 shows a detailed block diagram of the A Trigger Generator circuit. A schematic of this circuit is shown on diagram 1 at the rear of this manual.

Internal Trigger Preamp

The internal trigger signal from the vertical plug-in unit is connected to the Internal Trigger Preamp stage through terminals 13 and 15 of the interconnecting plug. The internal trigger signal at terminals 13 and 15 is push-pull signal and it is connected to the bases of Q14A and Q14B. Since the push-pull signal is of opposite polarity at the bases of Q14A and Q14B, it will have the opposite effect on each of these transistors. For example, if the signal at the base of Q14A is positive-going, it increases the current through this transistor. At the same time the signal at the base of Q14B is negative-going and it decreases the current through Q14B. The common-emitter coupling of Q14A and Q14B allows Q14A to aid in the current change through Q14B to produce a larger resultant change at the collector of Q14B. The Int Trig DC Level adjustment R7, in the base circuit of Q14A sets the quiescent DC output level of the Internal Trigger Preamp stage so the sweep will be triggered at the zero-volt level of the displayed signal when the A or B TRIG LEVEL control is centered.

The amplified trigger signal at the collector of Q14B is connected to the base of Q23A, and in slightly attenuated form to the base of Q23B through R21. Q23A and Q23B are connected as emitter followers in the complementary symmetry amplifier[1] configuration. This configuration overcomes the basic limitation of emitter followers; inability to provide equal response to both positive- and negative-going portions of a signal. This is remedied in this configuration by using an NPN transistor for one emitter follower, Q23A, and a PNP transistor for the other emitter follower, Q23B. Since Q23A is

[1]Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics," second edition, McGraw-Hill, New York, 1962. pp. 11-57—11-62.

an NPN transistor, it responds best to positive-going signals and Q23B, being a PNP transistor, responds best to negative-going signals. The result is a circuit which has equally fast response to both positive- and negative-going trigger signals while maintaining a low output impedance. The amplified internal trigger signal from the emitters of Q23A and Q23B is connected to the internal position of the A and B SOURCE switches through R27A and R27B.

Trigger Source

The A SOURCE switch, SW30A, selects the source of the A trigger signal. Three trigger sources are available; internal, line and external. A fourth position of the A SOURCE switch provides 10 times attenuation for the external trigger signal.

The internal trigger signal is obtained from the vertical plug-in unit through the Internal Trigger Preamp stage. This signal is a sample of the signal applied to the vertical plug-in unit. The line trigger signal is obtained from voltage divider R24-R25 connected between 6.3 volts AC and ground. This sample of the line frequency, about three volts RMS, is coupled to the A Trigger Generator circuit in the LINE position of the A SOURCE switch. The A COUPLING switch should not be in the AC LF REJ position when using this trigger source, as the signal will be blocked by the LF reject circuit.

External trigger signals applied to the A TRIG IN connector can be used to trigger the sweep in the EXT and EXT ÷ 10 positions of the A SOURCE switch. Input resistance at DC is about one megohm paralleled by about 30 picofarads in both external positions. However, when the A COUPLING switch is set to AC LF REJ, a 100-kilohm resistor, R30B is connected in parallel with the one-megohm input resistor, R30A, to provide attenuation of low-frequency signals. This provides an external input resistance of about 91 kilohms in this A COUPLING switch position. In the EXT÷10 position, a 10× frequency compensated attenuator is connected into the input circuit. This attenuator reduces the input signal amplitude 10 times to allow more A TRIG LEVEL conrol range. Input RC Characteristics in this position are about 10.1 megohm × 5 picofarads.

Trigger Coupling

The A COUPLING switch, SW30B, offers a means of accepting or rejecting certain components of the trigger signal. In the AC and AC LF REJ positions of the A COUPLING switch, the DC component of the trigger signal is blocked by coupling capacitors C30A or C30B. Low frequency components below about 60 hertz are attenuated in the AC position and below about 50 kilohertz in the AC LF REJ position. The DC position passes all signals from DC to 100 megahertz.

Input Cathode Follower

The Input Cathode Follower, V33, provides a high input impedance for the trigger signal. It also provides isolation between the A Trigger Generator circuit and the trigger signal source. Diodes D30 and D31 protect V33 if excessive input voltage is applied to the A TRIG IN connector. Diode D31 limits the positive excursion of the grid signal to about +15.5 volts and diode D30 limits the negative excursion to about —15.5 volts. The output signal at the cathode of V33 is connected to the Slope Comparator stage through R38.

Slope Comparator

Q44A and Q44B are connected as a difference amplifier (comparator)[2] to provide selection of the slope and level at which the A sweep is triggered. The reference voltage for the comparator is provided by the A TRIG LEVEL control R41, through emitter follower Q43. The A TRIG LEVEL control varies the base level of Q44B to select the point on the trigger signal where triggering occurs. Emitter follower Q43 isolates the A TRIG LEVEL control from the Slope Comparator stage to reduce the loading on the A TRIG LEVEL control and provide more linear trigger level adjustment. Diode D33 protects Q44A during the warmup time of V33 by limiting the negative excursion at the cathode of V33 to about —15.5 volts until the heater of V33 reaches operating temperature.

R44 establishes the emitter current of both Q44A and Q44B. The transistor with the most positive base controls the conduction of the comparator. For example, assume that the trigger signal at the cathode of V33 is positive-going and Q44A is forward biased. The increased current flow through R44 produces a larger voltage drop and the emitters of both Q44A and Q44B go more positive. A more positive voltage at the emitter of Q44B reverse biases this transistor since its base is held at the voltage set by the A TRIG LEVEL control and its collector current decreases. At the same time, Q44A is forward biased and its collector current increases. Notice that the signal currents at the collectors of Q44A and Q44B are opposite in phase. The sweep can be triggered from either the negative-going or positive-going slope of the input trigger signal by producing the trigger pulse from the signal at the collector of Q44B for — slope operation, or the signal at the collector of Q44A for + slope operation.

When the A TRIG LEVEL control is set to 0 (midrange), the base of Q44B is at about two volts positive. This corresponds to a zero-volt level at the grid of V33. The voltage drop of D44B and the base-emitter junction of Q44B sets the cathodes of D44A and D44B at about one volt positive. Since the base of Q44A must be about one volt more positive than the cathode level of D44A and D44B before Q44A and D44A are forward biased, the comparator switches around the zero-volt level of the trigger signal (zero-volt level of trigger signal corresponds to about one volt positive at this point). As the A TRIG LEVEL control is turned clockwise toward +, the voltage at the base of Q44B becomes more positive. This increases the current flow through R44 to produce a more positive voltage at the cathodes of D44A and D44B. Now the trigger signal must rise more positive before Q44A is biased on. The resultant CRT display starts at a more positive point on the displayed signal. When the LEVEL control is in the — region the effect is the opposite, to produce a resultant CRT display which starts at a more negative point on the trigger signal.

The slope of the input signal which triggers the sweep is determined by the A SLOPE switch, SW30C. When the A SLOPE switch is set to the — position, the collector of Q44A is connected to the +15-volt supply through D44C, R47 and R46. The anode of D44D is grounded and this diode is reverse biased. Now the collector current of Q44B must flow through D45B, R48, the parallel combination of D55 and R45-L45, and R46 to the +15-volt supply (see Fig. 3-3). Since the output pulse from the A Trigger Generator circuit is

[2] Phillip Cutler, "Semiconductor Circuit Analysis", McGraw-Hill, New York. pp. 365-372.

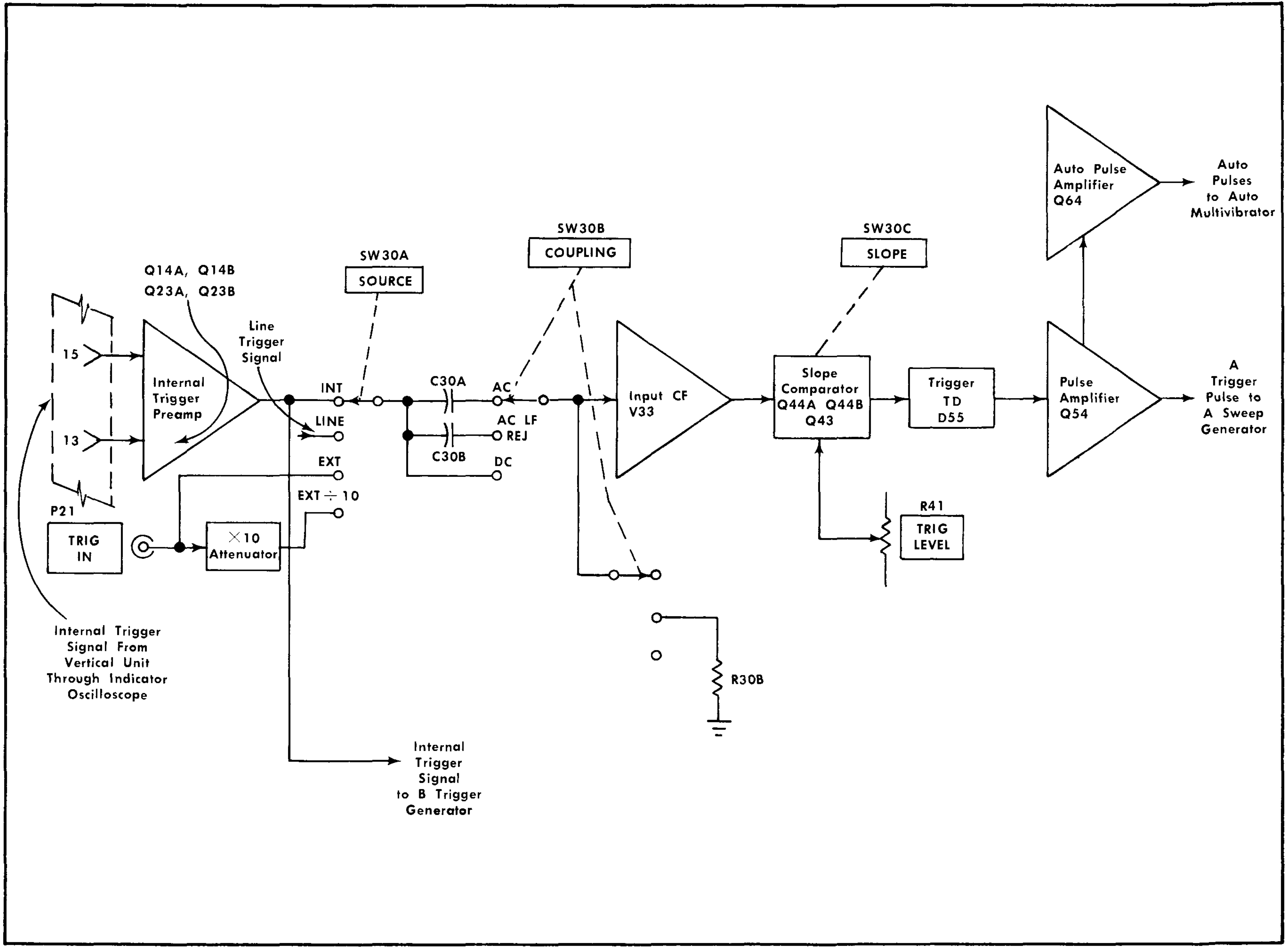


Fig. 3-2. A Trigger Generator detailed block diagram.

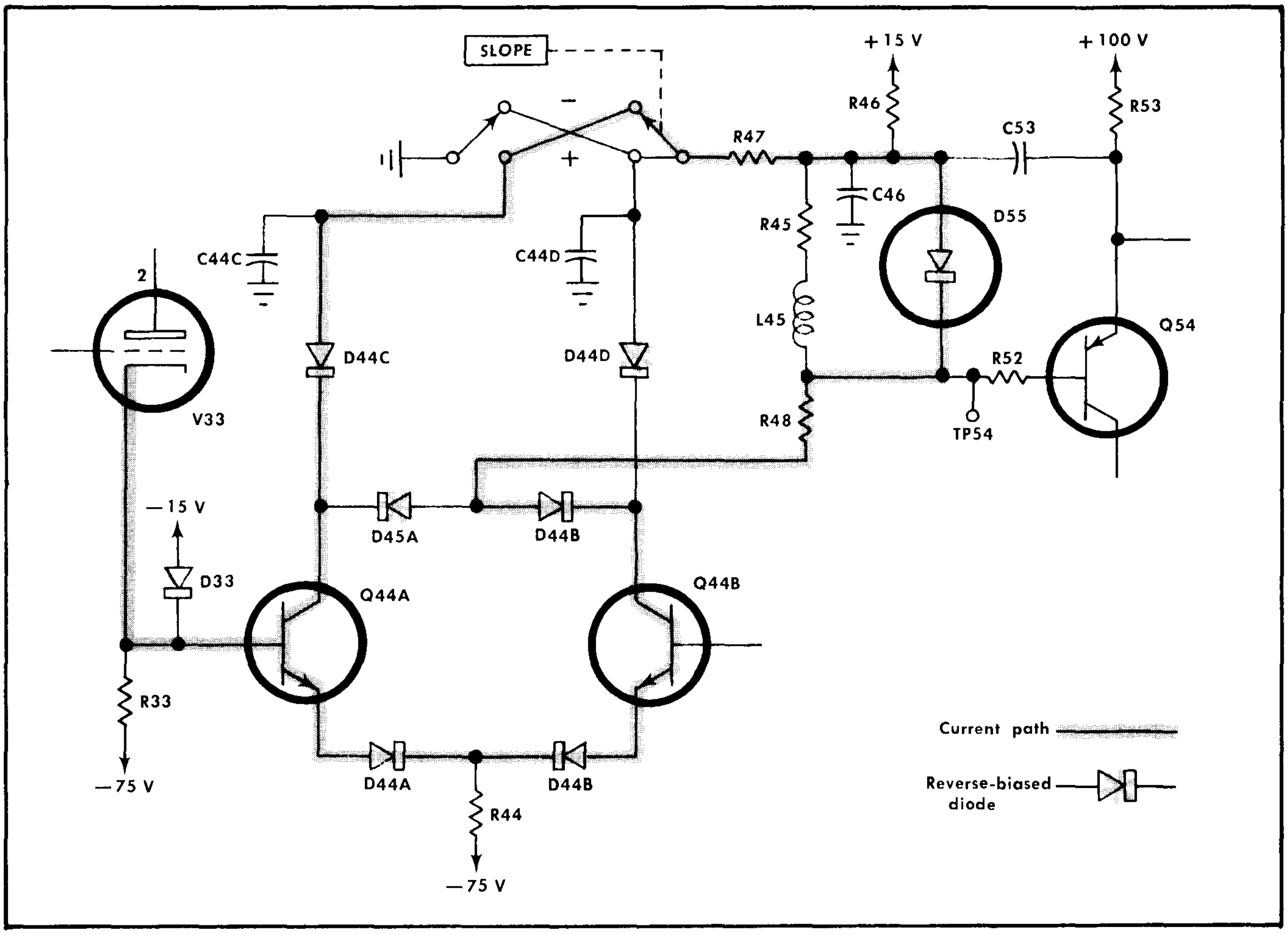


Fig. 3-3. Trigger path for negative-slope triggering (simplified diagram).

derived from the negative-going portion of the signal applied to the Trigger TD stage, the sweep is triggered on the negative-going portion of the input trigger signal (signal applied to Trigger TD stage is in phase with the input signal for — slope triggering). When the A SLOPE switch is set to +, conditions are reversed (see Fig. 3-4). Q44B is connected to the +15-volt supply through D44D, R47 and R46. The anode of D44C is grounded to divert the collector current of Q44A through the Trigger TD stage. The signal applied to the Trigger TD stage is now 180° out of phase with the input trigger signal, so the sweep is triggered on the positive-going portion of the input signal.

Trigger TD

The Trigger TD stage shapes the output of the Slope Comparator to provide a trigger pulse with a fast leading edge. Tunnel diode D55[3] is quiescently biased so it operates in its low-voltage state. The current from one of the transistors in the Slope Comparator stage is diverted through the Trigger TD stage by the A SLOPE switch. As this current increases due to a change in the trigger signal, tunnel diode D55 switches to its high-voltage state. L45 opposes the sudden change in current which allows more current to pass through D55 and switch it more quickly. As the current flow stabilizes, L45 again conducts the major part of the current. However, the current through D55 remains high enough to hold it in its high-voltage state. The circuit remains in this condition until the current from the Slope Comparator stage decreases due to a change in the trigger signal applied to the input. Then, the current through D55 decreases and it reverts to its low-voltage state.

[3]Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms", McGraw-Hill, New York, 1965. pp. 452-455.

Pulse Amplifier

The trigger signal from the Trigger TD stage is connected to the base of the Pulse Amplifier, Q54, through R52. The trigger pulse at this point is basically a negative-going pulse with a fast rise. The width of the pulse depends upon the waveshape of the input signal and the setting of the A TRIG LEVEL control. The negative-going pulse at the base of Q54 drives it into heavy conduction and the resulting current increase flows through R55, C54, Q54, C53 and R46. Due to the short time constants of the RC networks involving C53 and C54, the current of Q54 quickly returns to the level determined by resistors R53, R54 and R55. The resultant signal at the collector of Q54 is a positive-going fast-rise pulse with the width determined by the time constants of the RC networks in the circuit. This positive-going trigger pulse is connected to D120 in the A Sweep Generator circuit through R54. Diodes D56 and D57 limit the voltage change of the trigger

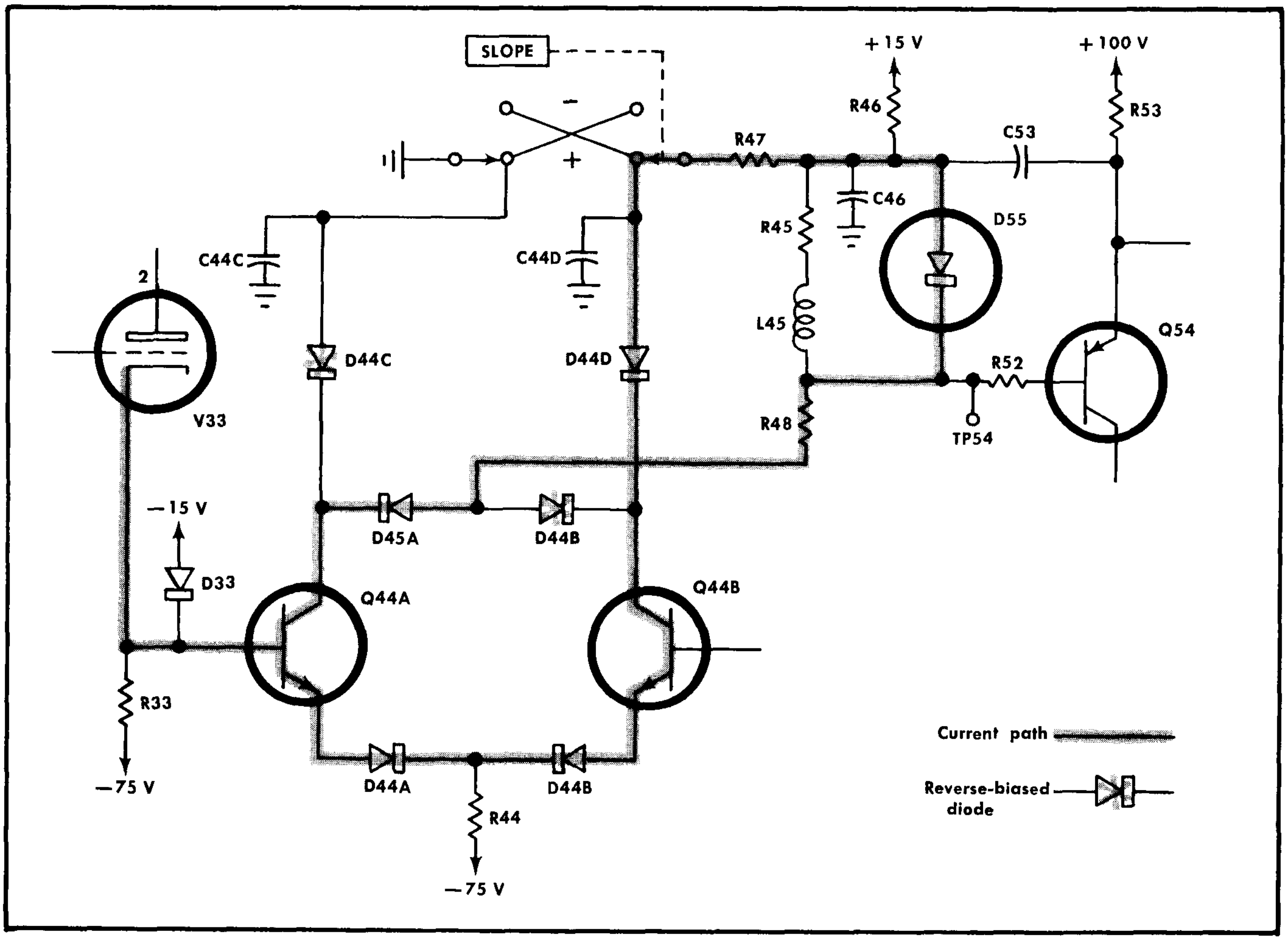


Fig. 3-4. Trigger path for positive-slope triggering (simplified diagram).

pulse between about —0.5 and +0.5 volts. A simultaneous negative-going pulse with the same width as the trigger pulse at the collector is available at the emitter of Q54. This pulse is connected to the Auto Pulse Amplifier stage.

Auto Pulse Amplifier

The negative-going pulse at the emitter of Q54 is connected to the base of Q64 through R61. This stage is similar to the Pulse Amplifier stage in that an output pulse is available from both the collector and emitter. Both signals are connected to the Auto Multivibrator stage in the A Sweep Generator circuit; the positive-going pulse at the collector through C102 and the negative-going pulse at the emitter through C63.

A SWEEP GENERATOR

General

The A Sweep Generator circuit produces a sawtooth voltage which is amplified by the Horizontal Preamp circuit to provide the sweep for the indicator oscilloscope. This output signal is generated on command (trigger pulse) from the A Trigger Generator circuit. This A Sweep Generator circuit also produces an unblanking gate to unblank the CRT of the indicator oscilloscope during A sweep time. In addition, this circuit produces several control signals for other circuits within this instrument and several output signals to the front-panel connectors. Fig. 3-5 shows a detailed block diagram of the A Sweep Generator circuit. A schematic of this circuit is shown on diagram 2 at the rear of the manual.

The TRIG MODE switch allows four modes of operation. In the FREE RUN position, the sweep free runs independent of any trigger signal. In the AUTO position, a stable display is presented when the LEVEL control is correctly adjusted and a trigger signal is available. However, when a trigger pulse is not present, the sweep free runs at the repetition rate selected by the A TIME/CM switch. Operation in the NORM position is much the same as AUTO except that a display is presented only when an adequate trigger pulse is present. In the SINGLE SWEEP position, operation is also similar to NORM except that the sweep is not recurrent. The following circuit description is given with the TRIG MODE switch set to NORM. Differences in operation for the other modes are then discussed later.

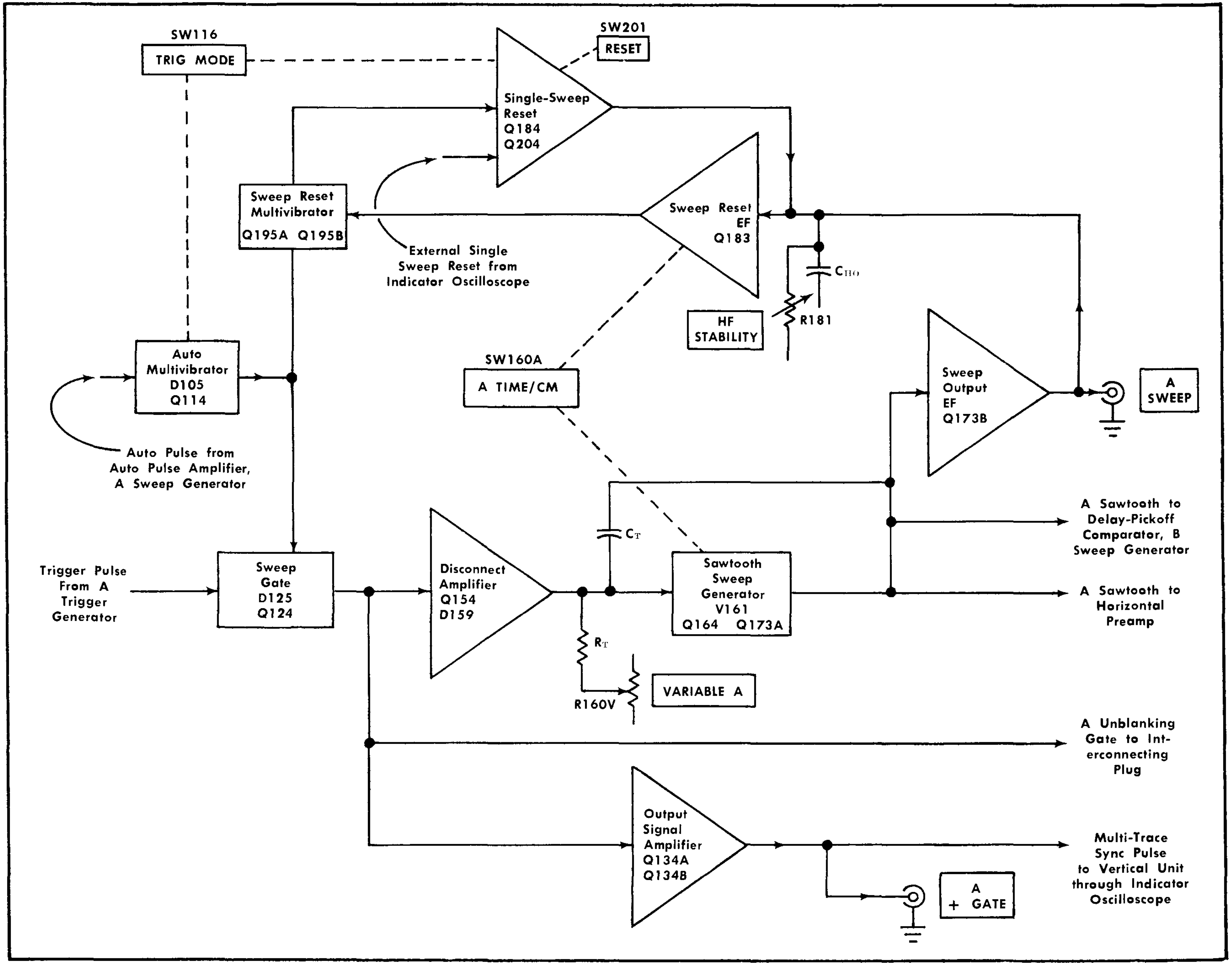


Fig. 3-5. A Sweep Generator detailed block diagram.

Normal Trigger Operation

Sweep Gate. The positive-going trigger pulse generated by the A Trigger Generator circuit is applied to the Sweep Gate stage through D120 and D121. Quiescently, current is flowing through R120-D121 and R118-D118. This holds tunnel diode D125 in its low-voltage state. When the positive-going trigger pulse is applied through D120, D121 is reverse biased. The current that was flowing through D121 and R120 now flows through D125 and it rapidly switches to its high-voltage state where it remains until reset by the Sweep Reset Multivibrator stage at the end of the sweep. The positive-going level at the anode of D125 is connected to the base of Q124 through C122 and R122. Q124 is turned on and its collector goes negative. This negative-going step is connected to the Disconnect Amplifier stage through C127 and R127 and the Output Signal Amplifier stage through C130 and R130. The signal at the collector of Q124 also provides the A unblanking gate.

Disconnect Amplifier. Q154 is quiescently conducting and it forward biases diode D158 and disconnect diode D159. The disconnect diode, D159, is quiescently conducting current through the Timing Resistor R160, VARIABLE A control R160V and A Swp Cal adjustment R160W. The negative-going gate signal from Q124 turns Q154 off and its collector goes negative. When the collector of Q154 goes negative, the disconnect diode is reverse biased and the quiescent current flow is interrupted. Now the timing current through the Timing Resistor begins to charge the Timing Capacitor, C160, and the sweep starts to run up. The disconnect diode is a fast turn-off diode with low reverse leakage. These characteristics improve the linearity at the start of the sweep and prevent the disconnect diode from affecting the timing current.

The Delay Start adjustment, R150, is adjusted to set the quiescent level at the grid of V161 to about zero volts (through D159) and the quiescent A sawtooth output level to about +2.4 volts (through D158 and R158) to provide a consistent starting point for the A sweep. The voltage level set by R150 is also connected to the Disconnect Amplifier in the B Sweep Generator circuit so it starts at the same point on the CRT also. Diode D155 protects disconnect diode D159 by preventing the collector level of Q154 from going more negative than about −0.6 volts when it is off.

Sawtooth Sweep Generator. The basic sweep generator circuit is a Miller Integrator circuit.[4] When the current flow through the disconnect diode is interrupted by the sweep gate signal, the Timing Capacitor, C_T, begins to charge through the Timing Resistor, VARIABLE A control and A Swp Cal adjustment. The Timing Capacitor and Resistor are selected by the A TIME/DIV switch to provide the various sweep rates listed on the front panel. Diagram 6 shows a complete diagram of the A TIME/DIV switch. The A Swp Cal adjustment (see Timing Switch diagram) allows calibration of this circuit for accurate sweep timing. The VARIABLE A control, R160V, (see Timing Switch diagram), provides continuously variable, uncalibrated sweep rates by varying the charge rate of the Timing Capacitor.

As the Timing Capacitor begins to charge negative towards the voltage applied to the Timing Resistor, the grid of V161 goes negative also. This produces a negative-going change at the cathode of V161 which is coupled to the base of Q164 through R163. Q164 ampifies and inverts the signal at the cathode of V161 to produce a positive-going sawtooth output. D163 clamps the cathode of V161 at about −0.5 volts to protect Q164 during the warmup time of V161. The sawtooth signal at the collector of Q164 is connected to the base of emitter follower Q173A. The positive-going sawtooth at the emitter of Q173A provides the A sawtooth output signal to the Horizontal Amplifier circuit and the Delay Pickoff Comparator stage in the B Sweep Generator circuit through R172 and R173. To provide a linear charge rate for the Timing Capacitor, the sweep output signal is also connected to the positive side of the Timing Capacitor. This feedback provides a constant charging potential for C160 which maintains a constant charge rate to produce a linear sawtooth output signal. The output voltage continues to go positive until the circuit is reset through the Sweep Reset Multivibrator.

Sweep Output Emitter Follower and Sweep Reset Emitter Follower. The positive-going A sawtooth output signal is connected to the base of the Sweep Output Emitter Follower stage, Q173B, through R177. The positive-going sawtooth at the emitter of Q173B provides the output signal at the A SWEEP connector on the front panel. The signal at the emitter of Q173B is also connected to the Holdoff Capacitor, C180 (C_{HO}) through diodes D180 and D181. As the sawtooth output rises positive, the Holdoff Capacitor charges positive and the base and emitter of the Sweep Reset Emitter Follower, Q183, rise positive also. This positive-going change is connected to the anode of D183.

Sweep Reset Multivibrator. The positive-going signal at the emitter of Q183 is connected to D183. This diode is quiescently reverse biased at the start of the sweep. As the sweep runs up, the anode of D183 is pulled positive and it is forward biased at a level about 0.5 volts more positive than the base level of Q195B. Then the positive-going sweep signal from the Sweep Reset Emitter Follower is connected to the base of Q195B. Q195A and Q195B are connected as a Schmitt bistable multivibrator[5]. Quiescently at the start of the sweep, Q195A is off and Q195B is conducting to produce a positive level at its collector. This positive level allows the Sweep Gate tunnel diode, D125, to be switched to produce a sweep as discussed previously. When D183 is forward biased by the positive-going signal from Q183, the base of Q195B goes positive and when the base level of Q195B exceeds the base level of Q195A (Q195A base level fixed by divider R190-R191), Q195B is reverse biased. Then Q195A comes into conduction and the collector level of Q195B goes negative to switch D125 back to its low-voltage state through R197 and R125-L125. D125 is held in its low-voltage state so it cannot accept incoming trigger pulses until after the Sweep Reset Multivibrator stage is reset. This ends the Sweep Gate stage output pulse and the A unblanking gate level rises positive to blank the indicator oscilloscope CRT. The positive-going change at the collector of Q124 forward biases Q154 in the Disconnect Amplifier stage to rapidly discharge the Timing Capacitor and pull the grid of V733 rapidly negative to its original level. This produces the retrace portion of the sawtooth signal. The Sawtooth Sweep Generator stage is now ready to produce another sweep as soon as the Sweep Reset Multivibrator stage is reset and another trigger pulse is received.

When Q195B is turned off to end the sweep, it remains off for a period of time to establish a holdoff period and allow

[4] **Ibid., pp. 540-548.**

[5] **Ibid., pp. 389-394.**

all circuits to return to their original conditions before the next sweep is produced. The holdoff time is determined by the discharge time of the Holdoff Capacitor, C180. As the sweep runs up, C180 is charged through D180 and D181. At the end of the sweep, D180 is reverse biased by the negative-going retrace portion of the sawtooth signal and the Holdoff Capacitor begins to discharge through R180 and R181. As the Holdoff Capacitor discharges, the emitter level of Q183 drops negative also. When Q195A comes on, its conduction raises the base level of Q195B positive through R193 and R199. This holds D183 reverse biased to block any changes at the emitter of Q183. However, as the emitter of Q183 falls low enough to forward bias D193, the current through R193, R199, R185 and R184 increases. This pulls the base of Q195B more negative until it is biased on. The emitter coupling between Q195A and Q195B turns Q195A off to end the holdoff period. Now the Sweep Reset Multivibrator has returned to its original condition and the collector of Q195B rises positive. The bias on the Sweep Gate tunnel diode D125 returns to a level that allows it to accept the next trigger pulse (D125 is enabled). The Holdoff Capacitor, C180, is changed by the A TIME/DIV switch to provide the correct holdoff time for the various sweep rates. Diagram 6 shows a complete diagram of the A TIME/DIV switch.

The HF STAB control, R181, varies the discharge rate of the Holdoff Capacitor by about 10% to provide a stable display at fast sweep rates. This change in holdoff allows sweep synchronization for less display jitter at the faster sweep rates. This control has little effect at slow sweep rates.

Output Signal Amplifier. The negative-going gate signal at the collector of Q124 when the Sweep Gate stage receives a trigger pulse is connected to the base of Q134A through R130 and C130. This produces a positive-going signal at the collector of Q134A which provides the output signal at the A +GATE output connector on the front panel. Diode D133 clamps the collector of Q134A to prevent the A +GATE signal from going more than about 0.5 volts more negative than ground. A negative-going gate signal is also produced at the emitter of Q134A. This negative-going signal is connected to the base of Q134B through C136. However, since Q134B is quiescently biased to cutoff, this negative pulse has no effect on Q134B. When the gate signal at the collector of Q124 returns positive to the quiescent level at the end of the sweep, the A +GATE output signal at the collector of Q134A drops negative to its quiescent level also. At the same time the emitter of Q134A rises positive. This positive-going step is differentiated by C136 and connected to the base of Q134B. Q134B is forward biased by the positive-going pulse at its base and its collector goes negative. This negative-going pulse provides the multi-trace sync pulse to the vertical plug-in unit through the associated indicator oscilloscope. The duration of the multi-trace sync pulse is short, due to the fast time constants in the circuit.

Free Run Operation

In the FREE RUN position of the TRIG MODE switch, D118 is reverse biased by the +15 volts applied to its cathode through R117. In the NORM mode of operation, D118 and R118 carry some of the quiescent current from Q195B before a trigger pulse is received. In FREE RUN mode, however, this extra current from Q195B must flow through tunnel diode D125. This current is sufficient to switch D125 to its high-voltage state immediately after the Sweep Reset Multivibrator resets following the holdoff period. The incoming trigger pulses have no affect on the sweep repetition rate.

Auto Mode Operation

Operation of the A Sweep Generator circuit in the AUTO position of the TRIG MODE switch is the same as for the NORM position when a trigger pulse is present. However, when a trigger pulse is not present, a free-running reference trace is produced as in the FREE RUN position. This occurs as follows:

The positive-going auto pulse at the collector of Q64 in the Auto Pulse Amplifier stage (A Trigger Generator circuit) is connected to the Auto Multivibrator through C102. Quiescently, when there is no trigger signal present, tunnel diode D105 is in its high-voltage state and Q114 is biased off. D114 is conducting through R116 and the cathode of D118 is raised more positive than its anode to hold it reverse biased. The circuit operates as just described for FREE RUN operation with the current from Q195B switching D125 to its high-voltage state immediately after the Sweep Reset Multivibrator resets following the holdoff period.

When the unit is correctly triggered, the positive-going auto pulse through C102 forward biases D102 and diverts the current from tunnel diode D105 and it switches to its low-voltage state. This drives Q114 rapidly into saturation; its collector drops negative and D114 is reverse biased. With D114 reverse biased, D118 can conduct through the Sweep Reset Multivibrator stage. Now, when the Sweep Reset Multivibrator stage resets after the holdoff period, the Sweep Gate tunnel diode D125 is enabled so that it can switch to its high-voltage state when the next trigger pulse arrives.

When Q114 is driven into saturation, C114 is discharged through R114. D113 is forward biased to form a parallel collector current path for Q114; R114-D113-R113 is parallel with R116. When the auto pulse through C102 ends, D102 is again reverse-biased and tunnel diode D105 reverts to the high-voltage state. Q114 turns off, but its collector cannot rise positive immediately, since it must wait for C114 to recharge. The charge path for C114 is through the parallel combination of D113-R113 and R114-R116. As the charge on C114 reaches about —7 volts, D113 becomes reverse biased and the charge path for C114 is only through R114-R116 (D113 anode level set by divider R106-R112-R113 between —75 and +15 volts). After about 80 milliseconds, C114 recharges to a level that forward biases D114. Now conditions become similar to those for FREE RUN operation. However, if the auto pulses (produced from applied trigger signal) are recurrent with a period less than about 80 milliseconds, D105 will be reset to its low state and C114 discharged again. Then the operation of the Sweep Gate tunnel diode is similar to NORM operation to produce a triggered display.

Single Sweep Operation

Operation of the Sweep Generator in the SINGLE SWEEP position of the TRIG MODE switch is similar to operation in the other modes. However, after one sweep has been produced, the Sweep Reset Multivibrator stage does not reset. All succeeding trigger pulses are locked out until the RESET button is pressed.

In the SINGLE SWEEP position of the TRIG MODE switch, +15 volts is connected to the base of Q183 and anode of D181 through R182. This clamps the base of Q183 at about +4.5 volts, which is not positive enough to reset the Sweep Reset Multivibrator. The HOLDOFF Capacitor, C180, cannot discharge any farther. Therefore, the Sweep Gate tunnel diode is held in a condition where it cannot accept trigger pulses. When the RESET button, SW201, is pressed, current flows through B200 and it ignites. The positive-going voltage change across R200 when B200 ignites is differentiated by C202 and the fast-rise, positive-going pulse is connected to the base of Q204. Diode D200 protects Q204 by preventing its base from going more negative than about —0.5 volts. A positive-going remote reset pulse applied to pin F of the connector on the rear panel of a compatible indicator oscilloscope is connected to this unit through terminal 27 of the interconnecting plug. This feature can be used to reset the A Sweep Generator circuit from a remote location.

The positive-going pulse at the base of Q204 produces a negative-going change at its collector. This level is connected to the base of Q183 through C204 and it pulls the base of Q195B negative through D193, R193 and R199 (in a similar manner to that described for the holdoff capacitor discharge for normal operation). When the base of Q195B is negative enough to bias it on, Q195B comes into conduction and Q195A turns off. Now the Sweep Gate tunnel diode, D125, is enabled since its anode is returned to a level where it can accept a trigger pulse. The negative-going change at the base of Q195B is also connected to the emitter of Q184 through R185. This turns Q184 on and its collector goes negative. Current flows through B186 and it ignites to indicate that the A Sweep Generator can be triggered when the next trigger pulse is received. Q184 and the RESET light, B186, remain on until Q195B turns off again at the end of the next sweep.

B TRIGGER GENERATOR

General

The B Trigger Generator circuit is basically the same as the A Trigger Generator circuit, so only the differences between the two circuit are discussed here. Portions of the circuit not described in the following discussion operate in the same manner as for the A Trigger Generator circuit. Fig. 3-6 shows a detailed block diagram of the B Trigger Generator circuit. A schematic of this circuit is shown on diagram 3 at the rear of this manual.

Trigger Source

The B SOURCE switch, SW70A, provides only two positions for selecting the B trigger signal; internal and external. The internal trigger signal is obtained from the Internal Trigger Preamp stage in the A Trigger Generator Circuit. External trigger signals applied to the B TRIG IN OR EXT INPUT connector can provide the triggering signal in the EXT position. The input resistance at DC is about one megohm paralleled by 30 picofarads.

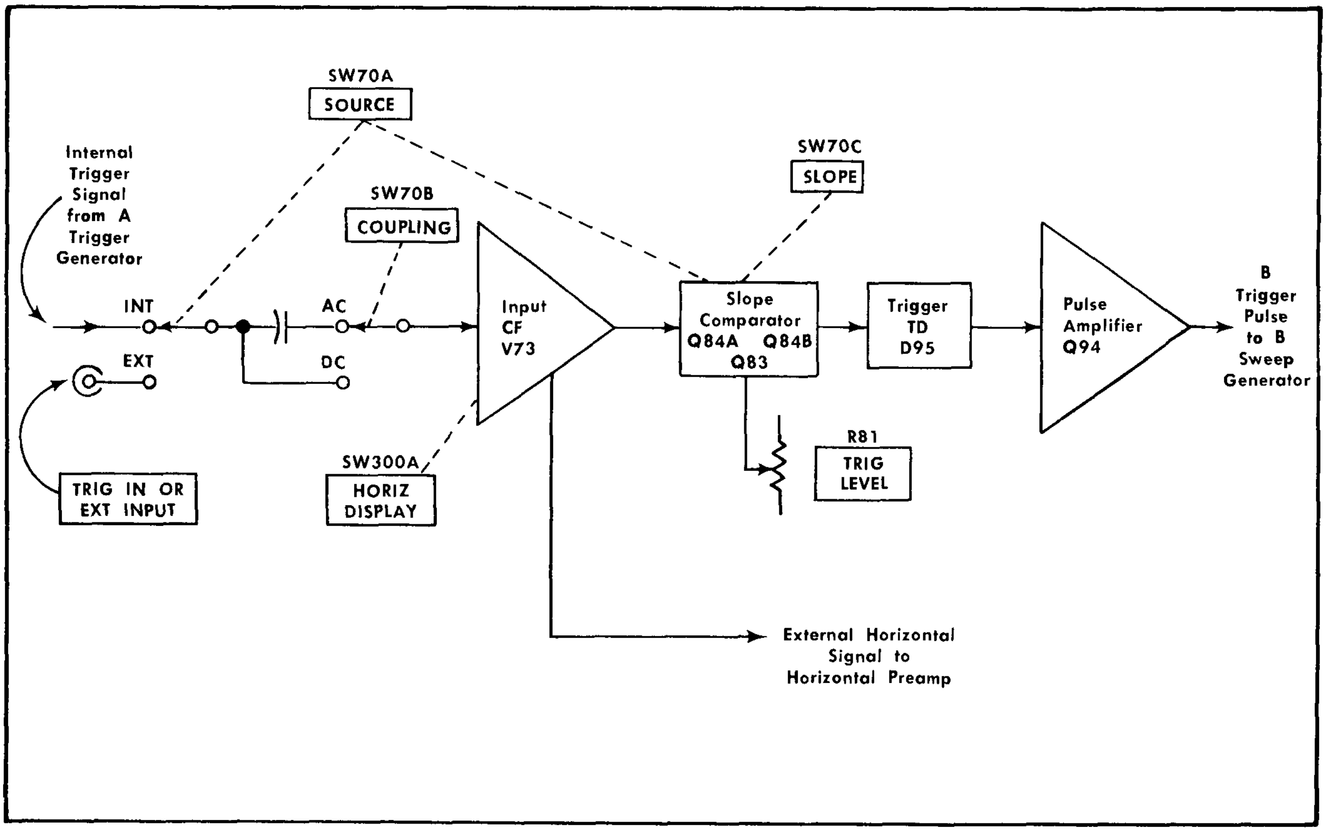


Fig. 3-6. B Trigger Generator detailed block diagram.

Trigger Coupling

The B COUPLING switch, SW70B, provides AC or DC coupling of the trigger signal. In the AC position, coupling capacitor C70A blocks the DC component of the trigger signal and low-frequency components below about 60 hertz are attenuated. The DC position passes all signals from DC to 100 megahertz.

Input Cathode Follower

The Input Cathode Follower stage, V73, operates in basically the same manner as described for the A Trigger Generator circuit. However, in the B Trigger Generator circuit, the HORIZ DISPLAY switch, SW300A, blocks the B Trigger Generator input signal in the modes where B triggering is not desired. In the B DLY'D BY A (not triggered), A INTEN BY B (not triggered) and A positions of the HORIZ DISPLAY switch, the cathode of V73 is connected to +100 volts through R75A and R76. At the same time, —15 volts is connected to the anodes of D73 and D74 through R75C-R75D and R75E-R75F-D75. This negative potential reverse biases both D73 and D74 and they block the B trigger signal. The current of V73 is diverted through R75A to maintain the correct current through V73.

In the A INTEN BY B (triggered) and B DLY'D BY A (triggered) positions of the HORIZ DISPLAY switch, +100 volts is connected to the anode of D73 through R75C and R76. This raises the anode potential of D73 positive enough to forward bias it and the B trigger signal can pass to the Slope Comparator to produce the trigger pulse. D74 remains reverse biased by the —15 volts applied to it through R75E-R75F-D75.

When the HORIZ DISPLAY switch is set to EXT INPUT, D74 is forward biased so the B trigger signal can pass to the Horizontal Preamp to produce horizontal deflection. The +100-volt potential is connected to the anode of D74 through D75-R75E-R76. D73 is again reverse biased by the —15 volt potential connected to its anode through R75C and R75D so it blocks the B trigger signal. D75 in series with D74 raises the quiescent DC level of the B trigger signal to about +7 volts so the external horizontal signal is centered on the display area when the horizontal position control is set near midrange.

Slope Comparator

The Slope Comparator in the B Trigger Generator circuit operates in basically the same way as described for the A Trigger Generator. However, an added network in the B Trigger Generator circuit allows the B TRIG LEVEL control to have about twice as much range in the EXT position of the B SOURCE switch as in the INT position. In the INT position, R82C limits the B TRIG LEVEL control current to the base of emitter follower Q83. Divider R82A-R82B adds enough current to the circuit at the base of Q83 so the B TRIG LEVEL control remains in the center of its range. When the B SOURCE switch is set to EXT, the divider R82A-R82B is disconnected. Also, R82C is effectively removed from the circuit and the B TRIG LEVEL control current is connected directly to the base of emitter follower Q83. Since R82C is not in the current path, more current reaches the base of Q83 to give the B TRIG LEVEL control about twice the range in the EXT positions as in the INT position.

Pulse Amplifier

The Pulse Amplifier stage in the B Trigger Generator circuit operates much as in the A Trigger Generator circuit. However, since there is no Auto Pulse Amplifier stage in the B Trigger Generator circuit, a pulse is available only at the collector of Q94. The output trigger pulse is applied to D220 in the B Sweep Generator circuit through C94-R94.

B SWEEP GENERATOR

General

The B Sweep Generator circuit is basically the same as the A Sweep Generator circuit. Only the differences between the two circuits are discussed here. Fig. 3-7 shows a detailed block diagram of the B Sweep Generator circuit. A schematic of this circuit is shown on diagram 4 at the rear of this manual.

Sawtooth Sweep Generator

The B sawtooth is produced in the same manner as the A sawtooth. The positive-going sawtooth at the collector of Q264 provides the B sweep signal through R265 and R259. This signal is also connected to the base of the Sweep Output and Reset EF through R265.

Sweep Output and Reset EF

Q273 performs both the sweep output emitter follower and sweep reset emitter follower functions in the B Sweep Generator circuit. The sawtooth connected to the base of Q273 from Q264 provides the output signal at the B SWEEP connector on the front panel through R274. It also provides the reset signal to the Sweep Reset Multivibrator through D273.

Delay-Pickoff Comparator

The Delay-Pickoff Comparator stage allows selection of the amount of delay from the start of the A sweep before the B Sweep Generator is turned on. This stage allows the start of B Sweep to be delayed between 0.30 and 10.30 times the setting of the A TIME/CM switch. Then, the B Sweep Generator is turned on and the display is presented at a sweep rate independent of the A Sweep Generator (determined by setting of the DELAYED SWEEP switch).

Q214A and B are connected as a voltage comparator. In this configuration, the transistor with the most positive base controls conduction. A dual transistor Q214 and a dual diode, D214, provide temperature stability for the comparator circuit. Reference voltage for the comparator circuit is provided by the DELAY TIME MULT dial, R211. The voltage supplied to this control is filtered by R210 and C210 to hold it constant and allow precise delay pickoff. The instrument is calibrated so that the major markings of the dial on R211 correspond to the major divisions of horizontal deflection on the graticule. For example, if the DELAY TIME MULT dial is set to 5.00, the B Sweep Generator is delayed five divisions of the A sweep

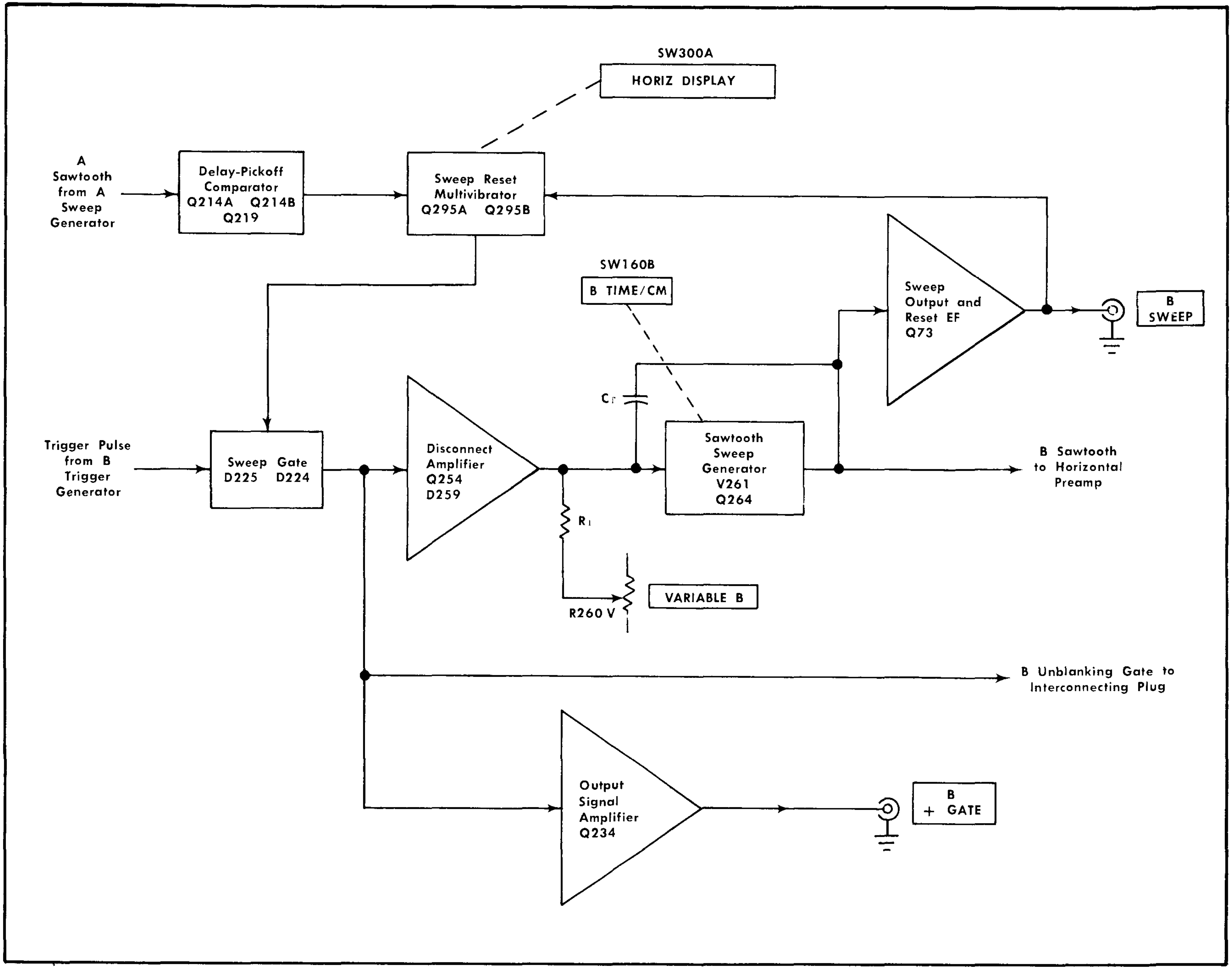


Fig. 3-7. B Sweep Generator detailed block diagram.

time before it can produce a sweep (B sweep delay time equals five times the setting of the A TIME/CM switch).

The output sawtooth from the A Sweep Generator circuit is connected to the base of Q214A. The quiescent level of the sawtooth biases Q214A off and its collector rises positive to about +17 volts. This level is connected to the base of Q219 and biases it off since the emitter of Q219 is clamped at about +15.5 volts by D219. With Q219 biased off there is no current for Q295A or Q295B, and they must be off also.

As the A sweep output sawtooth begins to run up, the base of Q214A also goes positive. When it goes more positive than the level at the base of Q214B (established by the DELAY TIME MULT dial), Q214A takes over conduction of the comparator and Q214B shuts off. This also raises the base of Q219 to about +15 volts and it turns on to become a stable current source for the Sweep Reset Multivibrator.

Sweep Reset Multivibrator

The basic B Sweep Reset Multivibrator configuration is the same as for A sweep. However, several differences do exist. Q219 in the Delay-Pickoff Comparator stage disconnects the current source for the B Sweep Reset Multivibrator and makes it inoperative until the A sawtooth reaches the level selected by the DELAY TIME MULT dial. Also, B sweep does not have a Holdoff Capacitor and associated circuit to reset the sweep after the retrace. Instead, the positive-going sweep from the B Sweep Output and Reset EF, Q273, is connected directly to the base of Q295B through D273. Diode D273 is forward biased when the sweep voltage at the emitter of Q273 rises about 0.5 volts more positive than the level at the base of Q295B as established by voltage divider R297-R298 between +100 volts and the collector of Q295A. Then Q295B turns on and its collector goes positive to switch the B Sweep Gate tunnel diode, D225, to its low-voltage state which resets the B sweep. Q295B remains on to hold the B Sweep Gate tunnel diode locked out until the A sweep ends. When the A sweep ends, Q219 is reverse biased by the quiescent level from Q214A and it interrupts the current source for Q295A and B. This locks out the B Sweep Gate tunnel diode until the A sawtooth reaches the selected level on the next A sweep.

When Q219 is turned on at the level selected by the DELAY TIME MULT dial, Q295B comes into conduction, since its base is held more negative than the base of Q295A. The collector of Q295B rises positive and the effect it has on the B Sweep Gate tunnel diode, D225, is determined by the HORIZ DISPLAY switch, SW300A. When SW300A is set to the A position, —15 volts is connected to the circuit through R296C. The value of R296C is such that most of the collector current from Q295B flows through R296C rather than through D225. The B Sweep Gate tunnel diode D225 is held in its low-voltage state throughout the entire A sweep time and it cannot be switched by the incoming trigger pulses. In the B DLY'D BY A and A INTEN BY B not-triggered positions (to left of A on front panel) and the EXT INPUT position, the —15-volt level is connected to the collector of Q295B through R296A. R296A is a larger resistor value than R296C and it shunts very little of the current from the B Sweep Gate tunnel diode D225. Enough of the Q295B current is available to D225 so it will switch to its high-voltage state immediately when the B Sweep Reset Multivibrator is turned on by the Delay-Pickoff Comparator stage. This produces a free-running B sweep similar to the FREE RUN mode in the A Sweep Generator. However, since the B Sweep is started at a fixed point on the A Sweep sawtooth, the display is relatively stable.

In the A INTEN BY B and B DLY'D BY A triggered positions of SW300A (to right of A on front panel), the current through the Sweep Gate tunnel diode D225 is determined by R296E. The resistance value of R296E is such that the Sweep Gate tunnel diode is enabled (but remains in its low-voltage state) when the Sweep Reset Multivibrator is turned on. Then, the next B trigger pulse can switch D225 to its high-voltage state and start the sweep (if the next B trigger occurs before he normal end of the A sweep). Since the B sweep is triggered by an incoming trigger pulse, this mode of operation produces the most stable delayed sweep display.

If the A sweep should end while the B sweep is still in progress, the negative-going retrace portion of the sawtooth at the base of Q214A will turn Q214A off and Q214B on when the base level of Q214A falls below the base level of Q214B. Then, the current source for the B Sweep Reset Multivibrator is interrupted by Q219 and the Sweep Gate tunnel diode is switched to its low-voltage state by the voltage level established at its anode by divider R296-R222-R223 from —15 volts to +15 volts.

Output Signal Amplifier

The Output Signal Amplfier stage in the B Sweep Generator circuit contains only one transistor, Q234. The signal at the collector of this transistor provides the output signal for the B +GATE connector on the front panel. There is no signal output at the emitter. R235 provides about the same load on the emitter of Q234 as the multi-trace sync network provides on the emitter of Q134A in the A Sweep Generator circuit.

HORIZONTAL PREAMP

General

The Horizontal Preamp circuit provides the output signal to the horizontal deflection system in the indicator oscilloscope. In all positions of the HORIZ DISPLAY switch except EXT INPUT, the horizontal deflection signal is a sawtooth from either the A Sweep Generator circuit or the B Sweep Generator circuit. In the EXT INPUT position, the horizontal deflection signal is obtained from the Input CF stage in the B Trigger Generator circuit. In addition, this circuit contains the horizontal magnifier circuit and the horizontal positioning network. Fig. 3-8 shows a detailed block diagram of the Horizontal Preamp circuit. A schematic of this circuit is shown on diagram 6 at the rear of this manual.

Input Signal EF

The input signal for the Horizontal Preamp is selected by the HORIZ DISPLAY switch, SW300A. In the triggered and not-triggered B DLY'D BY A positions of the HORIZ DISPLAY switch, the B sawtooth from the B Sweep Generator circuit is connected to the Input Signal EF. In the triggered and not triggered A INTEN BY B and A only positions, the A Sweep Generator output sawtooth is connected to the Input Signal EF. The intensified portion in the A INTEN BY B position is provided by the B unblanking pulse applied to the indicator oscilloscope. An external signal from the B Trigger Generator circuit provides the horizontal deflection in the EXT INPUT position (see B Trigger Generator discussion for more details).

The selected input signal is connected to the base of Q343 through zener diodes D340 and D341 and R341. Zener diodes D340 and D341 drop the DC voltage level of the input signal without attenuating the signal, to provide the correct operating level for the circuit. The horizontal deflection signal is connected to the Paraphase Amplifier stage through D346. Zener diode D342 and R342 provide feedback to the base of Q343 for linear operation.

Positioning EF

The horizontal position controls in the indicator oscilloscope set a DC voltage level at the base of the Positioning EF, Q313, which determines the horizontal position of the CRT display. Q313 is connected as an emitter follower and the voltage output as its emitter is connected to the base of Q313 in the Paraphase Amplifier stage through D321.

Paraphase Amplifier

The input signal from Q343 is connected to the base of Q344 through D346. Q324 and Q344 are connected as a common-emitter phase inverter (paraphase amplifier).[6] This stage converts the single-ended input signal to a push-pull output signal, provides adjustment to set the normal and magnified gain, and provides a magnifier which increases the horizontal sweep rate 10 times. The input signal at the base of Q344 produces equal, but opposite output signals at the collectors of Q324 and Q344. For example, the positive-going sawtooth applied to the base of Q344 forward biases it and the current through Q344 increases. This increase in current produces a negative-going sawtooth output signal at the collector of Q344. At the same time, the increase in current through Q344 produces a positive-going sawtooth at its emitter. The emitters of Q344 and Q324 are coupled together through either the norm-gain network, R331-R332, or the mag-gain network, R333-R334-R335. Variable resistor R331, Norm Gain, is adjusted to provide calibrated horizontal sweep rates. The Mag Gain adjustment, R334, allows the magnified sweep rates to be calibrated. The resistance ratio between the norm-gain network and the mag-gain network is 10:1; this means that about 10 times more signal change at the emitter of Q344 reaches the emitter of Q324 in the ×10 (magnified) position of the MAG switch, SW300B, than in the OFF (normal) position. The positive-going sawtooth connected to the emitter of Q324 from Q344 reverse biases Q324 and its current decreases. This decrease in current produces a

[6] Lloyd P. Hunter (ed.), p. 11-94.

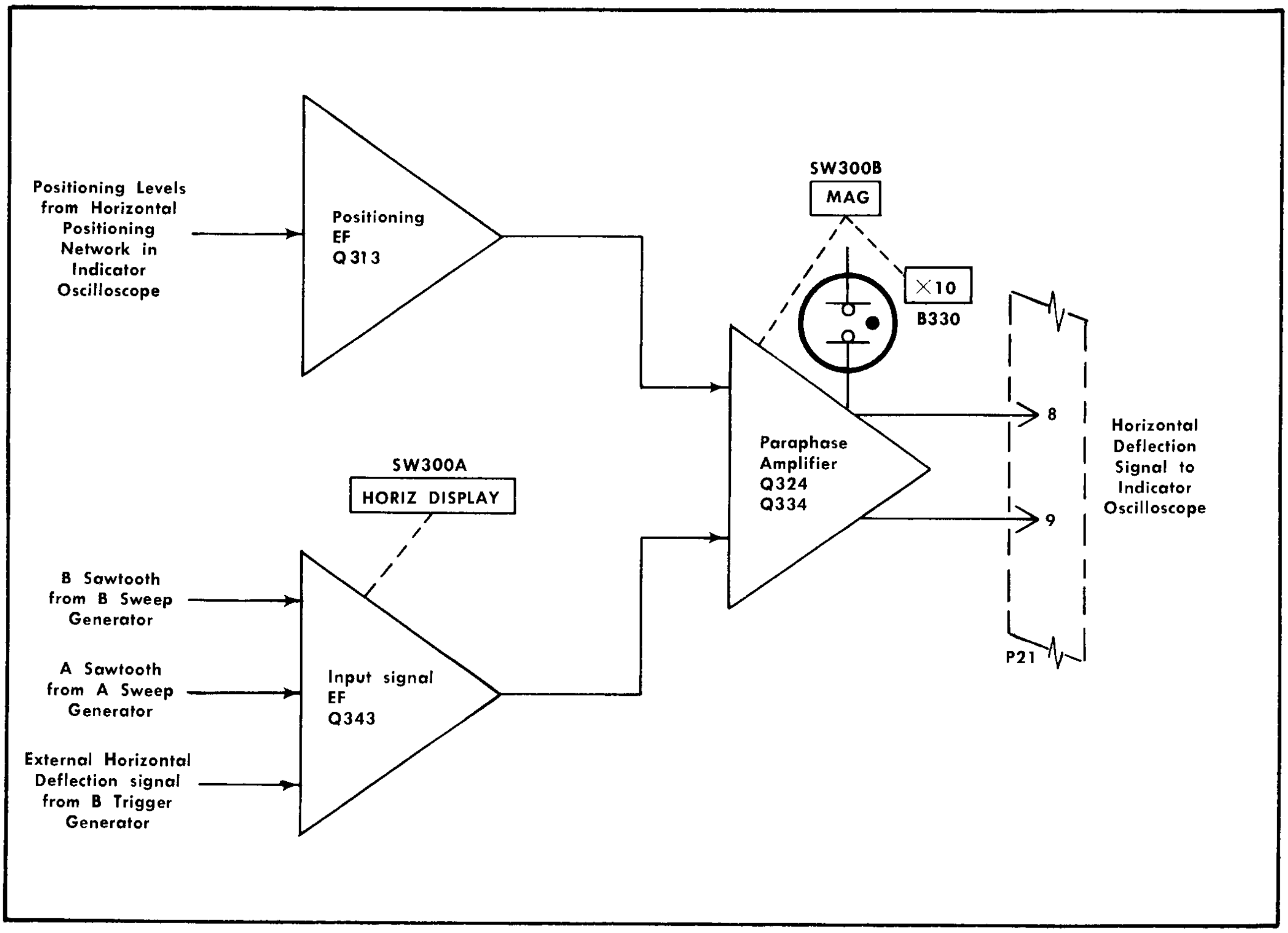


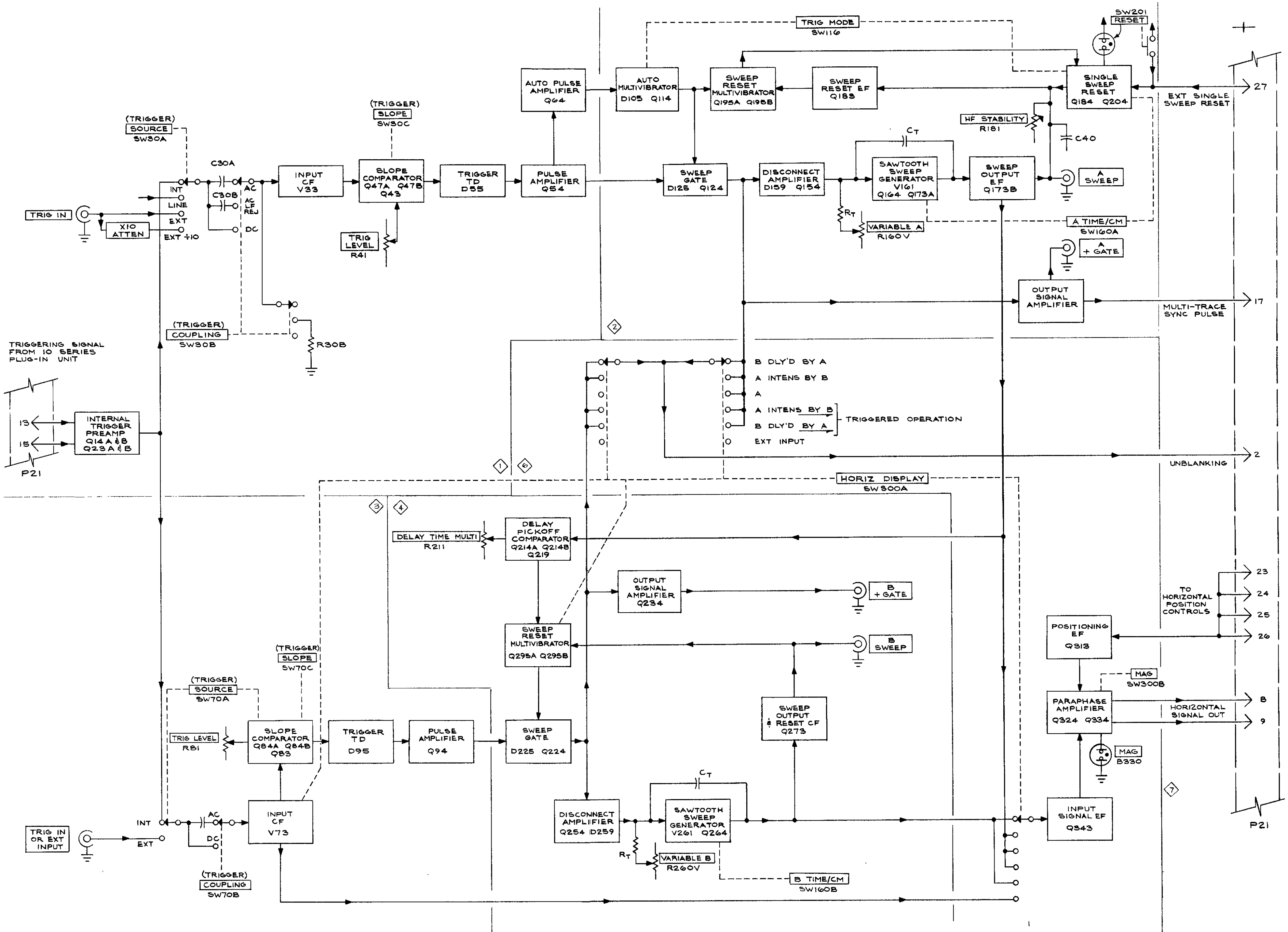
Fig. 3-8. Horizontal Preamp detailed block diagram.

positive-going sawtooth at the collector of Q324. The positioning level from the Positioning EF sets the bias level on Q324 and, in a manner similar to that just described for the sawtooth signal, it sets the bias level on Q344 to determine the horizontal position of the CRT display. To provide linear operation for the Paraphase Amplifier stage, R345 provides negative feedback from the collector to the base of Q344, and R323 provides negative feedback from the collector to the base of Q324.

When the MAG switch is set to ×10, B330 is connected between the +100 and —15-volt supplies through R330. B330 ignites to indicate that the sweep is magnified. Variable resistor R339, Mag Regis, is adjusted to balance the current through Q324 and Q344. This balances the output DC level from this circuit so a center-screen display does not shift horizontal position when the MAG switch is changed from OFF to ×10. The push-pull output sawtooth at the collectors of Q324 and Q344 is connected to the horizontal deflection system of the indicator oscilloscope through terminals 7 and 9 of the interconnecting plug.

INTERCONNECTING PLUG

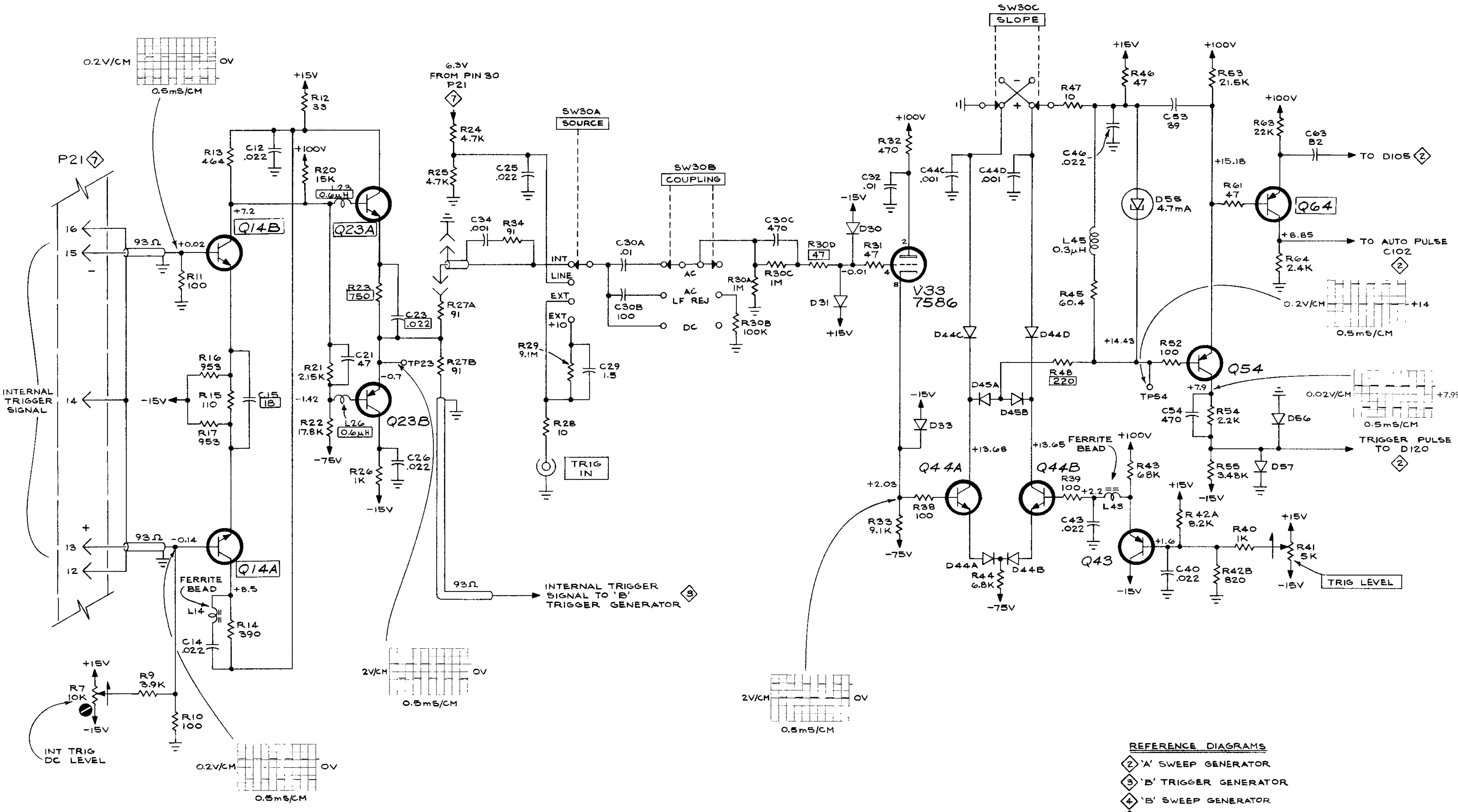
Diagram 7 shows the interconnections between the Type 11B2A and the indicator oscilloscope. This diagram also shows a portion of the HORIZ DISPLAY switch, SW300A, which determines the unblanking pulse connected to the CRT circuit of the indicator oscilloscope. In the A position of the HORIZ DISPLAY switch, the unblanking level for the CRT is determined by the A unblanking gate level from the A Sweep Generator circuit. When the HORIZ DISPLAY switch is set to either A INTEN BY B position, the trace intensity during the delay time (selected by A TIME/CM switch and DELAY TIME MULT dial) is determined by the A unblanking gate level (along with the indicator oscilloscope intensity control). Then, during the delayed sweep time, an intensified zone is shown on the trace to indicate that portion of the sweep which will be displayed at the delayed sweep rate selected by the DELAYED sweep switch (B TIME/CM). In both B DLY'D BY A positions, the display intensity is about the same as obtained in the A only position and is determined by a combination of both the A unblanking gate and the unblanking gate. In the EXT INPUT position of the HORIZ DISPLAY switch, —15 volts is connected to the indicator oscilloscope through R423. This partially unblanks the CRT; however, the indicator oscilloscope intensity control must normally be advanced also to produce a visible display. The unblanking gate level selected by the HORIZ DISPLAY switch is connected to the indicator oscilloscope through terminal 2 of the interconnecting plug.



TYPE 11B2A PLUG-IN

BLOCK DIAGRAM

167



REFERENCE DIAGRAMS

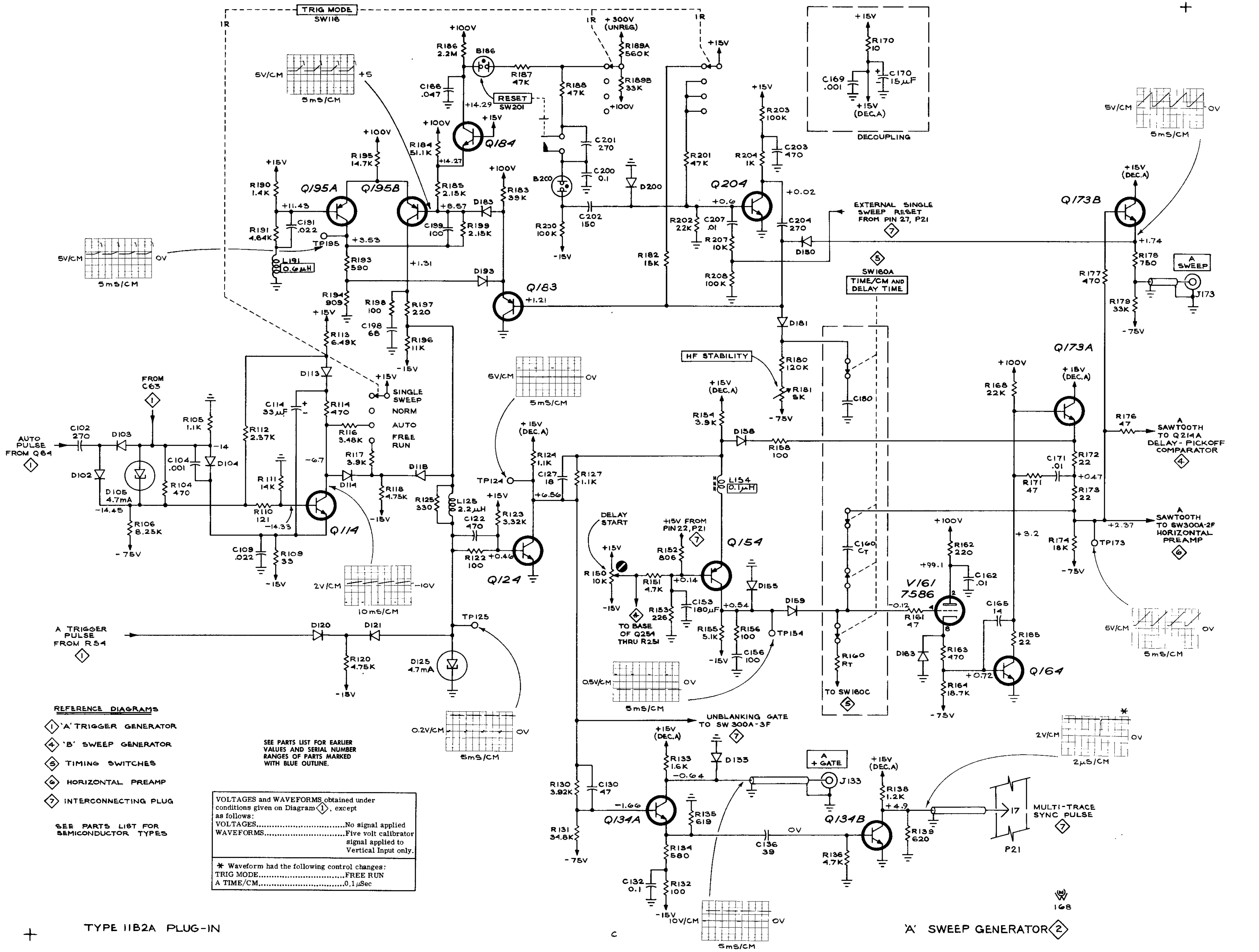
2 'A' SWEEP GENERATOR
3 'B' TRIGGER GENERATOR
4 'B' SWEEP GENERATOR
7 INTERCONNECTING PLUG

VOLTAGES and WAVEFORMS obtained under conditions given on left side of this diagram, except as follows:	
VOLTAGES	No signal applied
WAVEFORMS	Five volt calibrator signal applied to Vertical Input only.

168

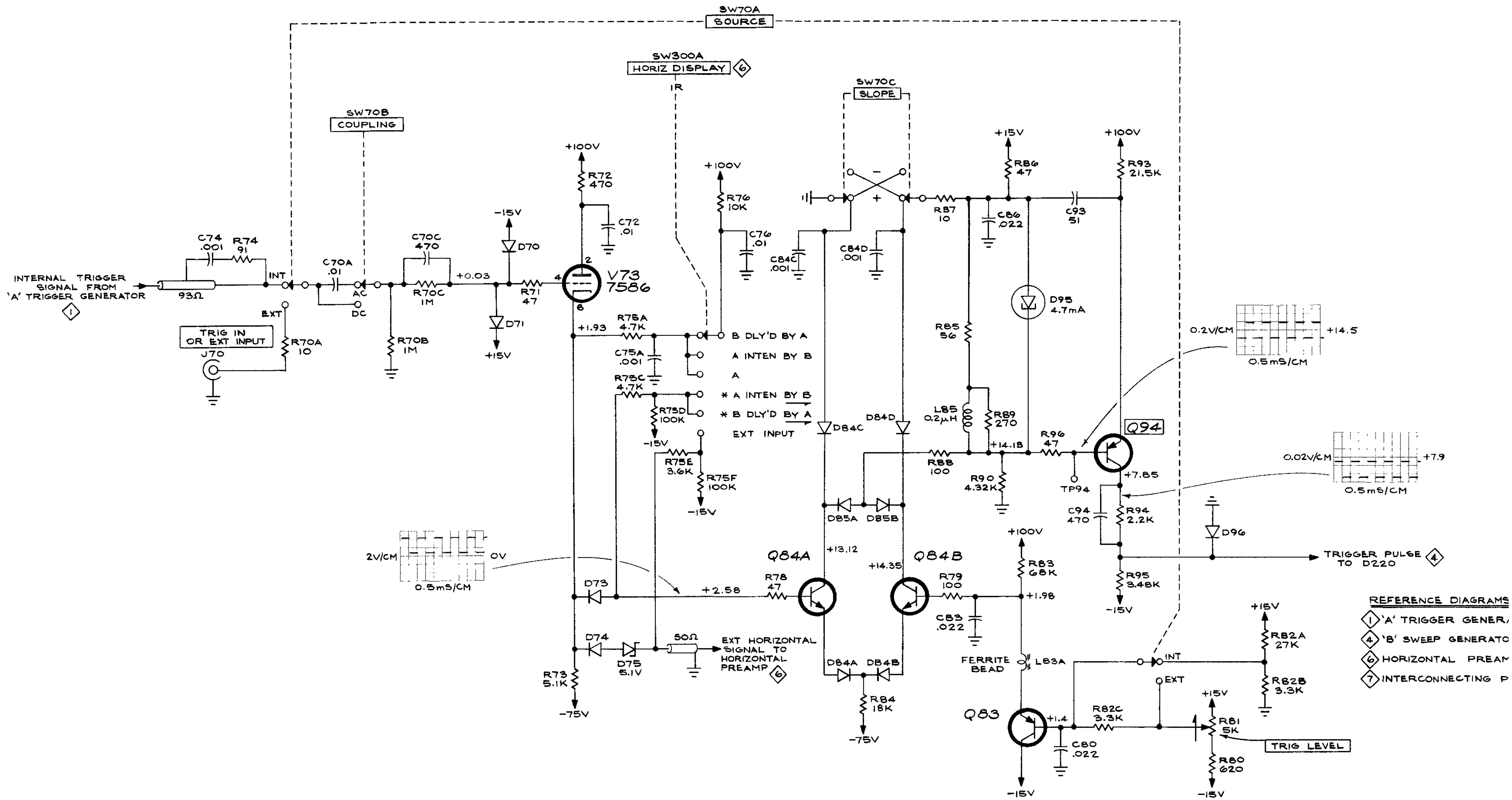
TYPE 11B2A PLUG-IN

'A' TRIGGER GENERATOR 1



TYPE 11B2A PLUG-IN

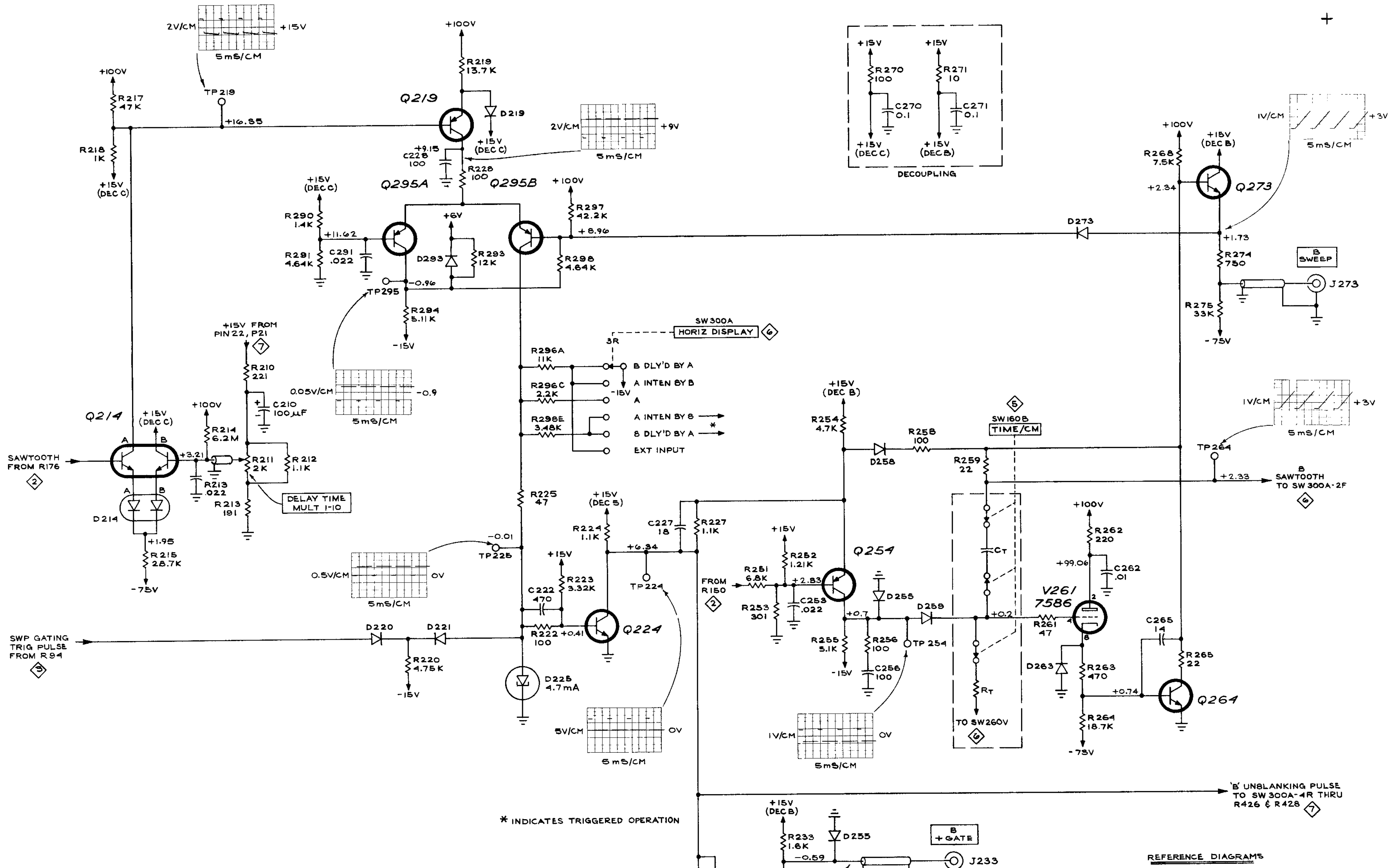
'A' SWEEP GENERATOR 2



TYPE 1182A PLUG-IN

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1, except as follows:
VOLTAGES.................................No signal applied
WAVEFORMS.............................Five volt calibrator signal applied to Vertical Input only.

* INDICATES TRIGGERED OPERATION



VOLTAGES and WAVEFORMS obtained under conditions given on Diagram ⟨1⟩, except as follows:
VOLTAGES................................No signal applied
WAVEFORMS..............................Five volt calibrator signal applied to Vertical Input only.

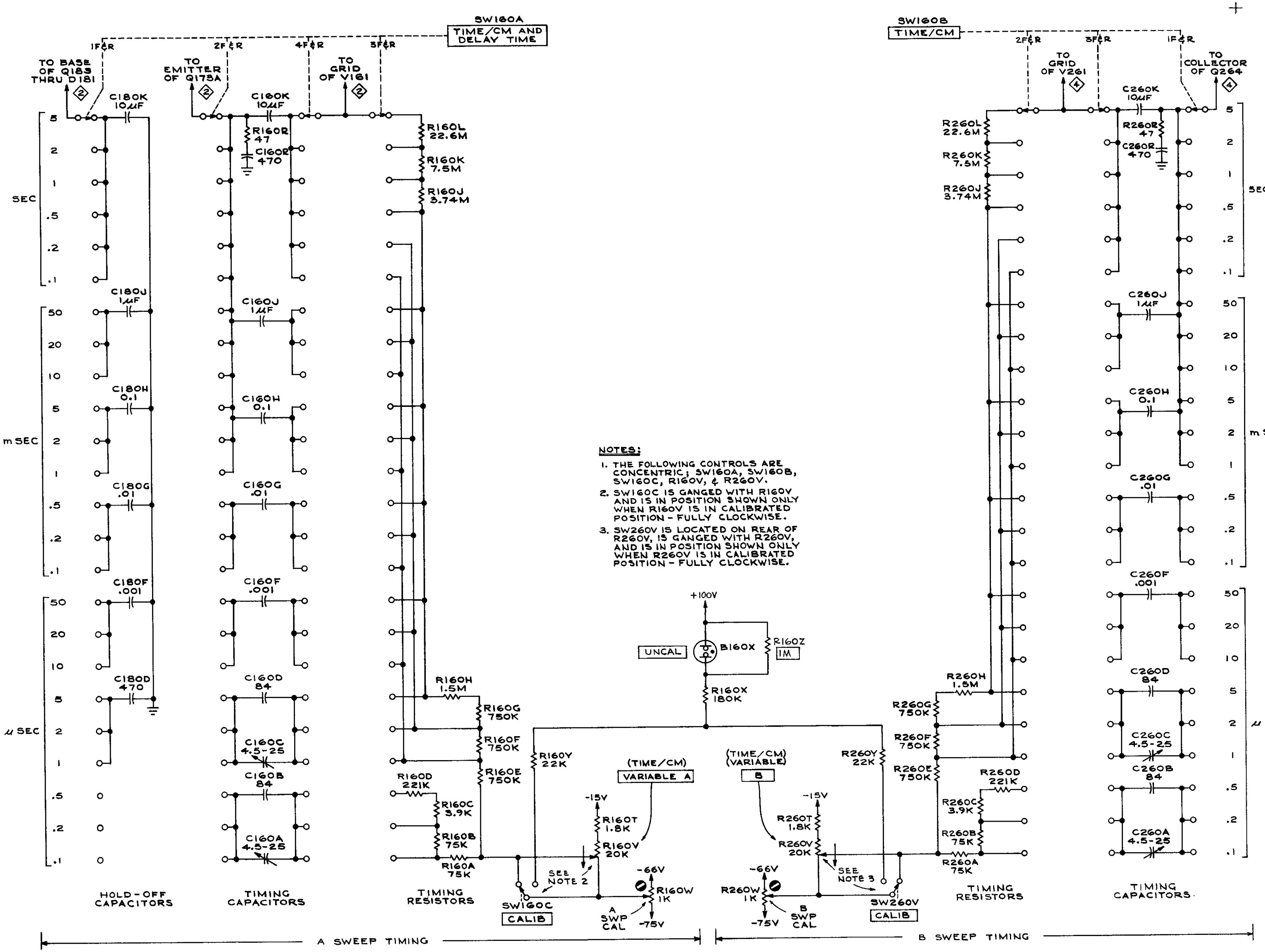
REFERENCE DIAGRAMS
⟨2⟩ 'A' SWEEP GENERATOR
⟨3⟩ 'B' TRIGGER GENERATOR
⟨5⟩ TIMING SWITCHES
⟨6⟩ HORIZONTAL PREAMP
⟨7⟩ INTERCONNECTING PLUG

TYPE 11B2A PLUG-IN

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

'B' SWEEP GENERATOR ⟨4⟩

167



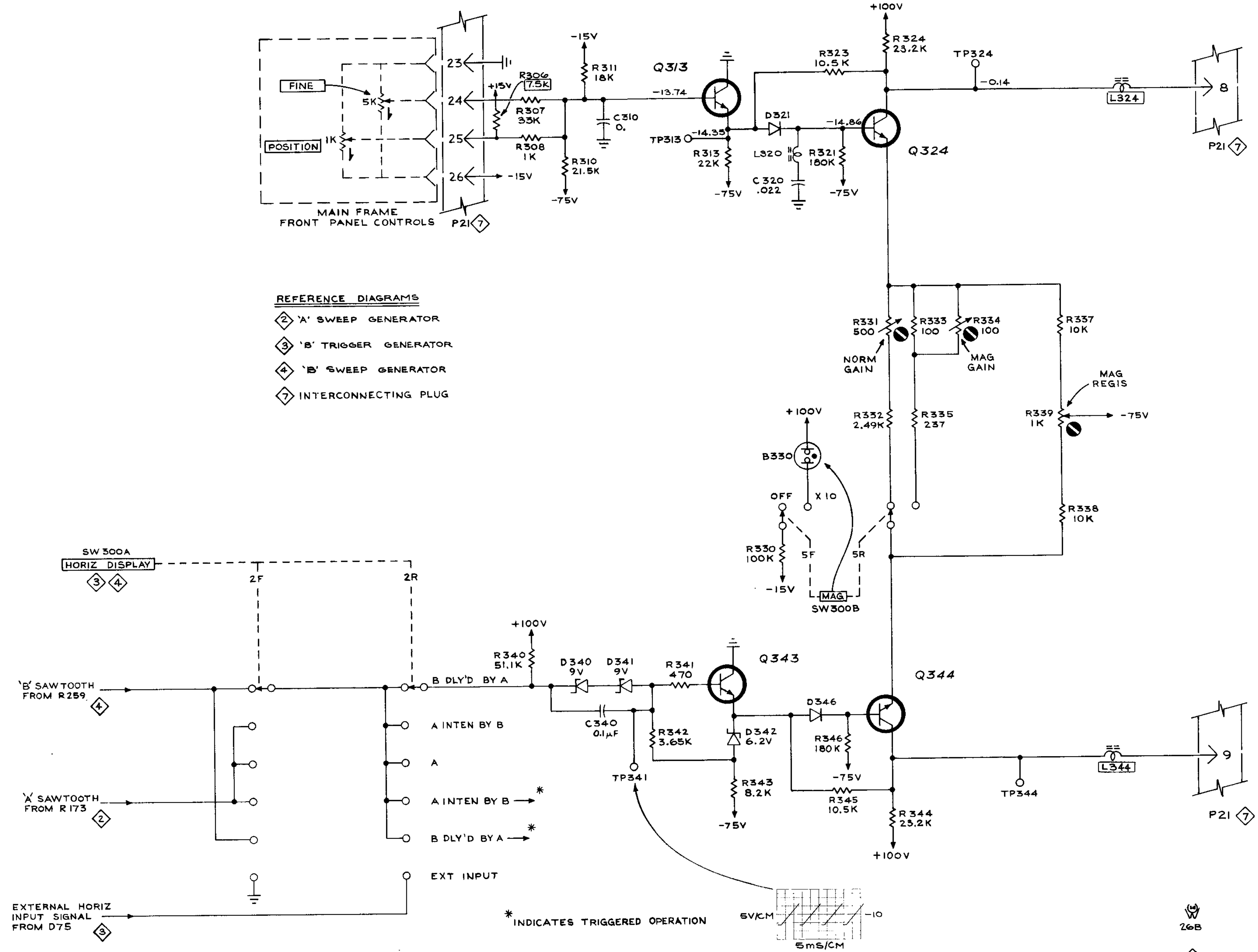
REFERENCE DIAGRAMS
(2) 'A' SWEEP GENERATOR
(4) 'B' SWEEP GENERATOR

TYPE 11B2A PLUG-IN

B

467

TIMING SWITCHES (5)



TYPE 11B2A PLUG-IN

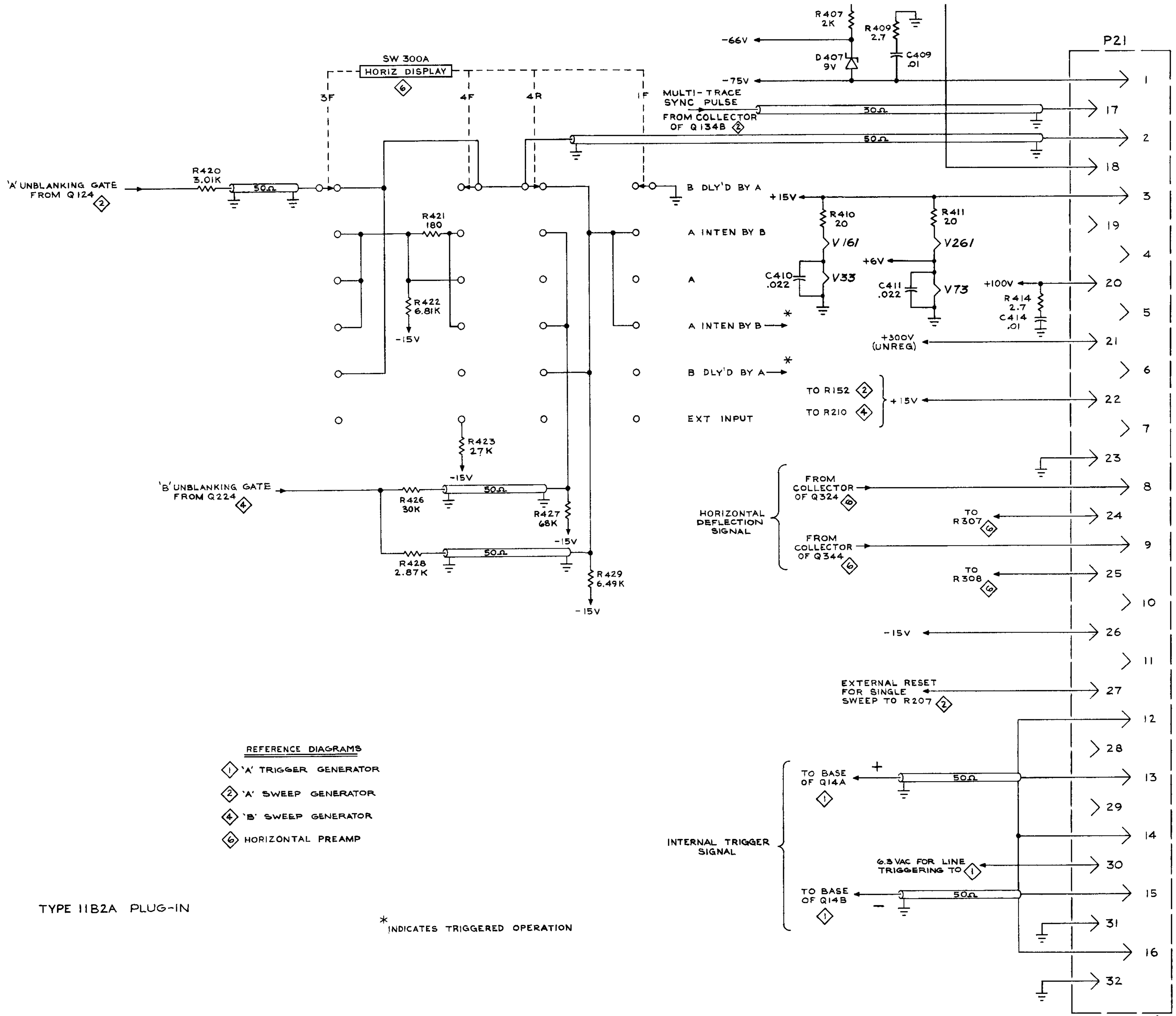
C

HORIZONTAL PREAMP 6

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram 1, except as follows:

VOLTAGES..............................No signal applied

WAVEFORMS..............................Five volt calibrator signal applied to Vertical Input only.



REFERENCE DIAGRAMS

1. 'A' TRIGGER GENERATOR
2. 'A' SWEEP GENERATOR
4. 'B' SWEEP GENERATOR
6. HORIZONTAL PREAMP

TYPE 11B2A PLUG-IN

* INDICATES TRIGGERED OPERATION

167

A

INTERCONNECTING PLUG 7