

INSTRUCTION MANUAL

TYPE 7B51 DELAYING TIME-BASE

Tektronix, Inc.

S.W. Millikan Way • P. O. Box 500 • Beaverton, Oregon 97005 • Phone 644-0161 • Cables: Tektronix
070-0976-00

869



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our 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.

Copyright © 1969 by Tektronix, Inc., Beaverton, Oregon. Printed in the United States of America. All rights reserved. Contents of this publication may not be reproduced in any form without permission of the copyright owner.

TABLE OF CONTENTS

SECTION 1	SPECIFICATION	Page
	Introduction	1-1
	Electrical Characteristics	1-1
	Sweep Rate	1-1
	Sweep Accuracy	1-1
	Sweep Length	1-1
	Sweep Hold-Off Time	1-1
	Delay Time Multiplier	1-1
	Range	1-1
	Accuracy	1-1
	Linearity	1-2
	Delay Jitter	1-2
	Trigger Sensitivity	1-2
	Internal Trigger Jitter	1-2
	External Trigger Input	1-2
	Level Range	1-2
	Bright Baseline	1-2
	P-P Auto Sensitivity	1-2
	Environmental Characteristics	1-2
	Altitude	1-2
	Transportation	1-2
	Physical Characteristics	1-2
	Finish	1-2
	Weight	1-2
	Dimensions	1-2
SECTION 2	OPERATING INSTRUCTIONS	
	General	2-1
	Installation	2-1
	Front Panel Controls and Connectors	2-1
	Test Setup Chart	2-4
	General Operating Information	2-4
	Sweep Calibration Check	2-4
	Simplified Operating Instructions	2-6
	Normal Sweep	2-6
	Magnified Sweep	2-6
	Delayed Sweep	2-6
	Pushbutton Switch Logic	2-6
	Triggered Light	2-7
	Trigger Mode	2-7
	Trigger Coupling	2-9
	Trigger Source	2-10
	Trigger Slope	2-10
	Trigger Level	2-10
	Horizontal Sweep Rate	2-10
	Sweep Magnifier	2-12
	Horizontal Position Control	2-12
	Applications	2-13
	Measurement Techniques	2-13
	Time Duration Measurements	2-14

TABLE OF CONTENTS **cont**

	Determining Frequency	2-14
	Risetime Measurements	2-15
	Delayed Sweep Time Measurements	2-16
	Delayed Sweep Magnification	2-17
	Pulse Jitter Measurements	2-18
SECTION 3	CIRCUIT DESCRIPTION	
	Introduction	3-1
	Block Diagram Description	3-1
	Detailed Circuit Description	3-3
	Trigger Preamp and Input Switching	3-3
	Trigger Generator	3-3
	Input Stage	3-3
	P-P Auto Stage	3-3
	Slope Comparator	3-3
	Trigger TD Stage	3-6
	Pulse Amplifier	3-6
	Sweep Gate Stage	3-7
	Bright Line Auto	3-7
	Sweep Generator	3-7
	Disconnect Amplifier	3-7
	Sawtooth Generator	3-9
	Sweep Start Amplifier	3-9
	Sweep Stop Comparator	3-9
	Holdoff Capacitor and Amplifier	3-9
	Sweep Holdoff Multivibrator	3-9
	Reset Control Amplifier	3-10
	Sweep Reset Multivibrator	3-10
	Single Sweep Operation	3-10
	Alternate Operation	3-10
	Delayed Sweep Operation	3-10
	Delay Pickoff Circuit	3-11
	Horizontal Preamp	3-11
	Readout Block	3-12
SECTION 4	MAINTENANCE	
	Preventive Maintenance	4-1
	General	4-1
	Cleaning	4-1
	Transistor Checks	4-1
	Recalibration	4-1
	Troubleshooting	4-2
	Troubleshooting Aids	4-2
	Troubleshooting Equipment	4-2
	Troubleshooting Techniques	4-2
	Corrective Maintenance	4-6
	Obtaining Replacement Parts	4-6
	Soldering Techniques	4-7
	Component Replacement	4-7

TABLE OF CONTENTS **cont**

SECTION 5	PERFORMANCE CHECK/CALIBRATION	5-1
	Introduction	5-1
	Test Equipment Required	5-1
	Short Form Procedure	5-2
	Performance Check/Calibration Procedure	5-4
	General	5-4
	Preliminary Control Settings	5-4
	Check or Adjust	
	Level Center	5-4
	P-P Auto Level Range	5-5
	Internal Trigger Centering	5-6
	Level/Slope Range	5-6
	Trigger Bandwidth	5-6
	External Trigger Input Compensation	5-6
	Sweep Jitter	5-7
	Trigger Modes	5-7
	Sweep Calibration	5-8
	Magnified Sweep Gain	5-8
	Magnifier Registration	5-9
	Sweep Length	5-9
	Variable Time/Div Range	5-9
	5 μ s Timing	5-10
	0.2 μ s Timing	5-10
	Sweep Timing Accuracy	5-10
	Magnified Sweep Timing	5-10
	Sweep Inhibit	5-11
	Delay Start (R590) and Delay Stop (R500)	5-12
	Delay Time Accuracy	5-13
	Delay Time Jitter	5-13
	Line Trigger Source	5-14
SECTION 6	ELECTRICAL PARTS LIST	
	Abbreviations and Symbols	
	Parts Ordering Information	
	Index of Electrical Parts List	
SECTION 7	DIAGRAMS AND MECHANICAL PARTS ILLUSTRATIONS	
	Diagrams	
	Mechanical Parts Illustrations (on reverse side of Diagrams)	
SECTION 8	MECHANICAL PARTS LIST	
	Mechanical Parts List Information	
	Index of Mechanical Parts Illustrations	
	Mechanical Parts List	
	Accessories	

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.

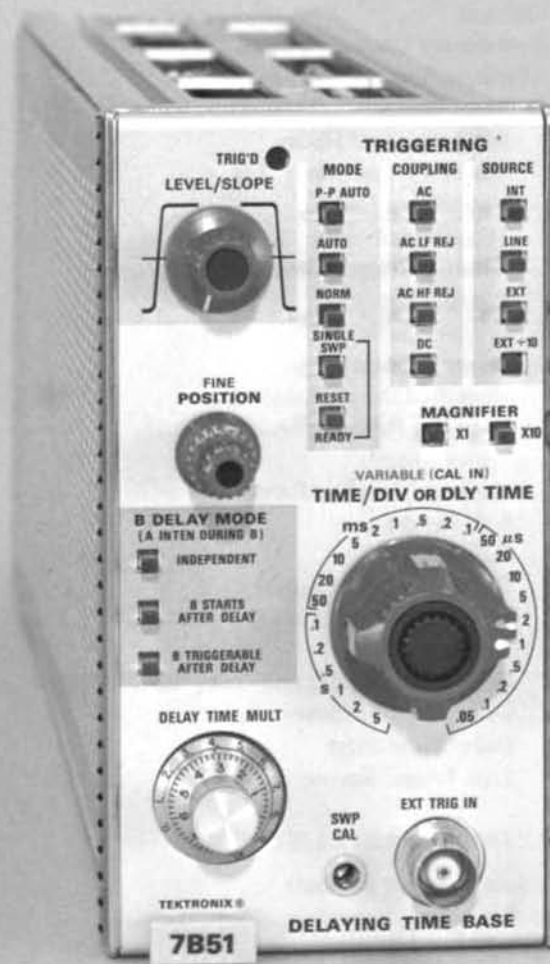


Fig. 1-1. Type 7B51 Delaying Time-Base.

Type 7B51

SECTION 1

SPECIFICATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type 7B51 Time Base Unit is designed specifically for use with Tektronix Type 7500-Series Oscilloscopes. However, it is compatible with all 7000-Series Oscilloscopes. The Type 7B51 provides calibrated sweeps from 5 seconds/division to 0.05 microsecond/divisions (5 nanoseconds/division with X10 MAGNIFIER). Sweep rates may be varied continuously (uncalibrated) between calibrated steps. Sweep triggering is to 100 megahertz or vertical amplifier bandwidth, whichever is less. The delaying sweep feature of the Type 7B51, in delayed sweep operation, gives continuous sweep delay from 0 to 10 times the setting of

the TIME/DIV OR DLY TIME selector. The sweep free-runs, providing a bright base line in the absence of adequate triggering signal in P-P AUTO and AUTO triggering modes.

The Performance Check procedure given in Section 5 provides a convenient method of checking performance of this instrument. The following electrical characteristics apply at an ambient temperature of 0°C to +50°C, unless otherwise noted. Warmup time for given accuracy is 20 minutes.

TABLE 1-1
ELECTRICAL CHARACTERISTICS

Characteristic	Performance			
Sweep Rate				
Calibrated Range	5 seconds/division to 0.05 microsecond/division in a 1-2-5 sequence. X10 magnifier extends sweep rate to 5 nanoseconds/division.			
VARIABLE Range (uncalibrated)	Continuously variable between calibrated sweep rates. Extends uncalibrated sweep rate to at least 12.5 seconds/division.			
Sweep Accuracy	Measured in 7500 series mainframe Calibrated with mainframe calibrator. +15°C to +35°C 0°C to +50°C			
Time Interval	Unmag	Mag	Unmag	Mag
Over Center 8 div				
5 s/div to 0.1 s/div and 0.2 μs/div to 0.05 μs/div	3%	3.5%	4%	5%
50 ms/div to 0.5 μs/div	2%	2.5%	3%	4%

Characteristic	Performance	
Over any 2 div interval within center 8 div	5%	7%
Exclude following portions of Magnified Sweep	Start of Sweep first 50 ns	End of Sweep beyond the 100th div
Sweep Length	10 divisions to 13 divisions	
Sweep Hold-Off Time		
5 s/Div to 5 μs/Div	1.5 times the TIME/DIV setting or less.	
2 μs/Div to 0.05 μs/Div	3.5 microseconds or less.	
DELAY TIME MULTIPLIER Range	0 to 10 times TIME/DIV setting	
Accuracy		
5 seconds/division to 1 second/division	Within 2%	
.5 milliseconds/division to 1 microsecond/division	Within 1%	

Specification—Type 7B51

Characteristic	Performance		
Multiplier Accuracy	Within 0.2%		
Differential Time Measurement	Within 1% and 2 minor divisions for delay times 1 μs to 0.5 s		
Accuracy	Within 2% and 2 minor divisions for delay times 1 s to 5 s		
Jitter	1 part or less in 50,000, of 10 times the TIME/DIV setting		
Trigger Sensitivity	Triggering Frequency Range ¹	Minimum Triggering Signal Required	
Coupling		INT	EXT
AC	30 Hz–10 MHz	0.3 Div	150 mV
	10 MHz–100 MHz	1.5 Div	750 mV
AC LF REJ ²	30 kHz–10 MHz	0.3 Div	150 mV
	10 MHz–100 MHz	1.5 Div	750 mV
AC HF REJ	30 Hz–50 kHz	0.3 Div	150 mV
DC	DC–10 MHz	0.3 Div	150 mV
	10 MHz–100 MHz	1.5 Div	750 mV
Single Sweep	Triggering requirements same as normal sweep. When triggered, sweep generator produces one sweep only.		
Internal Trigger Jitter	1 nanosecond or less at 75 megahertz.		
External Trigger Input			
Maximum Input Voltage	500 volts (DC + Peak AC). 500 volts (P-P AC) at 1 kilohertz or less.		
Input R and C	1 megohm within 2%; 20 picofarads within 2 picofarads.		

¹ On Internal Triggering Only, the specification for -3 dB frequency of the Vertical System replaces any frequency in the above table when the number in the table is greater than the -3 dB frequency of the Vertical Amplifier.

² Will not trigger on sine waves of 3 divisions or less internal or 1.5 volts external below 120 Hertz.

Characteristic	Performance
Level Range (Excluding P-P AUTO)	
EXT	At least +3.5 volts to -3.5 volts.
EXT $\div 10$	At least +35 volts to -35 volts.
Bright Baseline	Sweep free-runs in absence of triggering signal in P-P AUTO and AUTO.
P-P AUTO Operation	
Sensitivity	0.5 div Internal, 250 millivolts External.

TABLE 1-2
ENVIRONMENTAL CHARACTERISTICS

This instrument will meet the electrical characteristics given in Table 1-1 over the following environmental limits.

Characteristic	Performance
Altitude	
Non-operating	To 50,000 feet and -55°C .
Transportation	Qualified under National Safe Transit Committee test procedure 1A, category II.

TABLE 1-3
PHYSICAL CHARACTERISTICS

Finish	Front panel is anodized aluminum.
Dimensions	14 1/4 inches long by 2 5/8 inches wide by 5 inches high.
Weight	Approximately 1 3/4 pounds.

SECTION 2

OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

General

The Type 7B51 delaying sweep plug-in unit operates with a Tektronix 7000-series indicator oscilloscope and a 7A-series vertical plug-in unit to form a complete oscilloscope system. To use the Type 7B51 effectively, its operation and capabilities should be known. This section describes the operation of the front-panel controls, gives first-time and general operating information and lists some basic applications for this instrument.

Installation

The Type 7B51 is designed to operate in the horizontal plug-in compartments of Tektronix 7000-series oscilloscopes. The Type 7B51 can also be installed in a vertical plug-in compartment to provide a sweep that runs vertically on the CRT. However, when used in this manner, there is no retrace blanking or internal triggering provision and the unit may not meet the specifications given in Section 1. The instructions in this manual are written for use of the Type 7B51 in a horizontal plug-in compartment of the oscilloscope.

When the Type 7B51 is used with an oscilloscope which has two horizontal plug-in compartments, install this unit in the A (DELAYING TIME BASE) compartment. Then, if a delayed-sweep unit is installed in the B (right) compartment, delayed-sweep operation is available. The Type 7B51 will operate properly in the B compartment for all horizontal modes of operation except delaying sweep.

To install the Type 7B51 into a plug-in compartment, push it in until it fits firmly into the indicator plug-in compartment. To remove, pull the release latch (see Fig. 2-1) to disengage the unit from the indicator and pull it out of the plug-in compartment. Even though the horizontal gain of the indicator oscilloscope is standardized to minimize adjustment when inserting plug-in units, the sweep calibration of the Type 7B51 should be checked when it is inserted into the indicator to verify measurement accuracy. The procedure for checking the unit is given under Sweep Calibration Check in this section.

FRONT-PANEL CONTROLS AND CONNECTORS

General

All controls required for the operation of the Type 7B51 are located on the front panel of the unit (see Fig. 2-2). To make full use of the capabilities of this instrument, the

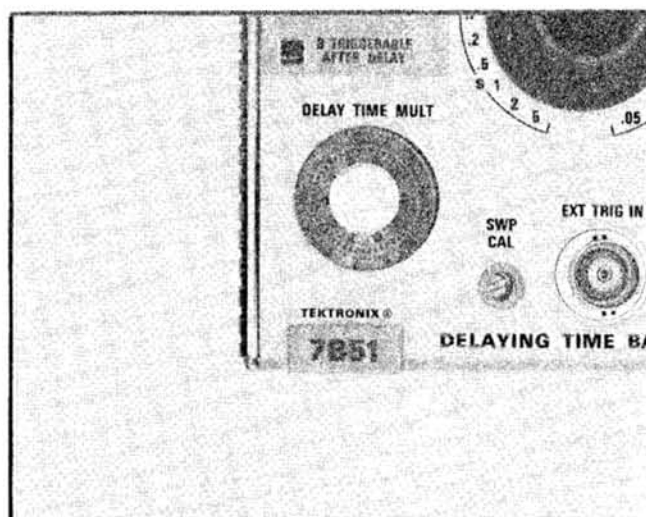


Fig. 2-1. Location of release latch.

operator should be familiar with the function and use of each of these controls. A brief description of the front-panel controls and connector is given here. More detailed information is given under General Operating Information.

Triggering Controls

LEVEL/SLOPE

Selects the amplitude point and slope of trigger signal on which the sweep is triggered. When the indicator line on the outer ring is to the left of center, the sweep is triggered on the positive-going slope of the trigger signal, as shown by the positive-going waveform. To the right of center, the sweep is triggered on the negative-going slope of the trigger signal as shown by the negative-going waveform.

TRIG'D

Light indicates that the sweep is triggered and will produce a display with correct setting of the POSITION control and the controls on the associated vertical unit and indicator oscilloscope.

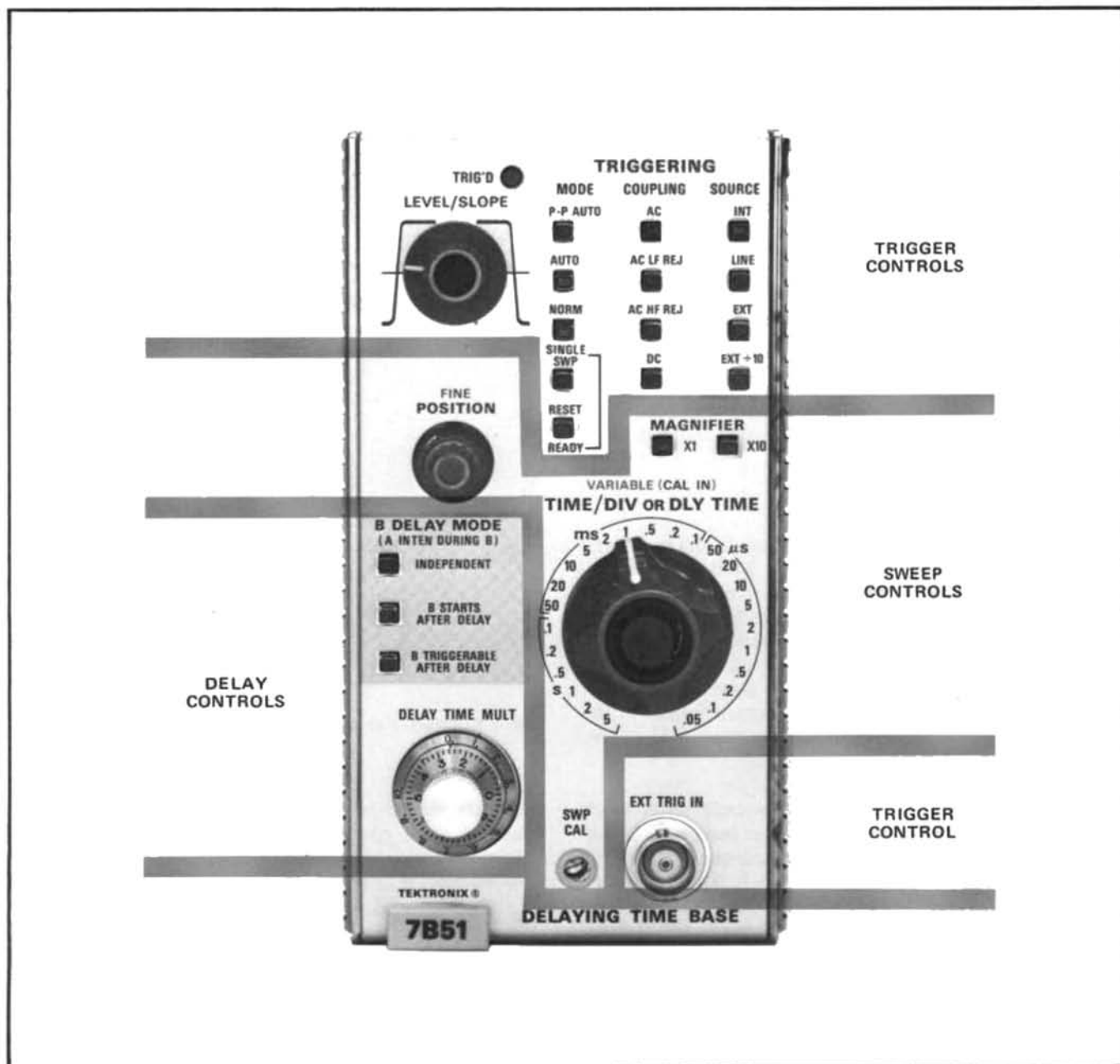


Fig. 2-2. Front-Panel controls and connector.

MODE

Series of push-button switches to select the trigger mode. Selected mode is indicated by lighted button.

P-P AUTO: Sweep automatically triggered at point selected by the LEVEL/SLOPE control when the trigger signal repetition rate is above about 200 hertz and within the frequency range selected by the COUPLING

switch. Triggered sweep can be obtained throughout the range of the LEVEL/SLOPE control. When the trigger repetition rate is below the lower frequency limit (or above upper limit for AC HF REJ) or when the trigger signal is inadequate, the sweep free runs at the sweep rate selected by the TIME/DIV switch to produce a reference trace.

AUTO: Sweep initiated by the applied trigger signal at point selected by the LEVEL/SLOPE control when the trigger signal repetition rate is above about 30 hertz and within the frequency range selected by the COUPLING switch. Triggered sweep can be obtained only over the amplitude range of the applied trigger signal. When the LEVEL/SLOPE control is outside the amplitude range, the trigger repetition rate is below the lower frequency limit (or above upper limit for AC HF REJ) or the trigger signal is inadequate, the sweep free runs at the sweep rate selected by the TIME/DIV switch to produce a reference trace.

NORM: Sweep initiated by the applied trigger signal at any point selected by the LEVEL/SLOPE control over the frequency range selected by the COUPLING switch. Triggered sweep can be obtained only over the amplitude range of the applied trigger signal. When the LEVEL/SLOPE control is outside the amplitude range, the trigger repetition rate is outside the frequency range selected by the COUPLING switch or the trigger signal is inadequate, there is no trace.

SINGLE SWP: Sweep initiated by the applied trigger signal at any point selected by the LEVEL/SLOPE control over the frequency range selected by the COUPLING switch. Triggered sweep can be obtained only over the amplitude range of applied trigger signal. After the first sweep is displayed, further sweeps cannot be presented until the RESET-READY push-button is pressed. When the LEVEL/SLOPE control is outside the amplitude range, the trigger repetition rate is outside the frequency range selected by the COUPLING switch, the trigger signal is inadequate or when the RESET-READY light is off, there is no trace.

COUPLING

RESET-READY: Push-button to reset the Sweep Generator for the next sweep in the single-sweep mode. The RESET-READY button remains lighted to indicate that the unit is ready to be triggered. After the unit is triggered and a sweep is completed, the RESET-READY light goes out until the button is pressed again.

Series of push-button switches to select the trigger coupling. Selected coupling is indicated by lighted button.

AC: Rejects DC and attenuates AC signals below about 30 hertz. Accepts signals between 30 hertz and 100 megahertz.

AC LF REJ: Rejects DC and attenuates signals below about 30 kilohertz. Accepts signals between 30 kilohertz and 100 megahertz.

AC HF REJ: Accepts signals between about 30 hertz and 50 kilohertz. Rejects DC and attenuates signals outside this frequency range.

DC: Accepts all trigger signals from DC to 100 megahertz.

Series of push-button switches to select the trigger source. Selected source is indicated by lighted button.

INT: Trigger signal obtained internally from a vertical unit.

LINE: Trigger signal obtained internally from a sample of the line voltage applied to this instrument.

EXT: Trigger signal obtained from an external signal applied to the EXT TRIG IN connector.

EXT ÷ 10: Trigger signal obtained from an external signal applied to the EXT TRIG IN connector as in the EXT position. In this position the external signal is attenuated 10 times before it is applied to the trigger circuit.

SOURCE

Operating Instructions—Type 7B51

EXT TRIG IN Input connector for external trigger signal.

Sweep Controls

POSITION Controls horizontal position of display.

FINE Provides more precise control of horizontal position.

TIME/DIV OR DLY TIME Selects the basic sweep rate of the output sawtooth and selects basic delay time (to be multiplied by the **DELAY TIME MULT** dial setting). The **VARIABLE** control must be in calibrated position and **MAGNIFIED** switch set to X1 for indicated sweep rate.

VARIABLE Two-position switch actuated by the **VARIABLE** knob to select calibrated or uncalibrated sweep rates. At the in position, the **VARIABLE** control is inoperative and the sweep rate is calibrated. When pressed and released, the knob moves out to activate the **VARIABLE** control for uncalibrated sweep rates. The sweep rate in each **TIME/DIV** switch position can be reduced to at least the sweep rate of the next adjacent position, to provide continuously variable sweep rates from 5 nanoseconds/division (X10 **MAGNIFIER** on) to about 12.5 seconds/division, with **MAGNIFIER** at X1.

MAGNIFIED Push-button switches to select the horizontal magnification. The Selected magnification is indicated by a lighted button.

X1: Magnified sweep at the basic sweep rate indicated by **TIME/DIV** switch.

X10: Magnified sweep at a sweep rate 10 times faster than the basic sweep rate indicated by the **TIME/DIV** switch. The portion of the normal sweep within the center division of the graticule is the portion shown in magnified form.

SWP CAL Screwdriver adjustment to set amplitude of the output sawtooth.

Delay Controls

B DELAY MODE (A INTEN DURING B)

Series of push-button switches to select the delay logic to the companion delayed-sweep unit (B). Selected delay mode is indicated by a lighted button.

INDEPENDENT: The Type 7B51 and the companion delayed-sweep unit (B) operate independently as normal time-base units.

B STARTS AFTER DELAY: The companion delayed-sweep unit (B) produces a sweep immediately following the delay time selected by the **TIME/DIV OR DLY TIME** switch and the **DELAY TIME MULT** dial.

B TRIGGERABLE AFTER DELAY: The companion delayed-sweep unit (B) produces a sweep after the first trigger pulse is received following the delay time selected by the **TIME/DIV OR DLY TIME** switch and the **DELAY TIME MULT** dial.

DELAY TIME MULT Provides variable delay for the delay pulse to the companion delayed-sweep unit (B) from 0 to 10 times the basic delay time selected by the **TIME/DIV OR DELAY TIME** switch.

TEST SETUP CHART

General

Fig. 2-3 shows the front panel of the Type 7B51. This chart can be reproduced and used as a test-setup record for special measurements, applications or procedures, or it may be used as a training aid for familiarization with this instrument.

GENERAL OPERATING INFORMATION

Sweep Calibration Check

Whenever the Type 7B51 is inserted into a plug-in compartment other than the one in which it was calibrated, the sweep calibration should be checked and readjusted if necessary. Allow five minutes warmup before performing this procedure.

1. Connect a one-kilohertz calibrator signal from the Indicator Oscilloscope Calibrator to the Vertical unit input connector.

TYPE 7B51 TEST SET-UP CHART

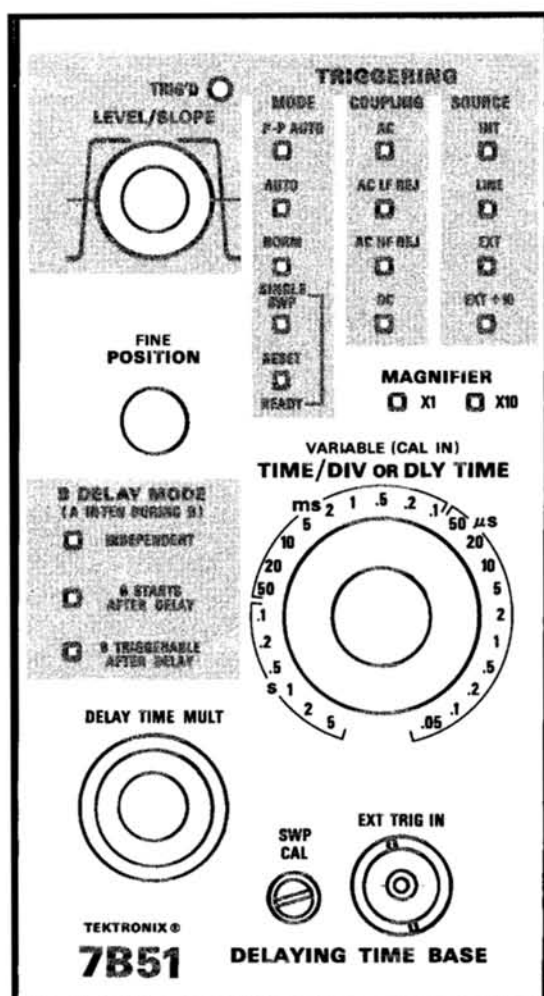


Fig. 2-3. Type 7B51 Test Setup Chart.

Operating Instructions—Type 7B51

2. Set the TIME/DIV switch to 1 ms and press the top TRIGGERING and B DELAY MODE pushbuttons.
3. Set the Vertical unit to display at least two divisions of the signal vertically.
4. Check the CRT display for one complete cycle per division.
5. If necessary, adjust the SWP CAL adjustment for one complete cycle per division.

Simplified Operating Instructions

The following information is provided to aid in quickly obtaining the correct settings for the Type 7B51 to present a display. The operator should be familiar with the complete function and operation of the unit as described in this section before using this procedure.

Normal Sweep. The following procedure will provide a stable display for most normal-sweep applications.

1. Select the TRIGGERING MODE, COUPLING and SOURCE which fit the requirements of the signal to be displayed.
2. Turn the LEVEL/SLOPE control to the desired slope.
3. If the green TRIG'D light is not on, adjust the LEVEL/SLOPE control throughout the range of the selected slope until the TRIG'D light comes on. If the light does not come on at any setting of the LEVEL/SLOPE control, the trigger signal is inadequate or the COUPLING and SOURCE switches are set incorrectly.
4. Set the TIME/DIV switch and POSITION control for a display which remains on the display area horizontally (VARIABLE control should be in CAL position for calibrated sweep rates).
5. If the display does not start at the correct point on the waveform, readjust the LEVEL/SLOPE control for the desired triggering.

Magnified Sweep. A magnified-sweep display can be obtained as follows after a normal-sweep display is obtained as given in steps 1-5 above.

1. Adjust the POSITION control to move the area to be magnified within the center division of the CRT.

2. If necessary, change the TIME/DIV switch setting so the complete area to be magnified is within the center division.

3. Press the X10-MAGNIFIED push-button.

4. Use the fine range of the POSITION control to establish precise positioning of the magnified display.

Delayed Sweep. The following procedure can be used to obtain a delayed-sweep display when the Type 7B51 is used in an oscilloscope that has dual time base capabilities and when used with a companion delayed-sweep unit (B). Obtain a display as given in steps 1-5 under Normal Sweep. Then proceed as follows:

1. Press the B STARTS AFTER DELAY push-button.
2. Set the indicator oscilloscope horizontal mode to display the A time base (Type 7B51).
3. Set the time/division switch of the companion delayed-sweep unit (B) so the intensified zone on the display is the desired length (intensified zone will be displayed in delayed form). If the intensified zone is not visible, adjust the indicator intensity controls.
4. Adjust the DELAY TIME MULT dial to position the intensified zone to the portion of the display to be delayed.
5. Set the indicator oscilloscope horizontal mode to display the B time base (delayed sweep unit).
6. If a delayed sweep with less jitter is desired, press the Type 7B51 B TRIGGERABLE AFTER DELAY push-button. The triggering controls of the companion delayed-sweep unit (B) must be set to obtain a stable display. See the instruction manual for that unit for further information.

Pushbutton Switch Logic

The TRIGGERING MODE, COUPLING and SOURCE switches and the B DELAY MODE switch are arranged in a sequence which places the most often-used position at the top of each series of pushbuttons. With this arrangement, a stable normal-sweep display can usually be obtained by pressing the top push-buttons; P-P AUTO, AC, INT and INDEPENDENT. When an adequate trigger signal is applied, the unit is triggered as indicated by the illuminated TRIG'D light at any setting of the LEVEL/SLOPE control. If the TRIG'D light is not on, either the trigger signal

applied to this unit from the vertical unit is inadequate or it is below the lower frequency limit of the AC COUPLING switch position. If the desired display is not obtained with the pushbuttons pushed in, other selections must be made. Refer to the following discussions or the instruction manuals for the associated indicator oscilloscope and vertical unit for more information.

Triggered Light

The TRIG'D light provides a convenient indication of the condition of the triggering circuits. If the TRIGGERING controls are correctly set and an adequate trigger signal is applied, the TRIG'D light is on. Under certain conditions, the TRIG'D light may be off, indicating that the sweep is not triggered. The cause might be a misadjusted LEVEL/SLOPE control, incorrectly set COUPLING or SOURCE switches, low trigger signal amplitude, or a trigger signal repetition rate outside the acceptable frequency range. This feature can be used as a general indication of correct triggering. It is particularly useful when setting up the trigger circuits when a trigger signal is available without a display on the CRT. It also indicates that this unit is correctly triggered when operating as a delaying-sweep unit (A).

Trigger Mode

The pushbuttons located under the MODE title (see Fig. 2-4) select the mode in which the sweep is triggered. The selected mode is indicated by a lighted pushbutton.

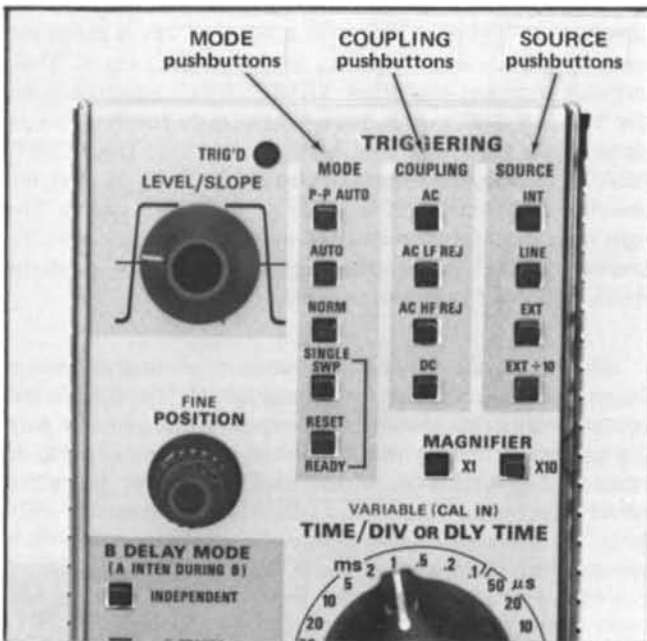


Fig. 2-4. Exploded view of front panel showing push-buttons associated with the MODE, COUPLING and SOURCE switches.

P-P AUTO. When the P-P AUTO pushbutton is pressed, a triggered display is provided at any setting of the LEVEL/SLOPE control whenever an adequate trigger signal is applied. The range of the LEVEL/SLOPE control in this mode is between about 10% and 90% of the peak-to-peak amplitude of the applied trigger signal. The LEVEL/SLOPE control can be set so the displayed waveform starts at any point within this range on either slope. In the P-P AUTO mode, the trigger circuit automatically compensates for changes in trigger signal amplitude for signals above the minimum amplitude requirement. Therefore, if the LEVEL/SLOPE control is set so the displayed waveform starts at a certain percentage-point on the leading edge of a low-amplitude signal, it triggers at the same percentage-point on the leading edge of a high-amplitude signal if the LEVEL/SLOPE control is not changed. This operation is illustrated in Fig. 2-5.

When the trigger repetition rate is below about 200 hertz (or outside the frequency range selected by the COUPLING switch), or when the trigger signal is inadequate, the sweep free runs at the sweep rate indicated by the TIME/DIV switch to produce a reference trace (TRIG'D light off). When an adequate trigger signal is again applied, the free-running condition ends and a triggered display is presented.

The P-P AUTO trigger mode is particularly useful when observing a series of waveforms, since it is not necessary to reset the LEVEL/SLOPE control for each observation. Also, because of the ease of obtaining a triggered display in this mode, the P-P AUTO trigger mode can be used for most applications and the remaining modes used only for special applications or when stable triggering is not obtainable in this mode.

AUTO. When the AUTO push-button is illuminated, a triggered display is presented with the correct setting of the LEVEL/SLOPE control (see Trigger Level discussion) whenever an adequate trigger signal is applied. The range of the LEVEL/SLOPE control in this mode is ± 8 vertical divisions. The TRIG'D light indicates when the display is triggered.

When the trigger repetition rate is below about 30 hertz (or outside the frequency range selected by the COUPLING switch) or when the trigger signal is inadequate, the sweep free runs at the sweep rate indicated by the TIME/DIV switch to produce a reference trace (TRIG'D light off). When an adequate trigger signal is again applied, the free-running condition ends and a triggered display is presented. When the LEVEL/SLOPE control is at a setting outside the amplitude range of the trigger signal, the sweep also free runs at the sweep rate indicated by the TIME/DIV switch. This type of free-running display can be useful when it is desired to measure only the maximum peak-to-peak amplitude of a signal without observing the waveshape such as in bandwidth measurements).

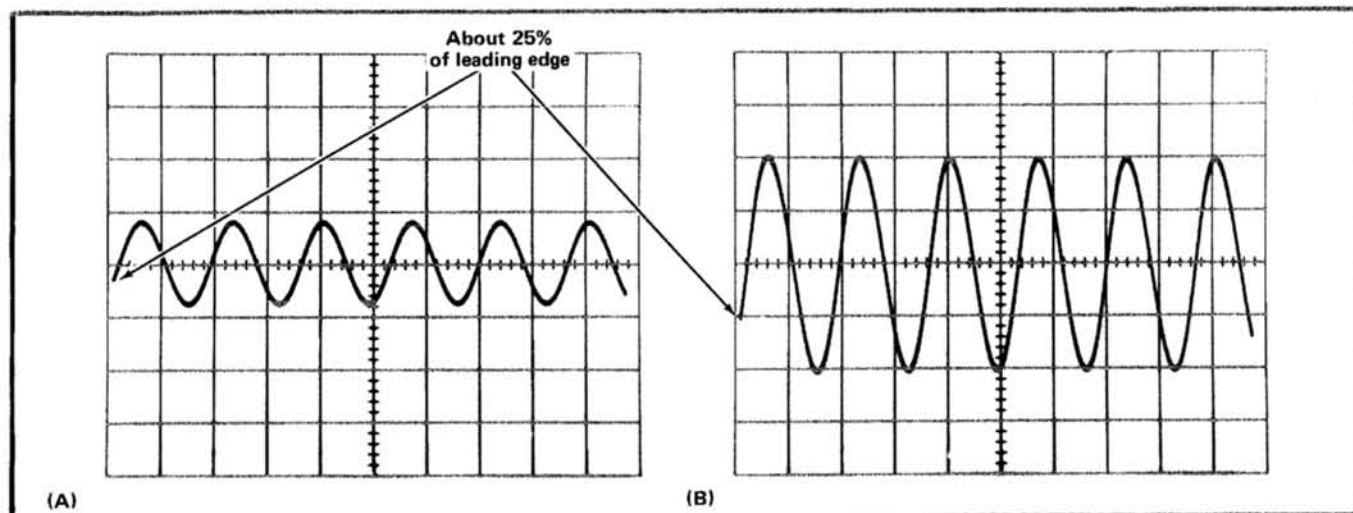


Fig. 2-5. LEVEL/SLOPE control operation for (P-P) AUTO mode triggering. (A) LEVEL/SLOPE control set so displayed waveform starts at about 25% point of a one-division waveform. (B) displayed waveform still triggered at about 25% of leading edge, when signal amplitude is increased, to produce a four-division display (LEVEL/SLOPE control at same setting for both waveforms).

NORM. When the NORM push-button is pressed, a triggered display is presented with the correct setting of the LEVEL/SLOPE control whenever an adequate trigger signal is applied. The range of the LEVEL/SLOPE control in this mode is ± 8 vertical divisions. The TRIG'D light indicates when the display is triggered.

The NORM trigger mode must be used to produce triggered displays with trigger repetition rates below about 30 hertz. When the LEVEL/SLOPE control is at a setting outside the amplitude range of the trigger signal, when the trigger repetition rate is outside the frequency range selected by the COUPLING switch or when the trigger signal is inadequate, there is no trace (TRIG'D light off).

SINGLE SWP. When the signal to be displayed is not repetitive or varies in amplitude, waveshape or repetition rate, a conventional repetitive type display may produce an unstable presentation. A stable display can often be obtained under these circumstances by using the single-sweep feature of this unit. The SINGLE SWP MODE is also useful to photograph non-repetitive or unstable displays.

To obtain a single-sweep display of a repetitive signal, first obtain the best possible display in the NORM MODE. Then without changing the other TRIGGERING controls, press the SINGLE SWP pushbutton. When ready to view the single-sweep display, press the RESET-READY pushbutton. A single trace is presented each time the RESET-READY pushbutton is pressed (as long as the repetitive signal remains connected to the system and TRIGGERING controls are correctly set) and further sweeps cannot be presented until the RESET-READY pushbutton is pressed again. If the displayed signal is a complex waveform com-

posed of pulses of varying amplitude, successive single-sweep displays may not start at the same point of the waveform. To avoid confusion due to the CRT persistence, allow the display to decay before pressing the RESET-READY pushbutton again. At fast sweep rates, it may be difficult to view the single-sweep display. The apparent trace intensity can be increased by reducing the ambient light level or using a viewing hood as recommended in the indicator instruction manual.

Non-repetitive, random signals can be displayed in the single-sweep mode by first obtaining the best possible display in the NORM MODE with a signal which is about the same amplitude and frequency as the random signal. Then without changing the other TRIGGERING controls, press the SINGLE SWP pushbutton. When ready for the random signal, press the RESET-READY pushbutton. The RESET-READY pushbutton remains lighted to indicate that the unit has been reset and is ready to produce a sweep. The light goes out after the random signal triggers the unit. To prepare the unit for another single-sweep display, press the RESET-READY pushbutton again.

When using the single-sweep mode to photograph waveforms, the graticule must be photographed separately in the normal manner to prevent over-exposing the film. Be sure the camera system is well protected against stray light, or operate the system in a darkened room. For repetitive waveforms, press the RESET-READY pushbutton only once for each waveform unless the signal is completely symmetrical. Otherwise, multiple waveforms may appear on the film. For random signals, the camera lens can be left open until the random signal triggers the unit (RESET-READY pushbutton lighted). Further information on photographic techniques is given in the camera instruction manual.

Trigger Coupling

The pushbuttons located below the COUPLING title (see Fig. 2-4) select the method in which the trigger signal is connected to the trigger circuits. The selected coupling is indicated by a lighted pushbutton. Each position permits selection or rejection of the frequency components of the trigger signal which trigger the sweep. Fig. 2-6 graphically illustrates the band of frequencies covered by each position of the COUPLING switch.

AC. In the AC position of the COUPLING switch, the DC component of the trigger signal is blocked. Signals with low-frequency components below about 30 hertz are attenuated. In general, AC COUPLING can be used for most applications. However, if the signal contains unwanted frequency components or if the sweep is to be triggered at a low repetition rate or DC level, one of the remaining COUPLING switch positions will provide a better display.

The triggering point in the AC position depends upon the average voltage level of the trigger signal. If the trigger signal occurs randomly, the average voltage level will vary, causing the triggering point to vary also. This shift of the triggering point may be enough so it is impossible to maintain a stable display. In such cases, use DC coupling.

AC LF REJ. In the AC LF REJ position, DC is rejected and low-frequency trigger signals below about 30 kilohertz are attenuated. Therefore, the sweep is triggered only by the higher-frequency components of the trigger signal. This position is particularly useful for providing stable triggering if the trigger signal contains line-frequency components. Also, the AC LF REJ position provides the best alternate-mode vertical displays at fast sweep rates when comparing two or more unrelated signals (with dual-trace vertical or slaved triggering operation for dual-vertical unit operation).

AC HF REJ. The AC HF REJ position passes all low-frequency signals between about 30 hertz and 50 kilohertz. DC is rejected and signals outside the above range are attenuated. When triggering from complex waveforms, this position is useful for providing stable display of the low-frequency components.

DC. DC COUPLING can be used to provide stable triggering with low-frequency signals which would be attenuated in the other modes, or with low-repetition rate signals. It can also be used to trigger the sweep when the trigger signal reaches a DC level selected by the setting of the LEVEL/SLOPE control. When using internal triggering, the setting of the vertical unit position controls affects the DC triggering point.

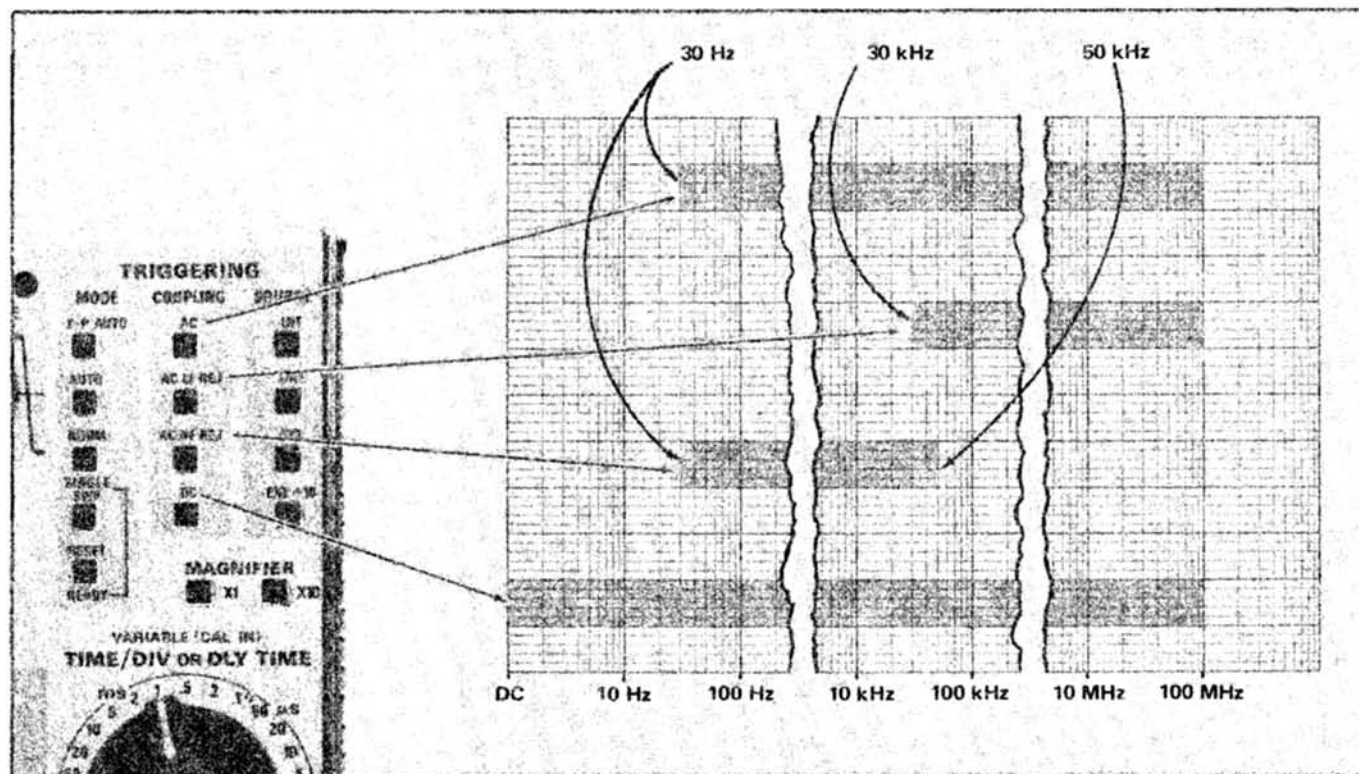


Fig. 2-6. Frequency range of each COUPLING switch position.

Trigger Source

The pushbuttons located below the SOURCE title (see Fig. 2-4) select the source of the trigger signal which is connected to the trigger circuits. The selected source is indicated by a lighted pushbutton.

INT. In the INT position of the SOURCE switch, the trigger signal is derived from the associated vertical unit. Further selection of the internal trigger signal may be provided by the associated vertical unit or indicator oscilloscope; see the instruction manuals for these instruments for information. For most applications, the INT-SOURCE position can be used. However, some applications require special triggering which cannot be obtained in the INT-SOURCE position. In such cases LINE- or EXT-SOURCE must be used.

LINE. The LINE position of the SOURCE switch connects a sample of the power-line voltage, to which the indicator oscilloscope is connected, to the trigger circuit. Line triggering is useful when the input signal is time-related (multiple or sub-multiple) to the line frequency. It is also useful for providing a stable display of a line-frequency component in a complex waveform.

EXT. An external signal connected to the EXT TRIG IN connector can be used to trigger the sweep in the EXT-SOURCE position. The external signal must be time-related to the displayed waveform for a stable display. An external trigger signal can be used to provide a triggered display when the internal signal is too low in amplitude for correct triggering or contains signal components on which it is not desired to trigger. It is also useful when signal tracing in amplifiers, phase-shift networks, wave-shaping circuits, etc. The signal from a single point in the circuit under test can be connected to the EXT TRIG IN connector through a probe or cable. The sweep is then triggered by the same signal at all times and allows amplitude, time relationship or waveshape changes of signals at various points in the circuit to be examined without resetting the TRIGGERING controls.

EXT ÷ 10. Operation in the EXT ÷ 10 position is the same as described for EXT except that the external signal is attenuated 10 times. Attenuation of high-amplitude external trigger signals is desirable to broaden the range of the LEVEL/SLOPE control.

Trigger Slope

The LEVEL/SLOPE control determines whether the trigger circuit responds on the positive-going or negative-going portion of the trigger signal. When the indicator line on the outer ring of the LEVEL/SLOPE control is to be left of center, the display starts on the positive-going portion of

the waveform (notice positive-going waveform to left of control. To the right of center, the display starts on the negative-going portion of the waveform (notice negative-going waveform). The effect of the LEVEL/SLOPE control on the displayed waveform is shown in Fig. 2-7. When several cycles of a signal appear in the display, the selection of the trigger slope is often unimportant. However, if only a certain portion of a cycle is to be displayed, correct setting of the LEVEL/SLOPE control is important to provide a display which starts on the desired slope of the input signal.

Trigger Level

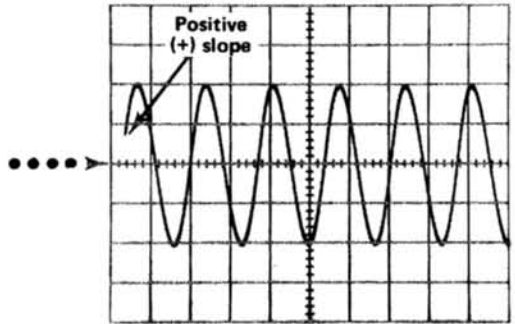
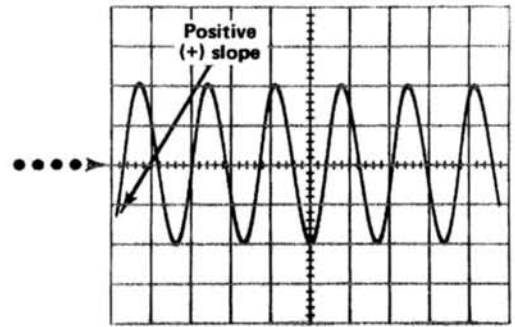
The LEVEL/SLOPE control determines the voltage level on the trigger signal at which the display is triggered, as well as selecting the trigger slope. The center knob of the LEVEL/SLOPE control provides about a 3:1 reduction in relation to the outer indicator ring, to allow precise level selection. This control can also be turned throughout the complete 360° rotation to allow continuous triggering over the selected slope. This is particularly useful in the P-P AUTO MODE. When the LEVEL/SLOPE control is set to the "O" on either the positive-going or negative-going waveform, the sweep is triggered near the zero-volt level of the trigger signal. As the LEVEL/SLOPE control is rotated away from the "O", the displayed waveform starts at a point corresponding to the position of the indicator line on the associated slope waveform (within amplitude range of trigger signal except in P-P AUTO MODE which provides triggered display throughout entire slope). For example if the LEVEL/SLOPE control is turned clockwise from the "O" on the positive-going slope, the displayed waveform starts at a more positive level. Fig. 2-7 illustrates the operation of the LEVEL/SLOPE control at different levels and slopes of a displayed waveform.

Before setting the triggering level, select the TRIGGERING SLOPE, MODE, COUPLING and SOURCE. Then adjust the LEVEL/SLOPE control so the displayed waveform starts at the desired point. The triggering slope can be changed at any time by rotating the LEVEL/SLOPE control to the corresponding point on the other slope waveform.

Horizontal Sweep Rate

The TIME/DIV switch provides 25 calibrated sweep rates ranging from 0.05 microsecond/division to five seconds/division. The VARIABLE TIME/DIV control must be in the calibrated position and the MAGNIFIER at X1 for the indicated sweep rate. The VARIABLE TIME/DIV control incorporates a two-position switch to determine if the sweep rate is calibrated or uncalibrated. When the VARIABLE knob is in the inward position, the VARIABLE TIME/DIV control is inoperative and the sweep rate is calibrated. When pressed and released, the VARIABLE knob moves outward to activate the VARIABLE TIME/DIV control for uncalibrated sweep rates. A calibrated sweep rate can be obtained at any position of the VARI-

CRT displays
obtained with
LEVEL/SLOPE
control in
positive-slope
region



CRT displays
obtained with
LEVEL/SLOPE
control in
negative-slope
region

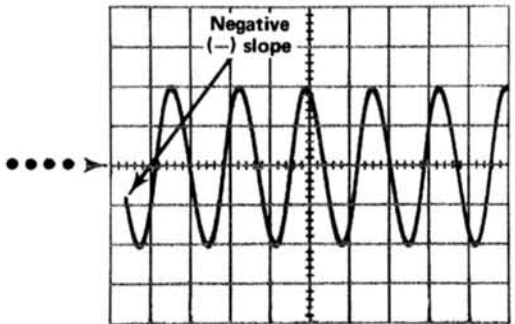
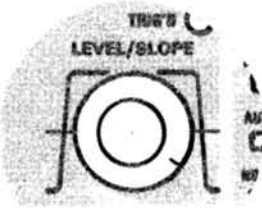
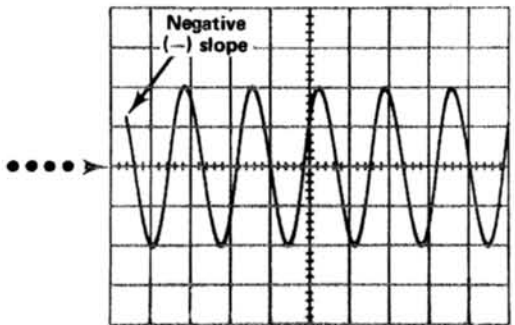
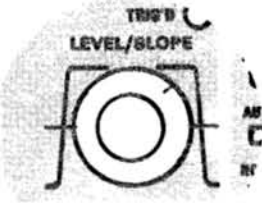


Fig. 2-7. Effect of LEVEL/SLOPE control on CRT display (AUTO P-P MODE).

ABLE TIME/DIV control by pressing in the VARIABLE knob. This feature is useful when a specific uncalibrated sweep rate has been obtained and it is desired to switch between this uncalibrated sweep rate and a calibrated sweep rate. Switching from uncalibrated to calibrated operation or vice versa does not affect the setting of the VARIABLE TIME/DIV control. The VARIABLE TIME/DIV control allows the sweep rate in each TIME/DIV switch position to be reduced to at least the sweep rate of the next adjacent switch position. This provides an overall uncalibrated variable sweep rate range from 50 nanoseconds/division (from 5 nanoseconds/division with MAGNIFIER at X10) to about 12.5 seconds/division.

When making time measurements from the graticule, the area between the second and tenth vertical lines of the graticule provides the most linear time measurement (see Fig. 2-8). Therefore, the first and last division of the display area should not be used when making accurate time measurements. Position the start of the timing area to the second vertical line (second line from the left) and adjust the TIME/DIV switch so the end of the timing area falls between the second and tenth vertical lines.

Sweep Magnifier

The sweep magnifier expands the sweep ten times. The center division of the unmagnified display is the portion visible on the screen in magnified form (see Fig. 2-9). Equivalent length of the magnified sweep is more than 100 divisions; any 10-division portion can be viewed by adjusting the horizontal POSITION control to bring the desired portion onto the viewing area. The dual-range feature of the horizontal POSITION control is particularly useful when the MAGNIFIER is set to X10 (see Horizontal Position Control discussion which follows).

To use sweep magnification, first move the portion of the display which is to be expanded to the center of the graticule. Then press the X10-MAGNIFIER pushbutton; the X10 button lights to indicate that the horizontal sweep rate is magnified. Whenever the X10-MAGNIFIER pushbutton is lighted, the equivalent magnified sweep rate can be determined by dividing the TIME/DIV switch setting by 10. For example, if the TIME/DIV switch is set to .05 μ s, the equivalent magnified sweep rate is 5 nanoseconds/division. The equivalent magnified sweep rate must be used for all time measurements when the X10-MAGNIFIER button is lighted. The equivalent magnified sweep rate is calibrated when the VARIABLE TIME/DIV control is in the calibrated position.

Horizontal Position Control

The Type 7B51 provides both fine and coarse adjustment of positioning. The coarse adjustment provides rapid horizontal positioning of the trace. Fine positioning is provided for more precise control of trace position.

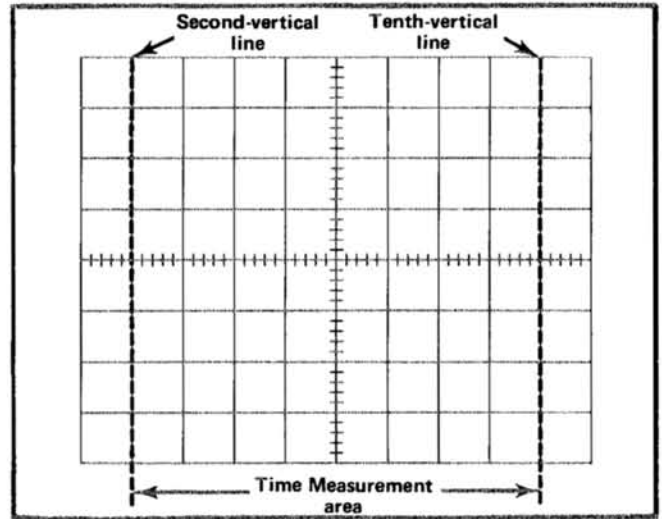


Fig. 2-8. Area of graticule used for accurate time measurements.

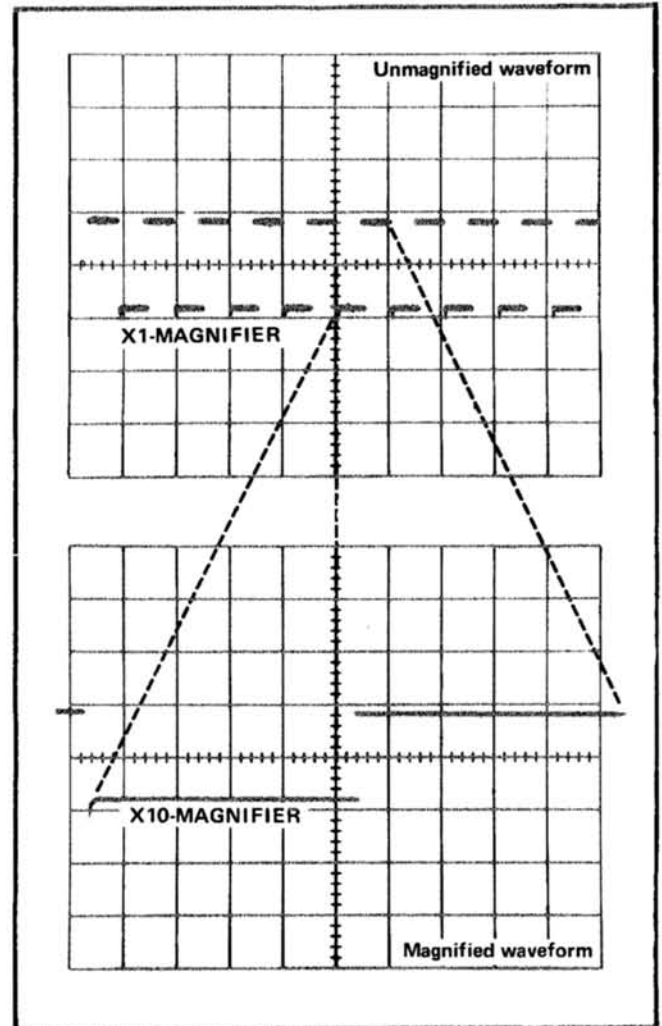


Fig. 2-9. Operation of sweep magnifier.

APPLICATIONS

General

The following information describes the procedures and techniques for making basic measurements with a 7500-series Oscilloscope. These applications are not described in detail, since each application must be adapted to the requirements of the individual measurement. This instrument can also be used for many applications not described in this manual. Contact your local Tektronix Field Office or representative for assistance in making specific measurements. Also, the following books describe oscilloscope measurement techniques which can be adapted for use with this instrument:

Harley Carter, "An Introduction to the Cathode Ray Oscilloscope", Philips Technical Library, Cleaver-Hume Press Ltd., London, 1960.

J. Czech, "Oscilloscope Measuring Techniques", Philips Technical Library, Springer-Verlag, New York, 1965.

Robert G. Middleton and L. Donald Payne, "Using the Oscilloscope in Industrial Electronics", Howard W. Sams & Co. Inc., The Bobbs-Merrill Company Inc., Indianapolis, 1961.

John F. Rider and Seymour D. Uslan, "Encyclopedia of Cathode-Ray Oscilloscopes and Their Uses", John F. Rider and Publisher Inc., New York, 1959.

John F. Rider, "Obtaining and Interpreting Test Scope Traces", John F. Rider Publisher Inc., New York, 1959.

Rufus P. Turner, "Practical Oscilloscope Handbook", Volumes 1 and 2, John F. Rider Publisher Inc., New York, 1964.

Measurement Techniques

Sweep Rates. To establish an arbitrary horizontal sweep rate based upon a specific reference frequency, proceed as follows:

1. Connect the reference signal to the INPUT connector. Set the VOLTS/DIV switch for four or five divisions of vertical deflection.

2. Set the TIME/DIV switch and the VARIABLE TIME/DIV control so one cycle of the signal covers an

exact number of horizontal divisions. Do not change the VARIABLE TIME/DIV control after obtaining the desired deflection. This display can be used as a reference for frequency comparison measurements.

3. To establish an arbitrary sweep rate so the repetition rate of an unknown signal can be measured accurately at any setting of the TIME/DIV switch, the repetition rate of the reference signal must be known. If it is not known, it can be measured before the VARIABLE TIME/DIV switch is set in step 2.

4. Divide the repetition rate of the reference signal (seconds) by the product of the horizontal deflection established in step 2 (divisions) and the setting of the TIME/DIV switch. This is the horizontal conversion factor:

	reference signal repetition rate (seconds)		
Horizontal	horizontal		TIME/DIV
Conversion =	deflection	X	switch
Factor	(divisions)		setting

5. To measure the repetition rate of an unknown signal, disconnect the reference signal and connect the unknown signal to the INPUT connector. Set the TIME/DIV switch to a setting that provides sufficient horizontal deflection to make an accurate measurement. Do not readjust the VARIABLE TIME/DIV control.

6. Measure the horizontal deflection in divisions and calculate the repetition rate of the unknown signal using the following formula:

	TIME/DIV	horizontal	horizontal
Repetition	switch	X conversion	X deflection
Rate	setting	factor	(divisions)

NOTE

If the horizontal magnifier is used, be sure to use the magnified sweep rate in place of the TIME/DIV switch setting.

Example. Assume a reference signal frequency of 455 hertz (repetition rate 2.19 milliseconds), a TIME/DIV switch setting of .2 ms, and the VARIABLE TIME/DIV control adjusted to provide a horizontal deflection of eight divisions. Substituting these values in the horizontal conversion factor formula (step 4):

Operating Instructions—Type 7B51

$$\begin{array}{rcl} \text{Horizontal} & 2.19 \text{ milliseconds} & \\ \text{Conversion} = & \frac{\quad}{.2 \times 8} & = 1.37 \\ \text{Factor} & & \end{array}$$

Then, with a TIME/DIV switch setting of $50 \mu\text{s}$, the repetition rate of an unknown signal which completes one cycle in seven horizontal divisions can be determined by using the repetition rate formula (step 6):

$$\begin{array}{rcl} \text{Repetition} & & \\ \text{Rate} = & 50 \mu\text{s} \times 1.37 \times 7 = & 480 \mu\text{s} \end{array}$$

This answer can be converted to frequency by taking the reciprocal of the repetition rate (see application on Determining Frequency Measurements).

Time-Duration Measurements

To measure time between two points on a waveform, use the following procedure:

1. Connect the signal to either Vertical plug-in.
2. Set the MODE switch to display the plug-in used.
3. Set the VOLTS/DIV switch to display about four divisions of the waveform.
4. Set the A Triggering controls to obtain a stable display.
5. Set the TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the time measurement points (see Fig. 2-8). (See the topic entitled Horizontal Sweep Rate in this section concerning non-linearity of first and last divisions of a display.)
6. Adjust the vertical POSITION control to move the points between which the time measurement is made to the center horizontal reference line.
7. Adjust the horizontal POSITION control to position the time-measurement points within the center eight divisions of the graticule.
8. Measure the horizontal distance between the time measurement points. Be sure the A VARIABLE control is set to CAL.

9. Multiply the distance measured in step 8 by the setting of the TIME/DIV switch. If sweep magnification is used, divide this answer by 10.

Example. Assume that the distance between the time measurement points is five divisions (see Fig. 2-10), and the TIME/DIV switch is set to $.1 \text{ ms}$ with the magnifier at X1. Using the formula:

$$\begin{array}{rcl} \text{Time Duration} = & \frac{\text{horizontal distance (divisions)} \times \text{TIME/DIV setting}}{\text{magnification}} \end{array}$$

Substituting the given values:

$$\text{Time Duration} = \frac{5 \times 0.1 \text{ ms}}{1}$$

The time duration is 0.5 milliseconds.

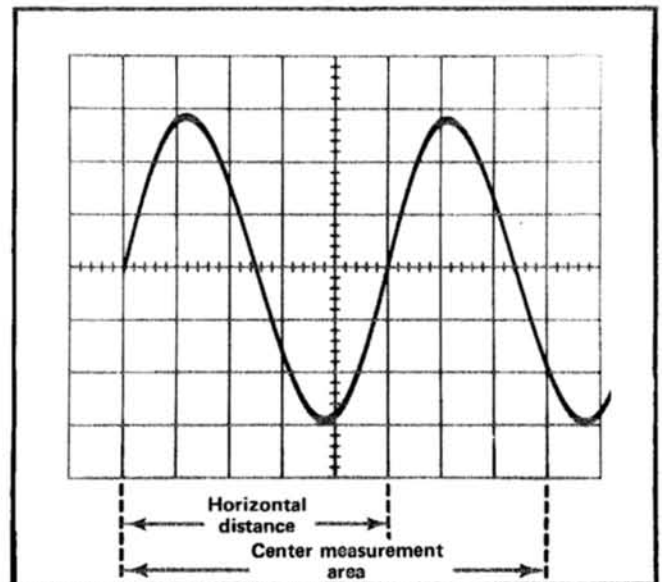


Fig. 2-10. Measuring the time duration between points on a waveform.

Determining Frequency

The time measurement technique can also be used to determine the frequency of a signal. The frequency of a periodically recurrent signal is the reciprocal of the time duration (period) of one complete cycle.

Use the following procedure:

1. Measure the time duration of one complete cycle of the waveform as described in the previous application.
2. Take the reciprocal of the time duration to determine the frequency.

Example. The frequency of the signal shown in Fig. 2-10 which has a time duration of 0.5 milliseconds is:

$$\text{Frequency} = \frac{1}{\text{time duration}} = \frac{1}{0.5 \text{ ms}} = 2 \text{ kilohertz}$$

Risetime Measurements

Risetime measurements employ basically the same techniques as time-duration measurements. The main difference is the points between which the measurement is made. The following procedure gives the basic method of measuring risetime between the 10% and 90% points of the waveform. Falltime can be measured in the same manner on the trailing edge of the waveform.

1. Connect the signal to either Vertical plug-in.
2. Set the MODE switch to display the plug-in used.
3. Set the VOLTS/DIV switch and the VARIABLE control to produce a signal an exact number of divisions in amplitude.
4. Center the display about the center horizontal line with the vertical POSITION control.
5. Set the A Triggering controls to obtain a stable display.
6. Set the TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the 10% and 90% points on the waveform.
7. Determine the 10% and 90% points on the rising portion of the waveform. The figures given in Table 2-1 are for the points 10% up from the start of the rising portion and 10% from the top of the rising portion (90% point).

TABLE 2-1

Vertical display (divisions)	10% and 90% points	Divisions vertically between 10% and 90% points
4	0.4 and 3.6 divisions	3.2
5	0.5 and 4.5 divisions	4.0
6	0.6 and 5.4 divisions	4.8

8. Adjust the horizontal POSITION control to move the 10% point of the waveform to the first vertical line of the graticule. For example, with a five-division display as shown in Fig. 2-11, the 10% point is 0.5 division up from the start of the rising portion.

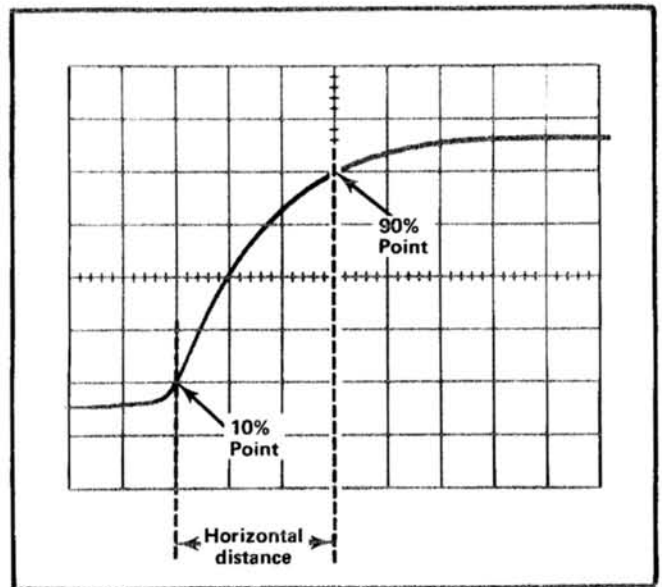


Fig. 2-11. Measuring risetime.

9. Measure the horizontal distance between the 10% and 90% points. Be sure the A VARIABLE control is set to CAL.
10. Multiply the distance measured in step 9 by the setting of the TIME/DIV switch. If sweep magnification is used, divide this answer by 10.

Example. Assume that the horizontal distance between the 10% and 90% points is four divisions (see Fig. 2-11) and the TIME/DIV switch is set to 1 μ s with the MAG switch set to X10. Applying the time duration formula to risetime:

$$\text{Time Duration (Risetime)} = \frac{\text{horizontal distance (divisions)} \times \text{TIME/DIV setting}}{\text{magnification}}$$

Substituting the given values:

$$\text{Risetime} = \frac{4 \times 1 \mu\text{s}}{10}$$

The risetime is 0.4 microsecond.

Delayed Sweep Time Measurements

The delayed sweep mode can be used to make accurate time measurements. The following measurement determines the time difference between two pulses displayed on the same trace. This application may also be used to measure time difference from two different sources (dual-trace) or to measure time duration of a single pulse. See Section one for measurement accuracy.

1. Connect the signal to either vertical plug-in. Set the Indicator Oscilloscope vertical MODE selector to display the plug-in being used. Set the horizontal MODE selector to CHOP or ALT (see Oscilloscope Manual discussion on horizontal mode switching) to display both Time-Base sweeps.

2. Set the VOLTS/DIV selector to produce a display about three divisions in amplitude (see Fig. 2-12).

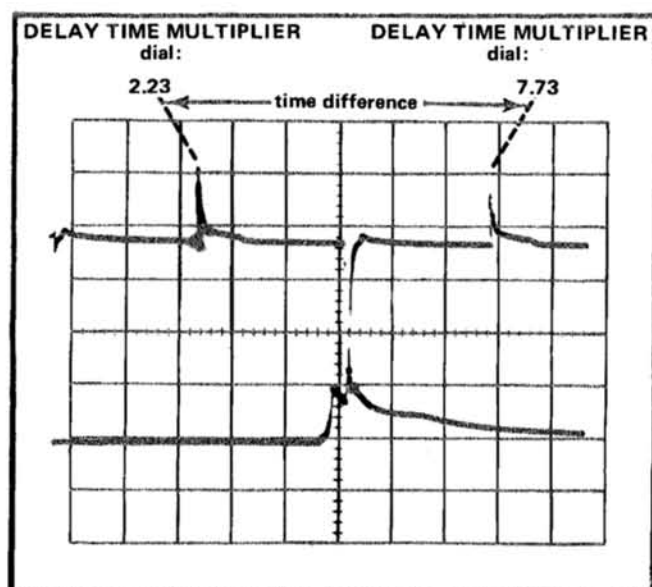


Fig. 2-12. Measuring time difference using delayed sweep.

3. Set the A TIME/DIV to a sweep rate which displays about six divisions between pulses. Adjust the A Triggering controls for a stable display.

4. Set the A Time-Base B DELAY MODE selector to B STARTS AFTER DELAY.

5. Set the B Time/div to a setting 1/100 of the A TIME/DIV sweep rate. This produces an intensified portion about 0.1 division in length.

NOTE

Do not change the A LEVEL control setting or the horizontal POSITION control setting in the following steps, as the measurement accuracy will be affected.

6. Turn the DELAY-TIME MULTIPLIER dial to move the intensified portion of the A sweep to the first pulse.

7. Adjust the DELAY-TIME MULTIPLIER dial to move the pulse (or rising portion) of the B sweep to the center vertical line. Note the setting of the DELAY-TIME MULTIPLIER dial.

8. Turn the DELAY-TIME MULTIPLIER dial clockwise until the second pulse is positioned to this same point (if several pulses are displayed, observe the intensified portion of the A sweep to locate the correct pulse). Again note the dial setting.

9. Subtract the first dial setting from the second and multiply by the delay time shown by the A TIME/DIV selector. This is the time interval between the pulses.

Example: Assume the first dial setting is 2.23 and the second dial setting is 7.73 with the TIME/DIV set to 5 μs (see Fig. 2-13).

Using the formula:

Time Difference =
(delayed sweep)

$$\text{second dial setting} - \text{first dial setting} \times \text{delay time (A TIME/DIV setting)}$$

Substituting the given values:

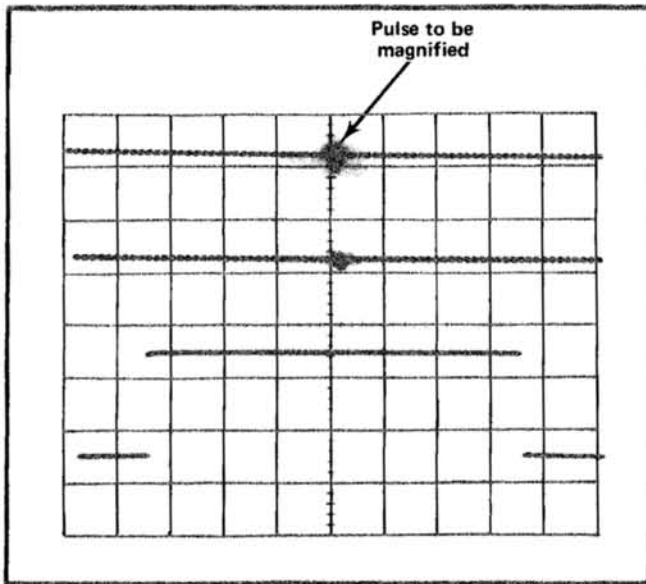


Fig. 2-13. Using delayed sweep for sweep magnification.

$$\text{Time Difference} = (7.73 - 2.23) \times 5 \mu\text{s}.$$

The time difference is 27.5 microseconds.

Delayed Sweep Magnification

The delayed sweep feature of the Type 7B51 can be used to provide higher apparent magnification than is provided by the MAG switch. The sweep rate of the DELAYED SWEEP (B sweep) is not actually increased; the apparent magnification is the result of delaying the B sweep an amount of time selected by the A TIME/DIV switch and the DELAY-TIME MULTIPLIER dial before the display is presented at the sweep rate selected by the B TIME/DIV switch. The following method uses the B STARTS AFTER DELAY position to allow the delayed portion to be positioned with the DELAY-TIME MULTIPLIER dial. If there is too much jitter in the delayed display, use the Triggered Delayed Sweep Magnification procedure.

1. Connect the signal to either vertical plug-in. Set the Indicator Oscilloscope vertical MODE selector to display the plug-in used and the horizontal MODE to CHOP or ALT to display both Time-Base sweeps.

2. Set the VOLTS/DIV selector to produce a display about three divisions in amplitude.

3. Set the A Time-Base B DELAY MODE selector to B STARTS AFTER DELAY. Adjust the A Triggering controls for a stable display.

4. Set the A TIME/DIV to a sweep rate which displays the complete waveform.

5. Position the start of the intensified portion with the DELAY-TIME MULTIPLIER dial to the part of the display to be magnified.

6. Set the B TIME/DIV to a setting which intensifies the full portion to be magnified. The start of the intensified trace remains as positioned above.

7. Time measurements can be made from the display in the conventional manner. Sweep rate is determined by the setting of the B TIME/DIV selector.

Example: The apparent magnification of the display shown in Fig. 2-13 with an A TIME/DIV setting of .1 ms and a B TIME/DIV setting of 1 μs is:

$$\text{Apparent Magnification (Delayed Sweep)} = \frac{\text{A TIME/DIV setting}}{\text{B TIME/DIV setting}}$$

Substituting the given values:

$$\text{Apparent Magnification} = \frac{1 \times 10^{-4}}{1 \times 10^{-6}} = 100$$

The apparent magnification is 100 times.

Triggered Delayed Sweep Magnification. The delayed sweep magnification method just described may produce too much jitter at high apparent magnification ranges. The B TRIGGERABLE AFTER DELAY position of the B DELAY MODE selector provides a more stable display, since the delayed display is triggered at the same point each time.

1. Set up the display as given in steps 1 through 6 above.

2. Set the B DELAY MODE selector to B TRIGGERABLE AFTER DELAY.

3. Adjust the B LEVEL control so the intensified portion on the trace is stable.

4. Inability to intensify the desired portion indicates that the B Triggering controls are incorrectly set or the

signal does not meet the triggering requirements. If the condition cannot be remedied with the B Triggering controls or by increasing the display amplitude (lower VOLTS/DIV setting), trigger the B sweep externally.

5. Measurement and magnification are as described above.

Displaying Complex Signals Using Delayed Sweep

Complex signals often consist of a number of individual events of differing amplitudes. Since the trigger circuits are sensitive to changes in signal amplitude, a stable display can normally be obtained only when the sweep is triggered by the event(s) having the greatest amplitude. However, this may not produce the desired display of a lower-amplitude portion which follows the triggering event. The delayed sweep feature provides a means of delaying the start of the B sweep by a selected amount following the event which triggers the A Sweep Generator. Then, the part of the waveform which contains the information of interest can be displayed.

Use the following procedure:

1. Set up the display as given in Delayed Sweep Magnification Steps 1 through 6.

2. Time measurements can be made from the display in the conventional manner. Sweep rate is determined by the setting of the B TIME/DIV selector.

Example. Fig. 2-14 shows a complex waveform as displayed on the CRT. The circled portion of the waveform cannot be viewed in any greater detail because the sweep is triggered by the larger amplitude pulses at the start of the display and a faster sweep rate moves this area of the waveform off the viewing area. The second waveform shows the area of interest magnified 10 times using Delayed Sweep. The DELAY-TIME MULTIPLIER dial has been adjusted so the delayed sweep starts just before the area of interest.

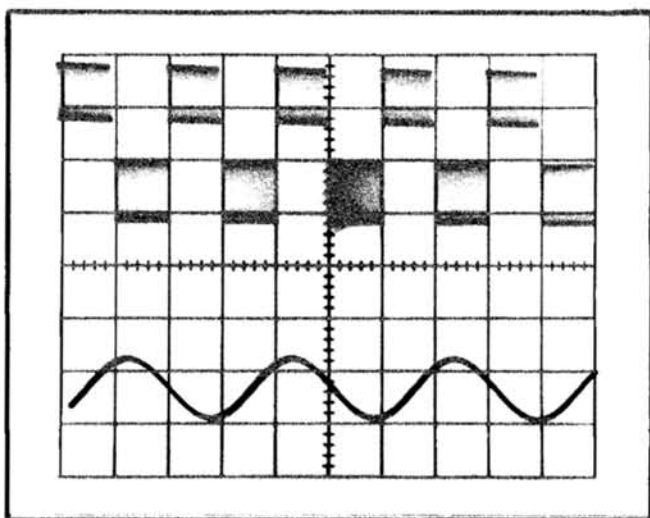


Fig. 2-14. Displaying a complex signal using delayed sweep.

Pulse Jitter Measurements

In some applications it is necessary to measure the amount of jitter on the leading edge of a pulse or jitter between pulses.

1. Set up the display as in the above procedure.

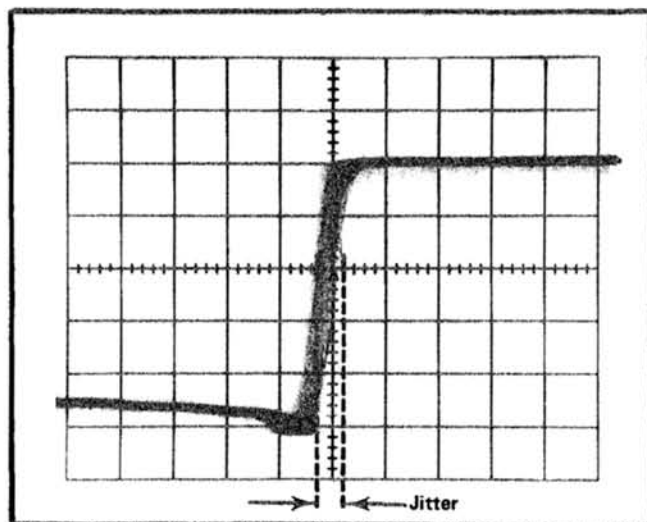


Fig. 2-15. Measuring pulse jitter.

2. Set the B DELAY MODE selector to B STARTS AFTER DELAY. Slight readjustment of the B Triggering LEVEL control may be necessary to produce as stable a display as possible.

3. Pulse jitter is shown by horizontal movement on the pulse (take into account inherent jitter of Delayed Sweep). Measure the amount of horizontal movement. Be sure both VARIABLE controls are set to CAL.

4. Multiply the distance measured in step 3 by the B TIME/DIV switch setting to obtain pulse jitter in time.

Example. Assume that the horizontal movement is 0.5 divisions (see Fig. 2-15), and the B TIME/DIV switch setting is .5 μ s.

Using the formula:

$$\text{Pulse Jitter} = \begin{matrix} \text{horizontal} \\ \text{jitter} \\ \text{(divisions)} \end{matrix} \times \begin{matrix} \text{B TIME/DIV} \\ \text{setting} \end{matrix}$$

Substituting the given values:

$$\text{Pulse Jitter} = 0.5 \times 0.5 \mu\text{s}$$

The pulse jitter is 0.25 microseconds.

SECTION 3

CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains a description of the circuitry used in the Type 7B51. 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 back of this manual. This diagram shows the overall relationship between all of the circuits. 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 7B51 before the individual circuits are discussed in detail. A basic block diagram of the Type 7B51 is shown in Fig. 3-1. Each block represents a major circuit within this instrument.

The Trigger Preamp circuit provides amplification for the internal trigger signal. The internal trigger signal is received from the Vertical Deflection System. The output from this circuit is connected to the Trigger Generator circuit.

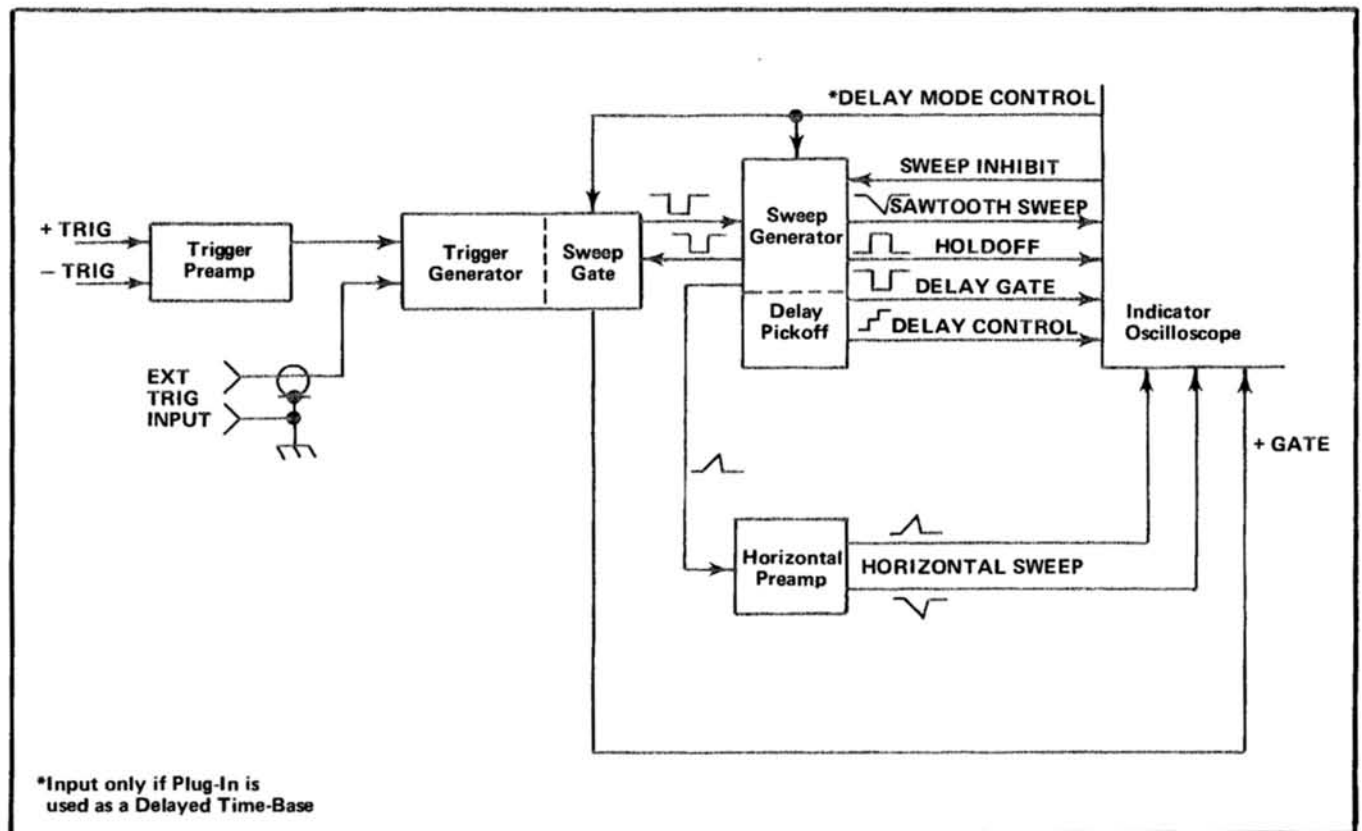


Fig. 3-1. Basic Block Diagram of the Type 7B51.

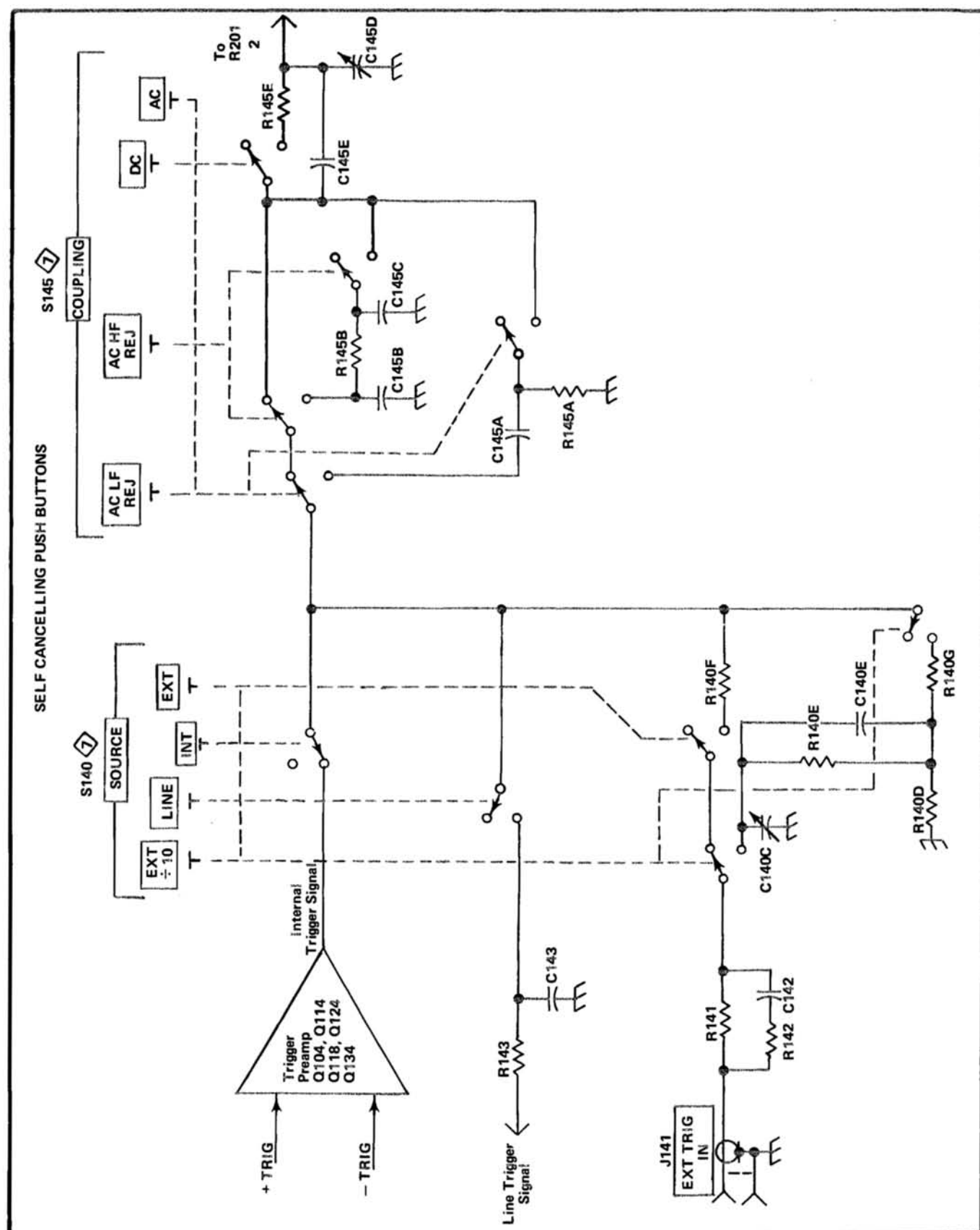


Fig. 3-2. Trigger Preamp and Input Switching Block Diagram.

The Trigger Generator circuits produce an output pulse which initiates the sweep signal produced by the Sweep Generator circuits. It also produces a + Gate for use by the Indicator Oscilloscope. The input signal to the Trigger Generator can be individually selected from among the following: the internal trigger signal from the Trigger Preamp, an external signal applied to the EXT TRIG INPUT connector, or a sample of the line voltage applied to the instrument. Each trigger circuit contains coupling and source controls.

The Sweep Generator circuit produces a linear sawtooth output signal when initiated by the Trigger Generator circuit. The slope of the sawtooth produced by the Sweep Generator is controlled by the TIME/DIV switch. The operating mode of the Sweep Generator is controlled by the TRIGGERING MODE switch. In the P-P AUTO and AUTO positions, the absence of an adequate trigger signal causes the sweep to free run. In the NORM position, a horizontal sweep is presented only when correctly triggered by an adequate trigger signal. The SINGLE SWEEP position allows only one sweep to be initiated after the circuit is reset with the RESET button.

The Horizontal Preamp is a single-ended to push-pull amplifier. It uses feedback (operational) amplifiers to achieve a great degree of stability. A X10 gain feature is incorporated into this amplifier. The sawtooth signal is received from the Sweep Generator circuit and changed to a push-pull output for use by the Indicator Oscilloscope to produce the horizontal display.

DETAILED CIRCUIT DESCRIPTION

Trigger Preamp and Input Switching

Trigger Preamp. The pushpull trigger signal from the Vertical Deflection System is converted to a single-ended output by the emitter-coupled stage, Q104-Q114. The output of Q114 drives current gain stage Q124-Q134. The DC level of the output is set by Internal Trigger Centering control, R135.

Input Switching. The TRIGGERING SOURCE switch, S140, selects the source of the trigger signal. Three trigger sources are available; internal, line and external. The external signal may also be passed through a $\div 10$ attenuator network.

The TRIGGERING COUPLING switch, S145, offers a means of attenuating high or low frequency components of the trigger signal. In addition to AC and DC coupling, C145A-R145A can be selected to provide low-frequency attenuation and R145B-C145B-C145C for high-frequency attenuation.

Trigger Generator

General. The Trigger Generator circuit produces trigger pulses to start the Sweep Generator circuit. These pulses are derived from either the internal trigger signal from the Vertical Deflection System, an external source, or from a sample of the line voltage applied to the instrument. Controls are provided in this circuit to select trigger LEVEL and SLOPE, and TRIGGERING MODE. Fig. 3-3 shows a detailed block diagram of the Trigger Generator circuit. Refer to the diagrams in Section 8 for complete circuit components.

Input Stage. The input source-follower, Q213A, provides a high input impedance for the trigger signal. It also provides isolation between the Trigger Generator and the input source. Input protection diodes, CR203 and CR206 protect Q213A from excessive input signals by clamping the gate of the input FET if the input exceeds about + or -6 volts. The signal at the source of Q213A is passed through emitter-follower Q214A to the base of Q224 in the Slope Comparator, and to the P-P Auto Trigger Level circuit.

P-P Auto Trigger Level Stage. The triggering level, with the MODE switch set to P-P AUTO, is controlled by the P-P Auto Trigger Level stage. The trigger input signal is applied through emitter-follower Q333, to reduce loading of the signal input stage. The signal is applied simultaneously to the bases of Q353 and Q373.

Assume a + input signal. This signal, coupled through emitter followers Q353-Q356, causes the emitter voltage to rise and charges C358 to the peak positive level of the input signal. C378 is charged in a similar manner to the peak negative level of the input signal. The peak-sensing capacitors, C358-C378, set the voltage levels applied to the LEVEL control (R260A). This allows the LEVEL control to be adjusted between the two voltage levels representing the most negative and most positive peaks of the trigger signal. The unit can be triggered at all positions of the LEVEL control if the minimum frequency and amplitude specifications are met. Q366-CR366 and Q386-CR386 provide temperature compensation for Q364 and Q384 respectively.

Slope Comparator. Q224 and Q234 are connected as a difference amplifier to provide selection of the slope and level at which the sweep is triggered. The reference voltage for the comparator (with the MODE selector at NORM) is provided by the LEVEL control, R260A, and the Level Center control, R385. R385 sets the level at the base of Q234 so that the display is triggered at the 0 volt DC level of the incoming trigger when the LEVEL control is centered. The LEVEL control varies the voltage at the base of Q234 to select the point on the trigger signal where triggering occurs.

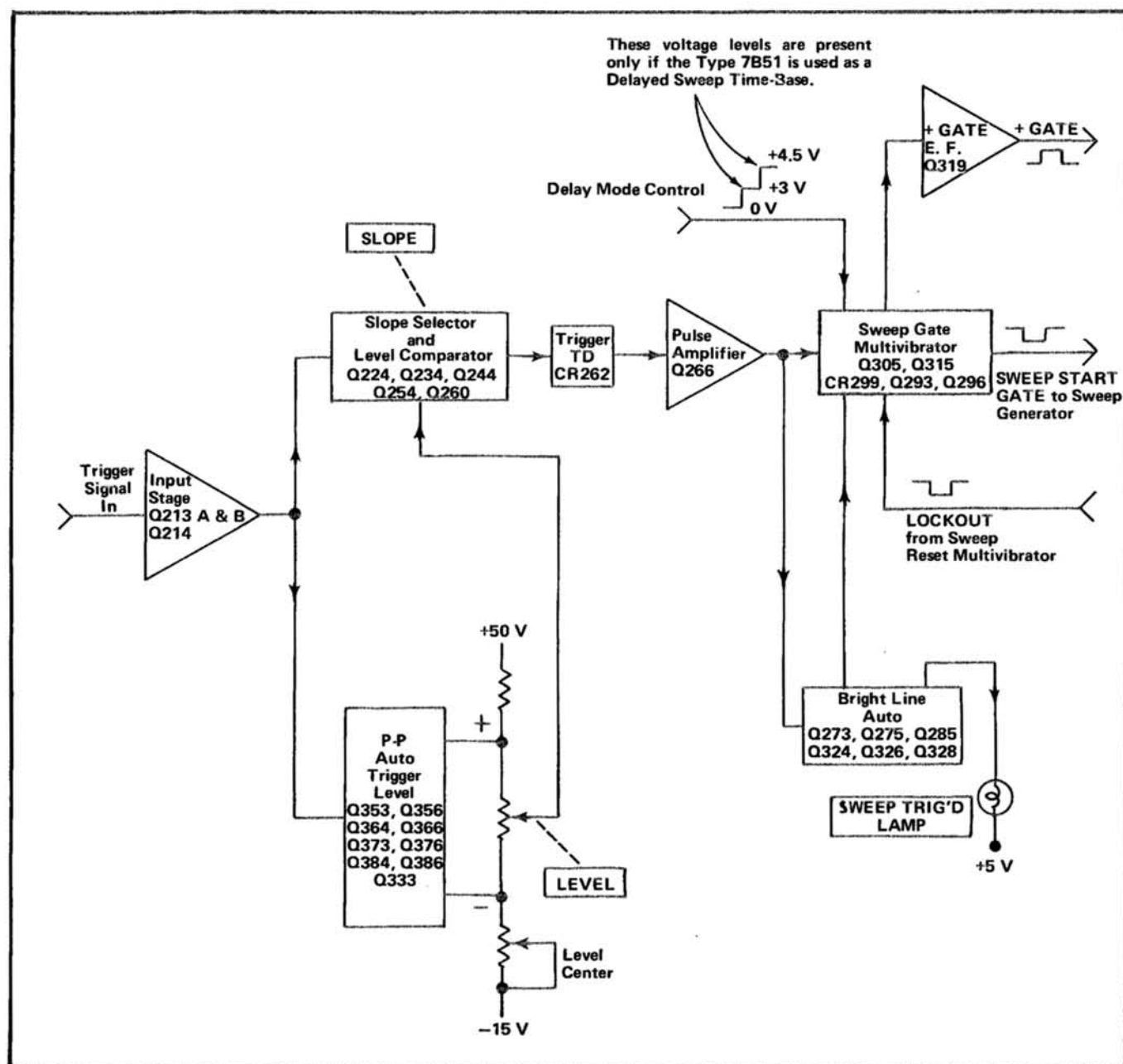


Fig. 3-3. Trigger Generator Block Diagram.

R221 establishes the emitter current for Q224 and Q234. The transistor with the most positive base controls conduction of the comparator. For example, assume that the trigger signal from the input stage is positive-going and Q224 is forward-biased. The increased current flow through R221 makes the emitter of Q234 more positive and since the base is held constant by the level control voltage, the current through Q234 decreases. The increase in current through Q224 makes the base of Q244 less positive and the decrease in current through Q234 makes the base of Q254 more positive. Refer to Fig. 3-4 for current paths for positive slope triggering. Notice that the signal currents at the collectors of Q224 and Q234 are opposite in phase. The sweep can be triggered from either the positive or negative

edge of the input signal. The selection is made by the SLOPE switch, S260.

When the LEVEL control is set to midrange (MODE switch to NORM) the base of Q234 is at about 0 volts. This corresponds to the 0 volt level at the input of Q213A, and the comparator switches at the zero volt level of the trigger signal. As the LEVEL control is turned clockwise from 0/+, the voltage on the base of Q234 becomes more positive. Now the trigger signal must rise to a more positive level before comparison takes place. The resultant CRT display starts at a more positive point on the displayed signal. When the LEVEL control is turned counterclockwise from 0/+

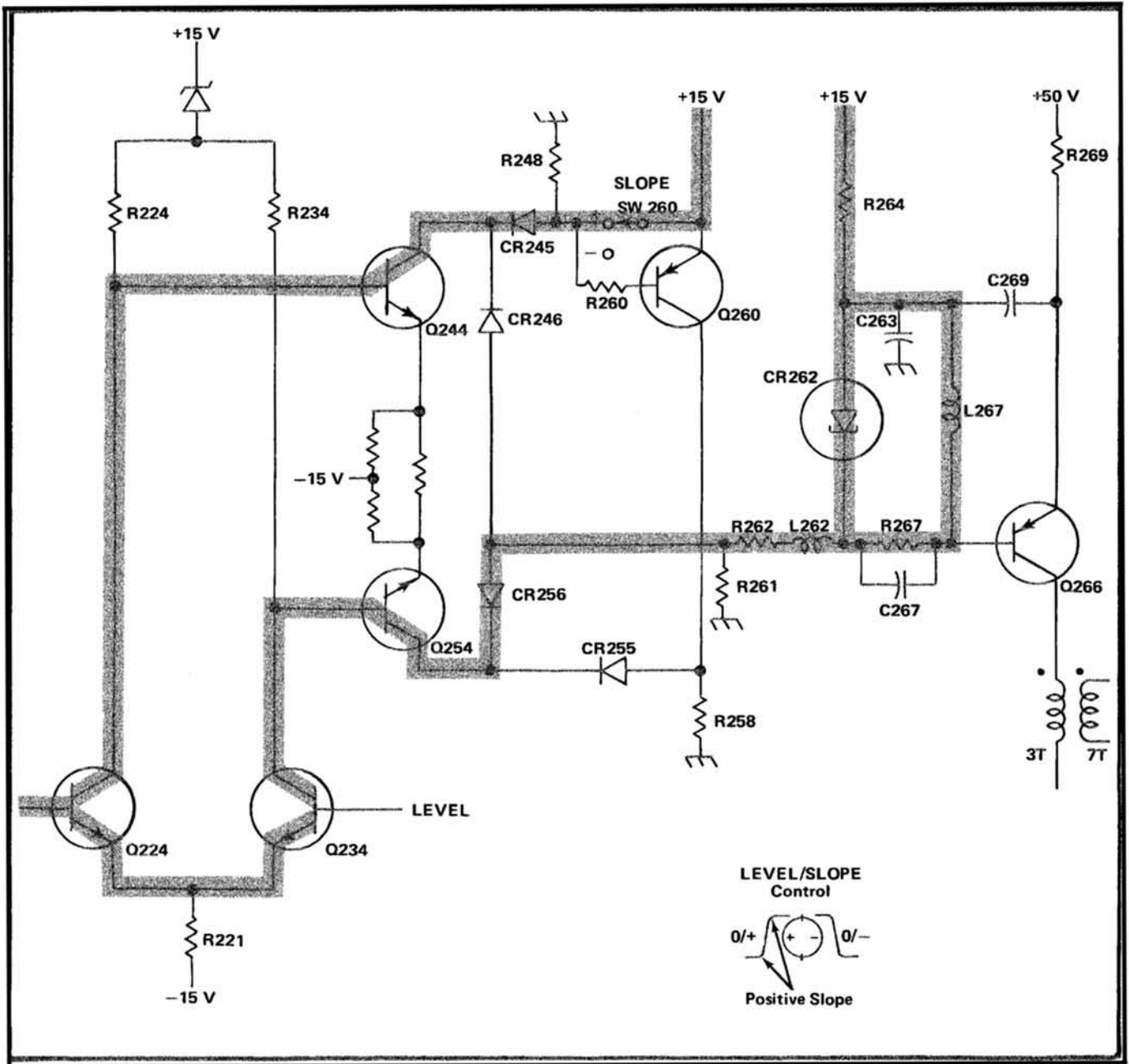


Fig. 3-4. Trigger Path for Positive Slope Triggering (simplified).

the result is the opposite of the above and produces a CRT display which starts at a more negative point along the + slope of the trigger signal.

The slope of the input signal which triggers the sweep is determined by the SLOPE switch, S260. When the SLOPE switch is set to the + position the collector of Q244 is connected to the +15 volt supply through CR245. This reverse-biases CR246 and holds Q260 cut off. With Q260 cut off, CR255 is reverse-biased. Now the collector current of Q254 must flow through CR256 and the parallel combination of

CR262 and R267-C267-L267 to the +15 volt supply. Since the output pulse from the Trigger Generator circuit is derived from the negative-going portion of the signal applied to the Trigger TD Stage, the sweep is triggered on the positive-going edge of the input signal.

With the SLOPE switch set to -, conditions are reversed (see Fig. 3-5). The collector of Q254 is connected to the +15 volt supply through CR255 and Q260. CR245 and CR256 are reverse-biased and the collector current from Q244 is diverted through the Trigger TD Stage. The signal applied to the Trigger TD Stage is now in phase with the

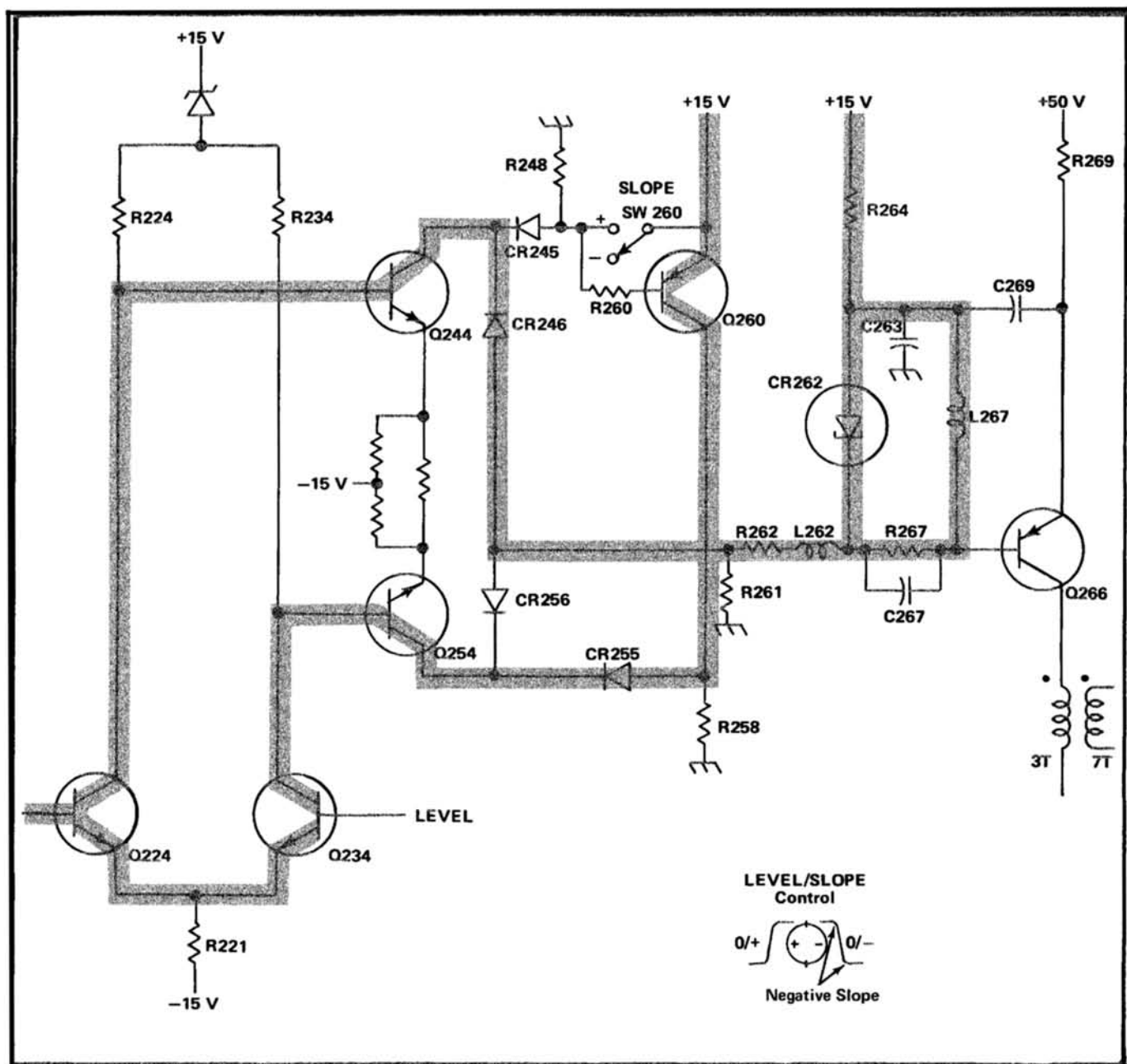


Fig. 3-5. Trigger Path for Negative Slope Triggering (simplified).

input trigger signal and the display is triggered on the negative-going edge of the input trigger signal.

Trigger TD Stage. The Trigger TD Stage shapes the output of the slope comparator to provide a trigger pulse with a fast leading edge. Tunnel diode CR262 is quiescently biased so that it is in its low-voltage state. The current from one of the transistors in the slope comparator stage is routed through the trigger TD stage by the SLOPE switch. The series-parallel combination of L267-R267-C267 with Q266 provide a resistive load for CR262 and form a

Schmitt circuit. As this current increases due to an appropriate change in the trigger input signal, tunnel diode CR262 switches to its high-voltage state. CR262 reverts to its low-voltage state when the current from the slope comparator decreases sufficiently.

Pulse Amplifier. The trigger pulse from the trigger TD stage is connected to the base of the pulse amplifier, Q266. The trigger pulse at this point is basically a negative-going pulse with a fast rise. The width of the pulse is determined by the waveshape of the input trigger signal and the setting

of the LEVEL control. The negative-going pulse at the base of Q266 drives it into heavy conduction, and the resultant current increase flows through LR275-Q273-T271-Q266-R269-C269-R264.

Due to the short time constant of the coupling to Q266, the current through Q266 quickly returns to a level determined by R269. The resultant signal at the collector of Q266 is a short-duration positive-going fast-rise pulse. The positive-going pulse at the collector of Q266 is passed through non-inverting isolation transformer T271 to the sweep gate stage.

Sweep Gate Stage. The sweep gate stage produces a negative-going step to start the sweep generator and a positive gate used by the indicator oscilloscope.

The positive-going pulse from the pulse amplifier is applied to the sweep gate stage through CR291. Tunnel diode CR299 is quiescently in its low-voltage state. When a positive pulse turns on CR291, the increased current through the tunnel diode rapidly switches it to its high-voltage state. At the end of the trigger pulse, CR291 is turned off. However, the current through R301-R303 will maintain the tunnel diode in its high-voltage state until reset by the sweep reset multivibrator at the end of the sweep.

The positive-going level at the anode of CR299 is applied to the base of Q305. Q305 turns on and the increased current causes a negative-going step on the collector. This negative-going step is used to enable the sweep generator. When Q305 turns on, emitter-coupled Q315 turns off and the positive-going step on its collector is passed through emitter-follower Q319 as the + Gate out.

At the end of the sweep, the negative-going lockout gate from the sweep reset multivibrator is applied to the base of Q296. As Q296 turns off Q293 turns on and steals current from CR299, reverting CR299 to its low-voltage state. This switches the sweep gate multivibrator back to its quiescent state (Q305 off, Q315 on). The circuit remains in this condition (CR299 in its low-voltage stage) until the lockout gate returns to its high-level. When the lockout gate goes high, Q296 turns on and Q293 is turned off. Now, CR299 is unlatched and ready for the next trigger pulse.

Bright Line Auto. The operation of the sweep gate stage in the P-P AUTO or AUTO MODE of operation is the same as for the NORM MODE just described when a trigger pulse is applied. However, when a trigger pulse is not present, a free-running trace is produced in the P-P AUTO and AUTO MODES.

With no trigger pulse applied to the circuit, Q273 is at a low current level. The anode of CR275 is at ground potential. This clamps the base of Q275 at about -0.7 volt and it is not conducting. C282 is charged to a positive level determined by R277, R322 and R323. The base voltage of Q324 is higher than that of Q326, so Q326 is conducting. This additional current from Q326 through CR299 switches CR299 to its high-voltage state, automatically retriggering the sweep each time the lockout gate goes to its high-voltage state. The result is that the sweep generator circuit is automatically retriggered at the end of each holdoff period and a free-running trace is produced. Since the trace free-runs at the sweep rate of the sweep generator circuit (as selected by the TIME/DIV switch), a bright reference trace is produced at all sweep rates. The sweep TRIGGERED lamp will not be lit, indicating an untriggered condition.

The sweep TRIGGERED lamp is lit each time a trigger pulse is received from the pulse amplifier, Q266. The trigger pulse turns on Q275, which discharges C282. CR277 is turned off and the base of Q324 becomes less positive. Q324 is turned on, pulling the base of Q328 positive to turn-on. Q328 collector current lights the sweep TRIGGERED lamp. Q326 is emitter-coupled to Q324, and is turned off by the conduction of Q324. This disconnects the bright line auto circuit from the sweep gate circuit when an adequate signal is present to prevent the sweep from free-running.

When the TRIGGERING MODE switch is in the NORM or SINGLE SWEEP position, the anode of CR321 is clamped to ground. This reverse-biases CR321 and disconnects the bright line auto circuit from the sweep gate circuit.

SWEEP GENERATOR

General

The Sweep Generator circuit (see Fig. 3-6) produces a sawtooth voltage which is changed from single-ended to push-pull by the Horizontal Preamp and used by the Indicator Oscilloscope to provide horizontal sweep deflection on the CRT. In addition, this circuit produces various control signals for use by the Indicator Oscilloscope as well as internal signals for use in the plug-in.

Normal Trigger Mode Operation

Disconnect Amplifier. The Disconnect Amplifier, Q526, is quiescently conducting current through R523 and the Timing Resistor, R530. The negative-going step from the Sweep Gate Multivibrator is applied to the base of the input emitter-follower, Q402. Q402 couples the negative step to the emitter of Disconnect Amplifier Q526, turning it off. The timing current through Timing Resistor R530, now starts to charge Timing Capacitor C530, enabling the Sweep Generator.

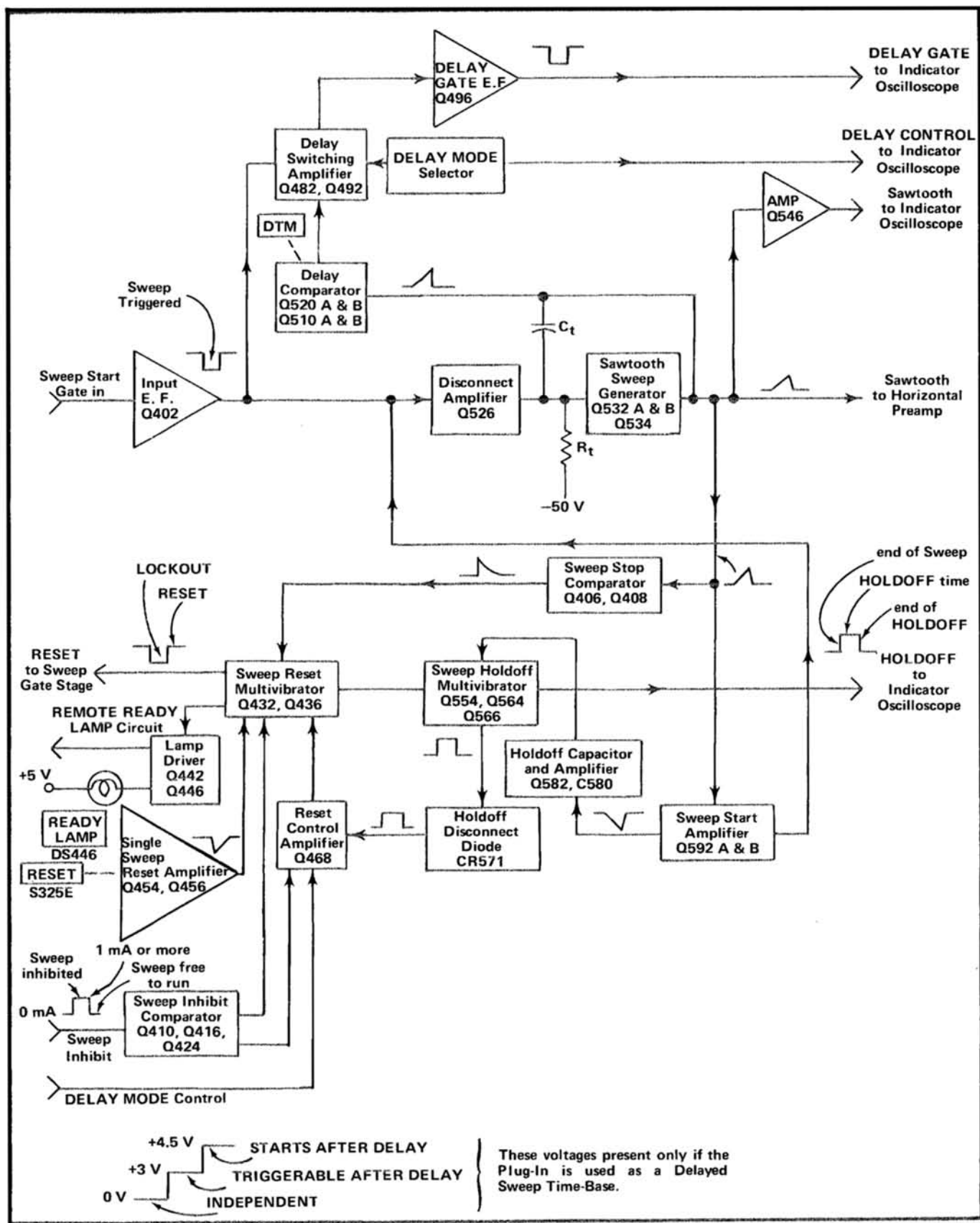


Fig. 3-6. Sweep Generator Block Diagram.

The Disconnect Amplifier is a low leakage transistor to improve timing at low sweep speeds and high temperatures. At the end of the sweep, Q526 turns on, discharging the Timing Capacitor. CR526 provides isolation between the Disconnect Amplifier and the input emitter-follower during holdoff time.

Sawtooth Sweep Generator. The basic sweep generator circuit is a Miller Integrator Circuit.¹ The current flow through the Disconnect Amplifier is interrupted by the signal from the Sweep Gate Stage.

Timing Capacitor C530 now begins to charge through Timing Resistor R530. The Timing Resistor and Timing Capacitor are selected by the TIME/DIV switch (a front panel control) to provide sweep rates as listed on the front panel.

As the Timing Capacitor begins to charge toward the voltage applied to the Timing Resistor, the gate of Q532A (which is tied to the junction of R530-C530), goes negative by the same amount. This decreases the current through Q532A, forcing more current through Q532B. This increase in Q532B drain current flowing through R534 gives a negative-going voltage at the base of Q534. This causes its collector voltage to pull up. The positive side of the Timing Capacitor, being tied to the collector of Q534, is also pulled up. This action results in a positive-going voltage being applied across the Timing Capacitor, maintaining a constant charging current and giving a linear rate of rise to the sawtooth output signal. The sawtooth output signal continues to rise in this manner until the Sweep Gate Multivibrator is switched to turn on the Disconnect Amplifier.

The sawtooth output from the collector of Q534 is connected to the Horizontal Preamp, the Delay Pickoff circuit, and through R539 to the Sweep Start Amplifier, Sweep Stop Comparator, and through amplifier Q546 to the Indicator Oscilloscope. CR534 protects against reverse emitter-base breakdown of Q534. CR529 protects against gate-source breakdown of Q532A.

Sweep Start Amplifier. Delay start adjustment R590 adjusts the base voltage of Q592A to set the quiescent voltage of the sawtooth. The collector current of Q592A, flowing through R523, establishes the correct starting point of the sawtooth output signal. L593-R593 prevent oscillations at the faster sweep rates. They are shorted out at the slower sweep rates. CR596 A and B prevent base-emitter breakdown of Q592 A and B.

The sawtooth output signal is applied through R539 to the base of Q592B. This positive-going signal causes Q592B to turn on harder, pulling down its collector voltage.

CR597 and CR598 switch the current in R596 to Q592B to make a more definite step. The negative-going voltage at the collector of Q592B is applied through current-limiting diode CR581 to the base of Q582 to charge the holdoff capacitor.

Sweep Stop Comparator. The Sweep Stop Comparator is used to terminate the sawtooth sweep when the sweep has reached a predetermined length. Quiescently Q406 is biased off by voltage divider, R404-R405. These resistors set the reference level for sweep termination at approximately +10.5 volts. When the sawtooth sweep rises to about +10.5 volts, Q408 is turned off. Q406 is turned on and the positive-going rise at the base of Q436 switches the reset multivibrator. The voltage at the collector of Q436 goes negative and this negative gate applied to the sweep gate circuit ends the sweep.

Holdoff Capacitor and Amplifier. Q582, which is turned on during sweep time, charges the holdoff capacitor. When the sweep ends, Q582 turns off. Now the holdoff capacitor starts to discharge toward -50 volts through R582, and at some sweep speeds, through R580. When the top of C580 discharges enough in the negative direction to forward-bias CR574 and CR579, the holdoff capacitor voltage is applied to the base of Q554. This drives Q554 to cutoff, switching the holdoff multivibrator to end holdoff time. Voltage limiting diodes CR580 and CR582 protect the base-emitter junction of Q582. CR581 limits the "on" base current of Q582. Capacitor C582 and the current through R581 determine the rate of charge of the holdoff capacitor, C580. VR576 and CR578 limit the negative voltage on the holdoff capacitor, C580.

The HF STAB control R260B through R583 varies the discharge rate of the holdoff capacitor 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. The HF STAB circuit has little effect at slow sweep rates.

Sweep Holdoff Multivibrator. Q554-Q564 are connected in a bistable Schmitt Trigger configuration. Quiescently, Q554 is off and Q564 is on. A positive pulse from the sweep reset multivibrator switches the holdoff multivibrator to its second stable state, Q554 on and Q564 off.

The sweep holdoff multivibrator is returned to its first stable state when the holdoff capacitor has charged negative enough to drive Q554 to cutoff. The fast switching action of the sweep holdoff multivibrator produces sharp leading and trailing edges for the sweep holdoff gate. The output of the multivibrator, coupled through emitter-follower Q566, goes to the indicator oscilloscope and to the holdoff disconnect diode.

¹MILLMAN & TAUB, pp 540-548

Circuit Description—Type 7B51

During sweep time the voltage on the holdoff capacitor reverse-biases CR579 and the current in R573 switches to CR572, turning off Q468. VR573 determines the time when the current switch takes place. During holdoff time, holdoff disconnect diode CR571 controls the current available to the reset control amplifier, Q468. The positive-going edge of the holdoff gate turns CR571 on. This moves the emitter of Q468 positive, turning it off. At the end of holdoff time the negative-going edge of the holdoff gate opens CR571, making the current through R468 available to the reset control amplifier.

Reset Control Amplifier. Q468 provides current to the base of Q436 to switch the sweep reset multivibrator to its reset state. The current through R468 into the emitter of Q468 is controlled by CR571 and CR572 as stated above, or by CR468 as explained under single-sweep operation.

Sweep Reset Multivibrator. The sweep reset multivibrator, Q432-Q436, resets the sweep gate TD at the end of holdoff time. In the reset state, Q432 is off and Q436 is conducting. The junction of R437-R438 is pulled up to its high level. The sweep is terminated by current from Q406 moving the base of Q436 positive to cutoff. This switches the multivibrator to its other stable state; Q432 on and Q436 off. The voltage at the junction of Q437-R438 drops negative to its low-level. This negative step is applied to the sweep gate stage to latch the sweep gate TD in its low-voltage state. At the end of holdoff time Q468 is turned on, driving the base of Q436 less positive. This turns Q436 on and the multivibrator switches back to its reset state. The voltage at the junction of R437-R438 is pulled up to its high level. This positive-going step is applied to the Sweep Gate Stage to unlatch the Sweep Gate TD, and the sweep circuits are ready for the next sweep to start.

Single Sweep Operation

General. Operation of the Sweep Generator Circuit in the SINGLE SWEEP position of the TRIGGERING 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 MODE switch, the -15 volts is removed from the top of R464. CR466 is opened and CR468 becomes forward-biased, opening a current path through R468-CR468-R466. Now, at the end of holdoff, there is no current through Q468 to pull down the base of Q436, and the Sweep Reset Multivibrator does not reset. The circuit remains in this condition until reset by the Single Sweep Reset Amplifier Stage.

Single Sweep Reset Amplifier. The Single Sweep Reset Amplifier produces a negative pulse to reset the Sweep Re-

set Multivibrator stage so another sweep can be produced in the SINGLE SWEEP mode of operation.

Quiescently, Q454 is conducting hard and Q456 is held cut off. When the RESET button is pressed, CR451 is turned on. This clamps the junction of CR451-CR453 at +0.6 volt. CR453 and CR454 open and the base of Q454 drops to zero volts, turning it off. This turns Q456 on hard, pulling down its collector voltage. This negative-going step applied to C457-CR459 produces a negative pulse at the base of Q436 which is sufficient to reset the sweep reset multivibrator. This enables the sweep gate TD, and the next trigger pulse will produce another sweep on the display. C456 provides positive feedback with a long time-constant to keep Q454 off long enough to prevent switching transients from producing multiple sweeps.

Lamp Driver. In the SINGLE SWEEP MODE, the base of Q446 is connected through CR446, CR448 and CR449 to the collector of Q436. When Q436 is cut off, during holdoff time and until the RESET button is pressed, the base of Q446 is biased to cutoff. When the RESET button is pressed, Q436 is turned on and its collector voltage rises. This positive-going voltage applied to the base of Q446 turns it on (C446 controls turn-on time). Q446 collector voltage drops and the READY lamp turns on. The READY lamp remains on until the end of the sweep when Q436 is again turned off.

Alternate Operation

In alternate operation the indicator oscilloscope provides a sweep inhibit current to the emitter of Q410. Q410 provides a low impedance input and a voltage drive for the inhibit comparator, Q416 and Q424. A sweep inhibit current input of 1 mA or greater turns Q410 on. This raises the base voltage of Q416, turning it on and turning Q424 off. The collector current of Q416 pulls the base of Q432 in a negative direction turning, Q432 on and Q436 off, to latch the sweep gate TD as described previously.

Delayed Sweep Operation

The Type 7B51 can be used in the right horizontal (B) compartment of the indicator oscilloscope as a delayed sweep time-base. In this position, the delay pickoff circuit and the B DELAY MODE switch will be inoperative.

In this mode of operation, the time-base in the left horizontal (A) compartment provides the sweep inhibit current to the emitter of Q410. The sweep inhibit circuit operates as described under Alternate Operation. The A time-base also provides a delay mode control voltage to the anodes of CR462 in the sweep generator and CR301 in the trigger generator.

The delay mode control voltage causes CR462 to conduct CR463 to turn off, CR464 to conduct and CR466 to turn off. This puts the B sweep in single sweep mode as described under Single Sweep Operation.

During sweep inhibit time, Q424 is turned off. This turns off CR428 and with CR463 off the current from R428 turns on CR469. C469 now charges to about +1.5 volts, turning on Q468. This does not reset the sweep, which is locked out by the conduction of Q416.

When sweep inhibit ends Q416 turns off, making the base of Q432 more positive. Q424 turns on to open CR469. C469 holds its charge long enough to allow Q468 to reset the sweep at the end of inhibit time. This action allows only one sweep at the end of inhibit time. This action allows only one sweep after each time the sweep is inhibited.

The delay mode control voltage is also connected to the sweep gate TD, CR299, through CR301 and R303. With the A time-base B DELAY MODE in B TRIGGERABLE AFTER DELAY the control voltage is about +3 volts, which is insufficient to cause CR301 to conduct. The sweep will wait for the first trigger after the delay interval to run. With the A time-base B DELAY MODE in B STARTS AFTER DELAY, the control voltage is about +4.5 volts. This is sufficient to cause CR301 to conduct and increase the current through R303 to the sweep gate TD, CR299. Now the TD will change to its high-level state and start the sweep as soon as it is enabled by the sweep reset multivibrator at the end of inhibit current to Q410.

When the INDEPENDENT mode is selected by the A Plug-in DELAY MODE switch, the sweep inhibit is held at about the 0 mA level. The delay mode control voltage is clamped to ground. The A time-base has no control over the B time-base and each operates as an independent Time-Base.

Delay Pickoff

Delay Comparator. The Delay 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 the B Sweep to be delayed from 0 to 10 times the Time-Base A TIME/DIV setting after the A Sweep starts. Then, the B Sweep Generator is turned on and operates at a sweep rate determined by the B TIME/DIV switch setting.

Q520A and Q520B operate as a voltage comparator. The FET with the most positive gate controls conduction. Reference voltage for the comparator is supplied by the DELAY TIME MULTIPLIER, R505, a front-panel control. Delay Stop R500 is provided for calibration of the Delay Pickoff circuit. R501-C501 filter out the power supply ripple to provide stability. This instrument is calibrated so that the major dial markings of the DTM correspond to a major division of the A Sweep horizontal display. For example, if the DELAY TIME MULTIPLIER is set to 5.00, the B Sweep Generator is delayed five divisions of the A Sweep time before it can produce a sweep.

Quiescently, with the DELAY MODE switch set to a delay mode, Q520A (having the most positive gate) is controlling the Delay Pickoff circuit. The output at the emitter of Q496 is at about +3.6 volts which inhibits the B sweep. The sawtooth output signal is applied to the gate of Q520B. When the sawtooth voltage rises above the level at the gate of Q520A (established by the DTM) Q520B takes over control of the comparator current. The increased current through Q520B makes the base of Q510B less positive. Q510B turns on and the current through R485 gives a positive-going signal on the base of Q492. Q482-Q492 is a fast switching circuit. The positive-going signal at the base of Q492 increases current through R489, and the emitter of Q482 moves in a positive direction. This decreases the conduction of Q482 and its collector voltage rises. This makes the base of Q492 more positive, reinforcing the original signal. The result of this regenerative action is very fast switching of this circuit.

The negative-going step at the collector of Q492 is applied to the base of Delay Gate Emitter-Follower Q496. The negative-going step at the emitter of Q496 is sent to the Indicator Oscilloscope as the Delay Gate. At the end of the sweep, the Delay Pickoff circuit reverts to its quiescent state to produce the positive-going step at the end of the Delay gate. Q472 aids in quickly returning the Delay Switching Amplifier to its quiescent state. Q472 is held cut off by the sweep start gate during sweep time. At the end of sweep time, Q472 turns on applying a positive-going signal to the base of Q482.

When the DELAY MODE switch is in INDEPENDENT the base of Q492 is clamped at about 0 volts. This turns it on hard and the Delay Gate output is held to its low level.

HORIZONTAL PREAMP

Input Amplifier. The Input Amplifier, Q764, is an operational (feedback) amplifier which provides stable gain and low input impedance. POSITION control R744 A and B, varies the DC level at the base of paraphase amplifier Q784 to position the display horizontally. R771-R772-Q774 supply a stable DC reference level to the base of Q794. Sweep Cal adjustment R740 adjusts the sawtooth input current. This controls the rate of rise of the sawtooth output of the Paraphase Amplifier.

Paraphase Amplifier. The Paraphase Amplifier, Q784-Q794, takes the single-ended input and converts it to a push-pull output for use in the Indicator Oscilloscope.

The negative-going sawtooth applied to the base of Q784 increases conduction in this half of the Paraphase Amplifier. Through emitter-follower action the negative-going sawtooth signal is also applied to the emitter of Q794, decreasing conduction through this half of the Paraphase Amplifier. The results of these actions are a positive-going sawtooth at the collector of Q784 and a negative-going sawtooth at the collector of Q794.

Circuit Description—Type 7B51

Magnifier. Relay K780, when energized parallels R782 with R786-R785 to increase the gain of the amplifier by a factor of 10. R785 is adjustable for calibration of the X10 gain. Mag Regis adjustment R795 is used to balance the output for no trace shift when switching the X1 to X10 magnification.

READOUT BLOCK

The Readout Block consists of switching resistors and a set of contacts operated by the X10 MAG relay. The switching resistors, selected by the setting of the Readout Switch (part of the TIME/DIV switch), are used to signal

the Indicator Oscilloscope of the setting of the TIME/DIV switch.

Refer to Schematic Diagram 4, Timing Switch, at the back of the manual to find the resistors associated with a particular setting of the TIME/DIV switch. The number 1, 2, or 5 is selected by resistors R704-R705-R706. The number of zeros is selected by resistors R711-R712-R713-R715. The TIME sub-unit (milli, micro, or nano) is selected by resistors R721-R722-R723-R724. R728-R729 select the symbol S (seconds). R701-R702 select the symbol > (greater than) when the VAR TIME/DIV knob is in the out (uncal) position. R715 is switched out by the X10 MAG to increase the displayed readout by a factor of 10.

SECTION 4

MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance and troubleshooting of the Type 7B51.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the Type 7B51 is subjected determines the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

The Type 7B51 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 may also provide an electrical conduction path.

The covers of the indicator oscilloscope minimize the amount of dust which reaches the interior of the Type 7B51. Operation of the system without the indicator oscilloscope covers in place necessitates more frequent cleaning. When the Type 7B51 is not in use, it should be stored in a protected location such as a dust-tight cabinet.

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

Exterior. Loose dust accumulated on the outside of the Type 7B51 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 detergent and water solution. Abrasive cleaners can not be used.

Interior. Dust in the interior of the instrument should be removed occasionally 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 a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces.

Visual Inspection

The Type 7B51 should be inspected occasionally for such defects as broken connections, broken or damaged circuit boards, improperly seated transistors or relay, and heat-damaged parts.

The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent a recurrence of the damage.

Transistor Checks

Periodic checks of the transistors in the Type 7B51 are not recommended. The best check of transistor performance is actual operation in the instrument. More details on checking transistor operation are given under Troubleshooting.

Recalibration

To ensure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in Section 5.

The Performance Check/Calibration Procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by calibration.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting of the Type 7B51. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description section for complete information.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in Section 8. The component 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.

Switch Cam Identification. Switch cam numbers shown on the diagrams indicate the position of the cam in the complete switch assembly. The cams are numbered from the front, or mounting end of the switch, toward the rear.

Resistor Color-Code. In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the Type 7B51. The resistance values of wire-wound resistors are printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color-coded on the components (some metal-film resistors may have the value printed on the body) with EIA color code. The color code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 4-1). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

Capacitor Marking. The capacitance 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 7B51 are color coded in picofarads using a modified EIA code (see Fig. 4-1).

Diode Color Code. The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes or a dot. For most silicon or germanium diodes with a series of stripes, the color code also indicates the type of diode or identifies the Tektronix Part Number using the resistor color code system (e.g., a diode color-coded blue- or pink-brown-gray-green indicates Tektronix Part Number 152-0185-00). The cathode and anode ends of metal-encased diodes can be identified by the diode symbol marked on the body.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 7B51:

1. Transistor Tester

Description: Tektronix Type 576 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

2. Volt-ohmmeter

Description: 20,000 ohms/volt. 0-500 volts DC. Accurate within 3%. Test probes must be well insulated.

Purpose: To measure voltages and resistances.

3. Test Oscilloscope

Description: DC to 100 MHz frequency response, 5 millivolts to 5 volts/division deflection factor. Use a 10X probe.

Purpose: To check waveforms in the instrument.

4. Plug-In Extender

Description: Rigid plug-in extender, Tektronix Part number 067-0589-00.

Purpose: Permits operation of the unit outside the plug-in compartment for better accessibility during troubleshooting.

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 ensure 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 under Corrective Maintenance.

1. Check Control Settings. Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section.

2. Check Associated Equipment. Before proceeding with troubleshooting of the Type 7B51, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the probe cable is not defective. The indicator oscilloscope and vertical plug-in unit can be checked for proper operation by substituting another time-base unit which is known to be operating properly (preferably another Type 7B51 or similar unit). If the trouble persists after substitution, the indicator oscilloscope and/or vertical plug-in unit is defective.

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

4. Visual Check. Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged components, etc.

5. Isolate Trouble to a Circuit. To isolate a trouble to a circuit, note the trouble symptom. The symptom often indicates the circuit in which the trouble is located. For example, if normal triggering can be obtained in the EXT mode but cannot be obtained in the INT mode, the trigger pre-amp or the input coupling circuit is probably at fault. When trouble symptoms appear, use the front-panel controls and the CRT display to try to isolate the trouble to one circuit. When the trouble appears in more than one circuit, check all affected circuits by taking voltage and waveform readings.

Fig. 4-2 provides a guide to aid in locating a defective circuit. This chart does not include checks for all possible defects; use steps 6 and 7 for further troubleshooting. Start from the top of the chart and perform the given checks on the left side of the page until a step is found which is not correct. Further checks and/or the circuit in which the trouble is probably located are listed to the right of this step.

After the defective circuit has been located, proceed with steps 6 and 7 to locate the defective component(s).

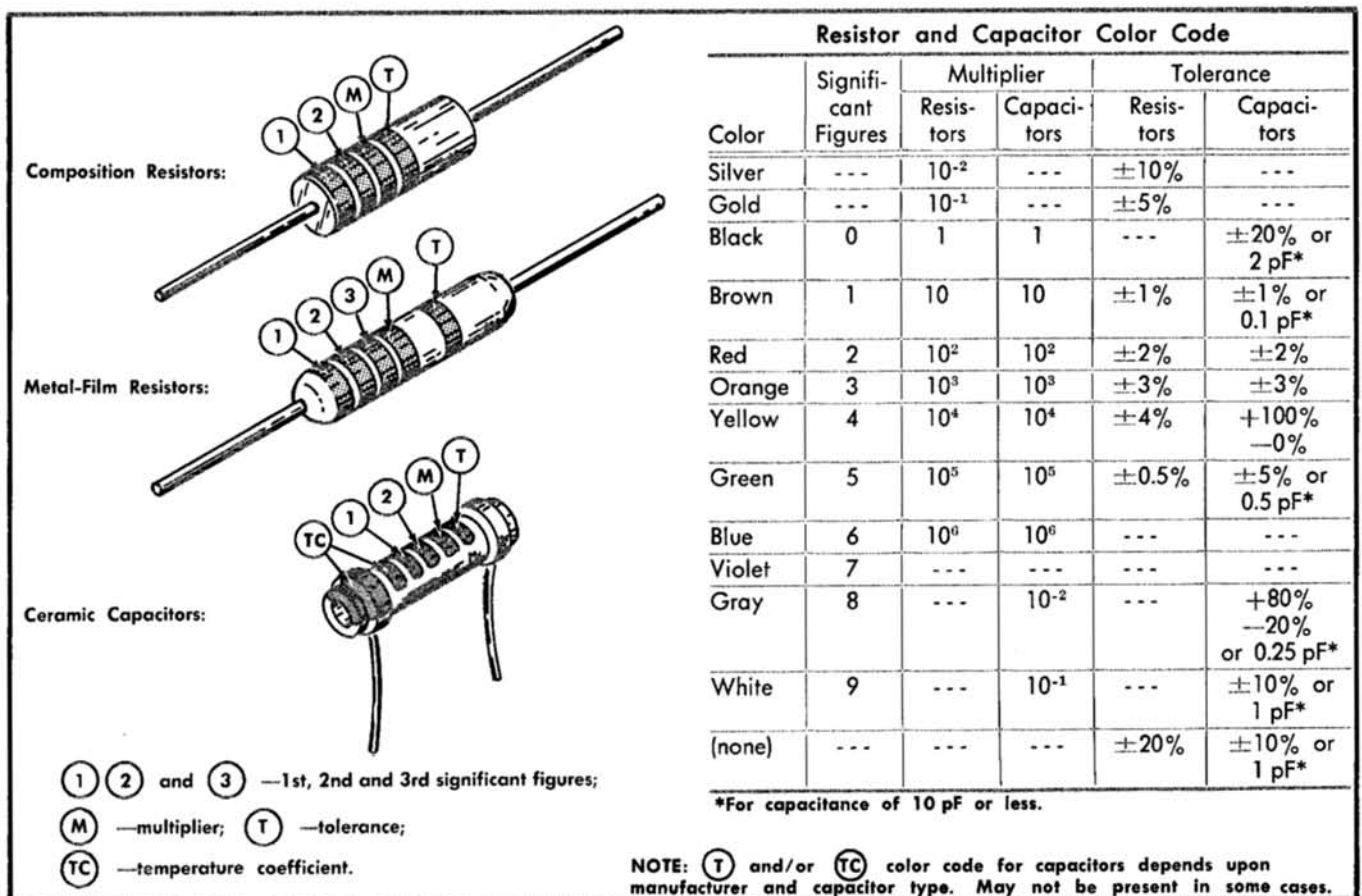


Fig. 4-1. Color-code for resistors and ceramic capacitors.

Maintenance—Type 7B51

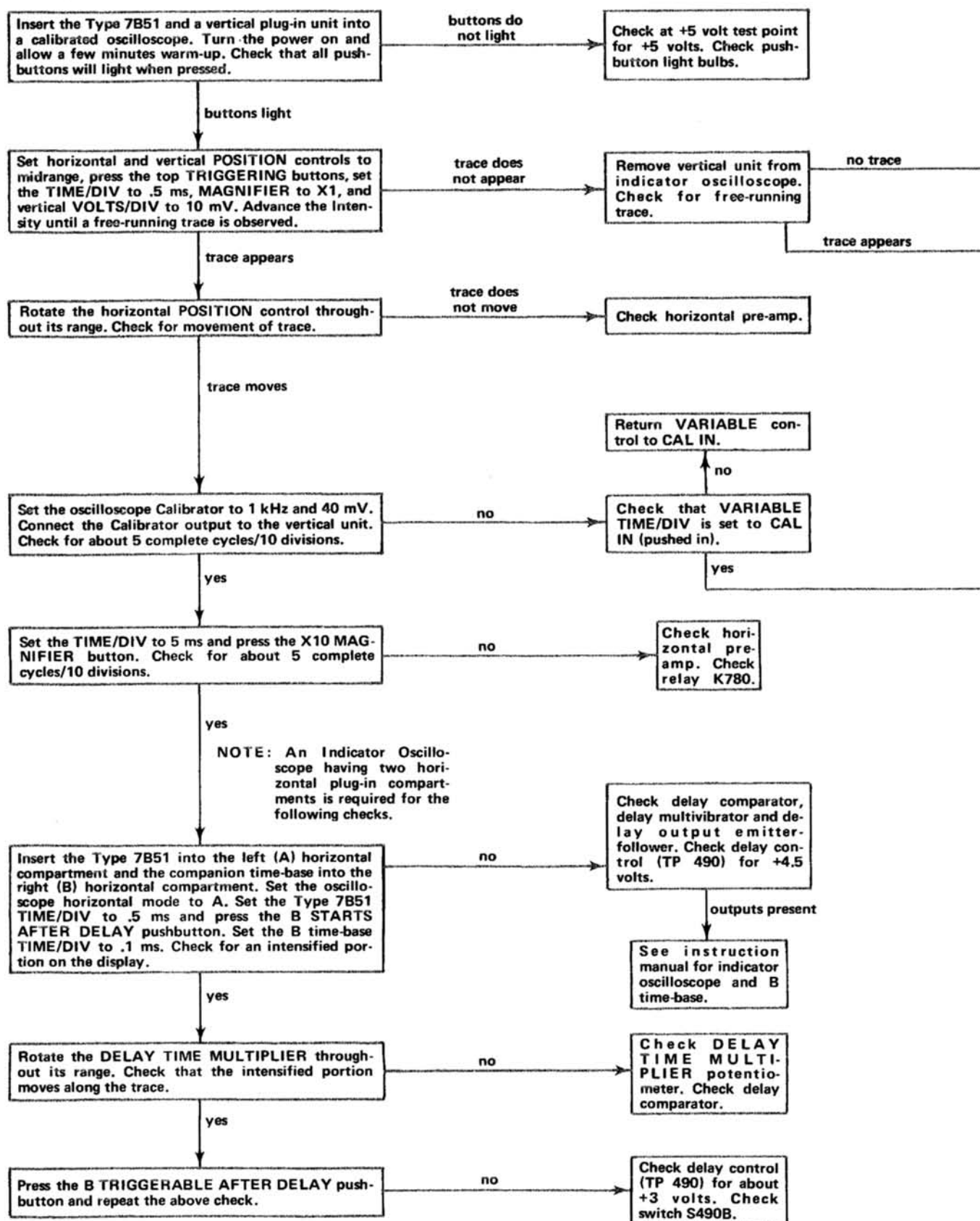
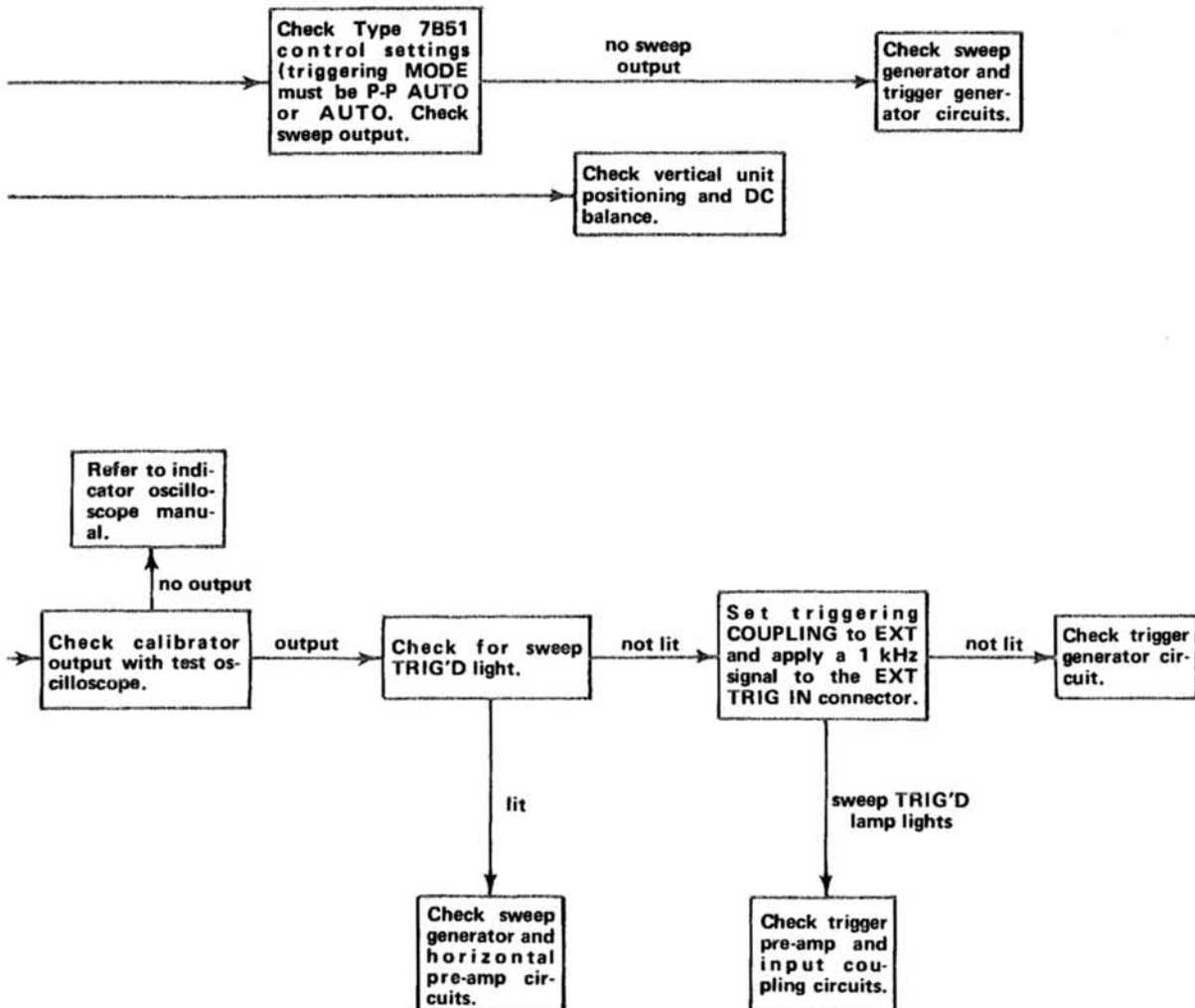


Fig. 4-2. Troubleshooting chart for the Type 7B51.



For a trouble not covered by this chart, use the troubleshooting methods in steps 6 and 7 of the troubleshooting techniques.

Fig. 4-2. Troubleshooting chart for the Type 7B51.

6. Check Voltages and Waveforms. Often the defective components can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

CAUTION

Do not clamp probe to pin connectors as this may break or damage the connectors.

NOTE

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

7. Check Individual Components. The following procedures describe methods of checking individual components in the Type 7B51. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

A. RELAY. The eight-pin relay used in the Type 7B51 is symmetrical and may be replaced in its socket facing either direction. This relay, which is plugged into the circuit board, may be removed and checked. Use an ohmmeter to check the 600 Ω resistance. The relay may also be actuated by placing +15 volts across the coil. The internal connections are printed on the body of the relay.

B. TRANSISTORS. The best check of transistor operation is actual performance under operating conditions. If a transistor is suspected of being defective, it can best be checked by substituting a new component or one which has been checked previously. However, be sure that circuit conditions are not such that a replacement transistor might also be damaged. If substitute transistors are not available, use a dynamic tester (such as Tektronix Type 576).

C. DIODES. 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 between 800 millivolts and 3 volts, the resistance should be very high in one direction and very low when the leads are reversed.

CAUTION

Do not use an ohmmeter scale that has a high internal current. High currents may damage the diode.

D. RESISTORS. Resistors can be checked with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

E. INDUCTORS. Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit. Partial shorting often reduces high-frequency response.

F. CAPACITORS. A leaky or shorted capacitor can best be detected by checking the resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter or by checking whether the capacitor passes AC signals.

8. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 7B51 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect the performance in the instrument, particularly at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect instrument performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the Type 7B51. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the parts list by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument Type.
2. Instrument Serial Number.
3. A description of the part (if electrical, include circuit number).
4. Tektronix Part Number.

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

Circuit Boards. The components mounted on the circuit boards in the amplifier can be replaced using normal circuit board soldering techniques. Keep the following points in mind when soldering on the circuit boards.

1. Use a pencil-type soldering iron with a power rating from 15 to 50 watts.
2. Apply heat from the soldering iron to the junction between the component and the circuit board.
3. Heat-shunt the lead of the component by means of a pair of long-nosed pliers.
4. Avoid excessive heating of the junction with the circuit board, as this could separate the circuit board wiring from the laminate.
5. Use electronic grade 60-40 tin-lead solder.

6. Clip off any excess lead length extending beyond the circuit board and clean off any residual flux with a flux-removing solvent. Be careful that the solvent does not remove any printing from the circuit board.

Metal Terminals. When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), use 60-40 tin-lead solder and a 15 to 50 watt soldering iron. 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 joint, clip off the excess.
4. Clean the flux from the solder joint with a flux-removing solvent.

Component Replacement

WARNING

Disconnect the equipment from the power source before replacing components.

Relay Replacement. The relay in the Type 7B51 is manufactured by Tektronix, Inc. If the relay fails, a replacement may be ordered from your local Tektronix Field Office or representative. The eight-pin DPDT relay may be replaced in its socket facing either direction, as this relay is symmetrical.

Transistor Replacement. Transistors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors may effect the calibration of this instrument. When transistors are replaced, check the operation of that part of the instrument which may be affected.

Replacement transistors should be of the original type or a direct replacement. Remount the transistors in the same manner as the original. Fig. 4-3 shows the lead configurations of the transistors used in this instrument. This view is as seen from the bottom of the transistor. When replacing transistors, check the manufacturer's basing diagram for correct basing.

Interconnecting Pins and Pin Socket Replacement. Two types of mating connectors are used for these interconnecting pins. If the mating connector is mounted on a plug-on circuit board, a special socket is soldered into the board. If the mating connector is on the end of a lead, a pin connector is used to mate with the interconnecting pin. The following information provides the replacement procedure for the various types of pins and pin sockets.

A. CIRCUIT BOARD PINS. To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Unsolder the damaged pin and pull it out of the circuit board. Press the new pin into the hole in the circuit board so the ferrule on the pin is centered in the hole in the board. (Notice that the ferrule is not centered on the pin; be sure the replacement pin is positioned in the same manner as the original.) Solder the pin on both sides of the circuit board. If the pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins. The inside radius of this bend should not be less than 0.025 inch.

B. CIRCUIT BOARD PIN SOCKETS. The pin sockets on the circuit boards are soldered to the rear of the board. To replace the sockets, first unsolder the socket (use a vacuum-type desoldering tool to remove excess solder). Straighten the tabs on the socket to remove it from the hole in the circuit board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the socket tabs to the circuit board.

NOTE

The spring tension of the terminal sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.

C. END-LEAD PIN CONNECTORS. The pin connectors used to connect the wires to the circuit board pins are clamped to the ends of the associated leads. To replace a damaged pin connector, first remove the old pin connector from the end of the lead. Clamp the new pin connector to the end of the lead. Some of the pin connectors are grouped together and mounted in a plastic holder. These connectors are removed and re-installed as a unit. To provide correct orientation of this multi-connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is moulded into the plastic housing of the multi-pin connector.

Switch Replacement. Two types of switches are used in the Type 7B51. The pushbutton switches and the cam-type switch should be replaced as a unit if damaged. The following special maintenance information is provided for the cam-type and pushbutton type switches.

CAUTION

Repair of the cam switch should only be undertaken by skilled maintenance personnel. Switch alignment and contact spacing must be carefully maintained for proper operation of the switch. The cam switch repair kit contains special alignment tools for use in repairing or replacing the cam and contacts. For information or assistance on maintenance of the cam switch contact your local Tektronix Field Office or representative.

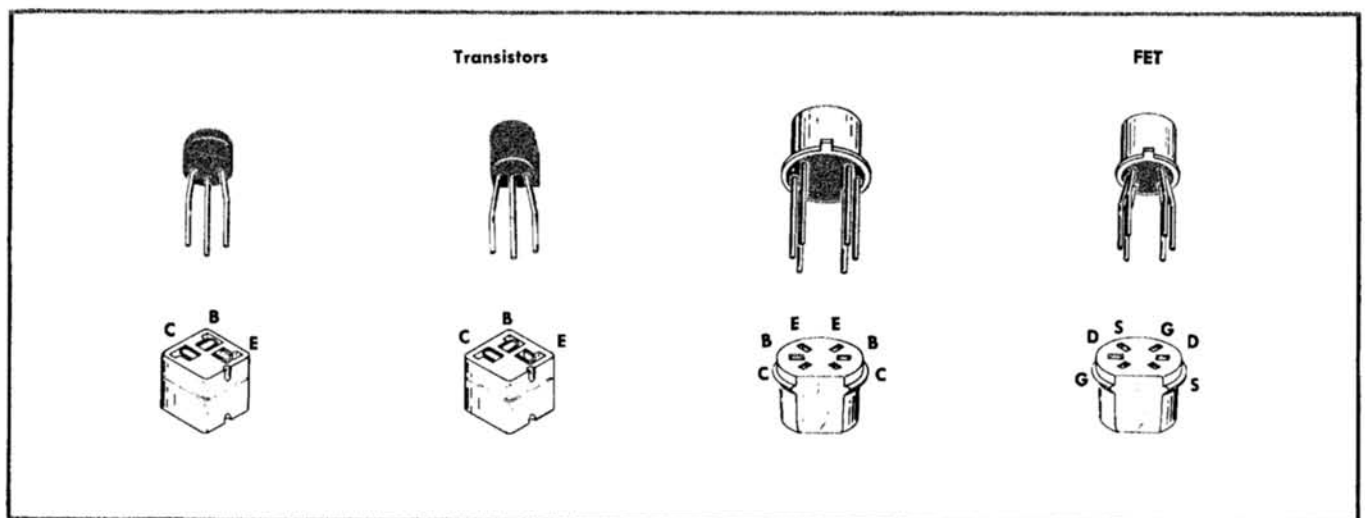


Fig. 4-3. Electrode configuration of transistors used in this instrument.

A. CAM-TYPE SWITCH. The cam-type switch (TIME/DIV) consists of a rotating cam, which is turned by the front panel knob, and a set of contacts mounted on an adjacent circuit board. These switch contacts are actuated by lobes on the cam. The TIME/DIV switch can be disassembled for inspection, cleaning, repair or replacement as follows:

1. Remove the four screws which hold the metal cover over the switch. The switch is now open for inspection or cleaning.
2. To completely remove the switch, loosen the set screw on the collar securing the VARIABLE shaft to the VARIABLE potentiometer and pull the shaft completely out the front of the unit. Loosen the two set screws on the TIME/DIV knob and remove the knob. Remove the plastic bushing from the access hole for the TIME/DIV shaft.
3. Remove the sweep generator board by loosening the four knurled screws and carefully lifting out.
4. Remove the six screws which hold the cam switch to the interface circuit board and remove the cam switch.
5. To remove the cam from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam out of the support block. Do not lose the small detent roller.
6. To replace defective switch contacts, unsolder the damaged contact and clean the solder from the hole in the circuit board. Following the procedure given in the instruction sheet included with the cam switch replacement kit, use the alignment tool to position the new contact in place. Solder the contact using the soldering techniques given previously in this section of the manual.
7. To re-assemble the switch, reverse the above procedure.

B. PUSH-BUTTON SWITCHES. Use the following procedure to replace the five pushbutton switches:

1. Loosen the set screws and remove the POSITION, LEVEL/SLOPE, TIME/DIV and VARIABLE knobs.
2. Remove the front panel to gain access to the switch mounting screws.

3. To remove the B DELAY MODE switch, remove the two phillips head screws and disconnect the multi-pin connector.

4. To remove the MAGNIFIER switch, remove the phillips head screw and disconnect the multi-pin connector.

5. To remove the TRIGGERING switches, remove the two phillips head screws from each of the MODE, COUPLING and SOURCE switches. Disconnect the following multi-pin connectors: DELAY TIME MULTIPLIER, B DELAY MODE, SWP CAL, POSITION, LEVEL/SLOPE, TRIG'D and MAGNIFIER. Disconnect the pin connectors from the SOURCE and COUPLING switches. Remove the four screws securing the front of the unit to the top and bottom and remove the front of the unit. Remove the TRIGGERING switches (the sweep generator board may have to be removed to take out the TRIGGERING MODE switch).

Light Bulb Replacement. To replace the light bulbs follow the above procedure to remove the switches. Remove the screw and cover from the back of the switch to expose the light bulb. Unsolder the two leads and remove the light bulb. Cut the leads of the replacement light bulb to the same length as those of the old bulb. Place insulating sleeves over the leads and replace the new bulb in the exact position of the old bulb.

Reassemble by reversing the above procedure.

Instrument Repackaging

If the Type 7B51 is to be shipped for long distances by commercial means of transportation, it is recommended that the instrument be repackaged in the original manner for maximum protection. The original shipping carton can be saved and used for this purpose. Repackaging information and/or new shipping cartons can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

NOTE

The plug-ins should not be shipped installed in an oscilloscope. The oscilloscope packaging material is not designed to protect the plug-ins.





Fig. 4-5. Time Base board (front view) showing location of components.

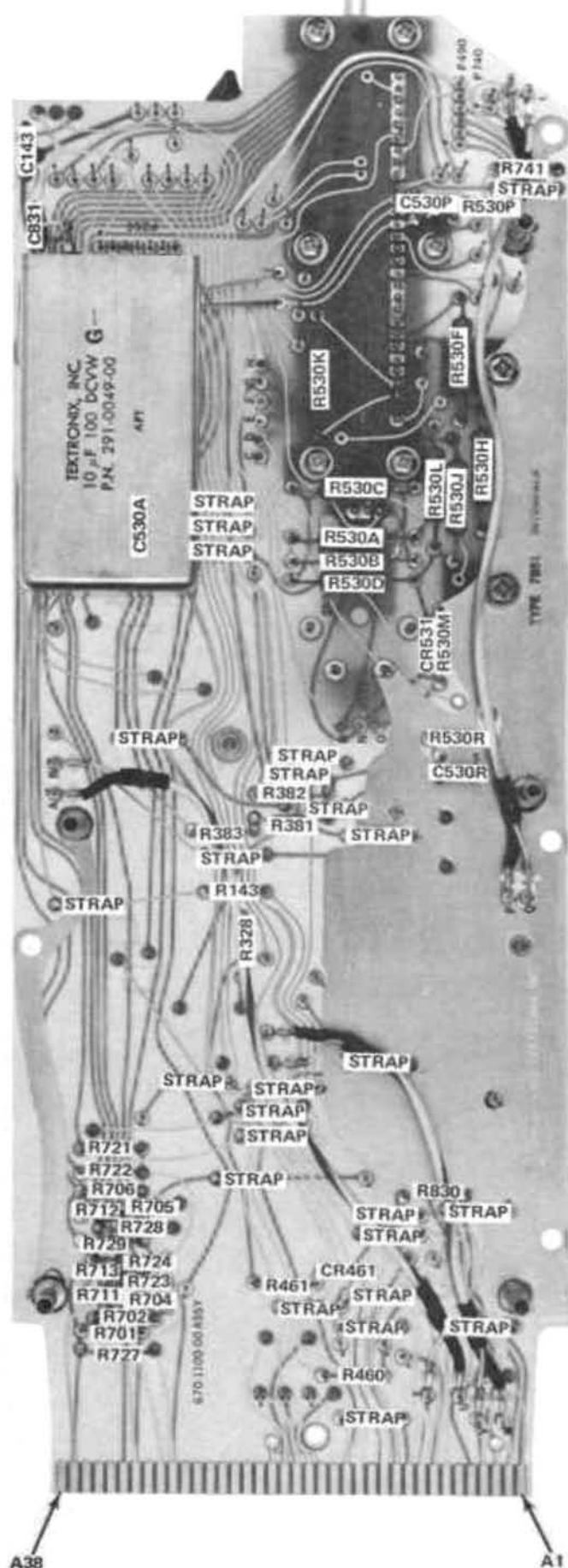


Fig. 4-6. Interface board (left side) showing location of components.

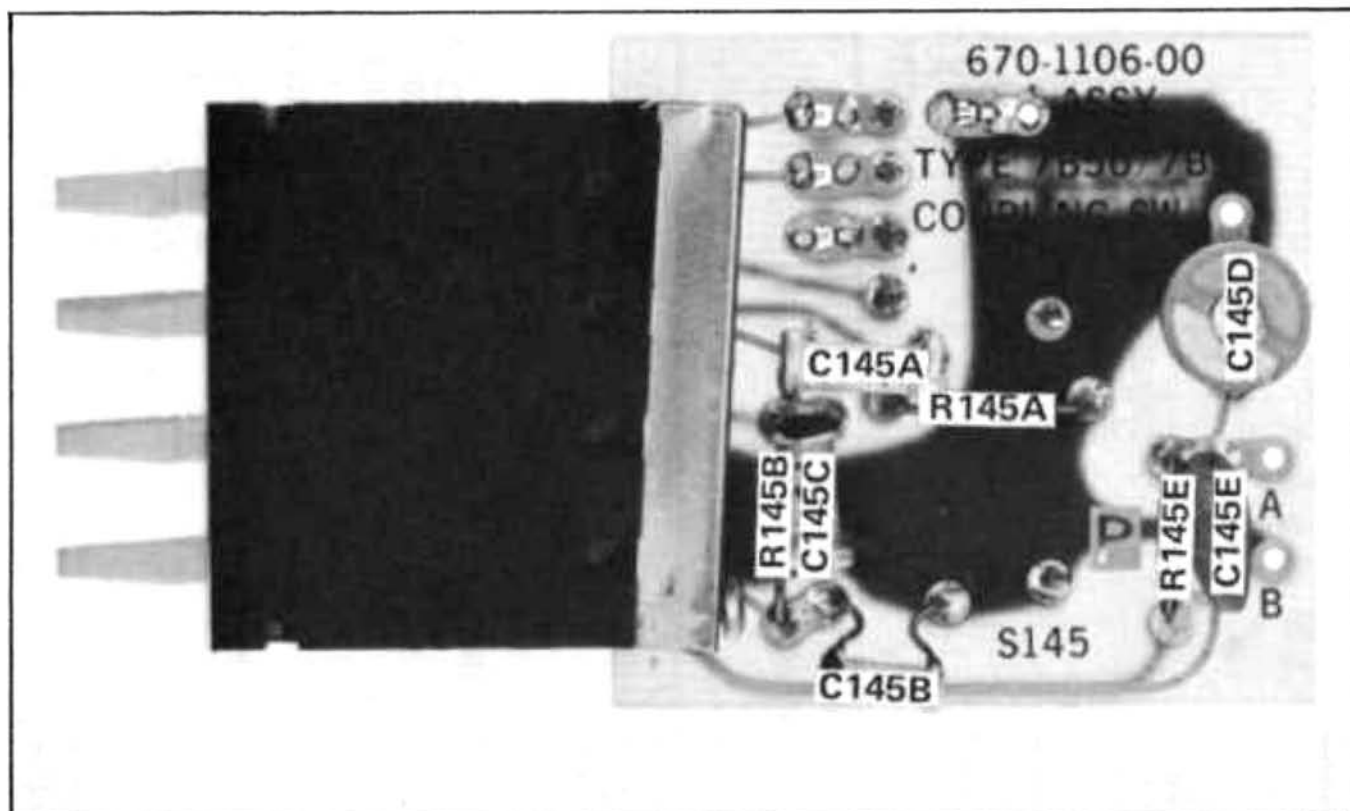


Fig. 4-7. Coupling switch board showing location of components.

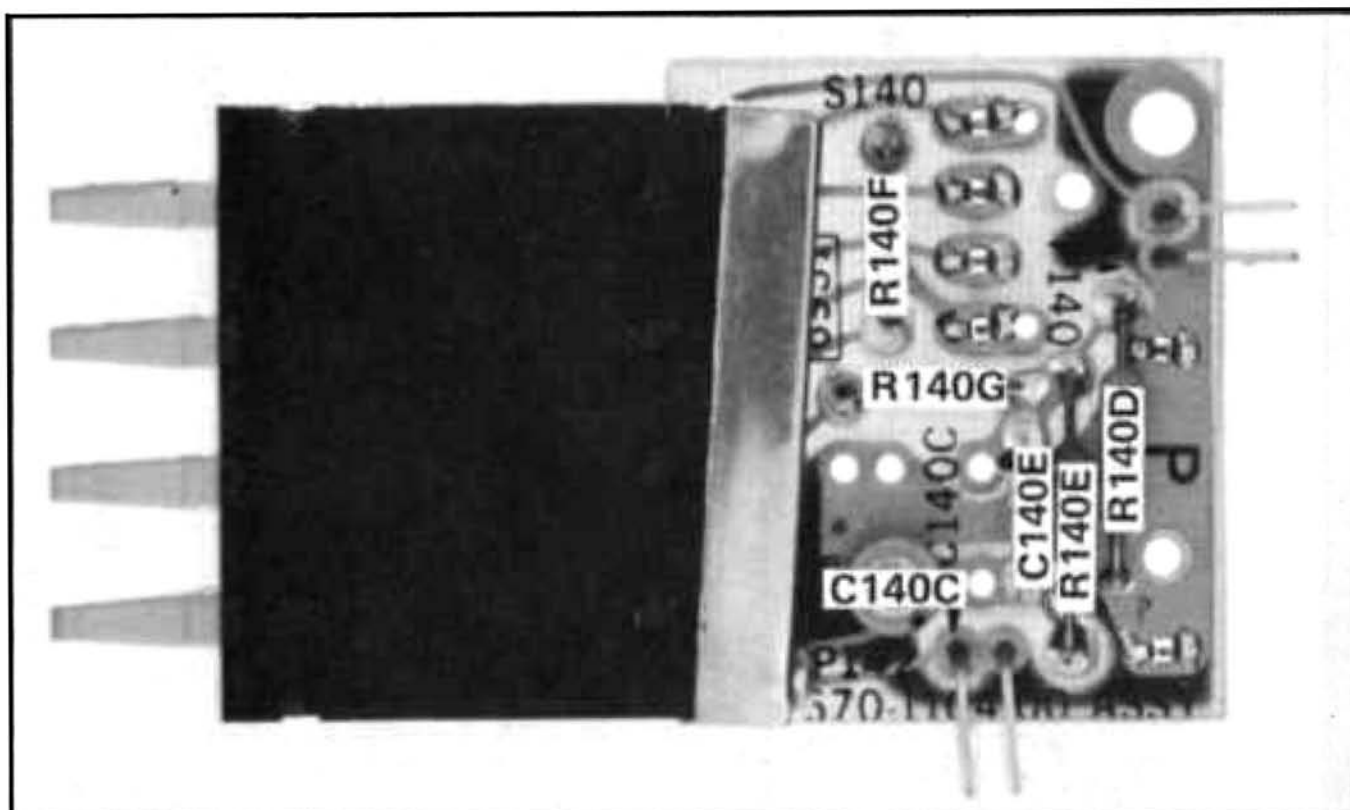


Fig. 4-8. Source switch board showing location of components.

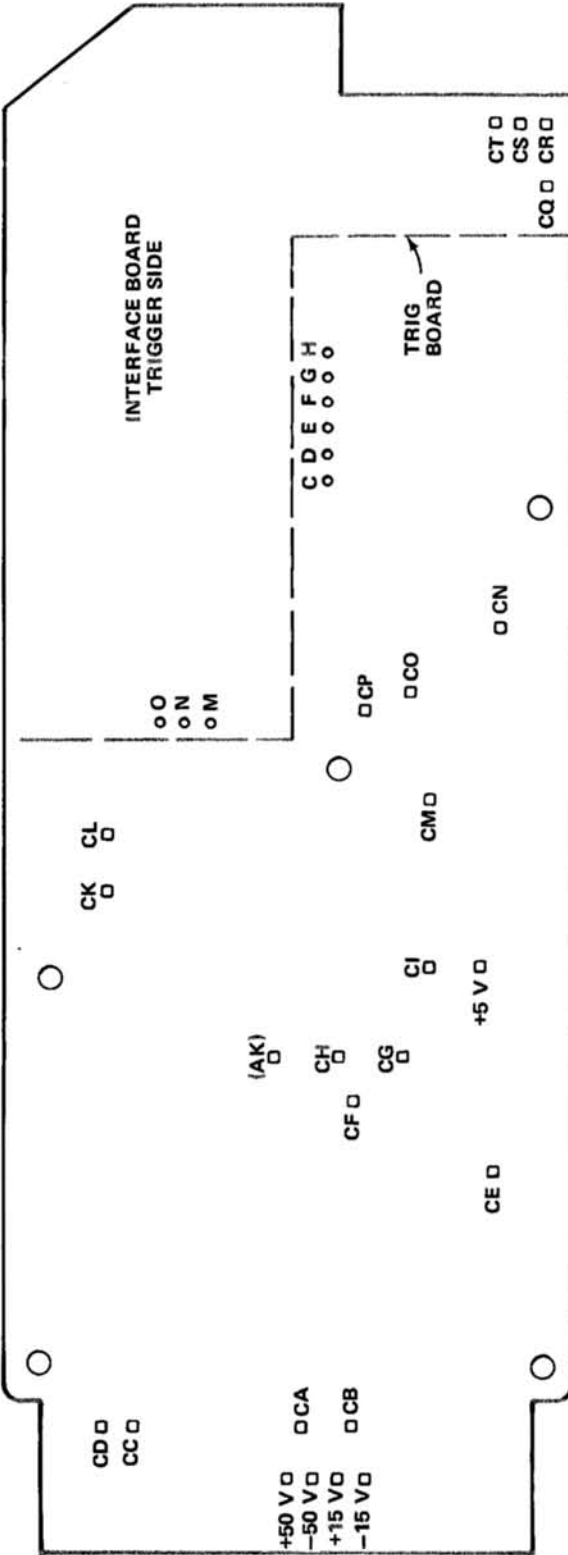


Fig. 4-9. Interface board (right side) showing location of square pin connectors.

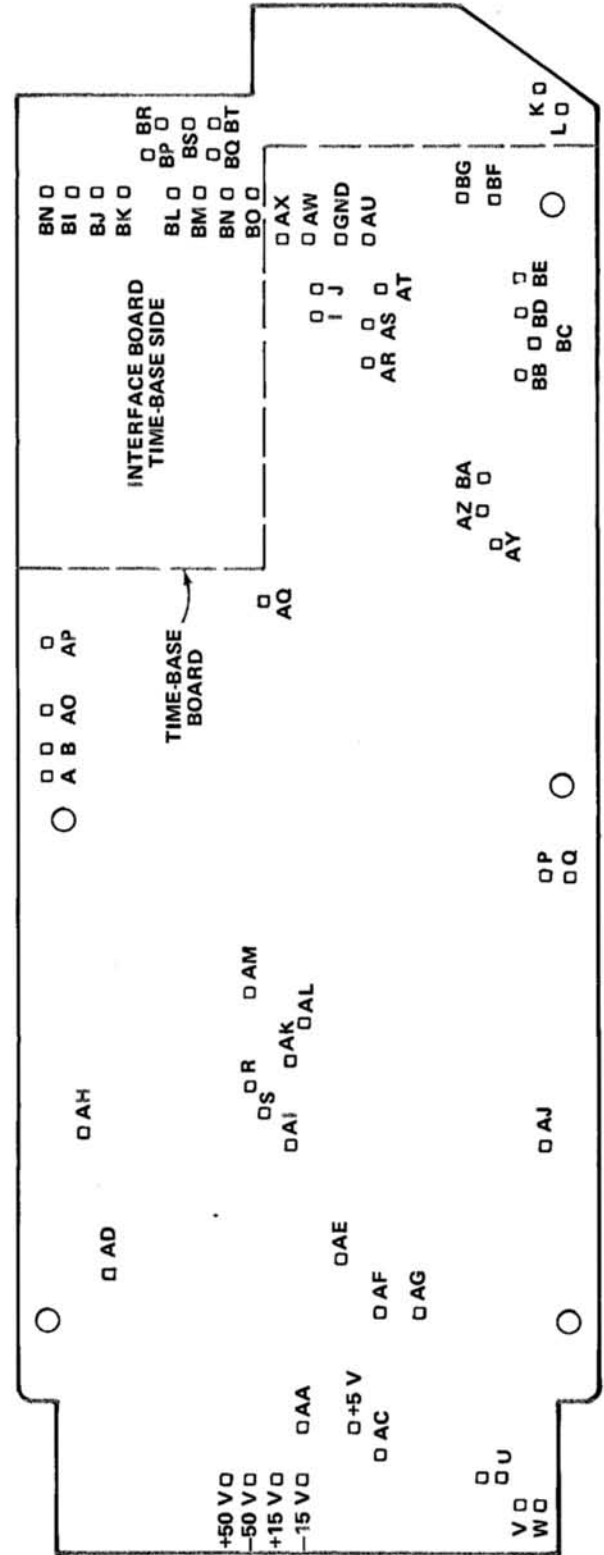


Fig. 4-10. Interface board (left side) showing location of square pin connectors.

SECTION 5

PERFORMANCE CHECK

CALIBRATION PROCEDURE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

To assure instrument accuracy, check the calibration of the Type 7B51 every 1000 hours, or every six months if used infrequently. Before calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance Section.

The complete Performance Check/Calibration Procedure can be used to check instrument performance without removing side covers or making internal adjustments, by performing all portions except the ADJUST part of the steps. Screwdriver adjustments which are accessible without removing the covers are adjusted as part of the performance check procedure. A note titled PERFORMANCE CHECK ONLY gives instructions which are applicable only to the performance check procedure.

Completion of each step in the complete Performance Check/Calibration Procedure insures that this instrument meets the electrical specifications given in Section 1. For best overall instrument performance, when performing a complete calibration procedure, make each adjustment to the exact setting even if the CHECK is within the allowable tolerance.

A Short-Form Procedure is given prior to the complete procedure. To facilitate instrument calibration for the experienced calibrator, the Short-Form Procedure lists the calibration adjustment necessary for each step and the applicable tolerances. This procedure also includes the step number and title as listed in the complete Performance Check/Calibration Procedure and the page number on which each step begins. Thus, the Short-Form Procedure can be used as an index to locate a step in the complete procedure. Another feature of the Short-Form Procedure is the spaces provided to record performance data or to check off steps as they are completed. This procedure may be reproduced and used as a permanent record of instrument calibration.

NOTE

All waveforms shown in this procedure were taken with a Tektronix Oscilloscope Camera System. Limits, tolerances and waveforms in this procedure are given as calibration guides and should not be interpreted as instrument specifications except as specified in Section 1.

A partial calibration is often desirable after replacing a component or to touch up an adjustment of a portion of the instrument between major recalibrations. For partial calibration, set the controls as given under Preliminary Control Setting and start with the nearest test equipment picture preceding the desired check or checks. If any controls need to be changed from the preliminary settings for this portion of the calibration procedure, they are listed under the heading Partial Procedure, following the equipment required picture. To prevent unnecessary recalibration of other parts of the instrument, readjust only if the tolerance given in the CHECK part of the step is not met. If readjustment is necessary, also check the calibration of any steps listed in the INTERACTION part of the step.

TEST EQUIPMENT REQUIRED

General

The following test equipment and accessories, or its equivalent, are required for complete calibration of the Type 7B51. Specifications given are the minimum necessary for accurate calibration. Therefore, some of the recommended equipment may have specifications which exceed those given. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Special Tektronix calibration fixtures are used in this procedure only where they facilitate calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Test time-base having delaying sweep capabilities and compatible with the Tektronix 7000-series oscilloscope. Type 7B51 used in these checks.

2. Vertical amplifier for use with Tektronix 7000-series oscilloscopes. Bandwidth, 100 MHz or greater; deflection factor, 5 volts to less than 50 millivolts. Tektronix Type 7A16 used in these checks.

3. Oscilloscope. Tektronix Type 7504 or Type 7704.

Performance Check/Calibration—Type 7B51

4. Plug-in extender. Tektronix Part Number 067-0589-00.

5. Low-frequency sine-wave generator. Frequency range, 20 hertz to greater than 50 kilohertz; output amplitude, 150 millivolts to 5 volts. For example, General Radio Model 1310-A Oscillator.

6. Constant amplitude sine-wave generator. Reference frequency, 50 kilohertz; frequency range, 10 megahertz to 100 megahertz; output amplitude variable from 150 millivolts to 5 volts. Tektronix Type 191 recommended.

7. Time-mark generator. Marker outputs, five seconds to five nanoseconds; marker accuracy, within 0.1%. Tektronix Type 184 Time-Mark Generator recommended.

8. Square-wave generator. Frequency, one kilohertz. Risettime, 20 nanoseconds or less at 0.5 volts. Tektronix Type 106 Square-Wave Generator recommended.

9. 1X probe with BNC connector. Tektronix Type P6011 recommended.

10. Input RC Normalizer. Time constant 1 megohm X 20 picofarads; connectors, BNC. Tektronix calibration fixture 067-0538-00.

11. Cable (two each). Connectors, BNC; Impedance, 50 ohms; length, 42 inches. Tektronix part number 012-0057-01.

12. BNC T connector, Tektronix Part Number 103-0030-00.

13. 10X attenuator, Tektronix Part Number 011-0059-01.

14. 50 ohm feedthrough termination, Tektronix Part Number 011-0049-01.

15. Adapter, GR to BNC female. Tektronix Part Number 017-0063-00.

SHORT-FORM PROCEDURE

Type 7B51 _____

Calibration Date _____

Calibrated By _____

1. Check/Adjust Level Center (R385) Page 5-4

Requirement: Stable triggering on both the positive slope and negative slope of the signal.

Performance: Correct _____; Incorrect _____.

2. Check/Adjust P-P Auto Level Range (R335-R336) Page 5-5

Requirement: A triggered display is obtained throughout 360° rotation of the LEVEL/SLOPE control with a six division signal applied.

Performance: Correct _____; Incorrect _____.

3. Check/Adjust Internal Trigger Centering (R135) Page 5-6

Requirement: With a 50 kHz sine-wave centered vertically on the CRT, check that the trigger point remains fixed as the Type 7A16 POSITION control is moved.

Performance: Correct _____; Incorrect _____.

4. Check Level/Slope Range Page 5-6

Requirement: Triggering over the complete range of a +3.5 volt to -3.5 volt input signal.

Performance: Correct _____; Incorrect _____.

5. Adjust External Trigger Input Compensation (C145D, C140C) Page 5-6

Requirement: With a 1 kHz square-wave applied to the EXT TRIG IN connector, adjust for best square corner.

Performance: Correct _____; Incorrect _____.

6. Check Trigger Bandwidth Page 5-6

Requirement: Trigger bandwidth meets the specifications given in Section 1. Refer to the complete procedure.

Performance: Correct _____; Incorrect _____.

7. Check Sweep Jitter Page 5-7

Requirement: No more than 0.2 division of jitter with TIME/DIV set to 5 ns and a 75 MHz signal applied.

Performance: Correct _____; Incorrect _____.

8. Check Trigger Modes Page 5-7

Requirement: Correct triggering in all modes. Refer to complete procedure.

Performance: Correct _____; Incorrect _____.

9. Check/Adjust Sweep Calibration (SWP CAL, a front-panel adjust) Page 5-8

Requirement: With TIME/DIV at 1 ms and 1 ms markers applied, check for one marker for each division. The second and tenth markers must line up exactly with their respective graticule lines.

Performance: Correct _____; Incorrect _____.

10. Check/Adjust Magnified Sweep Gain (R785) Page 5-8

Requirement: With TIME/DIV at 1 ms and MAGNIFIER at X10, apply .1 ms markers. Check for 1 marker for each division between the second and tenth vertical lines.

Performance: Correct _____; Incorrect _____.

11. Check/Adjust Magnifier Register (R795) Page 5-9

Requirement: No shift of display when switching MAGNIFIER between X1 and X10.

Performance: Correct _____; Incorrect _____.

12. Check Sweep Length Page 5-9

Requirement: Sweep length must be between 10 and 13 divisions.

Performance: Correct _____; Incorrect _____.

13. Check Variable Time/Div Page 5-9

Requirement: Continuously variable between calibrated settings of the TIME/DIV switch.

Performance: Correct _____; Incorrect _____.

14. Check/Adjust 5 μ s Timing (C530J) Page 5-10

Requirement: With 5 μ s markers applied and TIME/DIV set to 5 μ s, check for one marker each division. The second and tenth markers must line up with their respective graticule lines.

Performance: Correct _____; Incorrect _____.

15. Check/Adjust 0.2 μ s Timing (C530L) Page 5-10

Requirement: With .1 μ s markers applied and TIME/DIV set to .2 μ s, check for two markers each division. The second and tenth markers must line up with their respective graticule lines.

Performance: Correct _____; Incorrect _____.

16. Check Sweep Timing Accuracy Page 5-10

Requirement: Sweep timing accuracy over the center eight division must be within 2% from .05 μ s/Div to .5 s/Div and within 3% from 1 s/Div to 5 s/Div.

Performance: Correct _____; Incorrect _____ (list any discrepancies) _____.

17. Check Magnified Sweep Timing Page 5-10

Requirement: Magnified sweep timing accuracy over the center eight divisions must be within 2.5% from .05 μ s/Div to .5 s/Div and within 3.5% from 1 s/Div to 5 s/Div.

Performance: Correct _____; Incorrect _____ (list any discrepancies) _____.

18. Check Sweep Inhibit Page 5-11

Requirement: The intensified portion may be positioned to any part of the sweep.

Performance: Correct _____; Incorrect _____.

19. Check/Adjust Delay Start (R590) and Delay Stop (R500) Page 5-12

Requirement: With the Test Time-Base DELAY TIME MULTIPLIER set to 1.00 the intensified portion of the sweep starts at the second marker; with the DELAY TIME MULTIPLIER set to 9.00, the intensified portion of the sweep starts at the tenth marker.

Performance: Correct _____; Incorrect _____.

20. Check Delay Time Multiplier Accuracy Page 5-13

Performance Check/Calibration—Type 7B51

Requirement: Accurate within 1 minor division at each major dial division between 1.00 and 9.00.

Performance: Correct ; Incorrect

21. Check Delay Time Accuracy Page 5-13

Requirement: The delay time accuracy over the center eight divisions is within 1% between 1 μ s/Div and .5 s/Div; within 2% between 1 s/Div and 5 s/Div.

Performance: Correct ; Incorrect (list any discrepancies)

22. Check Delay Time Jitter Page 5-13

Requirement: Jitter does not exceed 1 part in 50,000 of 10 times the TIME/DIV setting.

Performance: Correct ; Incorrect

23. Check Line Trigger Source Page 5-14

Requirement: Stable triggering of the proper polarity with the LEVEL/SLOPE control at 0/+ and 0/—.

Performance: Correct ; Incorrect

PERFORMANCE CHECK/CALIBRATION PROCEDURE

General

The following procedure is arranged so the Type 7B51 can be calibrated with the least interaction of adjustments and reconnection of equipment. A picture of the test equipment required for each group of steps is given to aid in identification of the necessary equipment. The control settings continue from the preceding step(s) unless noted otherwise.

The following procedure uses the equipment listed under Test Equipment Required. If other equipment is substituted, control settings or calibration setup may need to be altered to meet the requirements of the equipment used. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is required.

NOTE

This instrument should be calibrated to an ambient temperature of $+25^{\circ}\text{C} \pm 10^{\circ}\text{C}$ for best overall accuracy. If the temperature is outside the given range, see Section 1 for the applicable tolerances.

Preliminary Control Settings

Test Time-Base (A horizontal plug-in compartment)

Level/Slope	0/+
Triggering	
Mode	P-P Auto
Coupling	AC
Source	Int
Position	Midrange
Magnifier	X1
B Delay Mode	Independent
Time/div	.1 ms
Variable	Cal In

Type 7B51 (B horizontal plug-in compartment)

LEVEL/SLOPE	0/+
TRIGGERING	
MODE	NORM
COUPLING	AC
SOURCE	EXT
POSITION	MIDRANGE
MAGNIFIER	X1
B DELAY MODE	INDEPENDENT
TIME/DIV	20 μ s
VARIABLE	CAL IN

Type 7A16

AC-GND-DC	DC
Volts/div	.5 V
Position	Midrange
Polarity	+ UP

Type 7504 Indicator Oscilloscope

A Intensity	CCW
B Intensity	CCW
Vertical Mode	Left
Horizontal Mode	A
A Trigger Source	Left Vert
B Trigger Source	Left Vert

Turn the indicator oscilloscope power on and advance the A Intensity until a free-running trace is observed. Center the trace on the CRT with the horizontal and vertical POSITION controls and allow several minutes warmup before proceeding with calibration.

CALIBRATION PROCEDURE

1. Check/Adjust Level Center (R385)

a. Test equipment required is shown in Fig. 5-1.

b. Connect a BNC "T" connector to the output of the low-frequency sine-wave generator. Using two 50 Ω BNC

coaxial cables, connect the Type 7A16 Input and the Type 7B51 EXT TRIG IN to the "T" connector.

c. Set the sine-wave generator to 50 kHz and adjust the amplitude for a 0.3 division (150 mV) display on the CRT.

d. Reset the indicator oscilloscope Horizontal Mode to B and advance the B Intensity.

e. CHECK—For a stable display triggered on the positive slope of the signal.

f. ADJUST—R385 for a stable display triggered on the positive slope of the signal.

g. Reset the Type 7B51 LEVEL/SLOPE to 0/—.

h. CHECK—For a stable display triggered on the negative slope of the signal.

NOTE

Slight readjustment of R385 may be necessary. Alternate between 0/+ and 0/— while adjusting R385 for optimum triggering on both the positive and negative slopes of the signal.

2. Check/Adjust P-P AUTO LEVEL Range (R335-R336)

a. Reset the Type 7B51 TRIGGERING MODE to P-P AUTO. Increase the sine-wave generator output to display a six division signal.

b. CHECK—A triggered display is obtained throughout 360° rotation of the LEVEL/SLOPE control.

c. ADJUST—R335 for a triggered display as the LEVEL/SLOPE control is rotated from 0/+ clockwise through top center to 0/—.

d. ADJUST—R336 for a triggered display as the LEVEL/SLOPE control is rotated from 0/+ counterclockwise through bottom center to 0/—.

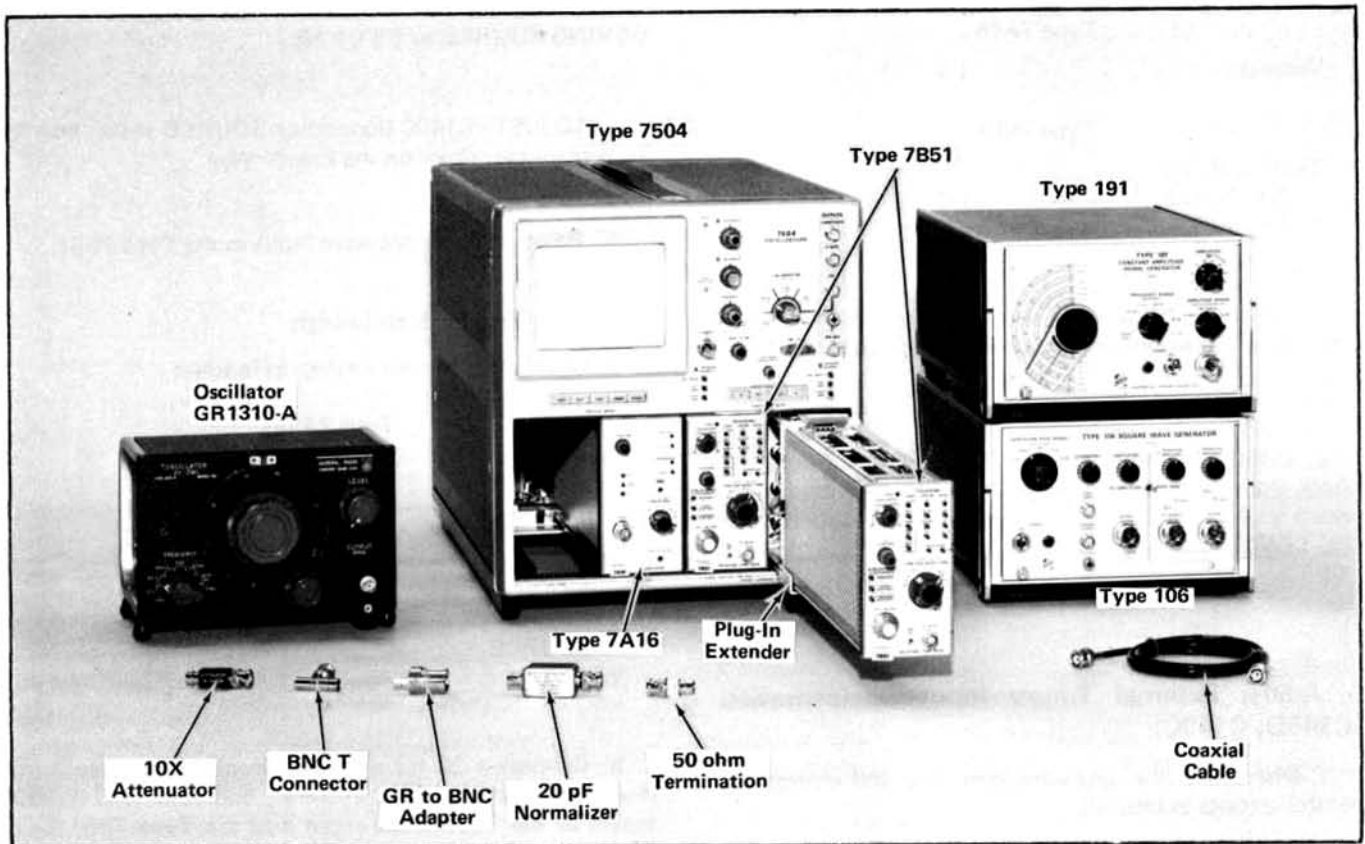


Fig. 5-1. Test equipment required for steps 1 through 8.

3. Check/Adjust Internal Trigger Centering (R135)

a. Reset the Type 7B51 TRIGGERING MODE to NORM, COUPLING to DC, SOURCE to INT and LEVEL/SLOPE to 0/+.

b. Center the 50 kHz sinewave vertically on the CRT so the display extends an equal distance above and below the center horizontal line.

c. CHECK—The trigger point is at the center horizontal line.

d. ADJUST—R135 to move the trigger point to the center horizontal line.

e. CHECK—Change the Type 7A16 Position control and check that the trigger point remains fixed at the center horizontal line.

4. Check Level/Slope Range

a. Change the control settings as follows:

Type 7A16	
Volts/div	1 V
Type 7B51	
TRIGGERING	
COUPLING	AC
SOURCE	EXT

b. Set the low-frequency sine-wave generator to 50 kHz and adjust the amplitude for a seven division display on the CRT.

c. CHECK—Rotate the LEVEL/SLOPE control and check that all levels of the display may be selected as the sweep trigger point. Check for no trigger (no display) with the LEVEL/SLOPE control near the top and near the bottom.

5. Adjust External Trigger Input Compensation (C145D, C140C)

a. Disconnect the sine-wave generator and change the control settings as follows:

Type 7A16	
Volts/div	.1 V

Type 7B51

TIME/DIV	1 ms
TRIGGERING	
COUPLING	DC
MODE	AUTO
SOURCE	INT

b. Connect a 1 kHz square wave from the Type 106 Hi-Amplitude output through a GR to BNC female adapter, a BNC coaxial cable, a 10X attenuator, a 50 ohm termination and a 20 pF normalizer to the Type 7A16 input. Adjust the Type 106 amplitude for a five division display.

c. Reset the Type 7B51 SOURCE to EXT. Connect the 1 kHz signal through the 10X attenuator, 50 ohm termination and 20 pF normalizer to the Type 7B51 EXT TRIG IN.

d. Connect a 1X probe from the Type 7A16 input to TP 217 (Type 7B51 trigger generator board).

e. ADJUST—C145D (located on COUPLING switch board) for best square corner on the square wave.

f. Remove the 10X attenuator and change the TRIGGERING SOURCE to EXT ÷ 10.

g. ADJUST—C140C (located on SOURCE switch board) for best square corner on the square wave.

h. Remove the square-wave input to the Type 7B51.

6. Check Trigger Bandwidth

a. Change the control settings as follows:

Type 7A16,	
Volts/Div	.5 V
Type 7B51	
TRIGGERING	
MODE	P-P AUTO
COUPLING	AC
SOURCE	INT
TIME/DIV	10 ms

b. Connect a 30 Hz sine wave from the low-frequency sine-wave generator through a "T" connector and coaxial cables to the Type 7A16 input and the Type 7B51 EXT TRIG IN. Adjust the sine-wave amplitude for a 0.3 division display. Reset the Type 7B51 TRIGGERING MODE to NORM.

TABLE 5-1

Type 7B51 COUPLING	SOURCE	sine-wave Gen. frequency	Stable Triggering	TRIG'D lamp lighted
AC	INT	30 Hz	yes	yes
AC	EXT	30 Hz	yes	yes
AC HF REJ	EXT	30 Hz	yes	yes
AC HF REJ	INT	30 Hz	yes	yes
DC	INT	30 Hz	yes	yes
DC	EXT	30 Hz	yes	yes
AC LF REJ	INT	30 kHz	yes	yes
AC HF REJ	INT	50 kHz	yes	yes
AC HF REJ	EXT	50 kHz	yes	yes
AC LF REJ	EXT	150 kHz	yes	yes
AC LF REJ	EXT	120 Hz	no trigger with 1.5 V	

c. CHECK—Stable triggering can be obtained with the LEVEL/SLOPE control at 0/+ and 0/-. Check that the TRIG'D lamp is lit.

d. CHECK—Using the control settings in Table 5-1, check for stable triggered and a lighted TRIG'D lamp for each condition listed. Maintain a 0.3 division display, except as noted. Use the Type 7B51 TIME/DIV control as necessary for optimum viewing of display.

e. Change the "T" connector from the low-frequency sine-wave generator to the Type 191 signal generator output connector (using a GR to BNC adapter). Set the Type 191 to 10 MHz and adjust the amplitude for a 0.3 division (150 mV) display.

f. CHECK—Using the control settings in Table 5-2, check for stable triggering and that the TRIG'D lamp is lighted for each condition listed. Note that the Type 191 amplitude is increased at 100 MHz.

7. Check Sweep Jitter

a. Set the Type 191 to 75 MHz. Set the Type 7B51 TIME/DIV to .05 μ s and MAGNIFIER to X10.

b. CHECK—For no more than 0.2 div (1 ns) of jitter. Disregard any slow drift.

8. Check Trigger Modes

a. Change the control settings as follows:

Type 7B51	
TIME/DIV	.1 μ s
TRIGGERING	
MODE	P-P AUTO
COUPLING	AC
SOURCE	INT

b. Set the Type 191 to 50 MHz and adjust the amplitude for a four division display.

c. CHECK—Turn the LEVEL/SLOPE control throughout its range and check for proper triggering at all positions. Remove the signal from the Type 7A16 and check for a free-running trace.

d. Reset the Type 7B51 TRIGGERING MODE to AUTO. Reconnect the 50 MHz signal to the Type 7A16.

e. CHECK—For proper triggering with the LEVEL/SLOPE control at 0/+ and 0/-. Check for a free-running display with the LEVEL/SLOPE control near the top and near the bottom.

f. Reset the Type 7B51 TRIGGERING MODE to NORM.

TABLE 5-2

Type 7B51 COUPLING	SOURCE	Type 191 frequency	amplitude	Stable Triggering	TRIG'D lamp
DC	EXT	10 MHz	0.3 div	yes	yes
DC	INT	10 MHz	0.3 div	yes	yes
AC LF REJ	INT	10 MHz	0.3 div	yes	yes
AC LF REJ	EXT	10 MHz	0.3 div	yes	yes
AC	EXT	10 MHz	0.3 div	yes	yes
AC	INT	10 MHz	0.3 div	yes	yes
AC	INT	100 MHz	1.5 div	yes	yes
AC	EXT	100 MHz	1.5 div	yes	yes
AC LF REJ	EXT	100 MHz	1.5 div	yes	yes
AC LF REJ	INT	100 MHz	1.5 div	yes	yes
DC	INT	100 MHz	1.5 div	yes	yes
DC	EXT	100 MHz	1.5 div	yes	yes

Performance Check/Calibration—Type 7B51

g. CHECK—For proper triggering with the LEVEL/SLOPE control at 0/+ and 0/-. Check for no trace with the LEVEL/SLOPE control near the top and near the bottom.

h. Reset the Type 7B51 TIME/DIV to 50 μ s and MAGNIFIER to X1. Set the Type 191 to 50 kHz and adjust the amplitude for a four division display. Adjust the Type 7B51 LEVEL/SLOPE for a stable display. Reset the TRIGGERING MODE to SINGLE SWEEP.

i. CHECK—Remove the signal from the Type 7A16. Press the Type 7B51 RESET button and check that the READY lamp is lighted. While observing the display, reconnect the signal to the Type 7A16 and check for one displayed sweep (it may be necessary to increase the INTENSITY to observe the display). Check that the READY lamp is out at the end of the sweep.

j. Reset the Type 7B51 TRIGGERING MODE to P-P AUTO and SOURCE to EXT. Adjust the Type 191 for a 1.5 division (750 mV) display.

k. CHECK—Rotate the LEVEL/SLOPE throughout its range and check for stable triggering at all positions.

l. Change the "T" connector from the Type 191 to the low-frequency sine-wave generator output connector.

m. Set the Type 7B51 TRIGGERING COUPLING to DC and SOURCE to INT. Set the Time/Div to 10 ms.

n. Set the low-frequency sine-wave generator to 50 Hz and adjust the amplitude for a 2 division display.

o. CHECK—A stable display can be obtained.

p. Remove the 50 Hz signal from the Type 7A16 and Type 7B51.

9. Check/Adjust Sweep Calibration (SWP CAL, a front-panel adjustment)

a. Reset the Type 7B51 TIME/DIV to 1 ms and COUPLING to AC.

b. Apply 1 ms markers from the Type 184 time-mark generator to the Type 7A16 Input.

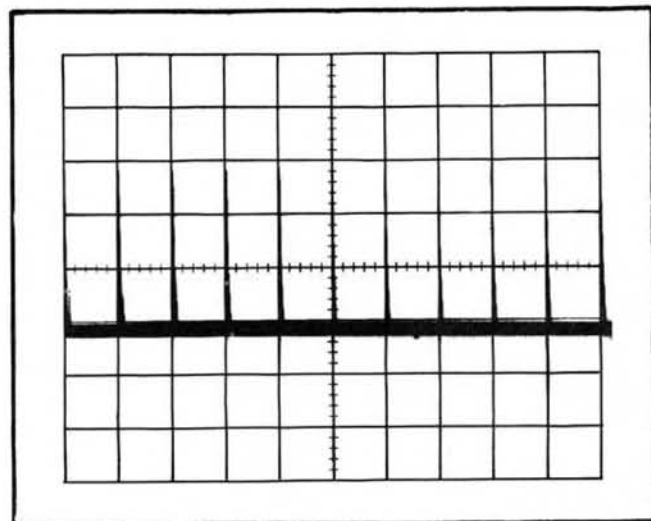


Fig. 5-2. Typical CRT display showing correct sweep calibration.

c. CHECK—CRT display for one 1 ms marker for each division between the second and tenth vertical lines (see Fig. 5-2).

NOTE

Unless otherwise noted, use the center eight horizontal divisions when checking or adjusting timing.

d. ADJUST—SWP CAL, a front-panel adjustment, for one marker for each division. The second and tenth markers must line up exactly with their respective graticule lines (use the horizontal POSITION control as necessary to line up the display).

e. CHECK—Timing accuracy is within 5% over any two division interval within the center eight divisions.

f. INTERACTION: Check 10, 11, 13, 14, 15, 16 and 17.

10. Check/Adjust Magnified Sweep Gain (R785)

a. Set the time-mark generator for .1 ms markers.

b. Set the Type 7B51 MAGNIFIER to X10.

c. CHECK—CRT display for one .1 ms marker for each division between the second and tenth vertical lines.

d. ADJUST—R785, Magnifier Gain, for one marker for each division (use the horizontal POSITION control as necessary to line up the display).

e. **CHECK**—Timing accuracy is within 5% over any two division interval within the center eight divisions.

f. **INTERACTION**: Check steps 11 and 17.

11. Check/Adjust Magnifier Registration (R795)

a. Set the time-mark generator for 5 ms markers.

b. Position the middle marker to the center vertical line (there are three markers on the total magnified sweep) with the horizontal **POSITION** control. See Fig. 5-3A.

c. Set the **MAGNIFIER** to X1.

d. **CHECK**—Middle marker remains at the center vertical line. See Fig. 5-3B.

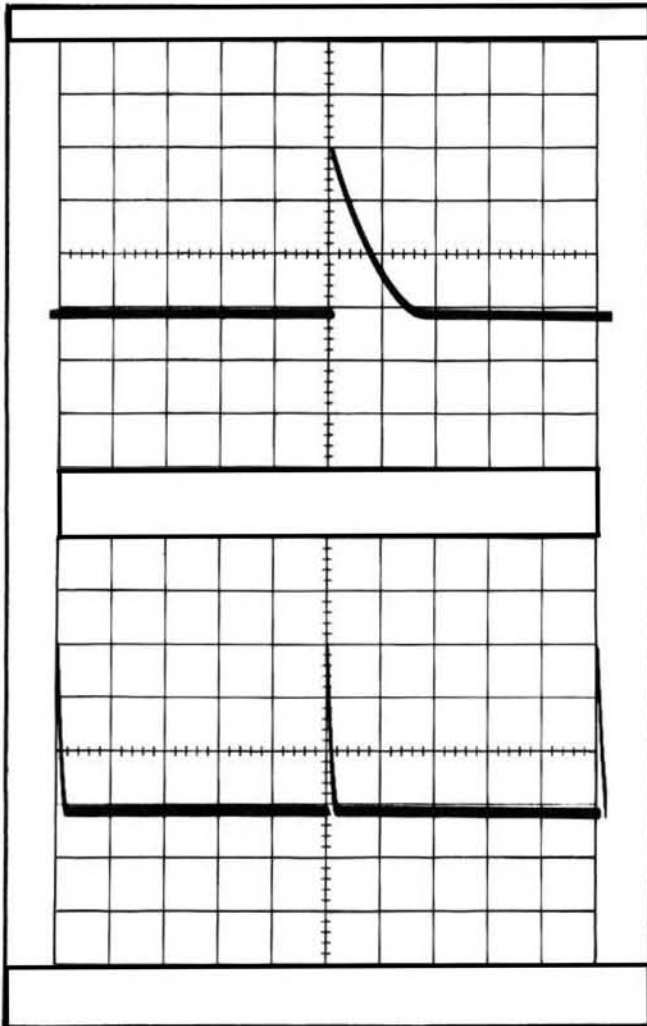


Fig. 5-3. Typical CRT display showing correct magnifier registration. (A) **MAGNIFIER** set to X10, (B) **MAGNIFIER** set to X1.

e. **ADJUST**— R795, Mag Regis, to position the middle marker to the center vertical line.

f. Alternately switch the **MAGNIFIER** between X1 and X10 and repeat steps b through e until no shift occurs when switching.

12. Check Sweep Length

a. Set the time-mark generator for 1 ms and .1 ms markers. Reset the **MAGNIFIER** to X1. Set the **TRIGGERING MODE** to **AUTO**.

b. Move the eleventh 1 ms marker to the center vertical line with the horizontal **POSITION** control (see Fig. 5-4).

c. **CHECK**—Sweep length must be between 10 and 13 divisions.

13. Check Variable Time/Div

a. Reset the Type 7B51 **TIME/DIV** to 2 ms. Set the time-mark generator for 10 ms markers.

b. Press and release the **VARIABLE TIME/DIV** knob and turn fully counterclockwise.

c. **CHECK**—CRT display for two-division maximum spacing between markers (indicates adequate range for continuously variable sweep rate between the calibrated steps; see Fig. 5-5). Return the **VARIABLE TIME/DIV** to the **CAL IN** position.

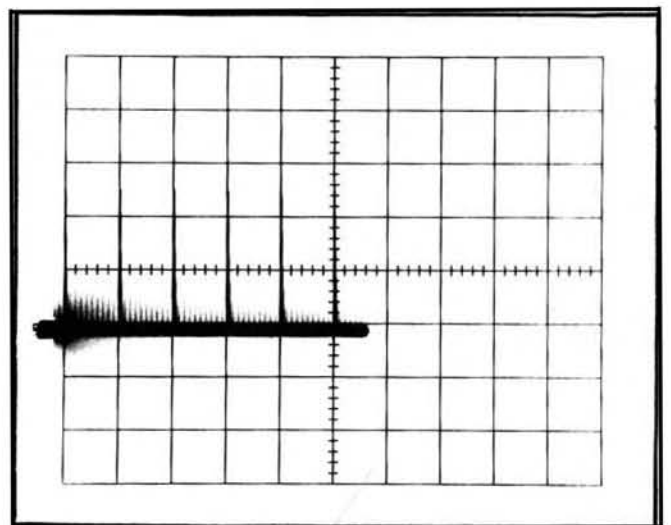


Fig. 5-4. Typical CRT display when checking sweep length.

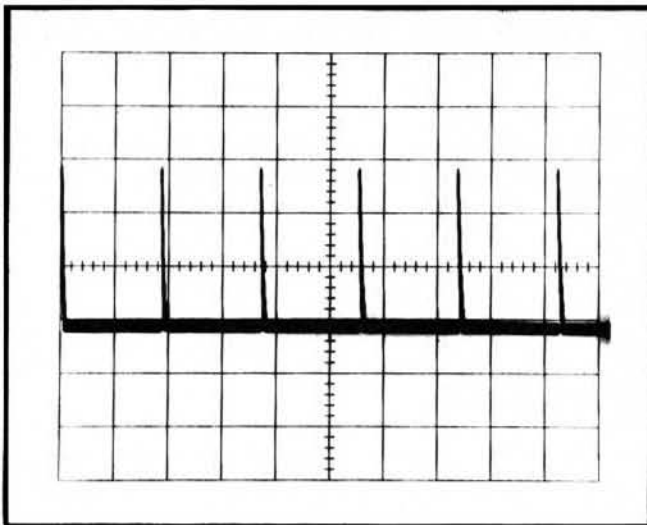


Fig. 5-5. Typical CRT display when checking VARIABLE control range.

14. Check/Adjust 5 μ s Timing (C530J)

- Set the time-mark generator for 5 μ s markers.
- Reset the Type 7B51 TIME/DIV to 5 μ s, TRIGGERING MODE to AUTO, and adjust the LEVEL/SLOPE for a stable display.
- CHECK—CRT display for one marker each division between the second and tenth vertical lines. Check that sweep timing is within 0.16 division (2%) over the center eight divisions. See Fig. 5-6.

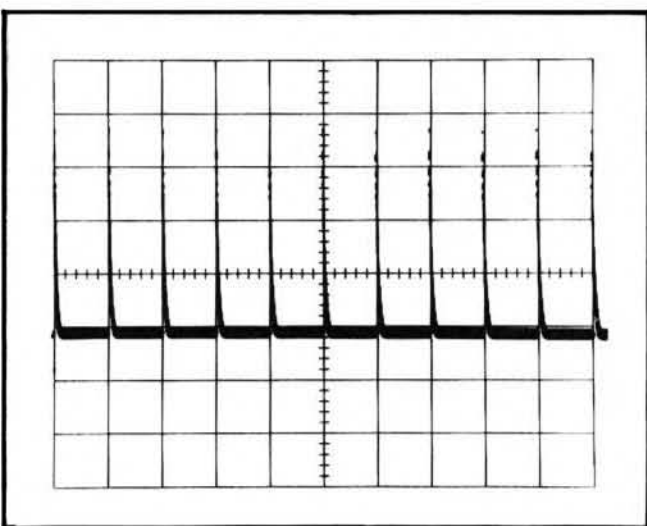


Fig. 5-6. CRT display showing correct 5 μ s timing.

- ADJUST—C503J for one marker each division. The second and tenth markers must coincide exactly with their respective graticule lines (use the horizontal POSITION control as necessary to line up display).

15. Check/Adjust 0.2 μ s Timing (C530L)

- Set the time-mark generator for .1 μ s markers.
- Reset the Type 7B51 TIME/DIV to .2 μ s.
- CHECK—CRT display for two markers each division over the center eight divisions. Check that sweep timing is within 0.16 division (2%) over center eight divisions. See Fig. 5-7.
- ADJUST—C530L for two markers each division. The markers at the second and tenth vertical lines must coincide exactly with their respective graticule lines (use the horizontal POSITION control as necessary to line up the display).

16. Check Sweep Timing Accuracy

- Using the TIME/DIV and time-mark generator settings given in Table 5-3, check that sweep timing accuracy over the center eight divisions of the display is within allowable limits.

17. Check Magnified Sweep Timing

- Set the Type 7B51 Magnifier to X10.

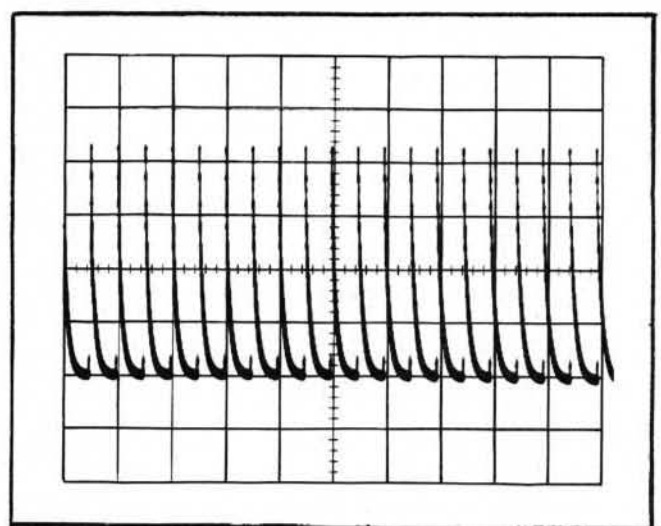


Fig. 5-7. CRT display showing correct .2 μ s timing.

TABLE 5-3

Type 7B51 TIME/DIV	Type 184 Markers	Markers/ Div	Allowable Error
.05 μ s	50 ns	1	± 0.16 div
.1 μ s	.1 μ s	1	± 0.16 div
.2 μ s	.1 μ s	2	± 0.16 div
.5 μ s	.5 μ s	1	± 0.16 div
1 μ s	1 μ s	1	± 0.16 div
2 μ s	1 μ s	2	± 0.16 div
5 μ s	5 μ s	1	± 0.16 div
10 μ s	10 μ s	1	± 0.16 div
20 μ s	10 μ s	2	± 0.16 div
50 μ s	50 μ s	1	± 0.16 div
.1 ms	.1 ms	1	± 0.16 div
.2 ms	.1 ms	2	± 0.16 div
.5 ms	.5 ms	1	± 0.16 div
1 ms	1 ms	1	± 0.16 div
2 ms	1 ms	2	± 0.16 div
5 ms	5 ms	1	± 0.16 div
10 ms	10 ms	1	± 0.16 div
20 ms	10 ms	2	± 0.16 div
50 ms	50 ms	1	± 0.16 div
.1 s	.1 s	1	± 0.16 div
.2 s	.1 s	2	± 0.16 div
.5 s	.5 s	1	± 0.16 div
1 s	1 s	1	± 0.24 div
2 s	1 s	2	± 0.24 div
5 s	5 s	1	± 0.24 div

b. CHECK—Using the TIME/DIV and time-mark generator settings given in Table 5-4, check that sweep timing accuracy over the center eight divisions is within the allowable limits.

c. Reset the MAGNIFIER to X1.

18. Check Sweep Inhibit

a. Set the time-mark generator for 1 ms markers.

b. Set the Type 7B51 TRIGGERING MODE to NORM, TIME/DIV to 50 μ s and adjust the LEVEL/SLOPE control for a triggered sweep.

c. Reset the Type 7504 Horizontal Mode to A; set the Test Time-Base Triggering Mode to Norm, Time/div to 1 ms and adjust Level Slope control for a triggered display.

d. Reset the Test Time-Base B Display Mode to B Starts After Delay.

e. CHECK—While rotating the Test Time-Base Delay Time Multiplier dial, check that the intensified portion may be positioned to any part of the sweep.

f. Reset the Test Time-Base B Delay Mode to B Triggerable After Delay.

g. CHECK—Turn the DELAY TIME MULTIPLIER dial and check that the intensified portion always starts at one of the 1 ms markers.

DELAY TIMING

Place the Test Time-Base in the indicator oscilloscope right (B) horizontal compartment and the Type 7B51 in the left (A) horizontal compartment. Change the control settings as follows:

TABLE 5-4

Type 7B51 TIME/DIV	Type 184 Markers	Markers Div	Allowable Error
5 s	.5 s	1	± 0.36 div
2 s	.1 s	2	± 0.36 div
1 s	.1 s	1	± 0.36 div
.5 s	50 ms	1	± 0.2 div
.2 s	10 ms	2	± 0.2 div
.1 s	10 ms	1	± 0.2 div
50 ms	5 ms	1	± 0.2 div
20 ms	1 ms	2	± 0.2 div
10 ms	1 ms	1	± 0.2 div
5 ms	.5 ms	1	± 0.2 div
2 ms	.1 ms	2	± 0.2 div
1 ms	.1 ms	1	± 0.2 div
.5 ms	50 μ s	1	± 0.2 div
.2 ms	10 μ s	2	± 0.2 div
.1 ms	10 μ s	1	± 0.2 div
50 μ s	5 μ s	1	± 0.2 div
20 μ s	1 μ s	2	± 0.2 div
10 μ s	1 μ s	1	± 0.2 div
5 μ s	.5 μ s	1	± 0.2 div
2 μ s	.1 μ s	2	± 0.2 div
1 μ s	.1 μ s	1	± 0.2 div
.5 μ s	50 ns	1	± 0.2 div
.2 μ s	20 ns	1	± 0.2 div
.1 μ s	10 ns	1	± 0.2 div
.05 μ s	5 ns ¹	1	± 0.2 div

¹Type 184 H.F. Selector Output

Performance Check/Calibration—Type 7B51

Type 7B51

LEVEL/SLOPE	0/+
TRIGGERING	
MODE	AUTO
COUPLING	AC
SOURCE	INT
MAGNIFIER	X1
B DELAY MODE	B STARTS AFTER DELAY
TIME/DIV	1 ms
DELAY TIME MULTIPLIER	1.00

Test Time Base

Level Slope	0/+
Triggering	
Mode	Norm
Coupling	AC
Source	Int
Magnifier	X1
B Delay Mode	Independent
Time/Div	10 μ s

19. Check/Adjust Delay Start (R590) and Delay Stop (R500)

a. With the Type 7B51 DELAY TIME MULTIPLIER fully counterclockwise, check that 0.00 is aligned with the index.

b. Set the time-mark generator for 1 ms markers. Adjust the Type 7B51 LEVEL/SLOPE for a display triggered on the positive slope of the marker. Set the Type 7B51 DELAY TIME MULTIPLIER to 1.00.

c. CHECK—The intensified portion of the sweep starts at the second marker (see Fig. 5-8).

d. ADJUST—Delay Start (R590) so the intensified portion of the sweep starts at the second marker.

e. Reset the Type 7B51 DELAY TIME MULTIPLIER to 9.00.

f. CHECK—The intensified portion of the sweep starts at the tenth marker (see Fig. 5-9).

g. ADJUST—Delay Stop (R500) so the intensified portion of the sweep starts at the tenth marker.

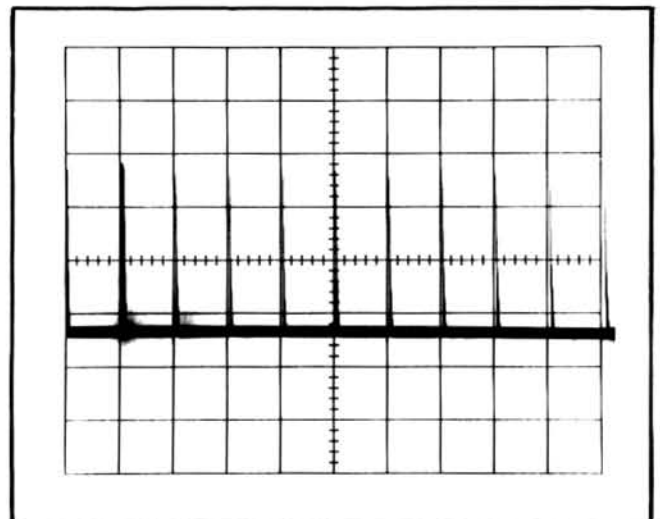


Fig. 5-8. Typical CRT display showing correct setting of delay start.

h. Change the Type 7504 Horizontal Mode to Alt and the Type 7B51 DELAY TIME MULTIPLIER to 1.00.

i. CHECK—The second marker begins at the start of the delayed (B) sweep (see Fig. 5-10).

j. ADJUST—Delay start (R590) so the second marker begins at the start of the delayed sweep.

k. Reset the DELAY TIME MULTIPLIER to 9.00.

l. CHECK—The tenth marker begins at the start of the delayed (B) sweep.

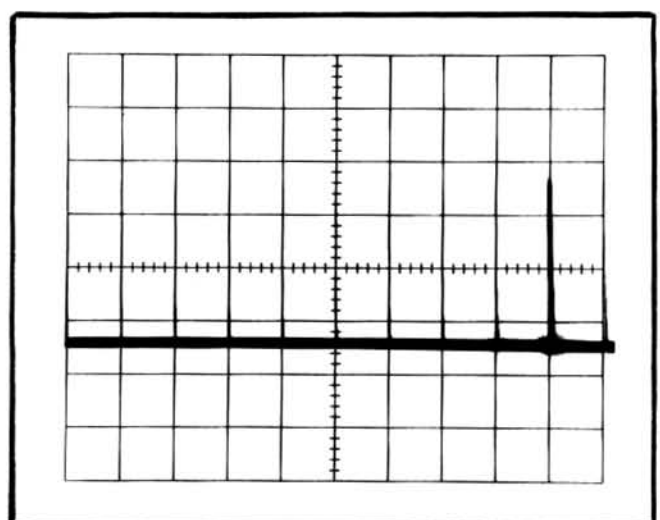


Fig. 5-9. Typical CRT display showing correct setting of delay stop.

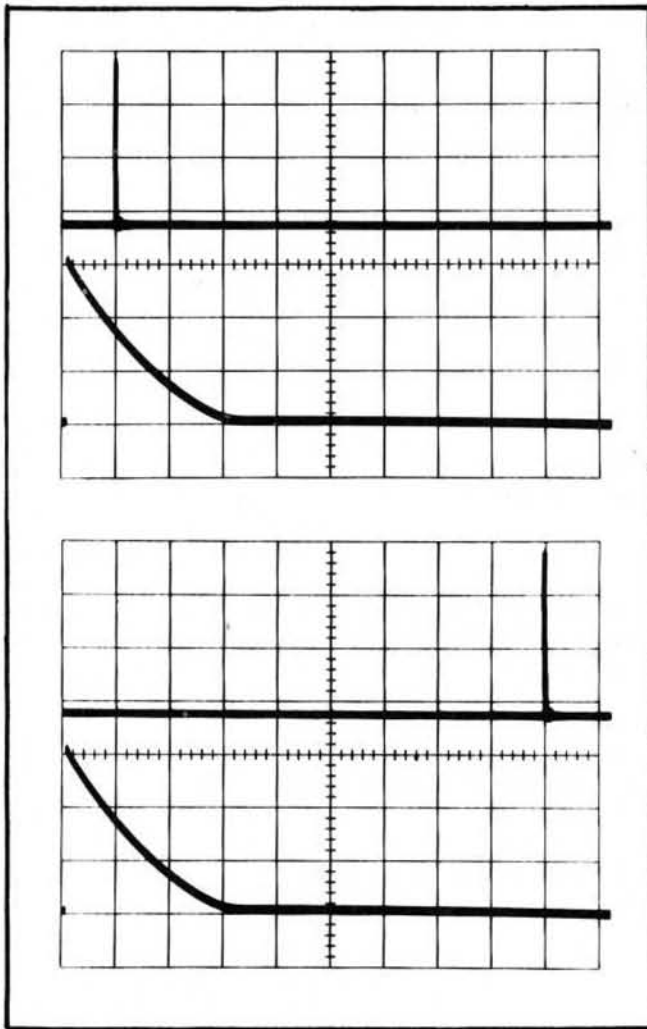


Fig. 5-10. Typical CRT display showing delay adjustments correctly set.

m. ADJUST—Delay Stop (R500) so the tenth marker begins at the start of the delayed (B) sweep.

NOTE

The Delay Start and Delay Stop adjustment interact. Repeat steps b through m as necessary.

20. Check Delay Time Multiplier Accuracy

a. Set the Type 7B51 DELAY TIME MULTIPLIER near 8.00 so the ninth marker begins at the start of the delayed sweep.

b. CHECK—The DELAY TIME MULTIPLIER deviation from 8.00 is within one minor division.

c. Repeat this check at each major dial division of the DELAY TIME MULTIPLIER between 1.00 and 9.00.

21. Check Delay Time Accuracy

a. Set the Type 7B51 DELAY TIME MULTIPLIER near 1.00.

b. CHECK—Using the settings given in Table 5-5, check the delay time accuracy is within the given tolerance. First set the DELAY TIME MULTIPLIER near 1.00. Adjust the DELAY TIME MULTIPLIER until the second marker starts at the beginning of the delayed (B) sweep; note the deviation from 1.00. Next, set the DELAY TIME MULTIPLIER near 9.00 and adjust until the tenth marker starts at the beginning of the delayed sweep; note the deviation from 9.00. Subtract the first reading from the second reading. The difference must be eight divisions \pm the allowable error given in Table 5-5.

TABLE 5-5

Type 7B51 DELAY TIME	Test Time-Base Time-div	Type 184 Markers	Allowable Error
1 μ s	.1 μ s	1 μ s	± 6 minor dial divisions
2 μ s	.1 μ s	1 μ s	
5 μ s	.5 μ s	5 μ s	
10 μ s	1 μ s	10 μ s	
20 μ s	1 μ s	10 μ s	
50 μ s	5 μ s	50 μ s	
.1 ms	10 μ s	.1 ms	
.2 ms	10 μ s	.1 ms	
.5 ms	50 μ s	.5 ms	
10 ms	1 ms	10 ms	
20 ms	1 ms	10 ms	
50 ms	5 ms	50 ms	
.1 s	10 ms	.1 s	± 10 minor dial divisions
.2 s	10 ms	.1 s	
.5 s	50 ms	.5 s	
1 s	.1 s	1 s	
2 s	.1 s	1 s	
5 s	.5 s	5 s	

22. Check Delay Time Jitter

a. Change the following control settings:

Test Time-Base

Time/Div .2 μ s

Type 7B51

DLY TIME 1 ms
DELAY TIME MULTIPLIER near 10.00

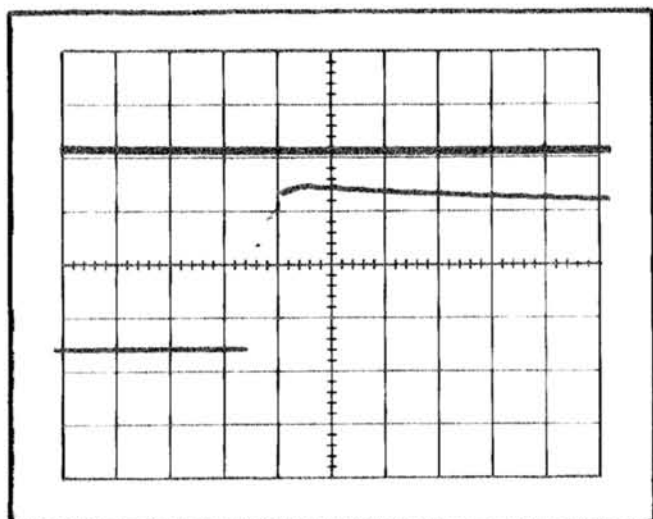


Fig. 5-11. Typical CRT display showing delay time jitter.

b. Apply 1 ms markers from the time-mark generator. Position the eleventh marker near the center of the display with the DELAY TIME MULTIPLIER.

c. CHECK—Jitter on the leading edge of the pulse does not exceed 1 division (1 part in 50,000 of 10 times the TIME/DIV setting). See Fig. 5-11. Disregard any slow drift.

d. Disconnect the time-mark generator.

23. Check Line Trigger Source

a. Change the following control settings:

Type 7B51

TRIGGERING	
MODE	NORM
COUPLING	AC
SOURCE	LINE
TIME/DIV	5 ms

Type 7A16

Volts/div	1 V
AC-Gnd-DC	AC

b. Connect a 1X probe from the Type 7A16 input to interface connector A4 (plug-in connector at the rear of the Type 7B51).

c. CHECK—For stable triggering of the proper polarity at 0/+ and 0/− of the LEVEL/SLOPE control.

d. Disconnect all test equipment.

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	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

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.

INDEX OF ELECTRICAL PARTS LIST

Title	Page No.
CHASSIS	6-1
INTERFACE Circuit Board Assembly	6-2
TIME BASE Circuit Board Assembly	6-3
TRIGGER Circuit Board Assembly	6-11
DELAY MODE Circuit Board Assembly	6-17
SOURCE Circuit Board Assembly	6-17
MODE AUTO Circuit Board Assembly	6-18
COUPLING Circuit Board Assembly	6-18
MAGNIFIER Circuit Board Assembly	6-19

SECTION 6

ELECTRICAL PARTS LIST

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
----------	-----------------------	-------------------------	------	-------------

CHASSIS

Bulb

DS328	150-0048-00			Incandescent #683
-------	-------------	--	--	-------------------

Capacitors

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

C142	281-0632-00		35 pF	Cer	500 V	1%
C530A			10 μ F			
C530B			1 μ F			
C530E	*295-0122-00		0.1 μ F			
C530F			0.01 μ F			
C530H			995 pF			

Timing capacitor assembly

Connector

J141	131-0352-02	B010100	B019999	Receptacle, electrical, BNC
J141	131-0955-00	B020000		Receptacle, electrical, BNC

Resistors

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

R141	323-0452-00		499 k Ω	1/2 W	Prec	1%
R142	315-0101-00		100 Ω	1/4 W		5%
R260A, B ¹	*311-0972-00		10 k Ω x 10 k Ω , Var			
R505	311-0946-00		50 k Ω , Var			
R531	311-0959-00		10 k Ω , Var			

R740	311-0486-00		500 Ω , Var			
R744A, B	*311-0965-00	B010100	10 k Ω x 10 k Ω , Var	B079999		
R744A, B	311-1162-00	B080000	10 k Ω x 10 k Ω , Var			

Switch

Wired or Unwired

S260 ²	*311-0972-00
-------------------	--------------

¹Furnished as a unit with S260.²Furnished as a unit with R260A,B.

INTERFACE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Description
	*670-1100-00	B010100	B109999	Complete Board
	*670-1100-01	B110000		Complete Board

Capacitors

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

C143	283-0080-00	0.022 μ F	Cer	25 V	+ 80% — 20%
C530P	281-0523-00	100 pF	Cer	350 V	
C530R	281-0536-00	1000 pF	Cer	500 V	10%
C831	283-0080-00	0.022 μ F	Cer	25 V	+ 80% — 20%

Semiconductor Device, Diodes

CR461	*152-0185-00	XB110000	Silicon	Replaceable by 1N4152
CR531	*152-0185-00		Silicon	Replaceable by 1N4152
CR702	*152-0185-00		Silicon	Replaceable by 1N4152
CR703	*152-0185-00		Silicon	Replaceable by 1N4152
CR704	*152-0185-00		Silicon	Replaceable by 1N4152
CR705	*152-0185-00		Silicon	Replaceable by 1N4152
CR711	*152-0185-00		Silicon	Replaceable by 1N4152
CR712	*152-0185-00		Silicon	Replaceable by 1N4152
CR721	*152-0185-00		Silicon	Replaceable by 1N4152
CR722	*152-0185-00		Silicon	Replaceable by 1N4152

Resistors

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

R143	315-0472-00	4.7 k Ω	$\frac{1}{4}$ W		5%
R144	315-0101-00	100 Ω	$\frac{1}{4}$ W		5%
R328	315-0200-00	20 Ω	$\frac{1}{4}$ W		5%
R381	321-0193-00	1 k Ω	$\frac{1}{8}$ W	Prec	1%
R382	321-0193-00	1 k Ω	$\frac{1}{8}$ W	Prec	1%
R383	315-0432-00	4.3 k Ω	$\frac{1}{4}$ W		5%
R460	315-0472-00	4.7 k Ω	$\frac{1}{4}$ W		5%
R461	315-0752-00	7.5 k Ω	$\frac{1}{4}$ W		5%
R530A	323-0568-08	8.06 M Ω	$\frac{1}{2}$ W	Prec	1%
R530B	323-0557-08	6.19 M Ω	$\frac{1}{2}$ W	Prec	1%
R530C	323-0546-08	4.75 M Ω	$\frac{1}{2}$ W	Prec	1%
R530D	323-0546-08	4.75 M Ω	$\frac{1}{2}$ W	Prec	1%
R530F	323-0767-07	1.425 M Ω	$\frac{1}{2}$ W	Prec	1/10%
R530H	323-0450-07	475 k Ω	$\frac{1}{2}$ W	Prec	1/10%
R530J	323-0450-07	475 k Ω	$\frac{1}{2}$ W	Prec	1/10%
R530K	323-0774-07	118.7 k Ω	$\frac{1}{2}$ W	Prec	1/10%
R530L	323-0774-07	118.7 k Ω	$\frac{1}{2}$ W	Prec	1/10%
R530M	321-0267-00	5.9 k Ω	$\frac{1}{8}$ W	Prec	1%
R530P	315-0330-00	33 Ω	$\frac{1}{4}$ W		5%
R530R	315-0220-00	22 Ω	$\frac{1}{4}$ W		5%
R531	311-0959-00	10 k Ω , Var			
R701	315-0154-00	150 k Ω	$\frac{1}{4}$ W		5%
R702	315-0133-00	13 k Ω	$\frac{1}{4}$ W		5%
R704	315-0154-00	150 k Ω	$\frac{1}{4}$ W		5%
R705	321-0344-00	37.4 k Ω	$\frac{1}{8}$ W	Prec	1%

INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R706	315-0753-00		75 kΩ	1/4 W		5%
R711	315-0753-00		75 kΩ	1/4 W		5%
R712	315-0154-00		150 kΩ	1/4 W		5%
R713	315-0753-00		75 kΩ	1/4 W		5%
R721	315-0753-00		75 kΩ	1/4 W		5%
R722	315-0154-00		150 kΩ	1/4 W		5%
R723	315-0154-00		150 kΩ	1/4 W		5%
R724	321-0356-00		49.9 kΩ	1/8 W	Prec	1%
R727	321-0335-00		30.1 kΩ	1/8 W	Prec	1%
R728	321-0344-00		37.4 kΩ	1/8 W	Prec	1%
R729	315-0154-00		150 kΩ	1/4 W		5%
R741	315-0470-00		47 Ω	1/4 W		5%
R830	315-0160-00		16 Ω	1/4 W		5%

Switches**Wired or Unwired**

S530 ³	*670-1100-00	B010100	B109999	Cam	TIME/DIV or DLY TIME
S530 ³	*670-1100-01	B110000		Cam	TIME/DIV or DLY TIME
S531 ³	*670-1100-00	B010100	B109999	Push-push	CAL IN
S531 ³	*670-1100-01	B110000		Push-push	CAL IN

TIME BASE Circuit Board Assembly

*670-1101-00	B010100	B019999	Complete Board
*670-1101-01	B020000	B049999	Complete Board
*670-1101-02	B050000	B069999	Complete Board
*670-1101-03	B070000	B099999	Complete Board
*670-1101-04	B100000		Complete Board

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

C406	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C409	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C421	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C431	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C434	281-0577-00		14 pF	Cer	500 V	5%
C441	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%
C446	290-0136-00		2.2 μ F	Elect.	20 V	
C456	290-0135-00	B010100	15 μ F	Elect.	20 V	
C456	290-0136-00	B060000	2.2 μ F	Elect.	20 V	
C457	281-0524-00		150 pF	Cer	500 V	
C466	283-0080-00		0.022 μ F	Cer	25 V	+80%—20%

³See Mechanical Parts List for replacement parts.

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Capacitors (cont)						
C469	283-0000-00			0.001 μ F	Cer	500 V
C488	290-0136-00			2.2 μ F	Elect.	20 V
C497	290-0136-00			2.2 μ F	Elect.	20 V
C499	290-0136-00			2.2 μ F	Elect.	20 V
C501	290-0134-00			22 μ F	Elect.	15 V
C516	283-0080-00			0.022 μ F	Cer	25 V
C524	281-0525-00			470 pF	Cer	500 V
C527	281-0523-00			100 pF	Cer	350 V
C530J	281-0093-00			5.5-18 pF, Var	Cer	
C530K	283-0126-00			82 pF	Cer	1000 V
C530L	281-0091-00			2-8 pF, Var	Cer	
C530M	281-0657-00			13 pF	Cer	500 V
C532	283-0080-00			0.022 μ F	Cer	25 V
C534	281-0626-00	B010100	B099999	3.3 pF	Cer	500 V
C534	281-0544-00	B100000		5.6 pF	Cer	500 V
C536	290-0136-00			2.2 μ F	Elect.	20 V
C538	281-0549-00			68 pF	Cer	500 V
C545	290-0136-00			2.2 μ F	Elect.	20 V
C551	281-0523-00			100 pF	Cer	350 V
C556	281-0552-00			25 pF	Cer	500 V
C561	290-0136-00			2.2 μ F	Elect.	20 V
C580A	283-0164-00			2.2 μ F	Cer	25 V
C580B	283-0191-00			0.022 μ F	Cer	50 V
C580D	283-0666-00			890 pF	Mica	100 V
C581	281-0546-00	XB070000		330 pF	Cer	500 V
C582	281-0504-00			10 pF	Cer	500 V
C583	283-0080-00			0.022 μ F	Cer	25 V
C591	281-0523-00			100 pF	Cer	350 V
C746	283-0080-00			0.022 μ F	Cer	25 V
C749	283-0080-00			0.022 μ F	Cer	25 V
C752	283-0080-00	XB050000		0.022 μ F	Cer	25 V
C763	281-0557-00			1.8 pF	Cer	500 V
C788	290-0284-00	B010100	B019999	4.7 μ F	Elect.	35 V
C788	283-0164-00	B020000		2.2 μ F	Cer	25 V
C789	283-0110-00	B010100	B019999	0.005 μ F	Cer	150 V
C789	283-0092-00	B020000		0.03 μ F	Cer	200 V
C799	290-0136-00			2.2 μ F	Elect.	20 V
C801	290-0177-00	B010100	B029999	1 μ F	Elect.	50 V
C801	290-0420-00	B030000		0.68 μ F	Elect.	75 V
C803	290-0136-00			2.2 μ F	Elect.	20 V
C805	290-0136-00			2.2 μ F	Elect.	20 V
C807	290-0136-00			2.2 μ F	Elect.	20 V
C809	283-0080-00			0.022 μ F	Cer	25 V
C811	283-0080-00			0.022 μ F	Cer	25 V
C813	290-0136-00			2.2 μ F	Elect.	20 V
C815	290-0136-00			2.2 μ F	Elect.	20 V

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Capacitors (cont)					
C817	290-0136-00			2.2 μ F	Elect. 20 V
C819	290-0136-00			2.2 μ F	Elect. 20 V
C820	290-0136-00			2.2 μ F	Elect. 20 V
C821	290-0177-00	B010100	B029999	1 μ F	Elect. 50 V
C821	290-0420-00	B030000		0.68 μ F	Elect. 75 V
Semiconductor Device, Diodes					
CR406	*152-0185-00			Silicon	Replaceable by 1N4152
CR412	*152-0185-00			Silicon	Replaceable by 1N4152
CR413	*152-0185-00			Silicon	Replaceable by 1N4152
CR414	*152-0185-00			Silicon	Replaceable by 1N4152
CR419	*152-0185-00			Silicon	Replaceable by 1N4152
CR427	*152-0185-00			Silicon	Replaceable by 1N4152
CR428	*152-0185-00			Silicon	Replaceable by 1N4152
CR431	*152-0185-00			Silicon	Replaceable by 1N4152
CR436	*152-0185-00			Silicon	Replaceable by 1N4152
CR446	*152-0185-00			Silicon	Replaceable by 1N4152
CR448	*152-0185-00			Silicon	Replaceable by 1N4152
CR449	*152-0185-00			Silicon	Replaceable by 1N4152
CR451	*152-0185-00			Silicon	Replaceable by 1N4152
CR452	*152-0185-00			Silicon	Replaceable by 1N4152
CR453	*152-0185-00			Silicon	Replaceable by 1N4152
CR454	*152-0185-00			Silicon	Replaceable by 1N4152
CR459	*152-0185-00			Silicon	Replaceable by 1N4152
CR462	*152-0185-00			Silicon	Replaceable by 1N4152
CR463	*152-0185-00			Silicon	Replaceable by 1N4152
CR464	*152-0185-00			Silicon	Replaceable by 1N4152
CR465	*152-0185-00			Silicon	Replaceable by 1N4152
CR466	*152-0185-00			Silicon	Replaceable by 1N4152
CR467	*152-0185-00			Silicon	Replaceable by 1N4152
CR468	*152-0185-00			Silicon	Replaceable by 1N4152
CR469	*152-0185-00			Silicon	Replaceable by 1N4152
CR472	*152-0185-00			Silicon	Replaceable by 1N4152
CR493	*152-0185-00			Silicon	Replaceable by 1N4152
CR494	*152-0185-00			Silicon	Replaceable by 1N4152
CR498	*152-0185-00			Silicon	Replaceable by 1N4152
CR526	*152-0185-00			Silicon	Replaceable by 1N4152
CR529	152-0246-00			Silicon	Low leakage 250 mW, 40 V
CR534	*152-0185-00			Silicon	Replaceable by 1N4152
CR548	152-0141-02			Silicon	1N4152
CR571	*152-0185-00			Silicon	Replaceable by 1N4152
CR572	*152-0185-00			Silicon	Replaceable by 1N4152
CR573	152-0279-00			Zener	1N751A 400 mW, 5.1 V, 5%
CR574	*152-0185-00			Silicon	Replaceable by 1N4152
VR576	152-0326-00			Zener	1N755A 400 mW, 7.5 V, 5%
CR578	*152-0185-00			Silicon	Replaceable by 1N4152
CR579	*152-0185-00			Silicon	Replaceable by 1N4152

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
Semiconductor Device, Diodes (cont)			
CR580	*152-0185-00	Silicon	Replaceable by 1N4152
CR581	*152-0185-00	Silicon	Replaceable by 1N4152
CR582	*152-0185-00	Silicon	Replaceable by 1N4152
CR596	152-0307-00	Silicon	Dual
CR597	*152-0185-00	Silicon	Replaceable by 1N4152
CR598	*152-0185-00	Silicon	Replaceable by 1N4152
Relay			
K780	*148-0034-00	Armature, dpdt	
Inductors			
L536	276-0507-00	Core, ferramic suppressor	
L593	*108-0440-00	8 μ H	
Transistors			
Q402	151-0188-00	Silicon	2N3906
Q406	151-0188-00	Silicon	2N3906
Q408	151-0188-00	Silicon	2N3906
Q410	151-0188-00	Silicon	2N3906
Q416	*151-0190-01	Silicon	Tek Spec
Q424	*151-0190-01	Silicon	Tek Spec
Q432	151-0188-00	Silicon	2N3906
Q436	151-0188-00	Silicon	2N3906
Q442	151-0188-00	Silicon	2N3906
Q446	151-0207-00	Silicon	2N3415
Q454	*151-0190-01	Silicon	Tek Spec
Q456	*151-0190-01	Silicon	Tek Spec
Q468	*151-0190-01	Silicon	Tek Spec
Q472	151-0188-00	Silicon	2N3906
Q482	*151-0190-00	Silicon	Tek Spec
Q492	*151-0190-01	Silicon	Tek Spec
Q496	*151-0190-01	Silicon	Tek Spec
Q510	*151-0261-00	Silicon	Dual, Tek Spec
Q520	151-1036-00	Silicon	FET, Dual, Tek Spec
Q526	*151-0289-00	Silicon	Tek Spec

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Transistors (cont)							
Q532	*151-1036-00	B010100 B100000	B099999	Silicon	FET, Dual, Tek Spec		
Q534	151-0188-00			Silicon	2N3906		
Q534	*151-0289-00			Silicon	Tek Spec		
Q546	151-0220-00			Silicon	2N4122		
Q554	*151-0190-01			Silicon	Tek Spec		
Q564	*151-0190-01	XB050000		Silicon	Tek Spec		
Q566	*151-0190-01			Silicon	Tek Spec		
Q582	151-0188-00			Silicon	Tek Spec		
Q592	151-0232-00			Silicon	Tek Spec		
Q752	*151-0289-00			Silicon	Tek Spec		
Q764	*151-0190-01			Silicon	2N3906		
Q774	*151-0190-01			Silicon	Dual		
Q784	151-0220-00			Silicon	2N4122		
Q794	151-0220-00			Silicon	2N4122		
Resistors							
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.							
R400	315-0101-00	B010100 B070000	B069999	100 Ω	1/4 W	5%	
R402	315-0751-00			750 Ω	1/4 W	5%	
R404	321-0247-00			3.65 k Ω	1/8 W	Prec	1%
R404	321-0237-00			2.87 k Ω	1/8 W	Prec	1%
R405	321-0282-00			8.45 k Ω	1/8 W	Prec	1%
R406	315-0220-00			22 Ω	1/4 W		5%
R408	322-0309-00			16.2 k Ω	1/4 W	Prec	1%
R409	315-0182-00			1.8 k Ω	1/4 W		5%
R411	321-0277-00			7.5 k Ω	1/8 W	Prec	1%
R412	315-0153-00			15 k Ω	1/4 W		5%
R413	315-0101-00			100 Ω	1/4 W		5%
R416	321-0315-00			18.7 k Ω	1/8 W	Prec	1%
R418	321-0222-00			2 k Ω	1/8 W	Prec	1%
R419	315-0221-00			220 Ω	1/4 W		5%
R421	315-0431-00			430 Ω	1/4 W		5%
R422	315-0112-00			1.1 k Ω	1/4 W		5%
R423	315-0220-00			22 Ω	1/4 W		5%
R424	315-0302-00			3 k Ω	1/4 W		5%
R426	315-0132-00			1.3 k Ω	1/4 W		5%
R427	315-0561-00			560 Ω	1/4 W	Prec	1%
R428	321-0300-00			13 k Ω	1/8 W		5%
R431	315-0470-00			47 Ω	1/4 W		5%
R432	321-0136-00			255 Ω	1/8 W	Prec	1%
R433	321-0129-00			215 Ω	1/8 W	Prec	1%
R434	321-0265-00			5.62 k Ω	1/8 W	Prec	1%
R435	321-0244-00			3.4 k Ω	1/8 W	Prec	1%

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R436	321-0167-00		536 Ω	$\frac{1}{8}$ W	Prec	1%
R437	315-0111-00		110 Ω	$\frac{1}{4}$ W		5%
R438	301-0621-00		620 Ω	$\frac{1}{2}$ W		5%
R439	315-0201-00		200 Ω	$\frac{1}{4}$ W		5%
R441	301-0470-00		47 Ω	$\frac{1}{2}$ W		5%
R444	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R448	321-0277-00		7.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R449	315-0472-00		4.7 k Ω	$\frac{1}{4}$ W		5%
R451	315-0223-00		22 k Ω	$\frac{1}{4}$ W		5%
R452	315-0153-00		15 k Ω	$\frac{1}{4}$ W		5%
R454	315-0472-00		4.7 k Ω	$\frac{1}{4}$ W		5%
R455	315-0682-00		6.8 k Ω	$\frac{1}{4}$ W		5%
R456	315-0153-00		15 k Ω	$\frac{1}{4}$ W		5%
R458	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R459	315-0123-00		12 k Ω	$\frac{1}{4}$ W		5%
R462	315-0752-00		7.5 k Ω	$\frac{1}{4}$ W		5%
R464	321-0271-00		6.49 k Ω	$\frac{1}{8}$ W	Prec	1%
R465	321-0234-00		2.67 k Ω	$\frac{1}{8}$ W	Prec	1%
R466	321-0277-00		7.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R468	321-0306-00		15 k Ω	$\frac{1}{8}$ W	Prec	1%
R469	321-0209-00	XB070000	1.47 k Ω	$\frac{1}{8}$ W	Prec	1%
R470	321-0230-00		2.43 k Ω	$\frac{1}{8}$ W	Prec	1%
R471	321-0271-00		6.49 k Ω	$\frac{1}{8}$ W	Prec	1%
R472	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R474	321-0150-00		357 Ω	$\frac{1}{8}$ W	Prec	1%
R475	321-0215-00		1.69 k Ω	$\frac{1}{8}$ W	Prec	1%
R477	321-0219-00		1.87 k Ω	$\frac{1}{8}$ W	Prec	1%
R482	321-0139-00		274 Ω	$\frac{1}{8}$ W	Prec	1%
R484	321-0241-00		3.16 k Ω	$\frac{1}{8}$ W	Prec	1%
R485	321-0196-00		1.07 k Ω	$\frac{1}{8}$ W	Prec	1%
R488	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R489	321-0203-00		1.27 k Ω	$\frac{1}{8}$ W	Prec	1%
R493	315-0241-00		240 Ω	$\frac{1}{4}$ W		5%
R494	321-0222-00		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R495	321-0203-00		1.27 k Ω	$\frac{1}{8}$ W	Prec	1%
R496	301-0152-00		1.5 k Ω	$\frac{1}{2}$ W		5%
R497	315-0331-00		330 Ω	$\frac{1}{4}$ W		5%
R498	315-0470-00		47 Ω	$\frac{1}{4}$ W		5%
R499	315-0331-00		330 Ω	$\frac{1}{4}$ W		5%
R500	311-0950-00		10 k Ω , Var			
R501	321-0399-00		140 k Ω	$\frac{1}{8}$ W	Prec	1%

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R503	321-0407-00		169 kΩ	1/8 W	Prec	1%
R511	321-0312-00		17.4 kΩ	1/8 W	Prec	1%
R512	321-0201-00		1.21 kΩ	1/8 W	Prec	1%
R515	322-0283-00		8.66 kΩ	1/4 W	Prec	1%
R516	315-0221-00		220 Ω	1/4 W		5%
R517	321-0312-00		17.4 kΩ	1/8 W	Prec	1%
R518	321-0201-00		1.21 kΩ	1/8 W	Prec	1%
R521	321-0299-00		12.7 kΩ	1/8 W	Prec	1%
R522	317-0102-00	XB040000	1 kΩ	1/8 W		5%
R523	321-0260-00		4.99 kΩ	1/8 W	Prec	1%
R524	315-0621-00		620 Ω	1/4 W		5%
R526	321-0269-00		6.19 kΩ	1/8 W	Prec	1%
R527	321-0193-00		1 kΩ	1/8 W	Prec	1%
R532	315-0122-00		1.2 kΩ	1/4 W		5%
R533	321-0219-00		1.87 kΩ	1/8 W	Prec	1%
R534	322-0281-00		8.25 kΩ	1/4 W	Prec	1%
R536	315-0220-00		22 Ω	1/4 W		5%
R537	308-0306-00		3.26 kΩ	3 W	WW	2%
R538	315-0101-00		100 Ω	1/4 W		5%
R539	315-0101-00		100 Ω	1/4 W		5%
R541	315-0131-00		130 Ω	1/4 W		5%
R542	321-0259-00		4.87 kΩ	1/8 W	Prec	1%
R543	315-0114-00		110 kΩ	1/4 W		5%
R544	321-0231-00		2.49 kΩ	1/8 W	Prec	1%
R545	315-0470-00		47 Ω	1/4 W		5%
R546	301-0102-00		1 kΩ	1/2 W		5%
R548	301-0561-00		560 Ω	1/2 W		5%
R551	321-0211-00		1.54 kΩ	1/8 W	Prec	1%
R552	321-0231-00		2.49 kΩ	1/8 W	Prec	1%
R554	321-0178-00		698 Ω	1/8 W	Prec	1%
R556	321-0260-00		4.99 kΩ	1/8 W	Prec	1%
R557	321-0239-00		3.01 kΩ	1/8 W	Prec	1%
R558	321-0193-00		1 kΩ	1/8 W	Prec	1%
R561	315-0820-00		82 Ω	1/4 W		5%
R564	321-0207-00		1.4 kΩ	1/8 W	Prec	1%
R565	315-0911-00		910 Ω	1/4 W		5%
R566	315-0101-00		100 Ω	1/4 W		5%
R567	301-0162-00		1.6 kΩ	1/2 W		5%
R568	315-0470-00		47 Ω	1/4 W		5%
R573	321-0295-00		11.5 kΩ	1/8 W	Prec	1%
R580C	323-0222-00		2 kΩ	1/2 W	Prec	1%

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Resistors (cont)							
R581	315-0223-00			22 kΩ	1/4 W		5%
R582	323-0289-00			10 kΩ	1/2 W	Prec	1%
R583	315-0104-00			100 kΩ	1/4 W		5%
R590	311-0950-00			10 kΩ, Var			
R591	321-0277-00			7.5 kΩ	1/8 W	Prec	1%
R592	321-0143-00	B010100	B069999	301 Ω	1/8 W	Prec	1%
R592	321-0147-00	B070000		332 Ω	1/8 W	Prec	1%
R593	315-0221-00			220 Ω	1/4 W		5%
R594	322-0273-00			6.81 kΩ	1/4 W	Prec	1%
R595	317-0102-00	XB040000		1 kΩ	1/8 W		5%
R596	322-0310-00			16.5 kΩ	1/4 W	Prec	1%
R599	322-0297-00			12.1 kΩ	1/4 W	Prec	1%
R715	315-0154-00			150 kΩ	1/4 W		5%
R742	321-0263-00			5.36 kΩ	1/8 W	Prec	1%
R743	321-0228-09			2.32 kΩ	1/8 W	Prec	1%
R745	315-0220-00			22 Ω	1/4 W		5%
R746	321-0262-01			5.23 kΩ	1/8 W	Prec	1/2%
R748	315-0220-00			22 Ω	1/4 W		5%
R749	321-0373-00			75 kΩ	1/8 W	Prec	1%
R755	303-0103-00	XB050000		10 kΩ	1 W		5%
R761	321-0225-00			2.15 kΩ	1/8 W	Prec	1%
R763	323-0205-07			1.33 kΩ	1/2 W	Prec	1%
R764	303-0302-00			3 kΩ	1 W		5%
R771	315-0152-00			1.5 kΩ	1/4 W		5%
R772	321-0244-00			3.4 kΩ	1/8 W	Prec	1%
R773	321-0205-00			1.33 kΩ	1/8 W	Prec	1%
R774	303-0332-00			3.3 kΩ	1 W		5%
R781	323-0272-00			6.65 kΩ	1/2 W	Prec	1%
R782	321-0735-07			1.001 kΩ	1/8 W	Prec	1/10%
R783	315-0752-00			7.5 kΩ	1/4 W		5%
R784	321-0228-00			2.32 kΩ	1/8 W	Prec	1%
R785	311-0597-00			50 Ω, Var			
R786	321-0088-09			80.6 Ω	1/8 W	Prec	1%
R788	317-0472-00			4.7 kΩ	1/8 W		5%
R789	317-0622-00	B010100	B019999	6.2 kΩ	1/8 W		5%
R789	317-0103-00	B020000		10 kΩ	1/8 W		5%
R791	323-0272-00			6.65 kΩ	1/2 W	Prec	1%
R794	321-0235-00			2.74 kΩ	1/8 W	Prec	1%
R795	311-0541-00			20 kΩ, Var			
R796	321-0289-00			10 kΩ	1/8 W	Prec	1%
R797	321-0289-00			10 kΩ	1/8 W	Prec	1%
R799	315-0101-00			100 Ω	1/4 W		5%
R801	315-0510-00			51 Ω	1/4 W		5%
R803	315-0470-00			47 Ω	1/4 W		5%
R805	315-0470-00			47 Ω	1/4 W		5%

TIME BASE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
Resistors (cont)			
R807	315-0101-00	100 Ω	$\frac{1}{4}$ W 5%
R809	315-0101-00	100 Ω	$\frac{1}{4}$ W 5%
R811	315-0221-00	220 Ω	$\frac{1}{4}$ W 5%
R815	315-0470-00	47 Ω	$\frac{1}{4}$ W 5%
R817	315-0910-00	91 Ω	$\frac{1}{4}$ W 5%
R819	315-0101-00	100 Ω	$\frac{1}{4}$ W 5%
R820	315-0100-00	10 Ω	$\frac{1}{4}$ W 5%
R821	315-0510-00	51 Ω	$\frac{1}{4}$ W 5%

TRIGGER Circuit Board Assembly

*670-1102-00	B010100	B089999	Complete Board
*670-1102-01	B090000		Complete Board

Capacitors

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

C102	281-0547-00	2.7 pF	Cer	500 V	10%
C103	281-0523-00	100 pF	Cer	350 V	
C104	283-0000-00	0.001 μ F	Cer	500 V	
C105	281-0509-00	15 pF	Cer	500 V	10%
C107	283-0030-00	0.022 μ F	Cer	25 V	+80% -20%
C112	281-0547-00	2.7 pF	Cer	500 V	10%
C114	283-0000-00	0.001 μ F	Cer	500 V	
C118	290-0177-00	1 μ F	Elect.	50 V	
C121	281-0518-00	47 pF	Cer	500 V	
C122	281-0509-00	15 pF	Cer	500 V	10%
C126	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C128	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C132	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C136	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C203	283-0000-00	0.001 μ F	Cer	500 V	
C206	283-0000-00	0.001 μ F	Cer	500 V	
C214	283-0000-00	0.001 μ F	Cer	500 V	
C215	281-0578-00	18 pF	Cer	500 V	5%
C217	283-0000-00	0.001 μ F	Cer	500 V	
C223	281-0562-00	39 pF	Cer	500 V	
C237	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C238	283-0000-00	0.001 μ F	Cer	500 V	
C243	281-0562-00	39 pF	Cer	500 V	
C248	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%
C258	283-0080-00	0.022 μ F	Cer	25 V	+80% -20%

TRIGGER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description		
		Eff	Disc			
Capacitors (cont)						
C263	283-0080-00			0.022 μ F	Cer	25 V
C267	281-0505-00			12 pF	Cer	500 V
C269	283-0000-00			0.001 μ F	Cer	500 V
C273	283-0080-00			0.022 μ F	Cer	25 V
C282	290-0263-00	B010100	B089999	2.7 μ F	Elect.	15 V
C282	290-0284-00	B090000		4.7 μ F	Elect.	35 V
C286	290-0284-00			4.7 μ F	Elect.	35 V
C293	283-0080-00			0.022 μ F	Cer	25 V
C307	283-0002-00			0.01 μ F	Cer	500 V
C318	290-0136-00			2.2 μ F	Elect.	20 V
C328	290-0134-00			22 μ F	Elect.	15 V
C334	283-0000-00			0.001 μ F	Cer	500 V
C339	283-0000-00			0.001 μ F	Cer	500 V
C354	290-0284-00			4.7 μ F	Elect.	35 V
C358	283-0111-00			0.1 μ F	Cer	50 V
C374	290-0284-00			4.7 μ F	Elect.	35 V
C378	283-0111-00			0.1 μ F	Cer	50 V
C391	283-0111-00			0.1 μ F	Cer	50 V
C393	290-0284-00			4.7 μ F	Elect.	35 V
C394	283-0080-00			0.022 μ F	Cer	25 V
C395	290-0284-00			4.7 μ F	Elect.	35 V
C397	283-0111-00			0.1 μ F	Cer	50 V

Semiconductor Device, Diodes

CR203	*152-0185-00	Silicon	Replaceable by 1N4152
CR206	*152-0185-00	Silicon	Replaceable by 1N4152
CR221	*152-0185-00	Silicon	Replaceable by 1N4152
VR225	152-0226-00	Zener	1N751A 400 mW, 5.1 V, 5%
CR231	*152-0185-00	Silicon	Replaceable by 1N4152
CR245	*152-0185-00	Silicon	Replaceable by 1N4152
CR246	*152-0185-00	Silicon	Replaceable by 1N4152
CR255	*152-0185-00	Silicon	Replaceable by 1N4152
CR256	*152-0185-00	Silicon	Replaceable by 1N4152
CR262	152-0386-00	Tunnel	25 pF, 10 mA
CR275	*152-0185-00	Silicon	Replaceable by 1N4152
CR277	*152-0185-00	Silicon	Replaceable by 1N4152
CR291	*152-0322-00	Silicon	Tek Spec
CR299	*152-0125-00	Tunnel	4.7 mA, Tek Spec
CR301	*152-0185-00	Silicon	Replaceable by 1N4152
CR321	*152-0185-00	Silicon	Replaceable by 1N4152
CR366	*152-0185-00	Silicon	Replaceable by 1N4152
CR386	*152-0185-00	Silicon	Replaceable by 1N4152

TRIGGER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Inductors				
L262	*108-0433-00			0.09 μ H
L267	*108-0552-00			80 nH
L275	*120-0382-00			Toroid, 14 turns, single
Transistors				
Q104	151-0223-00			Silicon 2N4275
Q114	151-0223-00			Silicon 2N4275
Q118	151-0223-00			Silicon 2N4275
Q124	151-0224-00			Silicon 2N3692
Q134	151-0220-00			Silicon 2N4122
Q213A, B	151-1011-01	B010100	B039999	Silicon FET, Dual
Q213A, B	151-1041-00	B040000		Silicon FET, Dual
Q214	151-0221-00			Silicon 2N4258
Q224	151-0223-00			Silicon 2N4275
Q234	151-0223-00			Silicon 2N4275
Q238	*151-0216-00			Silicon Replaceable by MOT MPS 6523
Q244	151-0223-00			Silicon 2N4275
Q254	151-0223-00			Silicon 2N4275
Q260	151-0220-00			Silicon 2N4122
Q266	151-0220-00			Silicon 2N4122
Q273	151-0220-00			Silicon 2N4122
Q275	151-0223-00			Silicon 2N4275
Q285	151-0224-00			Silicon 2N3692
Q293	151-0224-00			Silicon 2N3692
Q296	151-0224-00			Silicon 2N3692
Q305	151-0223-00			Silicon 2N4275
Q315	151-0223-00			Silicon 2N4275
Q319	*151-0190-01			Silicon Tek Spec
Q324	151-0220-00			Silicon 2N4122
Q326	151-0220-00			Silicon 2N4122
Q328	*151-0192-00			Silicon Replaceable by MPS 6521
Q333	151-0223-00			Silicon 2N4275
Q353	*151-0190-01			Silicon Tek Spec
Q356	*151-0190-01			Silicon Tek Spec
Q364	151-0188-00			Silicon 2N3906
Q366	*151-0190-01			Silicon Tek Spec
Q373	151-0188-00			Silicon 2N3906
Q376	151-0188-00			Silicon 2N3906
Q384	*151-0190-01			Silicon Tek Spec
Q386	151-0188-00			Silicon 2N3906

TRIGGER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R101	321-0071-00		53.6 Ω	$\frac{1}{8}$ W	Prec	1%
R103	321-0020-00		15.8 Ω	$\frac{1}{8}$ W	Prec	1%
R104	315-0131-00		130 Ω	$\frac{1}{4}$ W		5%
R105	321-0126-00		200 Ω	$\frac{1}{8}$ W	Prec	1%
R107	315-0750-00		75 Ω	$\frac{1}{4}$ W		5%
R111	321-0071-00		53.6 Ω	$\frac{1}{8}$ W	Prec	1%
R113	321-0020-00		15.8 Ω	$\frac{1}{8}$ W	Prec	1%
R114	315-0131-00		130 Ω	$\frac{1}{4}$ W		5%
R115	321-0126-00		200 Ω	$\frac{1}{8}$ W	Prec	1%
R116	315-0121-00		120 Ω	$\frac{1}{4}$ W		5%
R117	321-0189-00		909 Ω	$\frac{1}{8}$ W	Prec	1%
R118	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R119	323-0124-00		191 Ω	$\frac{1}{2}$ W	Prec	1%
R121	315-0821-00		820 Ω	$\frac{1}{4}$ W		5%
R122	321-0250-00		3.92 k Ω	$\frac{1}{8}$ W	Prec	1%
R126	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R128	315-0301-00		300 Ω	$\frac{1}{4}$ W		5%
R129	315-0510-00		51 Ω	$\frac{1}{4}$ W		5%
R132	321-0210-00		1.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R133	321-0324-00		23.2 k Ω	$\frac{1}{8}$ W	Prec	1%
R135	311-0463-00		5 k Ω , Var			
R136	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R201	315-0510-00		51 Ω	$\frac{1}{4}$ W		5%
R202	321-0452-00		499 k Ω	$\frac{1}{8}$ W	Prec	1%
R203	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R205	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R206	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R213	315-0511-00		510 Ω	$\frac{1}{4}$ W		5%
R214	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R215	315-0162-00		1.6 k Ω	$\frac{1}{4}$ W		5%
R217	315-0751-00		750 Ω	$\frac{1}{4}$ W		5%
R221	315-0162-00		1.6 k Ω	$\frac{1}{4}$ W		5%
R224	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R234	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R235	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R236	315-0241-00		240 Ω	$\frac{1}{4}$ W		5%
R237	315-0100-00		10 Ω	$\frac{1}{4}$ W		5%
R238	315-0512-00		5.1 k Ω	$\frac{1}{4}$ W		5%
R239	315-0475-00		4.7 M Ω	$\frac{1}{4}$ W		5%
R241	322-0261-00		5.11 k Ω	$\frac{1}{4}$ W	Prec	1%

TRIGGER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R243	315-0300-00			30 Ω	$\frac{1}{4}$ W	5%
R248	315-0103-00			10 k Ω	$\frac{1}{4}$ W	5%
R251	322-0261-00			5.11 k Ω	$\frac{1}{4}$ W	1% Prec
R258	315-0203-00			20 k Ω	$\frac{1}{4}$ W	5%
R260	315-0103-00			10 k Ω	$\frac{1}{4}$ W	5%
R261	315-0202-00			2 k Ω	$\frac{1}{4}$ W	5%
R262	315-0101-00			100 Ω	$\frac{1}{4}$ W	5%
R264	315-0100-00			10 Ω	$\frac{1}{4}$ W	5%
R267	317-0300-00	B010100	B069999	30 Ω	$\frac{1}{8}$ W	5%
R267	317-0390-00	B070000		39 Ω (nominal value)	Selected	
R269	315-0123-00			12 k Ω	$\frac{1}{4}$ W	5%
R271	315-0511-00			510 Ω	$\frac{1}{4}$ W	5%
R272	315-0103-00			10 k Ω	$\frac{1}{4}$ W	5%
R273	315-0512-00			5.1 k Ω	$\frac{1}{4}$ W	5%
R274	307-0103-00			2.7 Ω	$\frac{1}{4}$ W	5%
R275	315-0201-00			200 Ω	$\frac{1}{4}$ W	5%
R276	315-0752-00			7.5 k Ω	$\frac{1}{4}$ W	5%
R277	315-0303-00			30 k Ω	$\frac{1}{4}$ W	5%
R282	315-0271-00			270 Ω	$\frac{1}{4}$ W	5%
R283	315-0103-00			10 k Ω	$\frac{1}{4}$ W	5%
R286	315-0101-00			100 Ω	$\frac{1}{4}$ W	5%
R288	315-0152-00			1.5 k Ω	$\frac{1}{4}$ W	5%
R290	315-0101-00			100 Ω	$\frac{1}{4}$ W	5%
R291	315-0512-00			5.1 k Ω	$\frac{1}{4}$ W	5%
R292	317-0201-00			200 Ω	$\frac{1}{8}$ W	5%
R293	315-0391-00			390 Ω	$\frac{1}{4}$ W	5%
R294	315-0242-00			2.4 k Ω	$\frac{1}{4}$ W	5%
R295	315-0152-00			1.5 k Ω	$\frac{1}{4}$ W	5%
R296	315-0101-00			100 Ω	$\frac{1}{4}$ W	5%
R301	321-0239-00			3.01 k Ω	$\frac{1}{8}$ W	1% Prec
R303	321-0177-00			681 Ω	$\frac{1}{8}$ W	1% Prec
R305	321-0126-00			200 Ω	$\frac{1}{8}$ W	1% Prec
R307	307-0103-00			2.7 Ω	$\frac{1}{4}$ W	5%
R308	321-0144-00			309 Ω	$\frac{1}{8}$ W	1% Prec
R309	315-0271-00			270 Ω	$\frac{1}{4}$ W	5%
R311	321-0122-00			182 Ω	$\frac{1}{8}$ W	1% Prec
R312	321-0030-00			20 Ω	$\frac{1}{8}$ W	1% Prec
R313	323-0192-00			976 Ω	$\frac{1}{2}$ W	1% Prec
R315	321-0097-00			100 Ω	$\frac{1}{8}$ W	1% Prec
R318	315-0391-00			390 Ω	$\frac{1}{4}$ W	5%
R319	315-0302-00			3 k Ω	$\frac{1}{4}$ W	5%

TRIGGER Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
Resistors (cont)						
R322	315-0154-00	150 kΩ	1/4 W			5%
R323	315-0223-00	22 kΩ	1/4 W			5%
R324	315-0392-00	3.9 kΩ	1/4 W			5%
R326	321-0321-00	21.5 kΩ	1/8 W	Prec		1%
R327	321-0285-00	9.09 kΩ	1/8 W	Prec		1%
R328	315-0101-00	100 Ω	1/4 W			5%
R333	315-0302-00	3 kΩ	1/4 W			5%
R334	315-0471-00	470 Ω	1/4 W			5%
R335	311-0622-00	100 Ω, Var				
R336	311-0622-00	100 Ω, Var				
R338	315-0152-00	1.5 kΩ	1/4 W			5%
R339	315-0101-00	100 Ω	1/4 W			5%
R352	315-0915-00	9.1 MΩ	1/4 W			5%
R353	315-0154-00	150 kΩ	1/4 W			5%
R354	315-0101-00	100 Ω	1/4 W			5%
R356	315-0915-00	9.1 MΩ	1/4 W			5%
R358	307-0103-00	2.7 Ω	1/4 W			5%
R366	315-0104-00	100 kΩ	1/4 W			5%
R367	315-0202-00	2 kΩ	1/4 W			5%
R368	321-0258-00	4.75 kΩ	1/8 W	Prec		1%
R369	315-0100-00	10 Ω	1/4 W			5%
R372	315-0915-00	9.1 MΩ	1/4 W			5%
R374	315-0101-00	100 Ω	1/4 W			5%
R376	315-0915-00	9.1 MΩ	1/4 W			5%
R378	307-0103-00	2.7 Ω	1/4 W			5%
R384	321-0254-00	4.32 kΩ	1/8 W	Prec		1%
R385	311-0462-00	10 kΩ, Var				
R386	315-0104-00	100 kΩ	1/4 W			5%
R387	315-0152-00	1.5 kΩ	1/4 W			5%
R389	315-0100-00	10 Ω	1/4 W			5%
R391	315-0101-00	100 Ω	1/4 W			5%
R393	307-0106-00	4.7 Ω	1/4 W			5%
R394	315-0510-00	51 Ω	1/4 W			5%
R395	307-0106-00	4.7 Ω	1/4 W			5%
R397	315-0101-00	100 Ω	1/4 W			5%

Transformer

T271	*120-0632-00	Toroid, 2 windings
------	--------------	--------------------

DELAY MODE Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
----------	-----------------------	-------------------------	-------------	-------------

670-1103-00*Complete Board****Bulb**

DS490	*150-0057-01			Incandescent	7153AS15, selected
-------	--------------	--	--	--------------	--------------------

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

R490A	315-0820-00			82 Ω	$\frac{1}{4}$ W	5%
R490B	315-0201-00			200 Ω	$\frac{1}{4}$ W	5%

Switch

Wired or Unwired

S490 ⁴	*670-1103-00			Pushbutton	B DELAY MODE
-------------------	--------------	--	--	------------	--------------

SOURCE Circuit Board Assembly***670-1104-00****Complete Board****Bulb**

DS140	*150-0057-01			Incandescent	7153AS15, selected
-------	--------------	--	--	--------------	--------------------

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

C140C	281-0123-00			5-25 pF, Var	Cer		
C140E	281-0610-00			2.2 pF	Cer	200 V	± 0.1 pF

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

R140D	321-0361-00			56.2 k Ω	$\frac{1}{8}$ W	Prec	1%
R140E	321-0448-00			453 k Ω	$\frac{1}{8}$ W	Prec	1%
R140F	317-0470-00			47 Ω	$\frac{1}{8}$ W		5%
R140G	317-0470-00			47 Ω	$\frac{1}{8}$ W		5%

Switch

Wired or Unwired

S140 ⁴	*670-1104-00			Pushbutton	SOURCE
-------------------	--------------	--	--	------------	--------

⁴See Mechanical Parts List for replacement parts.

MODE AUTO Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
*670-1105-00		Complete Board		
Bulbs				
DS325	*150-0057-01		Incandescent	7153AS15, selected
DS446	*150-0057-01		Incandescent	7153AS15, selected
Switch				
Wired or Unwired				
S325 ⁵	*670-1105-00		Pushbutton	MODE

COUPLING Circuit Board Assembly

*670-1106-00		Complete Board		
Bulb				
DS145	*150-0057-01	Incandescent	7153AS15, selected	
Capacitors				
Tolerance $\pm 20\%$ unless otherwise indicated.				
C145A	281-0605-00	200 pF	Cer	500 V
C145B	281-0610-00	2.2 pF	Cer	200 V
C145C	281-0505-00	12 pF	Cer	500 V
C145D	281-0091-00	2-8 pF, Var	Cer	
C145E	283-0006-00	0.02 μ F	Cer	500 V
Resistors				
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R145A	315-0513-00	51 k Ω	$\frac{1}{4}$ W	5%
R145B	315-0333-00	33 k Ω	$\frac{1}{4}$ W	5%
R145E	317-0101-00	0.01 μ F	Cer	5%

⁵See Mechanical Parts List for replacement parts.

MAGNIFIER Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-1107-00			Complete Board
			Bulb	
DS780	*150-0057-01		Incandescent	7153AS15, selected
			Switch	
	Wired or Unwired			
S780 ⁶	*670-1107-00		Pushbutton	MAGNIFIER

⁶See Mechanical Parts List for replacement parts.

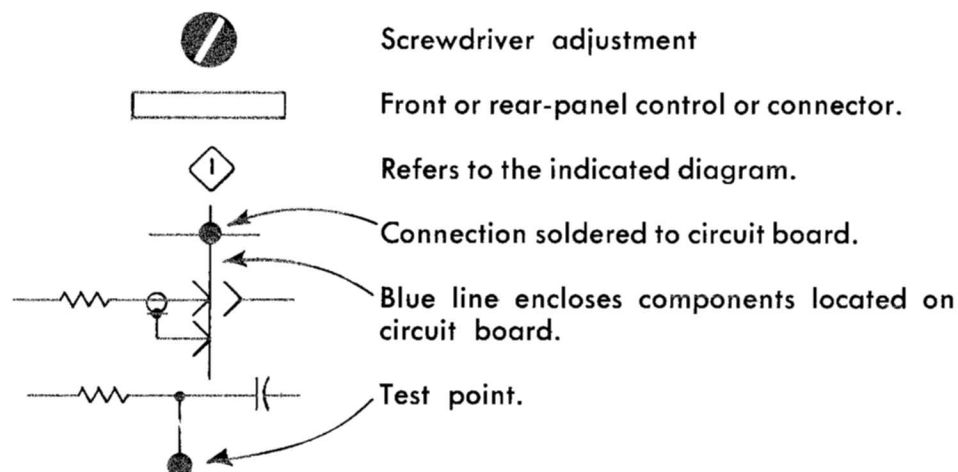
SECTION 7

DIAGRAMS

and

MECHANICAL PARTS ILLUSTRATIONS

The following special symbols are used on the diagrams:



VOLTAGE AND WAVEFORM TEST CONDITIONS

Voltage measurements and waveform photographs were obtained under the following conditions unless otherwise noted on the individual diagrams:

Type 7504 Oscilloscope

FOCUS	Optimum
INTENSITY (both)	Optimum
CALIBRATOR VOLTS	4 volts
CALIBRATOR RATE	B GATE
VERTICAL MODE	RIGHT
HORIZONTAL MODE	A
A TRIGGER SOURCE	RIGHT VERT
B TRIGGER SOURCE	LEFT VERT

Type 7B51 (B Horizontal Compartment)

LEVEL/SLOPE	0/+
TRIGGERING	
MODE	P-P AUTO
COUPLING	DC
SOURCE	INT
MAGNIFIER	X1
TIME/DIV	1 ms
B DELAY MODE	B STARTS AFTER DE- LAY
DELAY TIME MULT	5.00

Type 7A16 (Left Vertical Compartment)

POLARITY	+ UP
BANDWIDTH	FULL
AC-GND-DC	AC
VOLTS/DIV	.2 V
INPUT	Connected to Type 106 HI AMPLITUDE output. Type 106 amplitude ad- justed for a 5 division dis- play.

Voltmeter

Type	Non-loading DC VTVM
Sensitivity	20,000 ohms/volt
Range	0 to 50 volts
Type used for voltages on diagrams	General Radio Type 1806-A Electronic Volt- meter

Type 7A16 (Right Vertical Compartment) With 10X Probe, Test Vertical Amplifier

POLARITY	+ UP
BANDWIDTH	FULL
AC-GND-DC	DC
VOLTS/DIV	As shown on waveform using a 10X Probe.

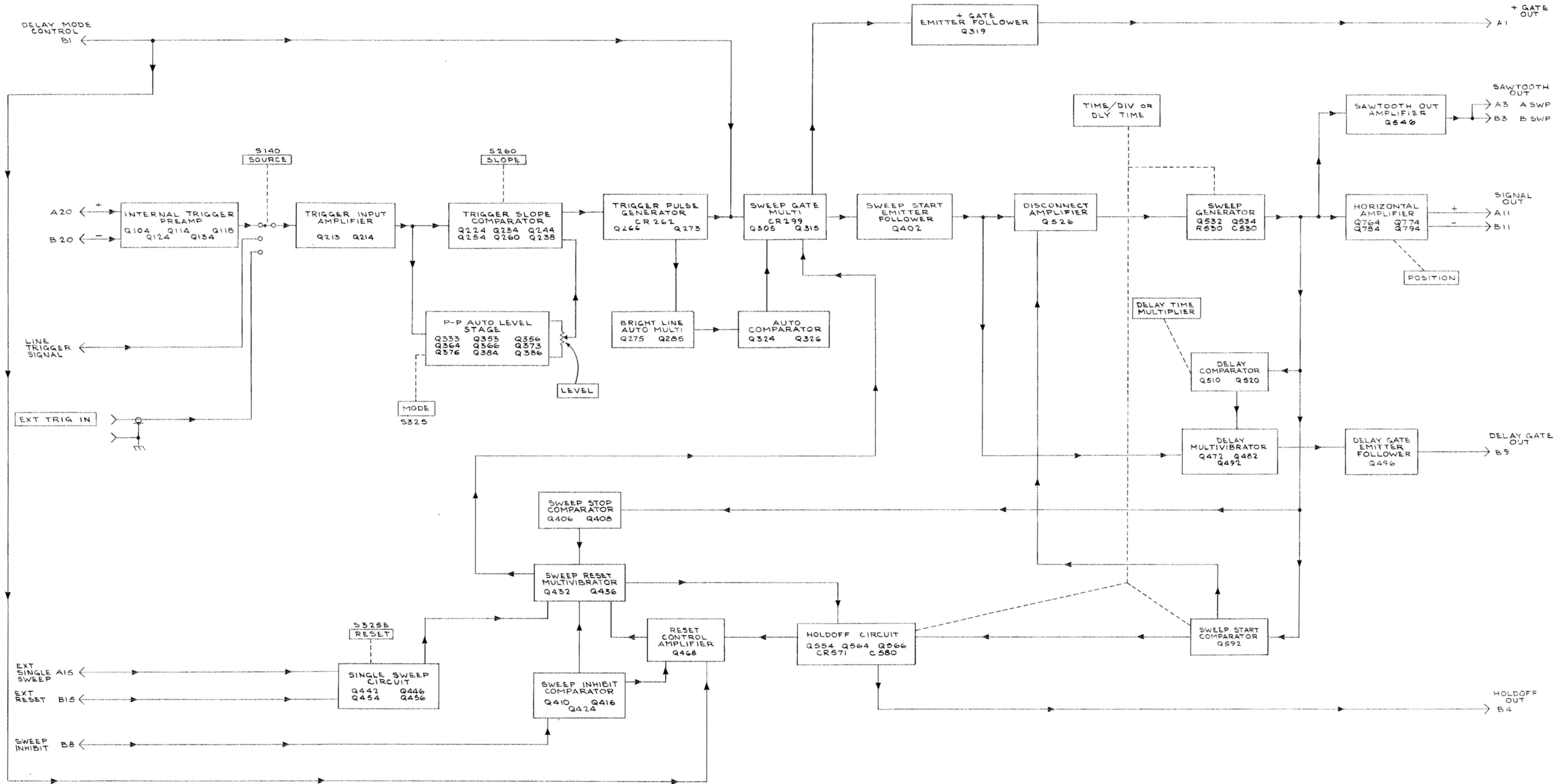
All voltages given on the diagrams are in volts. Waveforms shown are actual waveform photographs taken with a Tektronix Camera System. Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration or front-panel control settings.

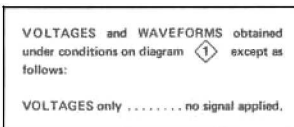
Type 7B51 (A Horizontal Compartment) Test Time-Base

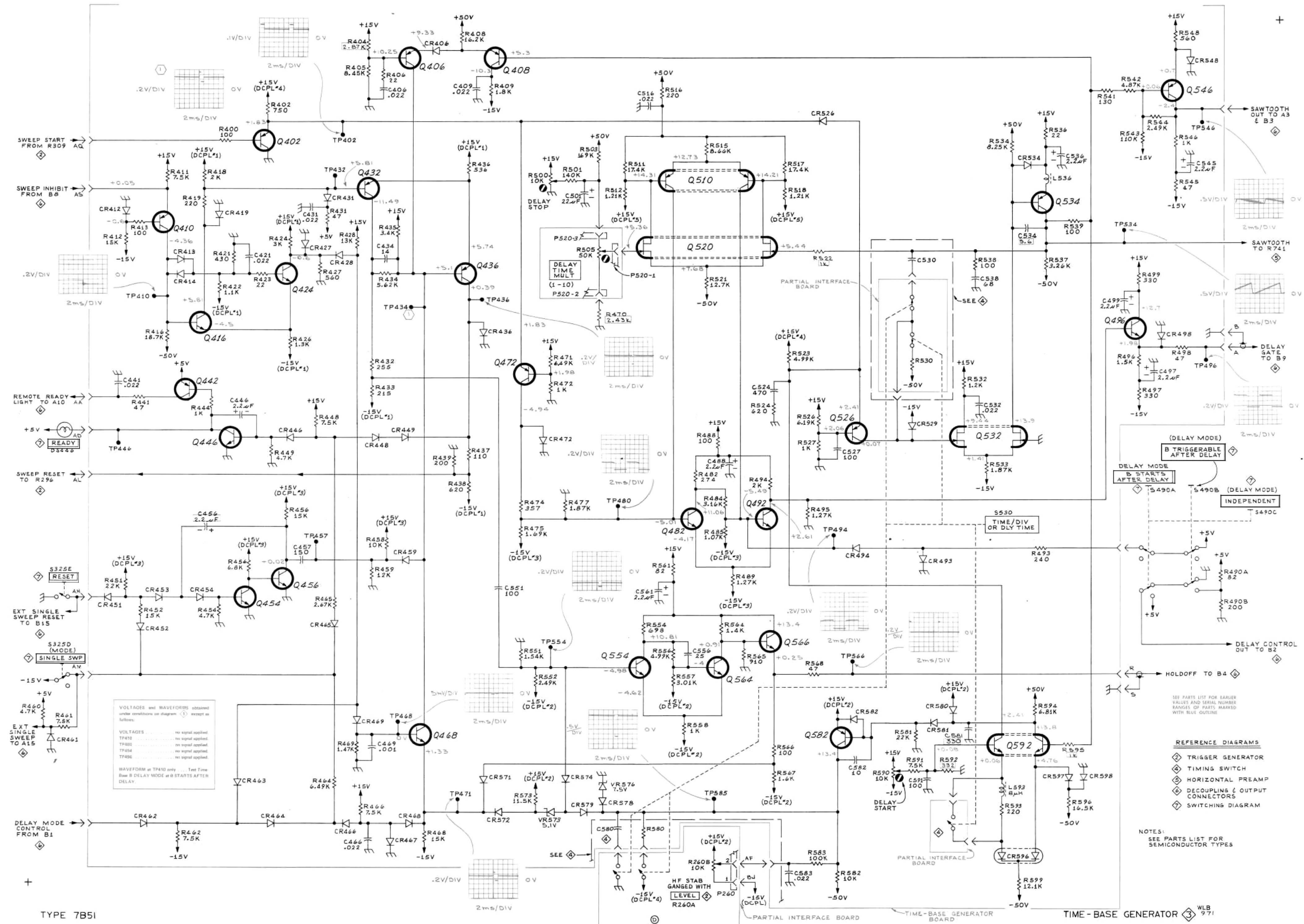
LEVEL/SLOPE	0/+
TRIGGERING	
MODE	P-P AUTO
COUPLING	AC
SOURCE	EXT
MAGNIFIER	X1
TIME/DIV	As shown on waveform
B DELAY MODE	INDEPENDENT (except as noted)
EXT TRIG IN	Connected to CALIBRA- TOR VOLTS output con- nector

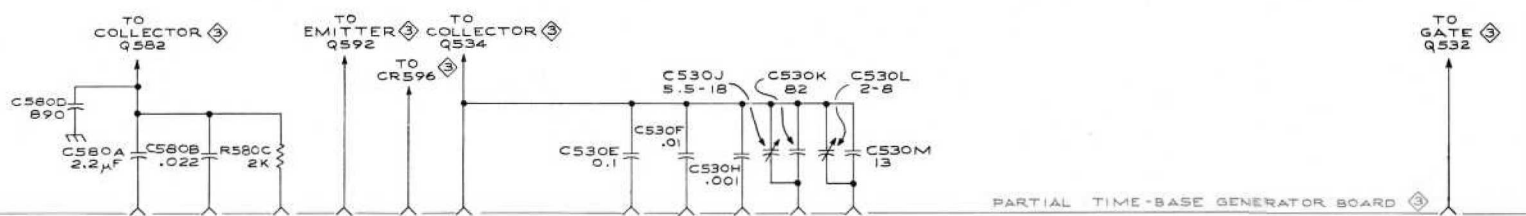
NOTE

Vertical deflection factor shown on waveforms does not include attenuation factor of the 10X Probe.







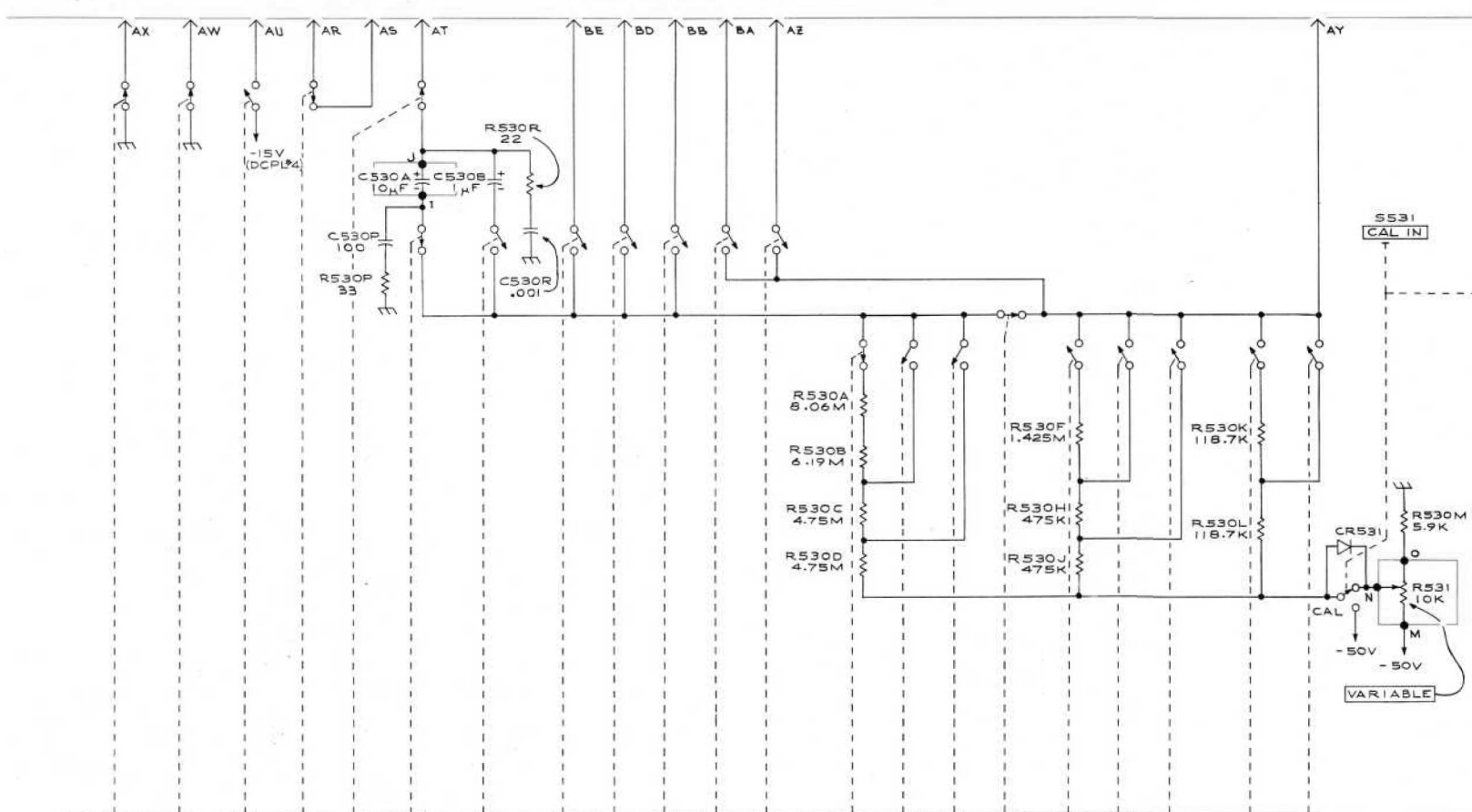


PARTIAL TIME-BASE GENERATOR BOARD

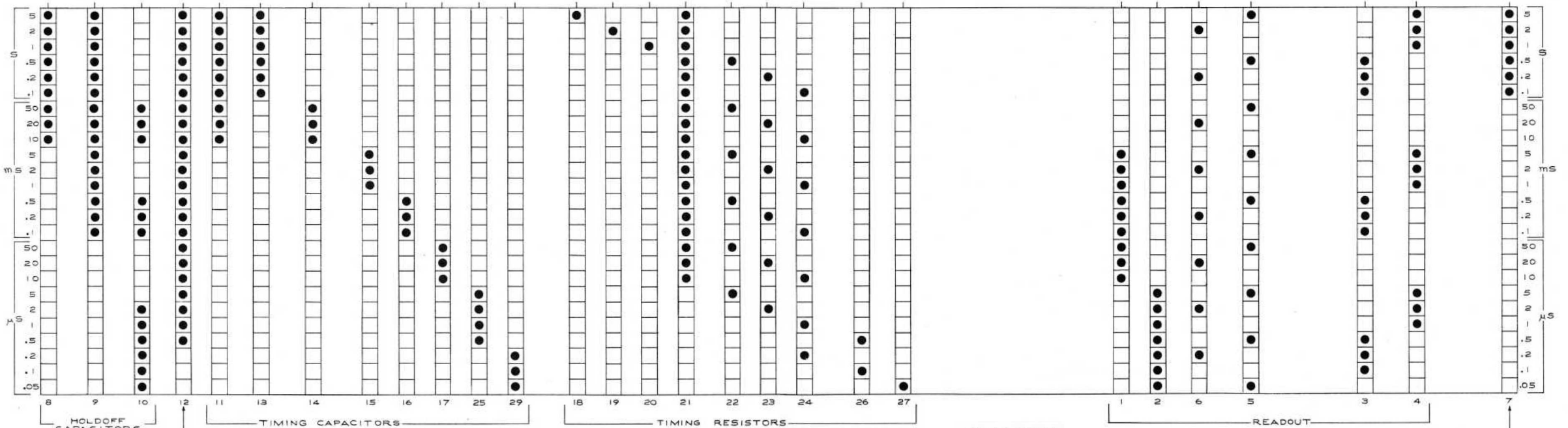
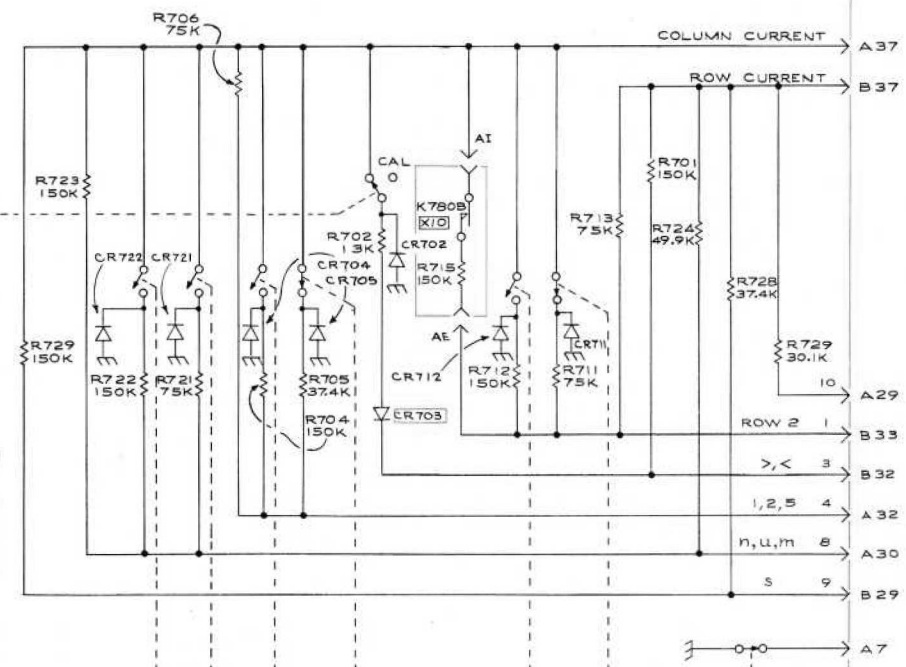
REFERENCE DIAGRAM

TIME-BASE GENERATOR

NOTE:
SEE PARTS LIST FOR
SEMICONDUCTOR TYPES

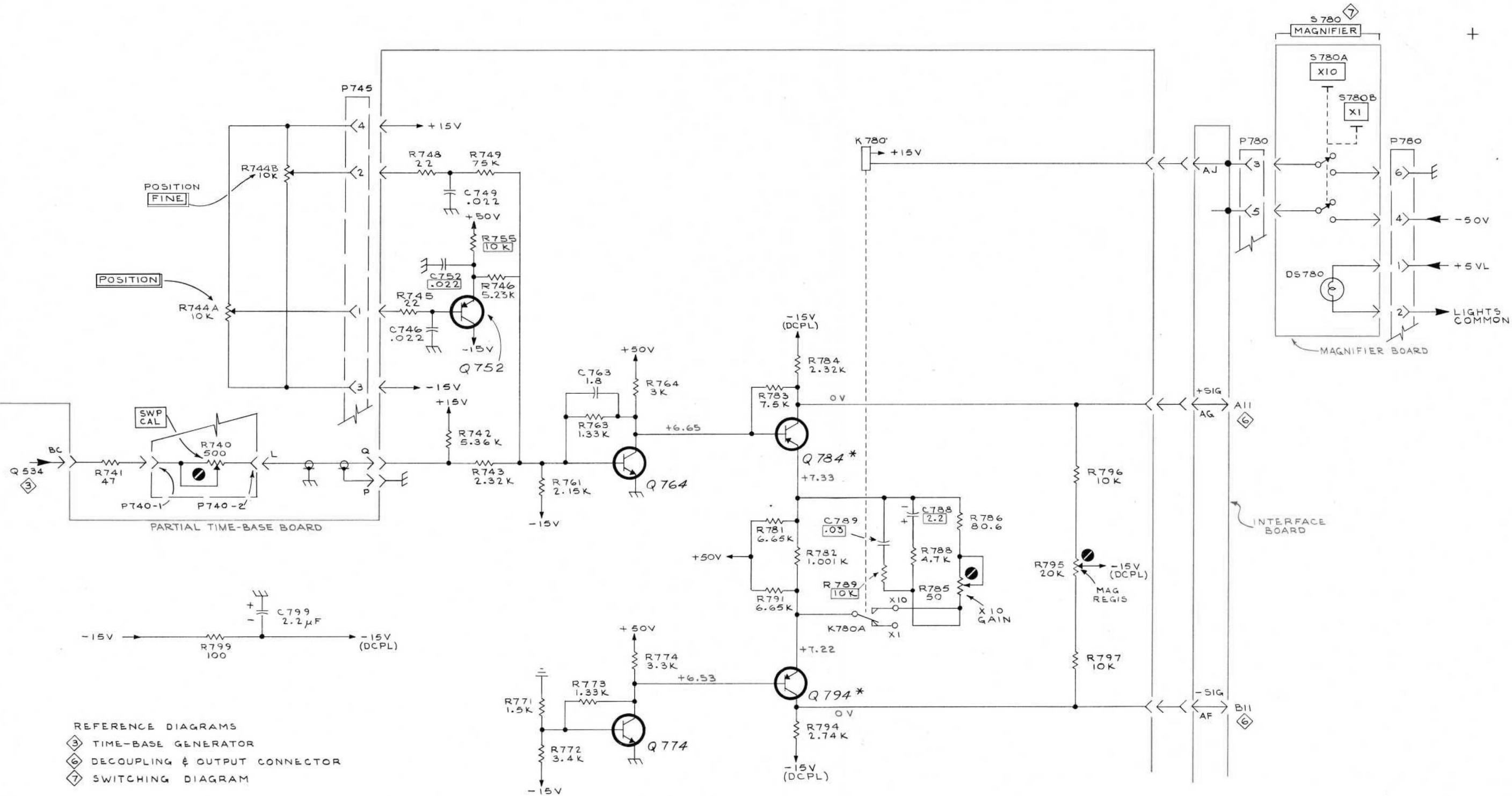


PARTIAL INTERFACE BOARD



TIME/DIV OR DLY TIME
S530
(TIME/DIV SWITCH SHOWN
IN 5 SEC POSITION)

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



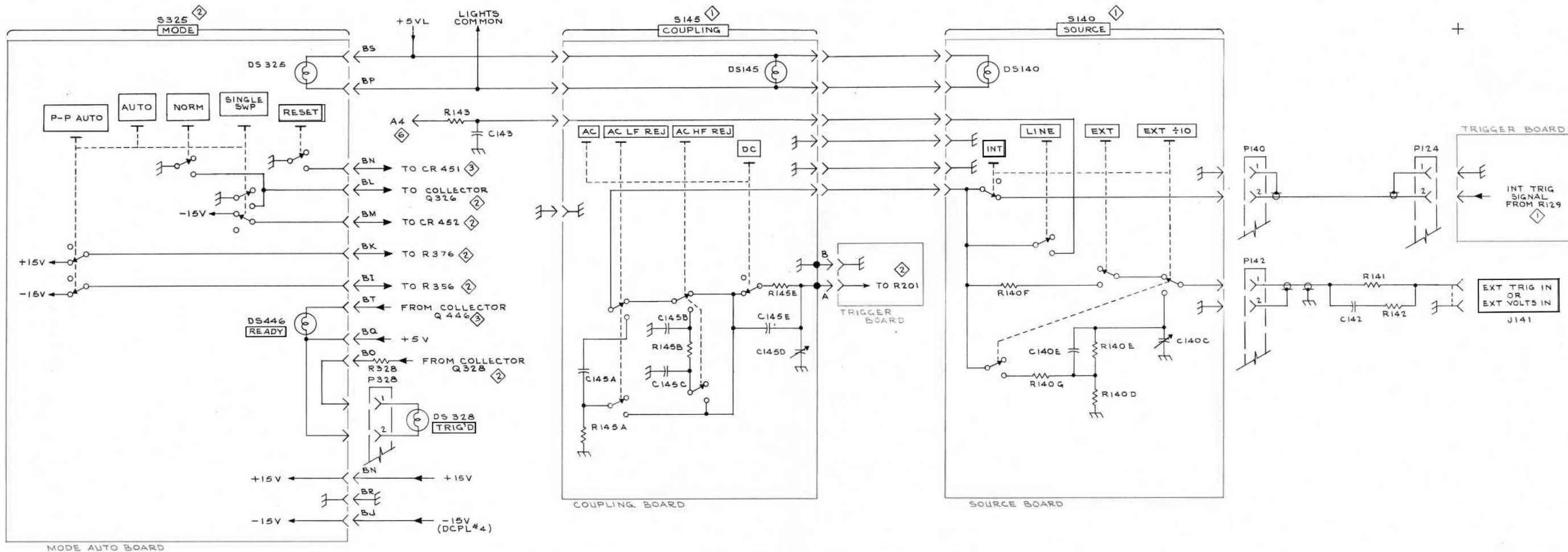
REFERENCE DIAGRAM
 ③ TIME-BASE GENERATOR
 ⑥ DECOUPLING & OUTPUT CONNECTOR
 ⑦ SWITCHING DIAGRAM

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

* TRANSISTORS IN SAME TEMP ENVIRONMENT

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

VOLTAGES obtained under conditions on diagram ① except, no signal applied.



- REFERENCE DIAGRAMS:**
- ① TRIGGER PREAMPLIFIER
 - ② TRIGGER GENERATOR
 - ③ TIME-BASE GENERATOR
 - ④ HORIZONTAL PREAMPLIFIER
 - ⑤ DECOUPLING & OUTPUT CONNECTOR

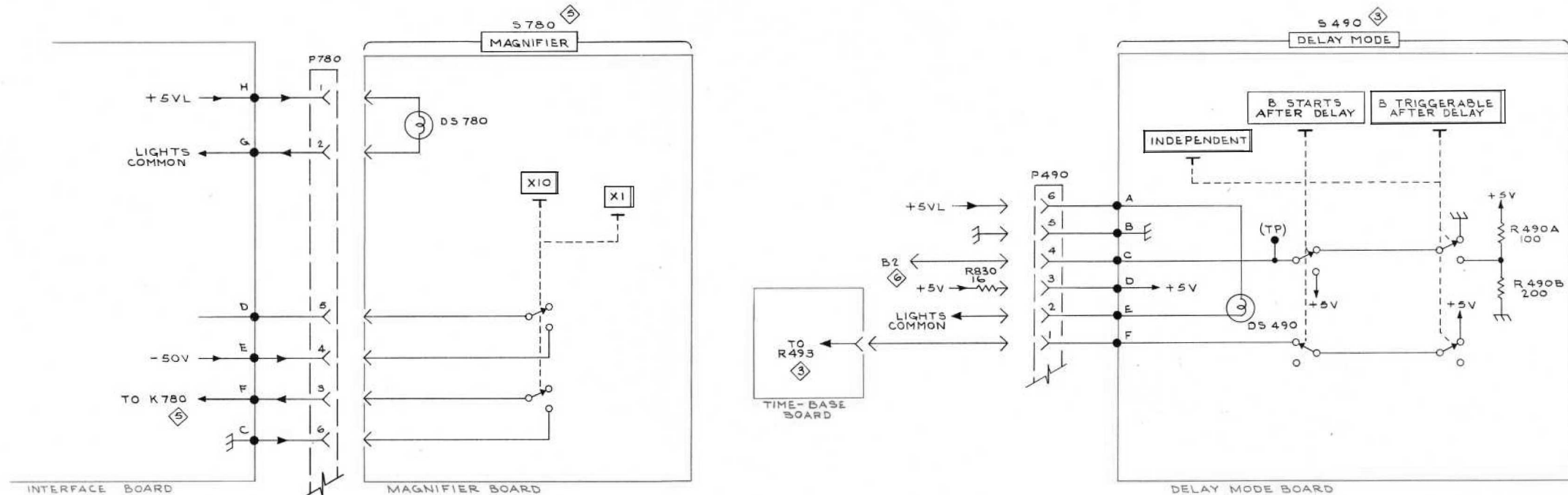


FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the 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 specified.

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.

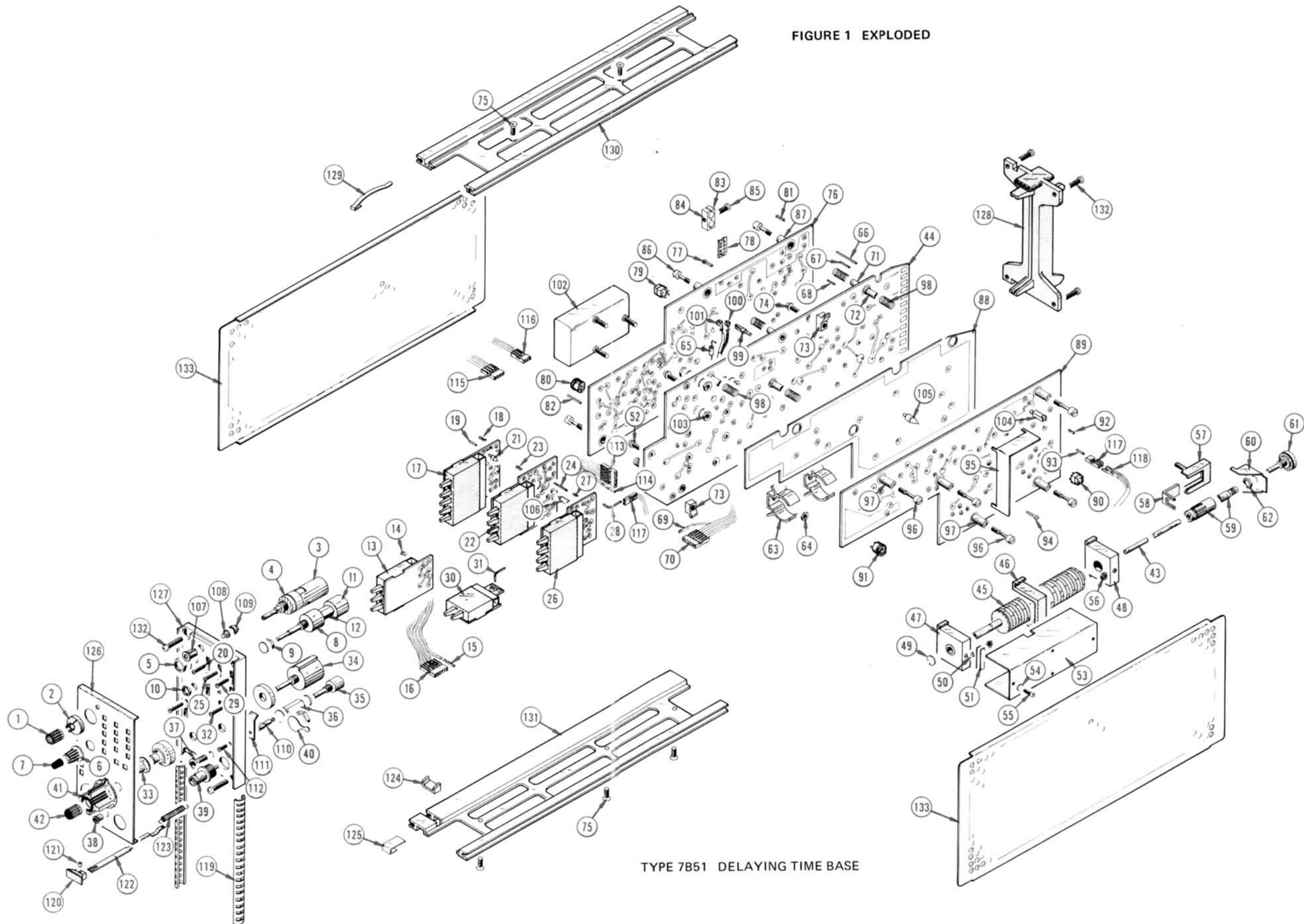
ABBREVIATIONS AND SYMBOLS

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.

INDEX OF MECHANICAL PARTS ILLUSTRATIONS

Title	Location (reverse side of)
Figure 1 Exploded	Switching Diagram

FIGURE 1 EXPLODED



TYPE 7B51 DELAYING TIME BASE

SECTION 8

MECHANICAL PARTS LIST

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q						Description
				t	y	1	2	3	4	
1-1	366-1064-00			1						1 KNOB, gray—LEVEL/SLOPE
	- - - - -			-						knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-2	354-0342-00			1						RING, knob skirt
-3	- - - - -			1						RESISTOR, variable
	- - - - -			-						resistor includes:
-4	214-1235-00			1						DRIVE, turns reduction
	- - - - -			-						mounting hardware: (not included w/drive)
	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-5	210-0590-00			1						NUT, hex., 3/8-32 x 5/16 inch
-6	366-1174-00	B010100	B079999	1						KNOB, gray—POSITION
	366-1077-00	B080000		1						KNOB, gray—POSITION
	- - - - -			-						knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-7	366-1173-00	B010100	B079999	1						KNOB, gray—FINE
	366-1319-00	B080000		1						KNOB, gray—FINE
	- - - - -			-						knob includes:
	213-0140-00			1						SCREW, set, 2-56 x 3/32 inch, HSS
-8	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-9	210-0465-00			1						NUT, hex., 1/4-32 x 3/8 inch
-10	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-11	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-12	210-0465-00			1						NUT, hex., 0.250-32 x 0.375 inch
-13	670-1103-00			1						ASSEMBLY, pushbutton switch—B DELAY MODE
	- - - - -			-						assembly includes:
	- - - - -			1						BULB
	380-0154-02			1						HOUSING, bulb cover
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-14	214-0579-00			1						PIN, test point
-15	131-0707-00			6						CONNECTOR, AWG 22 to 26 wire
-16	352-0164-00			1						HOLDER, terminal connector, 6 terminal
	- - - - -			-						mounting hardware: (not included w/assembly)
	211-0156-00			2						SCREW, 1-72 x 0.250 inch, FHS
-17	670-1105-00			1						ASSEMBLY, pushbutton switch—MODE (Triggering)
	- - - - -			-						assembly includes:
	- - - - -			1						BULB
	380-0156-03			1						HOUSING, bulb cover
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-18	136-0263-03			13						SOCKET, pin terminal
-19	131-0608-00			2						TERMINAL, post 0.365 inch
	- - - - -			-						mounting hardware: (not included w/assembly)
-20	211-0156-00			2						SCREW, 1-72 x 0.250 inch, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q t y	1	2	3	4	5	Description
1-21	386-1635-00			2						SUPPORT, circuit board, for 0.118 inch board height
-22	670-1106-00			1						ASSEMBLY, pushbutton switch—COUPLING (Triggering)
	- - - - -			-						assembly includes:
	- - - - -			1						BULB
	380-0155-02			1						HOUSING, bulb cover
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			-						SCREW, thread forming, #2 x 0.375 inch, PHS
-23	136-0327-00	B010100	B020479	4						SOCKET, terminal
	136-0327-01	B020480		4						SOCKET, terminal
-24	131-0590-00			6						TERMINAL, post, 0.67 inch
	- - - - -			-						mounting hardware: (not included w/assembly)
-25	211-0156-00			2						SCREW, 1-72 x 0.250 inch, FHS
-26	670-1104-00			1						ASSEMBLY, pushbutton switch—SOURCE (Triggering)
	- - - - -			-						assembly includes:
	- - - - -			1						BULB
	380-0155-02			1						HOUSING, bulb cover
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-27	136-0327-00	B010100	B020479	6						SOCKET, pin terminal
	136-0327-01	B020480		6						SOCKET, pin terminal
-28	131-0589-00			4						TERMINAL, post, 0.52 inch
	- - - - -			-						mounting hardware: (not included w/assembly)
-29	211-0156-00			2						SCREW, 1-72 x 0.250 inch, FHS
-30	670-1107-00			1						ASSEMBLY, pushbutton switch—MAGNIFIER
	- - - - -			-						assembly includes:
	- - - - -			1						BULB
	380-0148-01			1						HOUSING, bulb cover
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-31	131-0589-00			1						TERMINAL, post, 0.52 inch
	- - - - -			-						mounting hardware: (not included w/assembly)
-32	211-0156-00			1						SCREW, 1-72 x 0.250 inch, FHS
-33	331-0247-00			1						DIAL, CONTROL—DELAY TIME MULT
-34	- - - - -			1						RESISTOR, variable, w/hardware
-35	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
	210-0046-00			1						LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
-36	129-0252-00			1						POST, metallic, 0.471 inch long
-37	358-0409-00			1						BUSHING, machine thread
-38	358-0301-02			1						BUSHING, sleeve, front panel trim
-39	131-0352-02	B010100	B020419	1						CONNECTOR, 1 contact BNC, w/hardware
	131-0955-00	B020420		1						CONNECTOR, 1 contact BNC, w/hardware
	- - - - -			-						mounting hardware: (not included w/connector)
-40	210-0255-00			1						LUG, solder, 3/8 ID, SE

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y						Description
					1	2	3	4	5	
1-41	366-1103-00			1						KNOB, gray—TIME/DIV or DLY TIME knob includes:
	213-0020-00			2						SETSCREW, 6-32 x 1/8 inch, HSS
-42	366-1166-00			1						KNOB, red—VARIABLE (CAL IN) knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-43	384-0490-00			1						SHAFT, extension, 5.93 inches long
-44	670-1100-00	B010100	B109999	1						ASSEMBLY, circuit board—INTERFACE
	670-1100-01	B110000		1						ASSEMBLY, circuit board—INTERFACE assembly includes:
	388-1334-00			1						BOARD, circuit
-45	105-0116-00			1						DRUM, cam switch—TIME/DIV or DLY TIME
-46	401-0056-00			1						BEARING, rear
-47	401-0057-00			1						BEARING, front
-48	407-0653-00			1						BRACKET, support
-49	354-0219-00			1						RING, RETAINER
-50	214-1127-00			1						ROLLER, detent
-51	214-1139-00 ¹			-						SPRING, flat, gold
	214-1139-02 ¹			-						SPRING, flat, green
	214-1139-03 ¹			-						SPRING, flat, red
	210-0591-00			6						NUT, hex., 4-40 x 3/16 inch
-52	211-0116-00			6						SCREW, sems, 4-40 x 5/16 inch, PHB
-53	200-0963-00			1						COVER, cam switch mounting hardware: (not included w/cover)
-54	210-0001-00			4						LOCKWASHER, internal, #2
-55	211-0079-00			4						SCREW, 2-56 x 0.188 inch, PHS
-56	210-0405-00			4						NUT, hex., 2-56 x 3/16 inch
-57	351-0180-00			1						GUIDE, actuator
-58	214-1136-00			1						SLIDE, actuator
-59	214-1190-00			1						EXTENDER-RETRACTOR KNOB
-60	407-0553-00			1						BRACKET, variable resistor
-61	- - - - -			1						RESISTOR, variable mounting hardware: (not included w/resistor)
-62	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-63	344-0189-00			2						CLIP, capacitor mounting hardware for each: (not included w/clip)
	211-0601-00			1						SCREW, sems, 6-32 x 5/16 inch, PHS
-64	210-0407-00			1						NUT, hex., 6-32 x 1/4 inch
-65	131-0566-00			27						LINK, terminal connector
-66	131-0593-00			5						TERMINAL, post, 1.15 inches
-67	131-0590-00			68						TERMINAL, post, 0.67 inch
-68	131-0608-00			24						TERMINAL, post, 0.365 inch
-69	131-0707-00			6						CONNECTOR, AWG 22 to 26 wire
-70	352-0164-00			1						HOLDER, terminal connector, 6 terminal
-71	351-0185-00			3						GUIDE-POST, lock
-72	351-0188-00			7						GUIDE-POST, lock mounting hardware: (not included w/assembly)
-73	220-0547-01			5						NUT BLOCK
-74	211-0116-00			5						SCREW, sems, 4-40 x 5/16 inch, PHB
-75	211-0105-00			5						SCREW, 4-40 x 3/16 inch, FHS

¹Replace only with part bearing same color as the original part in your instrument.

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	1	2	3	4	5	Description
1-76	670-1101-00	B010100	B019999	1						ASSEMBLY, circuit board—TIME BASE
	670-1101-01	B020000	B049999	1						ASSEMBLY, circuit board—TIME BASE
	670-1101-02	B050000	B069999	1						ASSEMBLY, circuit board—TIME BASE
	670-1101-03	B070000	B099999	1						ASSEMBLY, circuit board—TIME BASE
	670-1101-04	B100000		1						ASSEMBLY, circuit board—TIME BASE
	- - - - -			-						assembly includes:
	388-1335-00	B010100	B049999	1						BOARD, circuit
	388-1335-01	B050000		1						BOARD, circuit
-79	136-0220-00	B010100	B049999	29						SOCKET, transistor, 3 pin
	136-0220-00	B050000		30						SOCKET, transistor, 3 pin
-80	136-0235-00			4						SOCKET, transistor, 6 pin
-81	136-0263-01			42						SOCKET, pin terminal
-82	131-0608-00			7						TERMINAL, post, 0.365 inch
-83	200-0945-00			1						COVER HALF, transistor, temp stabilizer, dual
-84	200-0945-01			1						COVER HALF, transistor, temp stabilizer, dual, threaded
-85	211-0062-00			1						SCREW, 2-56 x 5/16, RHS
-86	211-0155-00			5						SCREW, 4-40 x 0.081 inch, knurled
-87	361-0238-00			5						SPACER, sleeve
-88	388-0432-00			1						BOARD, circuit, shield
-89	670-1102-00	B010100	B089999	1						ASSEMBLY, circuit board—TRIGGER
	670-1102-01	B090000		1						ASSEMBLY, circuit board—TRIGGER
	- - - - -			-						assembly includes:
	388-1336-00			1						BOARD, circuit
-90	136-0220-00			33						SOCKET, transistor, 3 pin
-91	136-0235-00			1						SOCKET, transistor, 6 pin
-92	136-0263-01			21						SOCKET, pin terminal
-93	131-0508-00			4						TERMINAL, post, 0.365 inch
-94	214-0579-00			14						PIN, test point
-95	337-1237-00			1						SHIELD, electrical
-96	211-0155-00			5						SCREW, 4-40 x 0.081 inch, knurled
-97	361-0238-00			5						SPACER, sleeve
-98	214-1140-00			10						SPRING, helical compression
-99	351-0155-00			12						GUIDE, terminal lead
-100	131-0755-00			6						CONNECTOR, terminal, AWG 28 to 32 wire
-101	131-0512-00			6						CONNECTOR, terminal (coaxial cable)
-102	- - - - -			1						CAPACITOR
	- - - - -			-						mounting hardware: (not included w/capacitor)
	210-1092-00			3						WASHER, flat, 0.147 ID x 0.312 inch OD
-103	210-0407-00			3						NUT, hex., 6-32 x 1/4 inch
-104	352-0222-00			3						HOLDER, cable
-105	386-1657-00			5						SUPPORT, circuit board, for 0.185 inch board height
-106	386-1559-00			2						SUPPORT, circuit board, for 0.47 inch board height
-107	352-0157-00			1						HOLDER, lamp
-108	378-0602-00			1						LENS, lamp
-109	200-0935-00			1						CAP, lamp holder
-110	131-0809-00									
	- - - - -			-						mounting hardware: (not included w/terminal)
-111	131-0664-00			1						CONTACT, electrical, shaft ground
-112	211-0105-00			1						SCREW, 4-40 x 3/16 inch, 100° csk, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y						Description
					1	2	3	4	5	
1-113	352-0165-00			1						HOLDER, terminal connector, 7 terminal
-114	131-0707-00			23						CONNECTOR, AWG 22 to 26 wire
-115	352-0162-00			1						HOLDER, terminal connector, 4 terminal
-116	352-0161-00			1						HOLDER, terminal connector, 3 terminal
-117	352-0169-00			5						HOLDER, terminal connector, 2 terminal
-118	131-0708-00			3						CONNECTOR, AWG 28 to 32 wire
-119	348-0157-00	B010100	B010150	2						SHIELDING GASKET
	348-0235-00	B010151		2						SHIELDING GASKET
-120	366-1058-06			1						KNOB, latch
-121	214-1095-00			1						PIN, spring, split
-122	105-0076-00			1						RELEASE BAR, latch
-123	214-1280-00			1						SPRING, helical extension
-124	105-0075-00			1						BODY, latch
-125	214-1054-00			1						SPRING, flat, latch detent
-126	333-1164-00			1						PANEL, front
-127	386-1447-11			1						SUBPANEL, front
-128	386-1402-00			1						PANEL, rear
-129	214-1061-00			1						SPRING, flat, sliding ground
-130	426-0505-04			1						FRAME SECTION, top
-131	426-0499-04			1						FRAME SECTION, bottom
-132	213-0192-00			8						SCREW, thread forming, 6-32 x 1/2 inch, Fil HS
	361-0326-00			1						SPACER, sleeve
-133	337-1064-00			2						SHIELD, electrical

STANDARD ACCESSORIES

070-0976-00

1 MANUAL, instruction (not shown)

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.

ELECTRICAL PARTS LIST CORRECTION

DELAY MODE Circuit Board Assembly

CHANGE TO:

670-1103-02 Complete Board

REMOVE:

TP490 214-0579-00 Test Point

MECHANICAL PARTS LIST CORRECTION

SECTION 8 Page 8-1

CHANGE TO:

Fig. -13	670-1103-02	1	CIRCUIT BOARD ASSEMBLY-B DELAY MODE
	- - - - -	-	circuit board assembly includes:
	388-1337-02		CIRCUIT BOARD
	131-0722-00	1	Contact, elec.

ELECTRICAL PARTS LIST CORRECTION

DELAY MODE Circuit Board Assembly

CHANGE TO:

670-1103-02		Complete Board	
DS490	150-0048-01	Incandescent	
S490	670-1103-02	Pushbutton	B DELAY MODE

SOURCE Circuit Board Assembly

CHANGE TO:

670-1104-01		Complete Board	
DS140	150-0048-01	Incandescent	
S140	670-1104-01	Pushbutton	SOURCE

MODE Circuit Board Assembly

CHANGE TO:

670-1105-01		Complete Board	
DS325	150-0048-01	Incandescent	
DS446	150-0048-01	Incandescent	
S325	670-1105-01	Pushbutton	MODE

COUPLING Circuit Board Assembly

CHANGE TO:

670-1106-01		Complete Board	
DS145	150-0048-01	Incandescent	
S145	670-1106-01	Pushbutton	COUPLING

MAGNIFIER Circuit Board Assembly

CHANGE TO:

670-1107-01		Complete Board	
DS780	150-0048-01	Incandescent	
S780	670-1107-01	Pushbutton	MAGNIFIER

MECHANICAL PARTS LIST CORRECTION

Page 8-1

CHANGE TO:

Fig. 1-13	670-1103-02	1	ASSEMBLY, pushbutton switch-B DELAY MODE
-17	670-1105-01	1	ASSEMBLY, pushbutton switch-MODE (Triggering)

Page 8-2

CHANGE TO:

Fig. 1-22	670-1106-01	1	ASSEMBLY, pushbutton switch-COUPLING (Triggering)
-26	670-1104-01	1	ASSEMBLY, pushbutton switch-SOURCE (Triggering)
-30	670-1107-01	1	ASSEMBLY, pushbutton switch-MAGNIFIER