INSTRUCTION MANUAL

Serial Number ____________

TYPE 3B5

AUTOMATIC/ PROGRAMMABLE TIME BASE

Tektronix, Inc.

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

070-0538-00

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WARRANTY

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

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

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

Specifications and price change privileges reserved.

CONTENTS

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

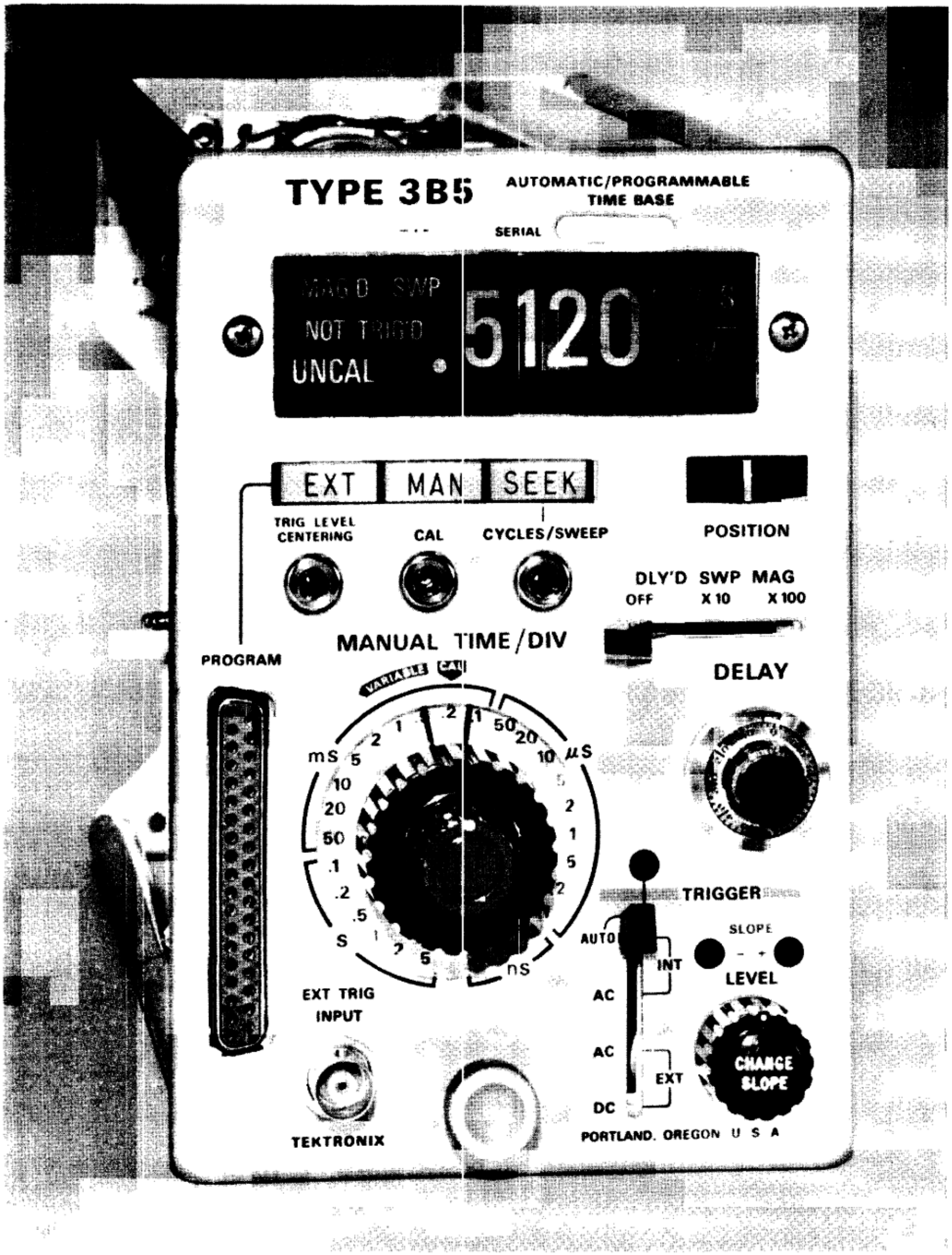


Fig. 1-1. Type 3B5 Automatic/Programmable Time Base unit.

SECTION 1
CHARACTERISTICS

The Tektronix Type 3B5 Automatic/Programmable Time Base unit provides automatic and programmable time-base features, in addition to conventional time-base features, for Tektronix oscilloscopes which accept 3-series time-base units[1]. The Type 3B5 provides automatic sweep rate and trigger seeking on Seek command either from the front-panel SEEK button, from a remote-seeking probe (through an associated automatic/programmable amplifier unit) or from an external source (through either the front-panel PROGRAM connector or the program connector of the associated automatic/programmable amplifier unit). All front-panel control functions (except variable sweep rate) can be externally programmed through the front-panel PROGRAM connector. The MANUAL TIME/DIV switch provides selection of sweep rates from 5 seconds/division to 10 nanoseconds/division with delayed sweep magnification of 10 and 100 times (up to a maximum magnified sweep rate of 0.1 microseconds/division).

[1]**Except the Type 561 (SN 5000 and below). When used in a Type 565, a vertical sweep is provided.**

A front-panel illuminated readout panel indicates sweep rate, magnified sweep (with correct indication of magnified sweep rate), non-triggered sweep and uncalibrated sweep. The readout panel functions in all modes of operation.

The characteristics which follow are divided into two categories. Characteristics listed in the Performance Requirement column are checked in the Performance Check and Calibration sections of this manual. Items listed in the Supplemental Information column are provided for reference use and do not directly reflect the measurement capabilities of this instrument. The Performance Check procedure given in Section 5 of this manual provides a convenient method of checking the Performance Requirements listed in this section. The following characteristics apply over an ambient temperature range of 0° C to +50° C, except as otherwise indicated. Warm-up time for given accuracy is five minutes.

ELECTRICAL CHARACTERISTICS

TRIGGERING

Characteristic	Performance Requirement	Supplemental Information
Source	Internal or external	
Coupling	AC internal AC or DC external	
Polarity	Sweep can be triggered from positive-going or negative-going portion of trigger signal.	Slope changed automatically each time CHANGE SLOPE button is pressed.
Mode	Auto triggering Normal triggering adjustable for desired level	
Internal Trigger Sensitivity AUTO and AC	0.5 division of deflection, minimum, 50 Hz to 20 MHz	Checked with Type 3A5 signal displayed, 10 millivolts/division or greater sine wave. Typically —3 dB down at 10 Hz
External Trigger Sensitivity AC	1.0 volt, peak to peak, 50 Hz to 20 MHz	Typically —3 dB down at 10 Hz
DC	1.0 volt, peak to peak, 10 Hz to 20 MHz	2.5 volts, peak to peak, DC to 10 Hz
Trigger LEVEL Control Range INT-AC		At least + and — 10 volts
EXT-AC	At least + and — 20 volts	
EXT-DC	At least + and — 10 volts	
AUTO		Approximately 10% and 90% of trigger signal transition with a minimum of 0.5 division, (10 millivolts/division or greater) 1 kHz sine wave displayed with Type 3A5
External Program Trigger Level Range		Same as front-panel range with current change between about 0 and 400 microamps
External Trigger Input RC Characteristics		Approximately 150 kilohms paralleled by about 22 pF
Maximum Input Voltage at EXT TRIG INPUT connector		100 volts, DC + peak AC

HORIZONTAL DEFLECTION SYSTEM

Characteristic	Performance Requirement	Supplemental Information
Sweep Rates		
Manual Mode	5 seconds/division to 10 nanoseconds/division in 27 calibrated steps. Sweep rate indicated on readout panel	Selected by front-panel MANUAL TIME/DIV switch. Steps in 1-2-5 sequence
Seek Mode	5 seconds/division to 0.1 microseconds/division in 24 calibrated steps. Sweep rate indicated on readout panel	Automatically selected when seek command is received. Steps in 1-2-5 sequence
External Mode	5 seconds/division to 10 nanoseconds/division in 27 calibrated steps. Sweep rate indicated on readout panel	Selected by external program connected to PROGRAM connector. Steps in 1-2-5 sequence
Sweep Accuracy (at 25° C, ±5°) 1 s to 10 ns	Within ±3% of indicated sweep rate	VARIABLE control fully clockwise (UNCAL readout off) and DLY'D SWP MAG switch set to OFF (MAG'D SWP readout off). 10, 20 and 50 ns accuracy must be checked in accordance with Performance Check
5 s and 2 s	Within ±5% of indicated sweep rate	
Variable Sweep Rate	Uncalibrated sweep rate to 2.5 times, or greater, the indicated sweep rate. s/DIV readout turns off and UNCAL readout turns on when VARIABLE control is not set to CAL position	Slowest sweep rate 12.5 seconds/division, or greater, in 5 s position
Sweep Length		
DLY'D SWP MAG at OFF	10.3 to 11.3 divisions	Measured at 1 ms/DIV sweep rate
DLY'D SWP MAG on	12 to 15 divisions	
Delayed Sweep Magnification	Basic sweep rates between 5 s and 1 μs can be magnified with the Delayed Sweep Magnifier. Calibrated DELAY control selects portion to be magnified. Basic sweep rates between 5 s and 10 μs can be magnified 100 times; basic sweep rates between 5 s and 1 μs can be magnified 10 times	Readout panel indicates correct magnified sweep rate
Magnified Sweep Accuracy (at 25° C, ±5°) 1 s to 1 μs	Within ±3% of sweep rate indicated on readout panel	VARIABLE control fully clockwise (UNCAL readout off)
5 s and 2 s	Within ±5% of sweep rate indicated on readout panel	
Calibrated Delay Range	Continuous from 0 to 10 divisions from the start of the trace	
Delay Accuracy	Within ±1.5% of full scale at 1 ms/DIV. Within ±3% of full scale at all other sweep rates	Calibrated at 1 ms/DIV. Exclude first 0.2 division of display. Includes incremental DELAY dial linearity
Incremental DELAY Dial Linearity	Within ±0.4% of full scale	Exclude first 0.2 division of display
Delayed Sweep Magnifier Jitter	3 parts or less per 10,000	Equal to 0.3 division or less when measured with ×100 magnification at 1 ms/DIV basic sweep rate
Output DC Level	+180 volts, ±10 volts	Beam positioned to CRT electrical center

SEEK MODE

Characteristic	Performance Requirement	Supplemental Information
Cycles Per Sweep	Between two and six cycles with nominal CYCLES/SWEEP setting obtained in Calibration procedure	Automatically selected when seek command is received. Front-panel CYCLES/SWEEP adjustment provides range of about 0.5 to 3 times this nominal setting
Automatic Seek Cycling Time	One to two seconds	When seek command is continuous
Automatic Seeking Time		500 milliseconds or less with 10 MHz sine wave input and Trigger Function switch set to INT-AUTO
Frequency Range for Seek Mode Operation	30 Hz to 20 MHz	
Seek Mono Pulse Width	1.0 to 1.8 seconds	

PROGRAMMABLE FUNCTIONS

<table>
<tr><th>Characteristic</th><th colspan="3">Performance Requirement</th><th>Supplemental Information</th></tr>
<tr><td>Trigger Function</td><td colspan="3">Int Auto—If not programmed
Int AC—Terminal 31
Ext AC—Terminal 30
Ext DC—Terminal 28</td><td rowspan="2">Grounding (zero volt) digital logic to given terminal of PROGRAM connector activates function</td></tr>
<tr><td>Trigger Slope</td><td colspan="3">+Slope—If not programmed
—Slope—Terminal 27</td></tr>
<tr><td>Trigger Level</td><td colspan="3"></td><td>Analog current change between about 0 and 400 microamps at terminal 15 of PROGRAM connector provides same trigger level range as front-panel LEVEL control</td></tr>
<tr><td>Sweep Rate
Multiplier</td><td colspan="3">×1—Terminal 2
×2—Terminal 3
×5—Terminal 5</td><td rowspan="9">Sweep multiplier, sweep decade and decade enable must be programmed for each sweep rate. Grounding (zero volt) digital logic to given terminals of PROGRAM connector activates function</td></tr>
<tr><td>Enable</td><td colspan="3">A—Terminal 23
B—Terminal 24</td></tr>
<tr><td rowspan="7">Decade</td><td colspan="2">Enable Logic</td><td rowspan="2">Terminal</td></tr>
<tr><td>A</td><td>B</td></tr>
<tr><td>1 s</td><td>0.1 s</td><td>6</td></tr>
<tr><td>10 ms</td><td>1 ms</td><td>8</td></tr>
<tr><td>0.1 ms</td><td>10 μs</td><td>9</td></tr>
<tr><td>1 μs</td><td>0.1 μs</td><td>11</td></tr>
<tr><td></td><td>10 ns</td><td>26</td></tr>
<tr><td>Horizontal Position</td><td colspan="3"></td><td>Analog current change between about 0 and 500 microamps at terminal 14 of PROGRAM connector provides ±3 division external horizontal position range</td></tr>
<tr><td>Delayed Sweep Magnifier</td><td colspan="3">OFF—Terminal 33
×10—Terminal 34
×100—Terminal 36</td><td>Grounding (zero volt) digital logic to given terminal of PROGRAM connector activates function</td></tr>
<tr><td>Magnifier Delay</td><td colspan="3"></td><td>Analog current change between about 350 and 200 microamps at terminal 17 of PROGRAM connector provides 0 to 10 division external delay range</td></tr>
<tr><td>External Mode Command</td><td colspan="3">Type 3B5 switches to External Mode when terminal 21 of PROGRAM connector is grounded</td><td></td></tr>
<tr><td>Remote Seek</td><td colspan="3">Type 3B5 switches to Seek Mode (except when External Mode Command is present) when terminal 12 of PROGRAM connector is grounded</td><td>Momentary ground produces two to six cycles (nominal adjustment) display; continuous ground recycles unit every one to two seconds</td></tr>
<tr><td>Single Sweep</td><td colspan="3"></td><td>+125-volt external holdoff lockout applied to terminal 7 and —12-volts reset momentarily applied to terminal 25 of PROGRAM connector provides single-sweep operation</td></tr>
</table>

ADDITIONAL FUNCTIONS AVAILABLE AT PROGRAM CONNECTOR

Characteristic	Performance Requirement	Supplemental Information
External Horizontal Input		Applied to terminal 4 of PROGRAM connector. Sweep lockout at terminal 7, external unblanking at terminal 13 and horizontal position centering at terminal 14 also necessary.
Deflection factor		5 volts/division ±5%
Bandwidth		DC to 750 kHz, or greater
Maximum input voltage		75 volts, DC + peak AC
Input resistance		Approximately 100 kilohms

Additional Functions *(cont)*

Characteristic	Performance Requirement	Supplemental Information		
Sweep Out		0.05 milliamp/division, ±10%, at terminal 16 of program connector[2]		
External Unblanking	—12 volts DC unblanks CRT	Apply to terminal 13 of PROGRAM connector		
Current Available from PROGRAM Connector (maximum)		Supply	Terminal	Current
		+125 V	18	30 mA
		—12.2 V	1	75 mA
		—100 V	19	1 mA

ENVIRONMENTAL CHARACTERISTICS

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

Characteristic	Performance Requirement	Supplemental Information
Temperature		
Operating	0° C to +50° C	
Non-operating	—40° C to +65° C	
Altitude		
Operating	15,000 feet maximum	
Non-operating	50,000 feet maximum	May be tested during non-operating temperature tests
Vibration		
Operating	Vibrate for 15 minutes along each axis at a total displacement of 0.015 inch (1.9 g at 50 c/s) with the frequency varied from 10-50-10 c/s in one-minute cycles. Hold at any resonant point for three minutes. If no resonant points are found, vibrate at 50 c/s for three minutes on each axis.	Instrument secured to vibration platform during test. Total vibration time about 55 minutes.
Shock		
Non-operating	One shock of 30 g, one-half sine, 11 millisecond duration along each major axis.	Guillotine type shock
Transportation	Meets National Safe Transit type of test when correctly packaged	
Package vibration	Vibrate for one hour slightly in excess of 1 g	Package should just leave vibration surface
Package drop	Drop from a height of 30 inches on one corner, all edges radiating from that corner and all flat surfaces	Total of 10 drops

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	
Chassis	Aluminum alloy
Panel	Aluminum alloy with anodized finish
Circuit boards	Glass-expoxy laminate
Dimensions	Fits 3-series compartments of 560-series Oscilloscopes
Connectors	
EXT TRIG INPUT	BNC
PROGRAM	37-terminal connector. Mates with Cinch No. DC-37P-C33 (Tektronix Part No. 131-0422-00)

[2]Similar output available at terminal 18 of the interconnecting plug.

STANDARD ACCESSORIES

Standard accessories supplied with the Type 3B5 are listed on the last pullout page at the rear of this manual. For optional accessories available for use with this instrument, see the current Tektronix, Inc. catalog.

SECTION 2
OPERATING INSTRUCTIONS

General Information

To effectively use the Type 3B5, the operation and capabilities of the instrument must be known. This section describes the operation of the front-panel controls and connectors, gives first time and general operating information, External Mode programming information and lists some basic applications for this instrument.

The Type 3B5 operates with the indicator oscilloscope and an amplifier unit to form a complete oscilloscope system. When used with an automatic programmable amplifier unit, a remote-seeking probe and an external programmer, a complete system is formed which has manual, automatic seeking, remote seeking and external programming measurement capabilities.

Installation

CAUTION

Turn off the oscilloscope power before inserting or removing the plug-in unit.

The Type 3B5 is designed for use in the Horizontal plug-in compartment of a 560-series indicator oscilloscope. However, the Type 3B5 can be inserted into the Vertical plug-in compartment of the indicator oscilloscope to provide a sweep that runs vertically on the CRT screen (no blanking provided and instrument may not meet performance requirements given in Section 1 if used in this manner). Since the horizontal and vertical deflection plate sensitivities of the oscilloscope are different, the Type 3B5 must be recalibrated to provide an accurate display for vertical deflection use. Throughout this manual, it is assumed that the Type 3B5 is used to provide horizontal deflection in the conventional manner.

To install the Type 3B5 in the oscilloscope, insert it into the plug-in compartment and push it in as far as possible. Be sure the securing latch at the bottom of the panel is out of the way (turn knob counterclockwise) to prevent damage to the oscilloscope front panel. Secure the plug-in into the compartment by turning the securing-latch knob clockwise until it is tight. To remove the plug-in from the compartment, turn the securing-latch knob several turns counterclockwise. Then, pull the plug-in partially out of the compartment with the knob and take hold of the plug-in by the support rods to remove it from the oscilloscope.

Whenever the Type 3B5 is transferred from one oscilloscope to another, the sweep calibration should be checked and adjusted if necessary to provide accurate measurements with the complete system. See Horizontal Gain Adjustment in this section for adjustment procedure.

Cooling

The Type 3B5 does not require special cooling other than that provided by the indicator oscilloscope. When operated within the ambient temperature range given in Section 1, the Type 3B5 provides accurate measurements (note exception for sweep accuracy).

FRONT-PANEL CONTROLS AND CONNECTORS

Introduction

All controls and connectors required for the operation of the Type 3B5 are located on the front panel of the unit (see Fig. 2-1). To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each of these controls and connectors. A brief description of the function or operation of the front-panel controls and connectors follows. More detailed information on control operation and use is given under General Operating Information.

Trigger Controls

EXT TRIG INPUT — Input connector for external trigger signal.

Trigger Function (not labeled) — Lever switch which selects the trigger source, coupling and mode.

INT-AUTO—Permits normal triggering on repetitive waveforms with repetition rates higher than 50 Hz. For lower repetition rates or when there is no trigger signal, the sweep generator free runs at the sweep rate to which it is set to provide a reference trace. Auto Trigger light indicates when unit is in the auto trigger mode.

INT-AC—Sweep triggered by internal signal from amplifier unit. Trigger circuit rejects DC and attenuates AC signals below about 50 Hz.

EXT-AC—Sweep triggered by external signal applied to the EXT TRIG INPUT connector. Trigger circuit rejects DC and attenuates AC signals below about 50 Hz.

EXT-DC—Sweep triggered by external signal applied to the EXT TRIG INPUT connector. Trigger circuit accepts AC and DC signals.

SLOPE — (+) and (—) lights indicate which slope of the trigger signal starts the sweep. When the (—) light is on, the sweep can be triggered on the negative-going slope of the trigger signal; the (+) light indicates that the sweep can be triggered on the positive-going slope of the trigger signal. Trigger slope is changed by pressing the CHANGE SLOPE button in the center of the LEVEL control.

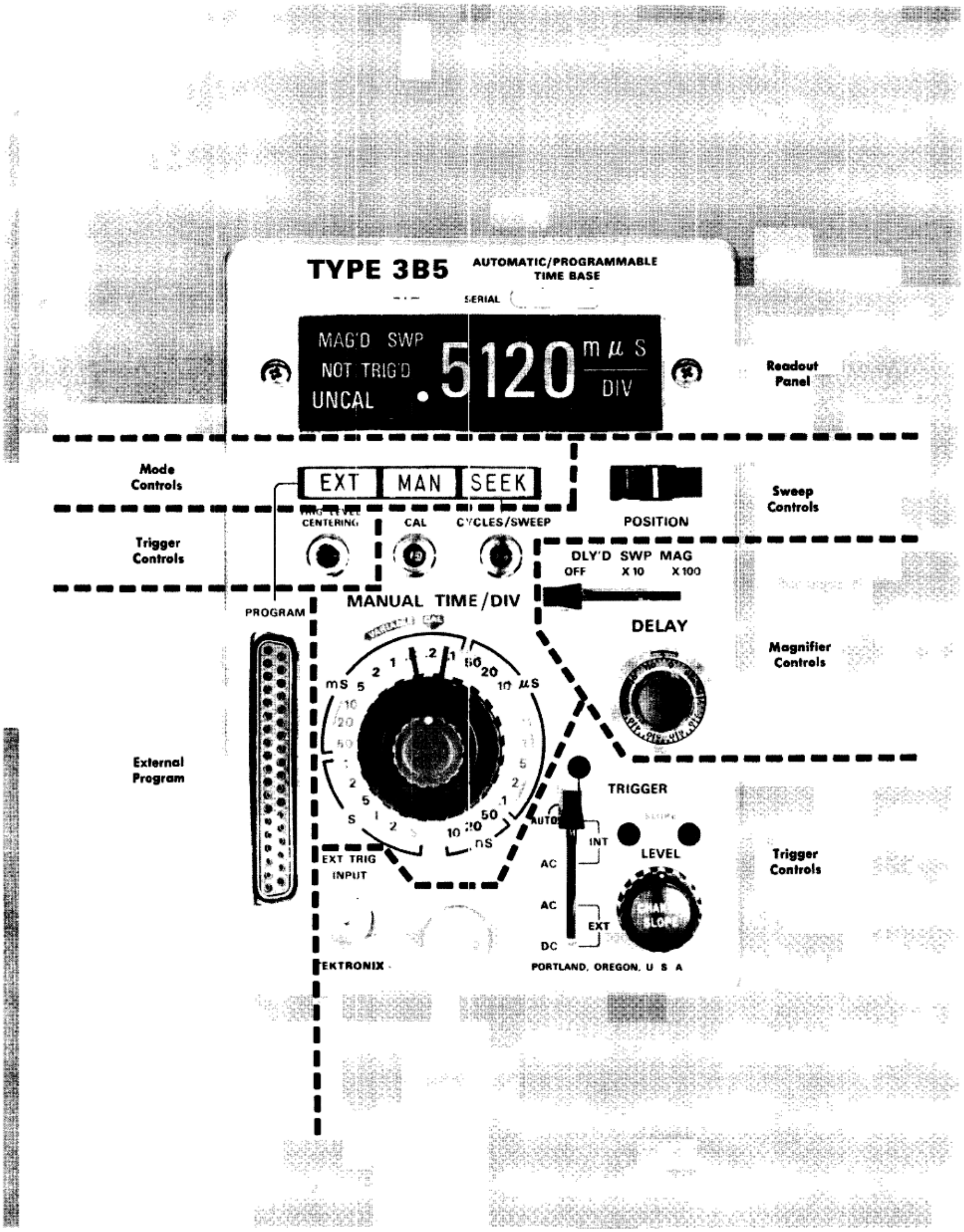


Fig. 2-1. Front-panel controls and connectors of the Type 3B5.

Auto Trigger (not labeled)	Light indicates that sweep is triggered in the auto trigger mode.
LEVEL	Normal Triggering—Selects amplitude point on trigger signal where sweep is triggered. Auto Triggering—Selects trigger level which is always within the peak-to-peak range of the trigger signal (typically adjustable between 10% and 90%).
TRIG LEVEL CENTERING	Screwdriver adjustment to set the trigger circuit for correct operation (see Calibration procedure for adjustment).

Mode Controls

EXT	When the EXT button is lit, the instrument operates in the External Mode. The instrument changes to, and remains in, the External Mode of operation when an external programmer is connected to the PROGRAM connector and a program is selected. The External Mode overrides the other modes.
MAN	Pushbutton to select the Manual Mode of operation (except when EXT light is on). When the MAN button is lit, the instrument operates in the Manual Mode. All functions can be controlled by the front-panel controls in this mode of operation. The instrument changes to the Manual Mode of operation when the MAN button is pressed, when the MANUAL TIME/DIV switch setting is changed when in the Seek Mode, or when the external program is disconnected.
SEEK	Pushbutton to select the Seek Mode of operation (except when EXT light is on). When the SEEK button is lit, the instrument operates in the Seek Mode. The instrument changes to the Seek Mode of operation when a seek command is received from the front-panel SEEK button, a remote-seeking probe through the associated automatic/programmable amplifier unit, remote seek from the front-panel PROGRAM connector or remote seek from the program connector of the associated automatic/programmable amplifier unit.

Sweep Controls

CAL	Screwdriver adjustment to set the horizontal gain of the unit. Used to set basic timing of this unit and to compensate for the differences in CRT deflection factor when changing indicator oscilloscopes.
CYCLES/SWEEP	Screwdriver adjustment to select the nominal number of cycles displayed in the Seek Mode of operation.
POSITION	Controls horizontal position of trace.
MANUAL TIME/DIV	Selects the sweep rate of the sweep generator in the Manual Mode of operation. When in Seek Mode operation, mode automatically changes from SEEK to MAN when the MANUAL TIME/DIV switch setting is changed.
VARIABLE	Provides continuously variable sweep rate to at least 2.5 times the readout indicated in the CAL position. Sweep rate is calibrated only when the control is set fully clockwise to CAL. s/DIV readout turns off and UNCAL readout turns on when VARIABLE control is not set to CAL.

Delayed Sweep Magnifier Controls

DELAY	Provides variable delay for the starting point of the magnified sweep. May be delayed between 0 and 10 divisions from the start of the trace.
DLY'D SWP MAG	Increases sweep rate after end of delay period selected by DELAY control. OFF—Normal sweep at sweep rate indicated on readout panel. ×10—Sweep rate increased 10 times after end of delay period (for basic sweep rates of 1 μs/DIV or slower). MAG'D SWP readout lights and the sweep-rate readout is corrected for the magnified sweep rate. ×100—Sweep rate increased 100 times after end of delay period (for basic sweep rates of 10 μs/DIV or slower). MAG'D SWP readout lights and the sweep-rate readout is corrected for the magnified sweep rate.

External Program

PROGRAM	37-terminal connector for external programming of the unit. Also provides output and input connections for various other instrument functions.

Readout Panel

MAG'D SWP	Indicates that the sweep rate is magnified. The sweep rate readout is automatically corrected to indicate the magnified sweep rate.
NOT TRIG'D	Indicates that sweep circuits are not triggered.
UNCAL	Indicates that VARIABLE control is not in CAL position. s/DIV readout turns off when UNCAL readout is on.
. - 5 - 1 - 2 - 0 - m - μ - s/DIV	Indicates sweep rate in all modes of operation. Automatically corrected when sweep is magnified.

FIRST-TIME OPERATION

The following steps will demonstrate the basic function of the controls and connectors of the Type 3B5 and also demonstrate the basic operation of this unit. It is recommended that this procedure be followed completely for first-time familiarization with the instrument.

The first 12 steps of this procedure describe the method of setting up the system for correct time measurements. These steps may be used to set up the unit when it is installed in an oscilloscope other than the one with which it was calibrated.

NOTE

The following procedure is written using a Tektronix Type 561A or 564. Other units may require slight changes in this procedure.

Set-up Information

1. With the indicator oscilloscope power turned off, insert the Type 3B5 into the horizontal plug-in compartment (complete installation instructions are given earlier in this section).

2. Insert a 3-series amplifier unit into the left plug-in compartment. (This procedure is written assuming that an automatic/programmable amplifier unit is used; if other units are used, some of the demonstrations may not apply.)

3. Set the oscilloscope intensity control counterclockwise.

4. Connect the oscilloscope to a power source which meets its voltage and frequency requirements.

5. Turn on the oscilloscope power switch. Allow about five minutes warm up so the units reach a normal operating temperature before proceeding.

6. Set the front-panel controls as follows:

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	5.00
MANUAL TIME/DIV	5 ms
VARIABLE	CAL
Trigger Function	INT-AUTO
LEVEL	Midrange
SLOPE	+

Amplifier Unit

Position	Midrange
Input coupling	DC
Volts/division	20 Millivolts
Mode	Manual

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Adjust for visible display
Calibrator	0.1 volts
Scale illumination	As desired
Power	On

7. Connect the oscilloscope calibrator output connector to the input of the amplifier unit with a BNC cable.

8. Press the SEEK buttons on both the automatic/programmable amplifier unit and the Type 3B5. The display should be between two and five divisions vertically with two to six cycles displayed horizontally.

9. Push the Type 3B5 MAN button and check the display for three complete cycles. More or less cycles may indicate incorrect CAL adjustment (applies for 60-Hz calibrator frequency only). See Horizontal Gain Adjustment in this section.

10. Hold the SEEK button depressed and note the readout panel indication and number of cycles in the display. Then, turn the CYCLES/SWEEP adjustment counterclockwise. Note that the sweep rate indicated on the readout panel increases and fewer cycles are displayed.

11. Hold the SEEK button depressed and turn the CYCLES/SWEEP adjustment clockwise. Note that the sweep rate decreases and more cycles are displayed.

12. Hold the SEEK button depressed and adjust the CYCLES/SWEEP adjustment for the desired number of cycles in the display (determines nominal number of cycles in Seek Mode display; sweep rate increases in 5-2-1 sequence). Normal adjustment is near midrange with between two and six cycles displayed. Release the SEEK button after the nominal range is obtained.

Operating Mode

13. Turn the MANUAL TIME/DIV switch to .1 ms. Note that the SEEK light goes off and the MAN light comes on when the MANUAL TIME/DIV switch is turned. Also, note that the sweep-rate readout changes as various sweep rates are selected.

14. Press the SEEK button. Note that the display returns to the same display as obtained in step 12.

15. Turn the MANUAL TIME/DIV switch to 20 ms.

16. Press the SEEK button. Note that the display again is the same as in step 12.

Sweep and Delayed Sweep Magnifier

17. Turn the VARIABLE control throughout its range. Note that the UNCAL readout comes on and the s/DIV readout turns off when the VARIABLE control is moved from the CAL position (fully clockwise). The sweep rate is slower by about 2.5 times when in the fully counterclockwise position as indicated by more cycles displayed on the CRT. Return the VARIABLE control to CAL.

18. Press the MAN button and set the DLY'D SWP MAG switch to ×10. Note that the CRT display is expanded starting at about the center of the display. Also note that the MAG'D SWP readout is on and the sweep rate as indicated by the readout panel is 10 times faster than the setting of the MANUAL TIME/DIV switch.

19. Set the DLY'D SWP MAG switch to OFF. Turn the POSITION control to move the right end of the trace to the center of the display. Now, return the DLY'D SWP MAG switch to the ×10 position. Note that the sweep length is increased several divisions when the magnifier is turned on. Return the start of the trace to the left edge of the graticule.

20. Turn the DELAY dial to 0.00. Note that the entire display is magnified.

21. Set the DLY'D SWP MAG switch to ×100. Note that the display is magnified further and the sweep-rate as indicated by the readout panel is 100 times faster than the setting of the MANUAL TIME/DIV switch.

22. Press the SEEK button. Note that a two to six division display is presented. Now turn the DELAY dial to about 0.50 and press the SEEK button again. Notice that the display changes. Finally, set the DELAY dial to about 1.00 and press the SEEK button again. Once again the display changes. This step illustrates that the desired magnified display may not be obtained when using the SEEK MODE.

23. Set the DLY'D SWP MAG switch to OFF, MANUAL TIME/DIV switch to 5 ms and press the SEEK button.

Triggering

24. Press the CHANGE SLOPE button. Note that each time the button is pressed the display starts on the opposite polarity and the SLOPE light changes from (+) to (—) or from (—) to (+).

25. Rotate the LEVEL control throughout its range. The display should remain stable at all positions indicating that the LEVEL control operates between about 10% and 90% of the triggering slope for auto triggering. Press the amplifier unit manual button and note that the LEVEL control operates the same even though the signal amplitude has changed (applies to auto triggering only). Return the LEVEL control to midrange and the amplifier unit to the seek mode.

26. Disconnect the input signal. Note that a reference trace is displayed and the NOT TRIG'D readout is on. Reconnect the input signal.

27. Set the Trigger Function switch to INT-AC and adjust the LEVEL control for a stable display. Then, press the SEEK button. Note that the trace is stable and the Auto Trigger light is off.

28. Rotate the LEVEL control clockwise while watching the readout panel. Note that after several degrees of rotation the NOT TRIG'D readout comes on briefly and then goes off again. Also note that the display remains stable and the Auto Trigger light has come on. Return the LEVEL control to midrange. This step illustrates that the unit automatically seeks a stable display when in the Seek Mode. Press the SEEK button and note that the Auto Trigger light goes off, indicating that the display is again triggered from the applied signal in the internal AC mode.

29. Press the MAN button. The display should be stable. Turn the LEVEL control throughout its range. Note that the display disappears and the NOT TRIG'D readout comes on after several degrees of rotation in either direction from the center point. Return the LEVEL control to midrange.

30. Set the Trigger Function switch to EXT-AC. Note that the NOT TRIG'D readout comes on. Press the SEEK button and note that a stable, automatically triggered display (Auto Trigger light is on) is presented even though the unit is set for external triggering and no trigger signal is connected to the EXT TRIG INPUT connector.

31. Connect the calibrator signal to both the amplifier unit input connector and the EXT TRIG INPUT connector with a BNC T connector and two BNC cables.

32. Set the indicator oscilloscope calibrator for 1.0 volts output.

33. Press the MAN button. The trigger controls should operate as described for INT-AC. Operation in the EXT-DC position is much the same also except the display is triggered at a specific DC level as selected by the LEVEL control. Set the LEVEL control for a stable display.

34. Press the SEEK button on both the amplifier unit and the Type 3B5. The display should be stable and the Auto Trigger light should be off, indicating that the unit is correctly triggered in the external AC mode. Disconnect the signal from the EXT TRIG INPUT connector and note that the display remains stable and the Auto Trigger light comes on (Seek Mode only).

35. Disconnect the input signal and set the Trigger Function switch to INT-AUTO.

Remote Seek

36. If a remote-seeking probe is available, the remote seek feature of this instrument can be demonstrated. Connect the probe to the automatic/programmable amplifier unit input connector and the remote seek lead to the remote seek connector.

37. Connect the probe tip to a signal source (such as the calibrator output). Press the seek button on the probe. Note that both the amplifier unit and the Type 3B5 switch to the Seek Mode and a stable, correct display is shown. Now connect the probe to a signal with a different amplitude and frequency within the capabilities of the instrument. Press the probe seek button and note that a correct display is again presented.

External Program

38. If a programmer is available, the external programmable features of this instrument can be demonstrated. Connect the programmer to the front-panel PROGRAM connectors. Set up the desired program(s) and turn the programmer on. Note that the EXT button lights and the readout panel indicates the programmed settings rather than the front-panel control settings.

39. Turn the programmer off or disconnect the program connections. Note that the unit returns to the Manual Mode as indicated by the MAN button.

40. This completes the basic operating procedure for the Type 3B5. Instrument operation not explained here, or operations which need further explanation will be discussed under General Operating Information.

CONTROL SETUP CHART

Fig. 2-2 shows the front panel of the Type 3B5 along with an enlarged view of the PROGRAM connector. 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

Horizontal Gain Adjustment

Whenever the Type 3B5 is inserted into a plug-in compartment other than the one in which it was calibrated, the CAL adjustment should be checked and readjusted if necessary. Allow about five minutes warm up before making this adjustment (procedure given for 50- or 60-hertz line-frequency calibrator; use the Calibration procedure for other calibrator frequencies).

1. Connect a one-volt square wave from the indicator oscilloscope calibrator to the amplifier unit input connector.

2. Set the MANUAL TIME/DIV switch to 5 ms (2 ms for 50 Hz), the Trigger Function switch to INT-AUTO and the LEVEL control to midrange.

3. Press the amplifier unit seek button.

4. Press the Type 3B5 MAN button.

5. CHECK—CRT display for three complete cycles over the 10-division display area (one complete cycle for 50-Hz calibrator).

6. ADJUST—CAL adjustment for three complete cycles over the 10-division display area (one complete cycle for 50-Hz calibrator).

NOTE

Althrough the preceding method provides a fairly accurate adjustment for most measurements, better accuracy can be obtained using the procedure given in the Calibration section of this manual.

Adjusting Number of Cycles in Seek Mode Display

The CYCLES/SWEEP adjustment on the front panel permits the operator to adjust the Type 3B5 for the nominal range of cycles displayed when in the Seek Mode of operation. Use the following procedure to adjust the CYCLES/SWEEP adjustment (for more information on operation in the Seek Mode, see Seek Mode Operation in this section).

1. Connect a signal (calibrator output or one-millisecond markers recommended) which is within the frequency and amplitude capabilities of the Seek Mode to the amplifier unit input connector.

2. Press the amplifier unit seek button.

3. Press the Type 3B5 SEEK button.

4. CHECK—CRT display for desired number of cycles.

5. ADJUST—Hold the Type 3B5 SEEK button depressed and adjust the CYCLES/SWEEP adjustment for the desired display. Allow time for the seek circuits to recycle between adjustments (one to two seconds).

NOTE

This adjustment selects a nominal range of operation and the exact number of cycles displayed for a particular signal will vary due to the sweep rate selected by the Seek Circuit. The sweep rate always increases in a 5-2-1 sequence.

Trigger Level Centering Adjustment

The TRIG LEVEL CENTERING adjustment should not be readjusted during normal use. A complete adjustment procedure is given in the Calibration section of this manual.

Trigger Source

Internal. For most applications, the sweep can be triggered internally. In the INT positions of the Trigger Function switch (or when selected by external program), the trigger signal is obtained from the amplifier unit. Two methods of internal triggering are provided; AUTO and AC. These methods are described fully under Trigger Coupling and Auto Triggering.

External. An external signal connected to the EXT TRIG INPUT connector can be used to trigger the sweep in the EXT positions of the Trigger Function switch (or when selected by external program). The external signal must be time-related to the displayed signal to produce a stable display. Use an external trigger signal 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 INPUT connector through a signal probe or cable. Then, the sweep is triggered by the same signal at all times and allows amplitude, time relationship or wave shape changes of signals at various points in the circuit to be examined without resetting the trigger controls.

The external trigger signal can be either AC or DC coupled (see Trigger Coupling for further information). Since DC trigger coupling is provided only in the EXT source position, the sweep must be triggered from an external signal to take advantage of this feature.

Trigger Coupling

AC. AC trigger coupling is provided in both the INT and EXT positions of the Trigger Function switch. The DC component of the trigger signal is blocked and all AC signals below about 50 Hz are attenuated. In general, AC coupling can be used for most applications. However, if the sweep is to be triggered at a certain DC level, DC coupling (EXT position) must be used.

The triggering point in the AC position depends upon the average voltage level of the trigger signal. If trigger signals occur randomly, the average voltage level will vary, which causes the triggering point to vary also. This shift of the

TYPE 3B5 CONTROL SET-UP CHART

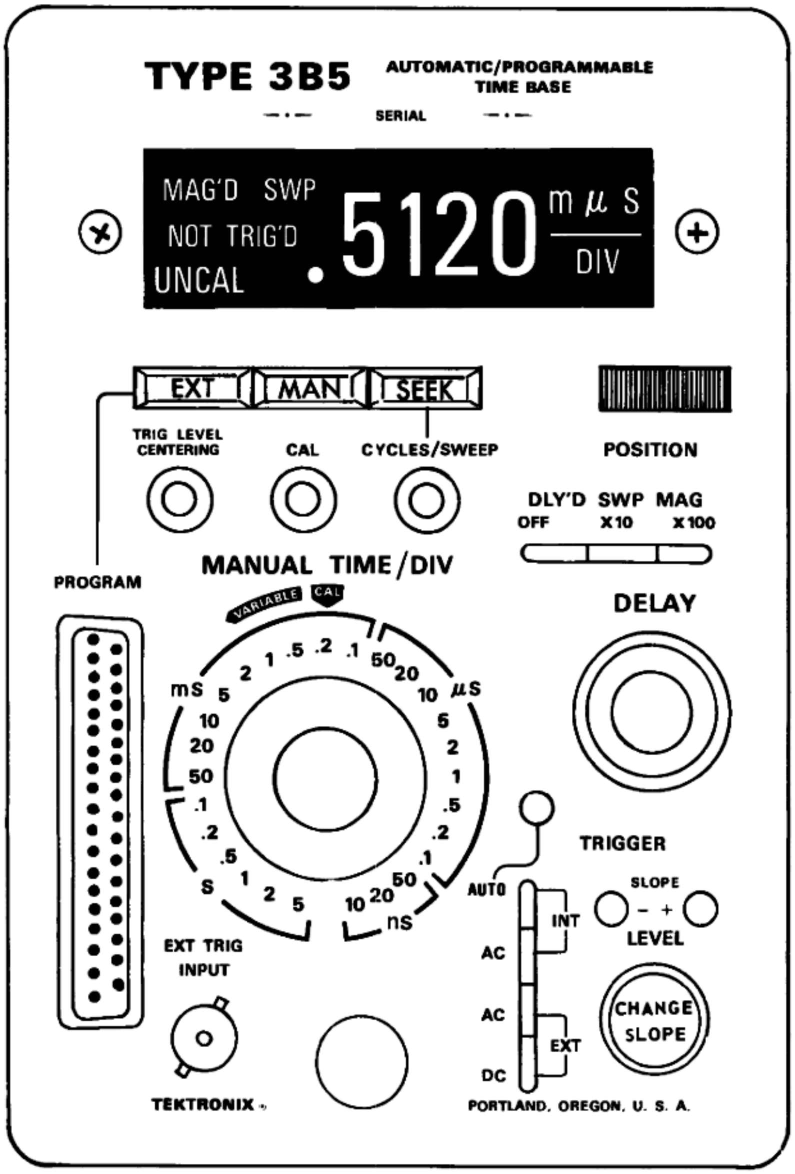


Fig. 2-2. Control set-up chart.

triggering point may be enough so it is impossible to maintain a stable display. In such cases, use DC coupling.

DC. DC trigger coupling is available only when the sweep is triggered from an external signal in the EXT position. DC coupling can be used to provide stable triggering with low-frequency signals which would be attenuated in the AC position or with low-repetition rate signals. The LEVEL control can be adjusted to provide triggering at the desired DC level on the waveform.

Trigger Slope

The Trigger SLOPE lights indicate the portion of the trigger signal to which the trigger circuits respond. When the minus (—) light is on, the display starts on the negative-going portion of the waveform; the plus (+) light indicates that the display starts on the positive-going portion of the waveform. The trigger slope can be changed by pressing the CHANGE SLOPE button (or by external program). Each time the button is pressed the trigger slope changes from (—) to (+) or vice versa. The operation of the CHANGE SLOPE switch in conjunction with the LEVEL control is shown in Fig. 2-3.

When several cycles of a signal are displayed, the trigger slope is often unimportant. However, if only a certain portion of a cycle is to be displayed, correct slope setting is important to provide a display which starts at the desired point on the input signal.

Trigger Level

The front-panel Trigger LEVEL control (or external program level control) selects the voltage level on the triggering waveform at which the sweep is triggered. When the LEVEL control is set in the clockwise region, the trigger circuit responds at a more positive point on the trigger signal. When the LEVEL control is in the counterclockwise region, the trigger circuits responds at a more negative point on the trigger signal. Fig. 2-3 illustrates this effect for both trigger slope conditions.

The NOT TRIG'D readout on the readout panel provides a convenient indication of the condition of the trigger circuit. If the LEVEL control is correctly adjusted with an adequate trigger signal applied, the readout is off. However, if the LEVEL control is misadjusted, the Trigger Function switch incorrectly set, or the trigger signal too low in amplitude, the NOT TRIG'D readout lights up. This readout feature can be used for a general indication of correct triggering and is particularly useful when setting up the trigger circuits when a trigger signal is available without a trace displayed on the CRT (such as single sweep operation).

To set the LEVEL control, first select the trigger source, coupling and slope. Then set the LEVEL control to midrange (except for DC coupling). If the display does not start at the desired point, adjust the LEVEL control for correct triggering. With DC coupling (external trigger only), stable triggering may be obtained at any setting of the LEVEL control as determined by the DC level of the trigger signal. To obtain correct DC trigger level, turn the LEVEL control counterclockwise. Then, turn the LEVEL control clockwise until the display is triggered at the correct DC level on the displayed signal.

Auto Triggering

The sweep is automatically triggered in the INT-AUTO position of the Trigger Function switch (or when selected by external program). Auto triggering can be used for most applications. This trigger mode provides a stable display when a trigger signal is available (above about 50 Hz). Complete rotation of the LEVEL control provides a range of adjustment between about 10% and 90% of the peak-to-peak level of the triggering slope. The front-panel LEVEL control also determines the auto triggering level for External Mode operation. The trigger circuit automatically compensates for differences in trigger signal amplitude to provide this range of LEVEL control adjustment for all signals which meet the minimum amplitude requirements. When the LEVEL control is set for the desired triggering point at a certain percentage of the leading edge, it triggers at this same point even if the signal amplitude is increased (e.g., if set to trigger at the 30% point on a one-division signal, it also triggers at the 30% point if the amplitude is increased to eight divisions; see Fig. 2-4).

NOTE

The auto trigger mode may not produce the desired display of complex signals such as pulse trains near the low-frequency limit of this mode (about 50 hertz). The triggering point may shift from the desired pulse to a lower amplitude pulse which follows. The resultant display will appear unstable. In such cases, use normal internal triggering or external triggering.

The auto trigger mode is particularly useful when a reference trace is needed and no trigger signal is available. Then, the Sweep Generator free runs to produce a reference trace. The trace also free runs when the repetition rate of the trigger signal drops below about 50 Hz. When a trigger signal is again present, the free running condition ends and the sweep returns to a triggered, stable display.

When a seek command is received in the INT-AC, EXT-AC, EXT-DC positions of the Trigger Function switch, the trigger circuits automatically switch to auto triggering if a trigger signal is not present or if the LEVEL control is misadjusted. Then, a stable auto triggered display is presented, if possible. This feature assures that a stable display is presented, whenever possible, in the Seek Mode of operation.

Selecting Sweep Rate

The MANUAL TIME/DIV switch selects the calibrated sweep rate for the Sweep Generator in the Manual Mode of operation. The VARIABLE control provides continuously variable sweep rates between the settings of the MANUAL TIME/DIV switch. Whenever the UNCAL readout is on, the sweep rate is uncalibrated. The readout is off when the VARIABLE control is set to the CAL position.

When making time measurements from the graticule, the area between the first and ninth graticule lines provides the most linear time measurements (see Fig. 2-5). Therefore, the first and last division of the display should not be used for making accurate time measurements. Position the start of the timing area to the first graticule line and set the MANUAL TIME/DIV switch so the end of the timing area falls between the first and ninth graticule lines.

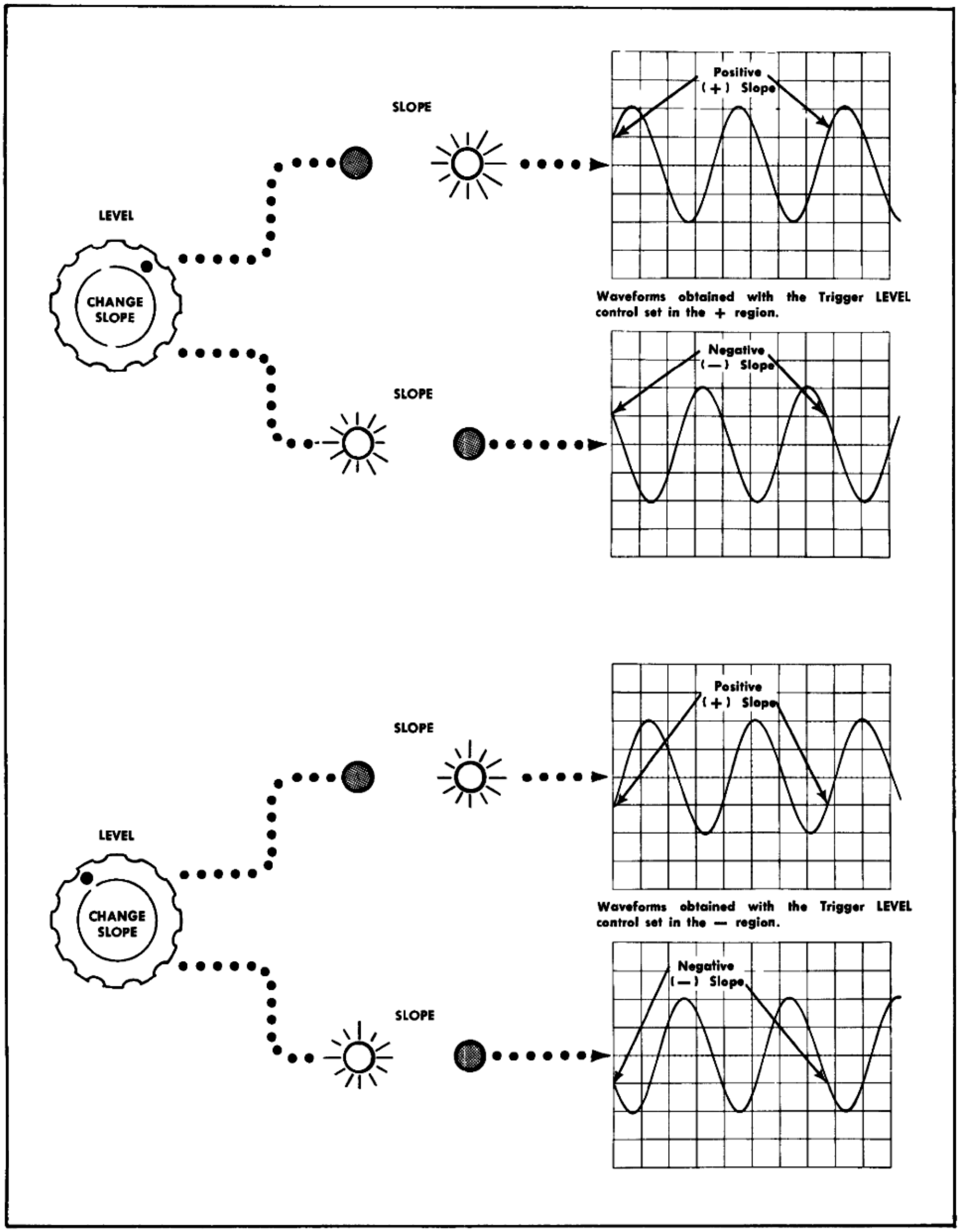


Fig. 2-3. Effects of Trigger LEVEL control and CHANGE SLOPE button (shown for internal triggering or external triggering from an in-phase, time-related trigger signal).

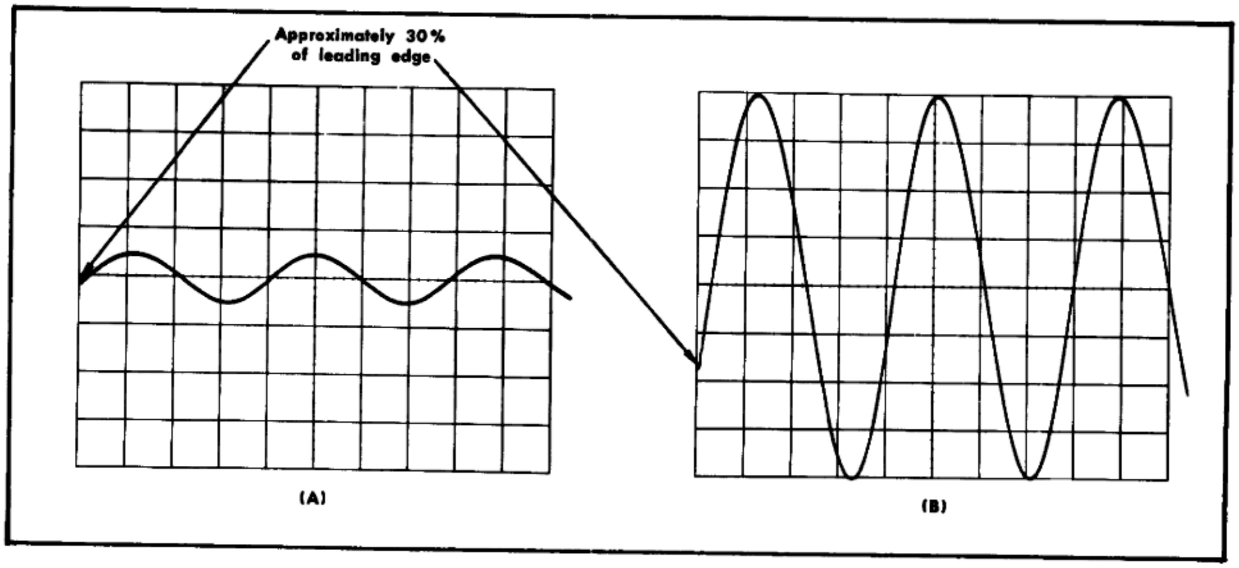


Fig. 2-4. LEVEL control operation for auto triggering. (A) LEVEL control set to trigger at about the 30% point on a one-division waveform, (B) Display still triggers at about the 30% point when the amplitude is increased to produce an eight-division display (LEVEL control not adjusted for second waveform).

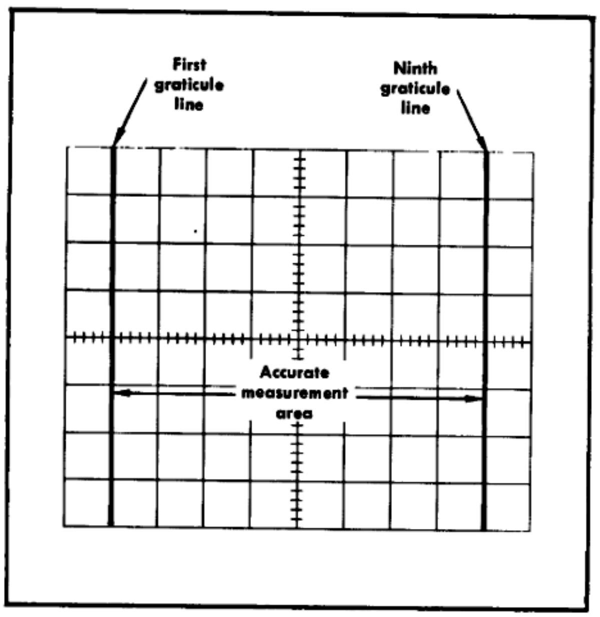


Fig. 2-5. Area of graticule used for accurate time measurements.

The sweep rate is selected automatically in the Seek Mode or may be externally programmed in the External Mode. More information on these modes of operation is given under Seek Mode Operation and External Programming, respectively.

Sweep Output

The sawtooth sweep signal is available at terminal 16 of the front-panel PROGRAM connector for external applications. This signal is also connected to terminal 18 of the interconnecting plug for operation of special purpose amplifier units (such as spectrum analyzer plug-ins).

Delayed Sweep Magnification

The sweep rate can be increased 10 or 100 times with the DLY'D SWP MAG switch (or by external program) to magnify the portion of the trace which follows the delay period. The start of the magnified portion can be positioned with the DELAY dial (or external program delay) to magnify any portion after 0 to 10 divisions delay from the start of the trace. Delayed Sweep Magnification is limited to sweep rates of one microsecond/division or slower. The sweep magnification automatically returns to ×10 when set for ×100 with sweep rates between five microseconds/division and one microsecond/division; magnification is off (×1) for sweep rates faster than one microsecond/division in any position of the DLY'D SWP MAG switch.

NOTE

The sweep rates between 10 ns and .5 μs cannot be magnified with the delayed sweep magnifier. However, the Delayed Sweep Magnifier Intensifier circuit is operative in these positions and can be used to provide a brighter trace (complete trace intensified) without readjusting the indicator oscilloscope intensity level.

To use the delayed sweep magnifier, first select a sweep rate with the MANUAL TIME/DIV switch which correctly displays the portion to be magnified (or press SEEK button). Then set the DLY'D SWP MAG switch for the desired magnification (×10 or ×100). Turn the DELAY dial to position the magnified portion so the desired part of the sweep is magnified. Fig. 2-6 shows a typical waveform as it would appear magnified 10 times and 100 times (DELAY dial set to 1.95).

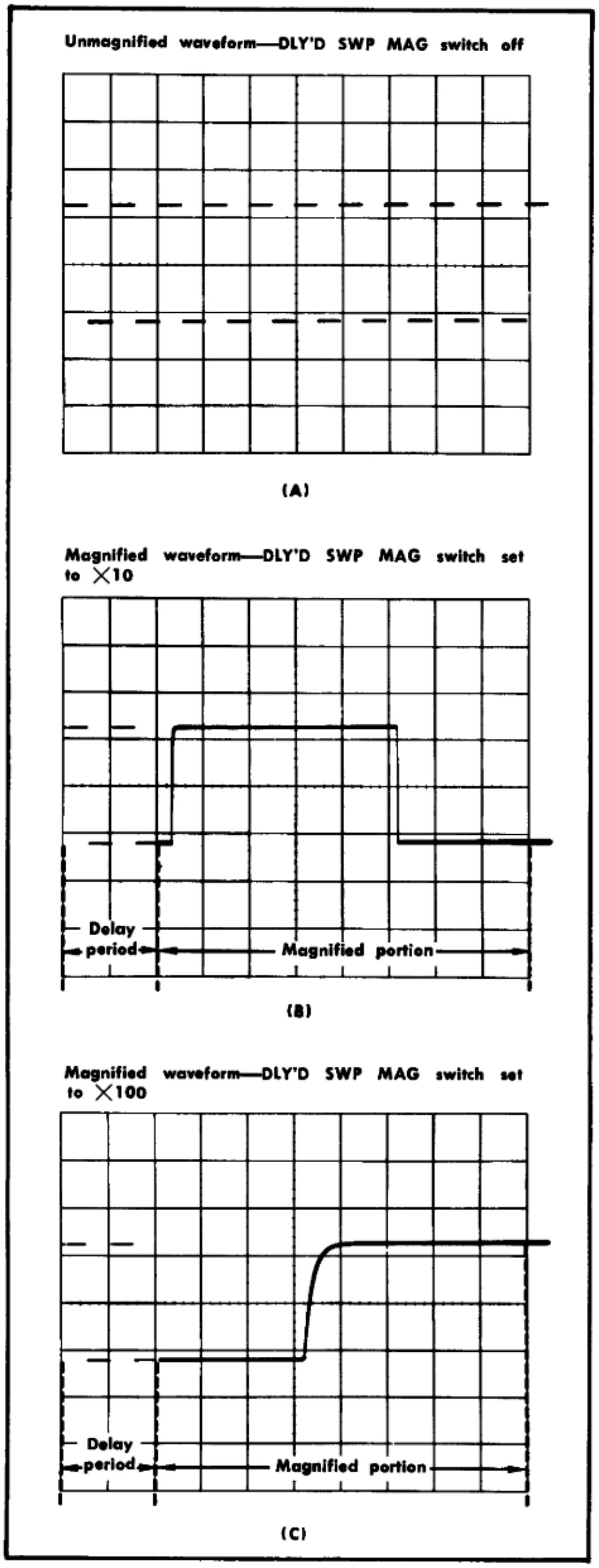


Fig. 2-6. Delayed sweep magnifier operation with DELAY dial setting of 1.95.

The desired magnified display may not be obtained in the Seek Mode. The seek circuits determine the sweep rate during the first few divisions of the display to produce a display showing between two and six cycles of the waveform (nominal adjustment). If the last portion of the display is magnified, an inadequate display may be presented.

Single Sweep

When the signal to be displayed is not repetitive or varies in amplitude, shape or time, a conventional display may produce an unstable presentation. To avoid this, the Type 3B5 can be used in the single-sweep mode by connecting the circuit shown in Fig. 2-7 to the PROGRAM connector. The circuit shown also provides correct input levels for external horizontal operation (explained under External Horizontal Deflection which follows). The single-sweep feature is also useful for photographing non-repetitive signals.

To use the single-sweep mode, construct the circuit shown in Fig. 2-7 and connect it to the front-panel PROGRAM connector. Then, make sure the trigger circuits will trigger on the event you wish to display by obtaining the best possible display in the normal manner (for random signals set the trigger circuit to trigger on a signal which is approximately the same amplitude and frequency as the random signal). Then set the switch to the single sweep position and press the reset button. The reset light indicates when the Sweep Generator has been reset and the light goes out when the circuit is locked out at the end of the sweep. After the reset button is pressed, the next trigger pulse initiates the sweep and a single trace is presented on the screen. Then, the Sweep Generator is locked out until reset. To prepare the circuit for another single-sweep display, press the reset button again.

External Horizontal Deflection

In some applications, it is desirable to display one signal versus another (X-Y) rather than against time (internal sweep). The circuit shown in Fig. 2-7, which can be connected to the PROGRAM connector, provides a means for applying an external signal to the Horizontal Amplifier for this type of display. This circuit provides sweep lockout through terminal 7, external unblanking through terminal 13, horizontal position centering through terminal 14 and external horizontal deflection through terminal 4.

Readout Panel

The readout panel on the front of the unit indicates instrument operation in all operating modes. The readout panel indicates sweep rate, magnified sweep (with correct magnified sweep rate), absence of trigger signal and uncalibrated sweep rate. Since this panel is easily visible from a distance, it is particularly useful when using the remote-seeking probe.

Seek Mode Operation

In the Seek Mode of operation, the Type 3B5 automatically seeks a stable display at a sweep rate which displays between two and six cycles of the signal (with nominal CYCLES/SWEEP adjustment). A seek command may be given from the front-panel SEEK button, a remote-seeking

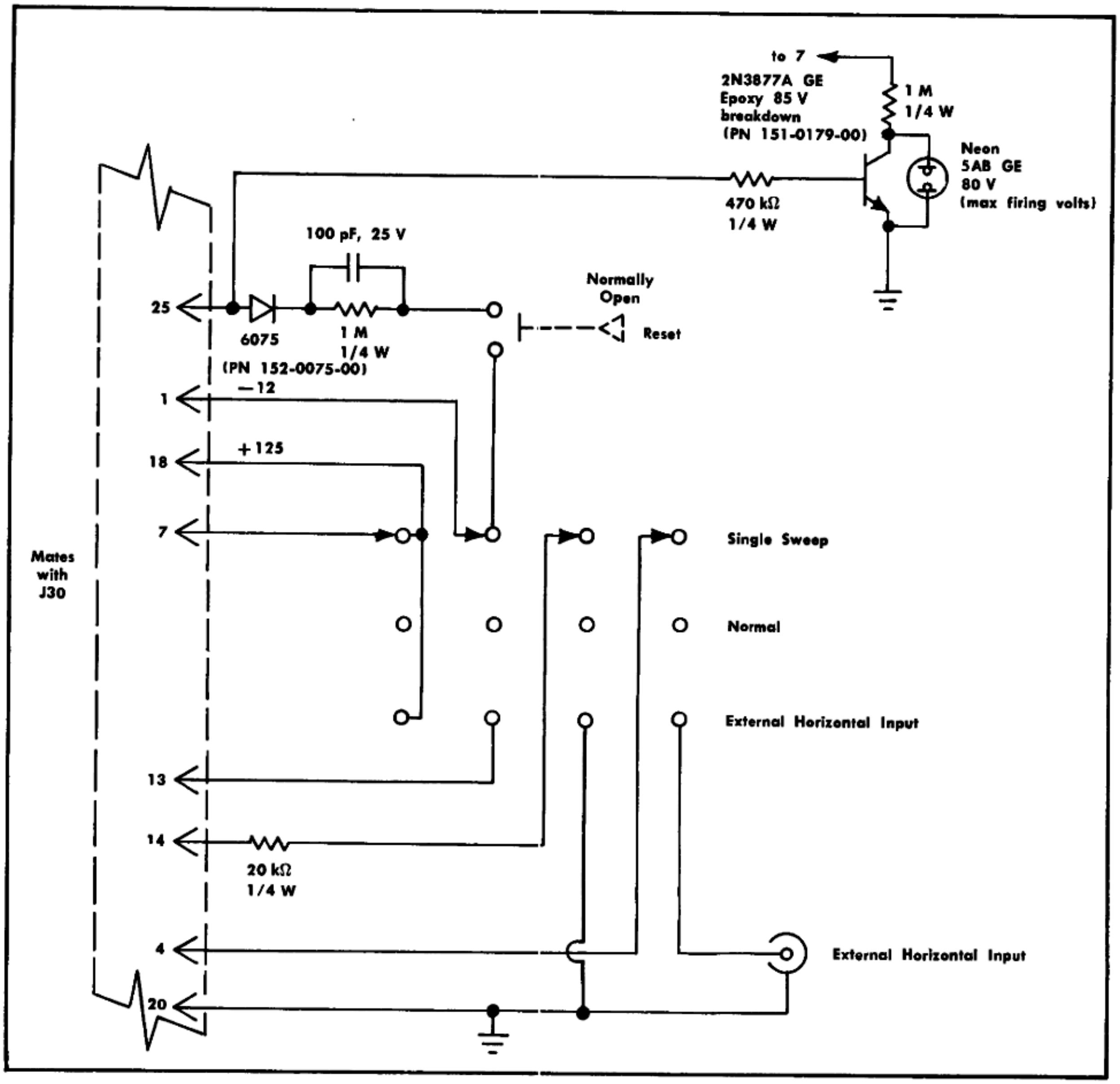


Fig. 2-7. Circuit to provide single sweep and external horizontal input for the Type 3B5.

probe through the associated automatic/programmable amplifier unit or remote seek through the front-panel PROGRAM connector or the program connector of the associated automatic/programmable amplifier unit. When the front-panel SEEK button is pressed or a seek command is applied to the front-panel PROGRAM connector, only the Type 3B5 seek circuits operate. When the seek command is received through the associated automatic/programmable amplifier unit, both units seek but the Type 3B5 seek circuits operate after the amplifier unit has completed its cycle. The Type 3B5 does not seek when the seek button on the amplifier unit is pressed.

When the Type 3B5 receives a seek command, the seek circuits first seek a trigger signal in the mode selected by the Trigger Function switch. If a trigger signal is present, the seek circuits then seek a sweep rate which displays between two and six cycles of the trigger signal (with nominal CYCLES/SWEEP adjustment). (Full description of the electrical operation of the seek circuits is given in the Circuit Description section.) If a trigger signal is not present (or the LEVEL control is incorrectly set), the seek circuits switch to auto triggering and again check for a trigger signal. If a trigger signal is present in the auto trigger mode, the seek circuits seek a sweep rate which produces the correct display. If a trigger signal still is not present the NOT TRIG'D readout comes on and no sweep-rate seeking is performed; the sweep free runs (normally at two seconds/division). However, if a subsequent seek command is received and the correct trigger signal is then available for the original setting of the trigger controls, the seek circuits allow the trigger circuit to return to the original mode of operation. Trigger seeking as just described insures a correctly triggered display in the Seek Mode even if the Trigger Function switch is set to the wrong position, the LEVEL control is incorrectly set or a trigger signal is not applied (external triggering).

External Mode

General. Most of the functions of the Type 3B5 can be externally programmed through the front-panel PROGRAM connector in the External Mode. This feature allows the Type 3B5 to be set up for previously established conditions for use in assembly-line testing or similar repetitive measurement applications. When External Mode operation is used, all functions must be externally programmed (note exceptions shown in Table 2-2 for trigger function, trigger slope and horizontal position). Operation in the External Mode is basically the same as just described under General Operating Information. A programmer which has facilities for programming all External Mode parameters of the Type 3B5 and the associated automatic/programmable amplifier unit is available from Tektronix. However, the following information is provided if the operator desires to design his own programmer.

Program connector. Fig. 2-8 shows the front-panel PROGRAM connector, J30, with all terminals identified as to their function. (Notice that some of these terminals are used for functions other than External Mode programming.) The view shown of J30 is as seen when looking at the front panel of the Type 3B5 (same as when looking at the rear of the mating connector).

Current ratings. Table 2-1 lists the maximum power-supply current which can be drawn out of the Type 3B5 through the PROGRAM connector. Table 2-2 lists the current which flows through the terminals of the PROGRAM connector when the associated program is actuated (grounding logic). Any external switches or components must be capable of handling this current.

TABLE 2-1

Maximum Power Supply Current Available from J30[1]

J30 Terminal	Current (milliamps)
1 (—12.2 V)	75
18 (+125 V)	30
19 (—100 V)	1

[1]Maximum available current when used with an amplifier unit which also draws maximum current.

Program logic. Both digital and analog program logic levels are used in the Type 3B5. For functions which require a switching action (e.g., trigger function), digital logic is used. To activate a digitally programmed function, grounding logic (zero volts) is applied. The function is inactive when the circuit is left open (or a —12-volt holding level is applied). Notice the typical currents listed in Table 2-2 which must be supplied when the logic level is zero volts (function active). Analog logic is used for functions which require a variable program (e.g., trigger level). The analog functions are programmed by connecting a program current to the applicable terminal of J30. This current should be variable over the range given in the typical current column of Table 2-2 to provide a full range of external program adjustment

Establishing the program. Table 2-2 lists all programmable functions of the Type 3B5, the applicable PROGRAM connector terminal and the type of logic required. Refer to Fig. 2-8 for location of the terminals within the PROGRAM connector.

TABLE 2-2

Programmable Function	Logic Type[2]	J30 Terminal	Typical Current
Trigger Function			
Int Auto	Absence of function program selects Auto (front-panel LEVEL control operative)		
Int AC	Digital	31	3 milliamps
Ext AC	Digital	30	15 milliamps
Ext DC	Digital	28	30 milliamps
Trigger Slope			
+Slope	Absence of slope program selects + slope		
—Slope	Digital	27	3 milliamps
Sweep Multiplier[3]			
×1	Digital	2	5 milliamps
×2	Digital	3	5 milliamps
×5	Digital	5	5 milliamps
Sweep Decade[3]			
1 s, 0.1 s	Digital	6	10 milliamps
10 ms, 1 ms	Digital	8	10 milliamps
0.1 ms, 10 μs	Digital	9	10 milliamps
1 μs, 0.1 μs	Digital	11	10 milliamps
10 ns	Digital	26	20 milliamps
Decade Enable[3]			
A (1 s, 10 ms, 0.1 ms, 1 μs	Digital	23	5 milliamps
B (0.1 s, 1 ms, 10 μs, 0.1 μs, 10 ns)	Digital	24	5 milliamps
Sweep Magnification			
×1 (OFF)	Digital	33	25 milliamps
×10	Digital	34	15 milliamps
×100	Digital	36	15 milliamps
External Mode Command	Digital	21	5 milliamps
Trigger Level	Analog	15	≈0-400 microamps range
Horizontal Position	Analog	14	≈0-500 microamps range[4]
Delay	Analog	17	≈200-350 microamps range

[2]Digital logic is grounding logic (zero to —1 volt) for an active program and open circuit (or —12 volts holding level) for an inactive program. Analog functions are current programmed.

[3]Sweep multiplier, sweep decade and decade enable logic must be programmed for each sweep rate (see Table 2-3).

[4]Operates as a vernier for the front-panel POSITION control. Both controls can position trace.

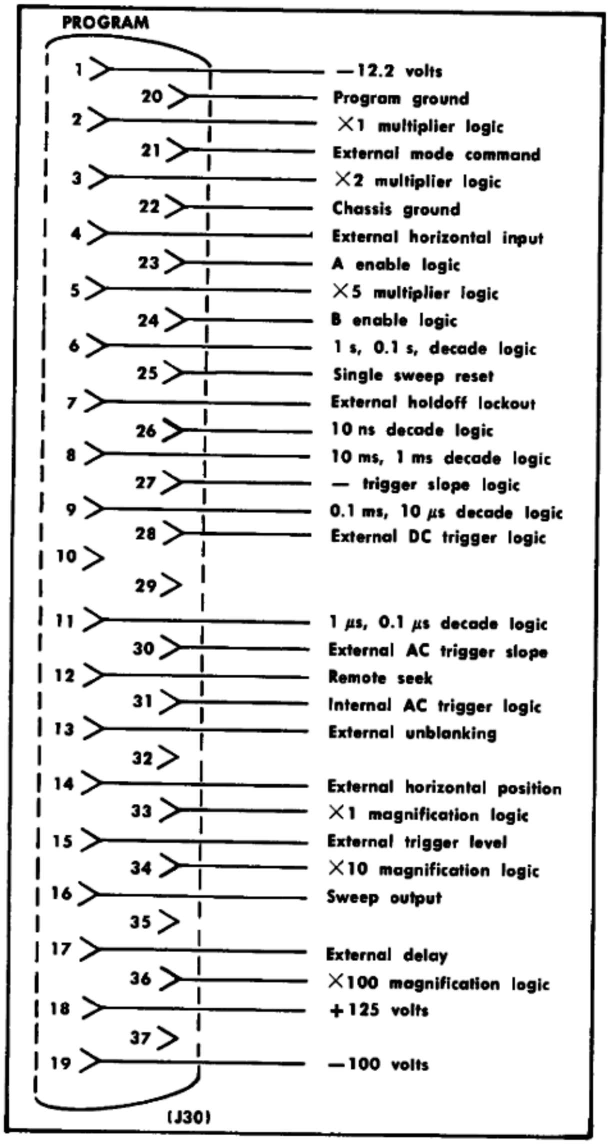


Fig. 2-8. Front-panel PROGRAM connector.

The following functions must be programmed for each individual program.

1. Trigger function (absence of program provides Int Auto operation).

2. Trigger slope (absence of program provides + slope operation).

3. Sweep rate (sweep multiplier, sweep decade and decade enable must be programmed; see Table 2-3).

4. Sweep magnification.

5. Trigger level (except for auto operation).

6. Horizontal position (front-panel POSITION control may be used if not programmed).

7. Delay.

TABLE 2-3

Sweep Rate Programming

Sweep Rate	Connect Program to Following Terminals of J30		
	Multiplier	Decade	Enable
5 second	5	6	23
2 second	3	6	23
1 second	2	6	23
0.5 second	5	6	24
0.2 second	3	6	24
0.1 second	2	6	24
50 millisecond	5	8	23
20 millisecond	3	8	23
10 millisecond	2	8	23
5 millisecond	5	8	24
2 millisecond	3	8	24
1 millisecond	2	8	24
0.5 millisecond	5	9	23
0.2 millisecond	3	9	23
0.1 millisecond	2	9	23
50 microsecond	5	9	24
20 microsecond	3	9	24
10 microsecond	2	9	24
5 microsecond	5	11	23
2 microsecond	3	11	23
1 microsecond	2	11	23
0.5 microsecond	5	11	24
0.2 microsecond	3	11	24
0.1 microsecond	2	11	24
50 nanosecond	5	26	24
20 nanosecond	3	26	24
10 nanosecond	2	26	24

8. External mode command (may be momentarily actuated by holding front-panel EXT button depressed).

If more than one external program is connected to the Type 3B5, diode isolation, negative bias levels (—12 volts) and program switching must be provided to isolate the inactive programs from the active program. Components used must be able to handle the currents listed in Table 2-2.

BASIC APPLICATIONS

General

The following information describes the procedure and technique for making basic measurements with a Type 3B5 Automatic/Programmable Time Base unit and associated amplifier unit and indicator oscilloscope. These applications are not described in detail since each application must be adapted to the requirements of the individual measurements. Familiarity with the Type 3B5 and associated units will permit these basic applications to be applied to a variety of uses. All of these applications are given for Manual Mode operation; however, they can be adapted for either Seek Mode or External Mode operation.

Ⓐ

Time-Duration Measurements

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

1. Connect the signal to the input connector of the amplifier unit.

2. Set the volts/division switch to display about five divisions of the waveform.

3. Set the Type 3B5 Trigger controls to obtain a stable display.

4. Set the MANUAL TIME/DIV switch to the fastest sweep rate that displays less than eight divisions between the time measurement points on the waveform (see Fig. 2-9). See the topic entitled Selecting Sweep Rate in this section, concerning non-linearity of first and last divisions of display.

5. Adjust the amplifier unit position control to move the points between which the time measurement is made to the center horizontal line.

6. Adjust the Type 3B5 POSITION control to move the starting point of the time measurement area to the first graticule line.

7. Measure the horizontal distance between the time measurement points. Be sure the VARIABLE control is set to CAL.

8. Multiply the distance measured in step 7 by the sweep rate indicated on the readout panel to obtain time duration.

Example. Assume that the distance between the time measurement points is five divisions (see Fig. 2-9) and the indicated sweep rate is .1 ms/DIV with the magnifier off.

Using the formula:

$$\text{Time Duration} = \begin{array}{c}\text{horizontal}\\ \text{distance}\\ \text{(divisions)}\end{array} \times \begin{array}{c}\text{indicated}\\ \text{sweep rate}\\ \text{(readout)}\end{array}$$

Substituting the given values:

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

The time duration would be 0.5 milliseconds.

Frequency Measurements

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 cycle.

Use the following procedure:

1. Measure the time duration of one cycle of the signal as described in the previous application.

2. Frequency of the signal is the reciprocal of the time duration of one cycle.

Example. The frequency of the signal shown in Fig. 2-9 which has a time duration of 0.5 milliseconds would be:

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

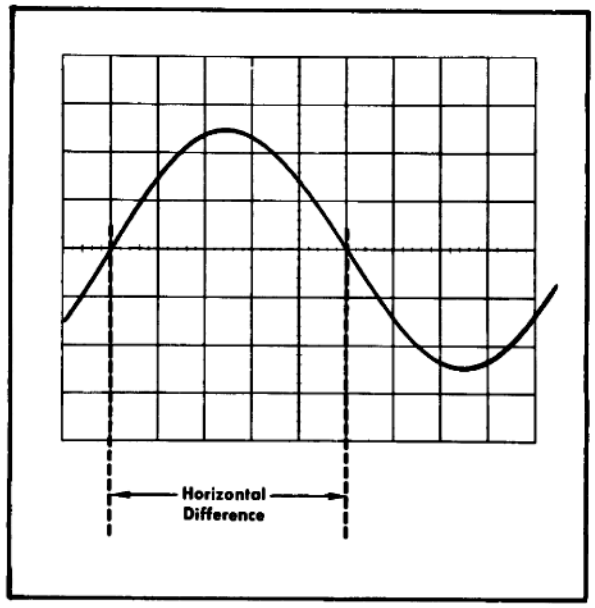


Fig. 2-9. Measuring the time duration between points on a waveform.

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 the input connector of the amplifier unit.

2. Set the volts/division switch and variable volts/division control to produce a display an exact number of divisions in amplitude.

3. Center the display about the center horizontal graticule line.

4. Set the MANUAL TIME/DIV switch to the fastest sweep rate that displays less than eight divisions horizontally between the 10% and 90% points on the waveform.

5. Determine the 10% and 90% points on the rising portion of the waveform. The figures given in Table 2-4 are for the points 10% up from the start of the rising portion and 10% down from the top of the rising portion (90% point).

6. Adjust the Type 3B5 POSITION control to move the 10% point of the waveform to the first graticule line. For example, with a five-division display as shown in Fig. 2-10, the 10% point would be 0.5 division up from the start of the rising portion.

7. Measure the horizontal distance between the 10% and 90% points. Be sure the VARIABLE control is set to CAL.

8. Multiply the distance measured in step 7 by the sweep rate indicated on the readout panel to obtain risetime.

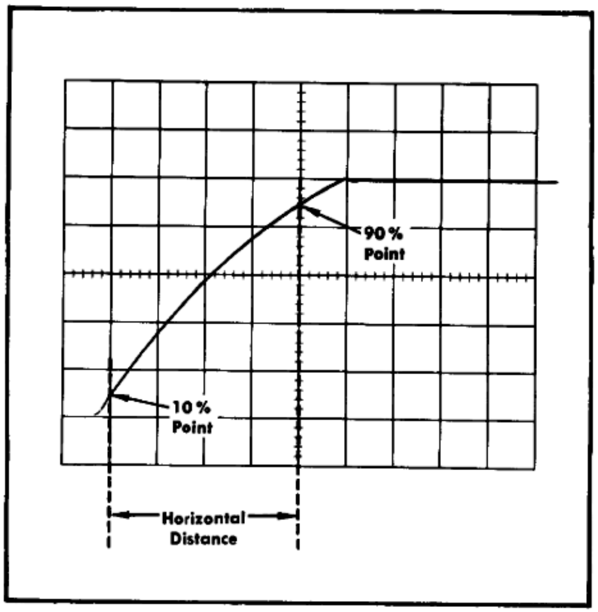


Fig. 2-10. Measuring risetime.

Example. Assume that the horizontal distance between the 10% and 90% points is four divisions (see Fig. 2-10) and the indicated sweep rate is 0.1 μs/DIV.

Applying the time duration formula to risetime:

$$\text{Risetime (Time Duration)} = \text{horizontal distance (divisions)} \times \text{indicated sweep rate}$$

Substituting the given values:

$$\text{Risetime} = 4 \times 0.1\ \mu s$$

The risetime would be 0.4 microsecond.

TABLE 2-4

Vertical Display (Divisions)	10% and 90% points
4	0.4 division
5	0.5 division
6	0.6 division
7	0.7 division
8	0.8 division

Time-Difference Measurements

The calibrated sweep rate of the Type 3B5 when used with a dual-trace amplifier unit allows measurement of time difference between two separate events. To measure time difference, use the following procedure.

1. Set the input coupling switches of the amplifier unit to the desired coupling positions.

2. Connect the reference signal to the channel 1 input connector and the comparison signal to the channel 2 input connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the input connectors.

3. If the signals are of opposite polarity, invert the display on one channel (signals may be of opposite polarity due to 180° delay; if so, take into account in final delay calculation).

4. Set the volts/division switches to produce four- or five-division displays.

5. Set the Type 3B5 Trigger LEVEL control for a stable display (trigger from channel 1 only or externally trigger from reference signal).

6. Set the MANUAL TIME/DIV switch for a sweep rate which shows three or more divisions horizontally between the two waveforms.

7. Adjust the amplifier unit position controls to center each waveform (or the points on the display between which the measurement is made) in relation to the center horizontal line.

8. Adjust the Type 3B5 POSITION control so the channel 1 (reference) waveform crosses the center horizontal line at a vertical graticule line.

9. Measure the horizontal difference between the time measurement points on the channel 1 waveform and the channel 2 waveform (see Fig. 2-11).

10. Multiply the measured difference by the sweep rate indicated on the readout panel to obtain time difference.

Example. Assume that the sweep rate indication is 5 μs/DIV and the horizontal difference between the time measurement points is 4.5 divisions (see Fig. 2-11).

Using the formula:

$$\text{Time Delay} = \text{horizontal difference (divisions)} \times \text{indicated sweep rate}$$

Substituting the given values:

$$\text{Time Delay} = 4.5 \times 5\ \mu s$$

The time delay would be 22.5 microseconds.

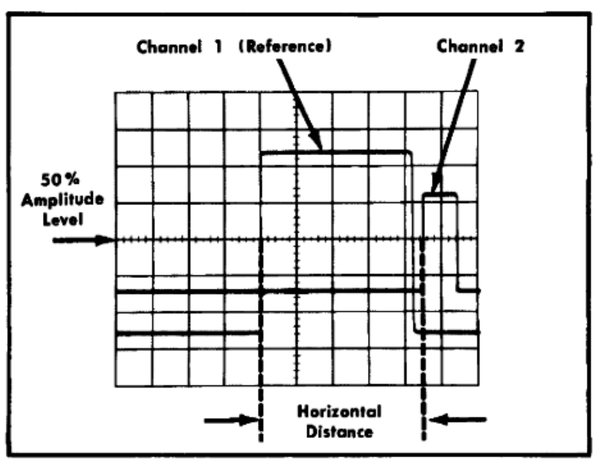


Fig. 2-11. Measuring time difference between two pulses.

Delayed Sweep Magnifier Time Measurements

The delayed sweep magnifier can be used to make more precise time measurements. Overall accuracy of the time measurement will be affected by the following factors.

a. Accuracy of the Sweep Generator at the sweep rate used.

b. DELAY dial incremental linearity.

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.

1. Connect the signal to the amplifier unit input connector

2. Set the volts/division switch to produce a display about four divisions in amplitude.

3. Set the MANUAL TIME/DIV switch to a sweep rate which displays about eight divisions horizontally between the pulses.

4. Adjust the Trigger controls for a stable display.

5. Set the DLY'D SWP MAG switch to ×10 or ×100.

6. Adjust the DELAY dial to move the magnified portion to the start of the first pulse.. Note the reading on the DELAY dial.

7. Turn the DELAY dial clockwise until the magnified portion is positioned to the start of the second pulse. Again note the dial reading.

8. Subtract the first DELAY dial reading from the second and multiply by the sweep rate indicated by the MANUAL TIME/DIV switch to obtain time difference. This is the time interval between the pulses.

Example. Assume the first dial reading is 1.31 and the second dial reading is 8.81 with the MANUAL TIME/DIV switch set to 2 μs; see Fig. 2-12.

Using the formula:

$$\text{Time Difference (delayed sweep)} = \left(\text{second dial reading} - \text{first dial reading}\right) \times \text{MANUAL TIME/DIV setting}$$

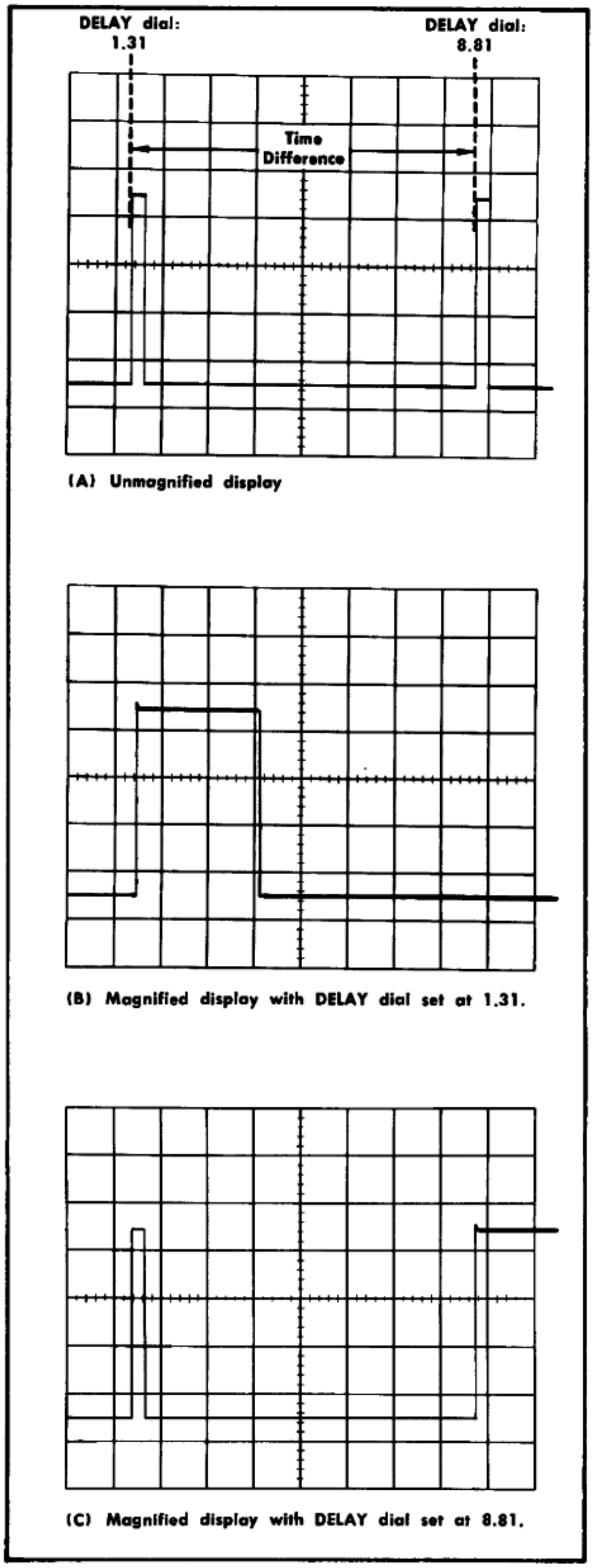
Substituting the given values:

$$\text{Time Difference} = (8.81 - 1.31) \times 2\ \mu\text{s}.$$

The time difference would be 15 microseconds.

Displaying Complex Signals Using Delayed Sweep Magnification

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 magnification feature provides a means of delaying

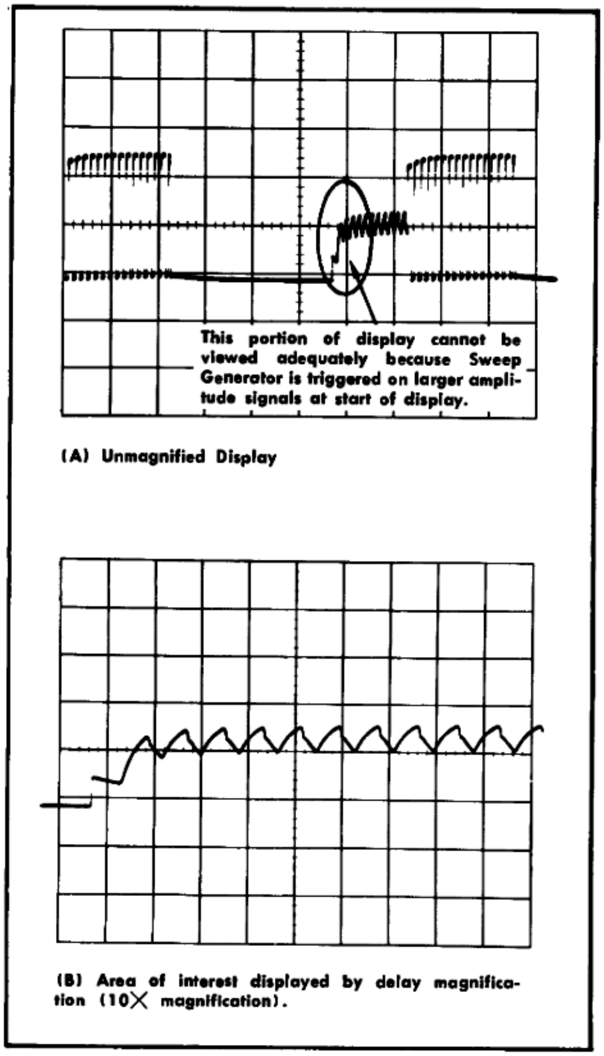


(A) Unmagnified display

(B) Magnified display with DELAY dial set at 1.31.

(C) Magnified display with DELAY dial set at 8.81.

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



(A) Unmagnified Display

(B) Area of interest displayed by delay magnification (10× magnification).

Fig. 2-13. Displaying a complex signal using delayed sweep magnification.

the start of the magnified portion by a selected amount following the event which triggers the Sweep Generator. Then, the part of the waveform which contains the information of interest can be displayed. Use the following procedure:

1. Connect the signal to the amplifier unit input connector.

2. Set the volts/division switch to produce a display about four divisions in amplitude.

3. Set the MANUAL TIME/DIV switch to a sweep rate which displays the complete waveform.

4. Adjust the Trigger controls for a stable display.

5. Set the DLY'D SWP MAG switch to ×10 or ×100.

6. Adjust the DELAY dial to position the start of the magnified portion to the part of the display to be magnified.

7. If necessary, adjust the Type 3B5 POSITION control to display the complete magnified portion.

8. Time measurements can be made on this portion of the display in the normal manner. The magnified sweep rate is indicated on the readout panel.

Example. Fig. 2-13A shows a complex waveform as displayed on the indicator oscilloscope 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 with the delayed sweep magnifier. The DELAY dial has been adjusted so the magnifier starts just before the area of interest. The display has been repositioned with the POSITION control to view the entire magnified portion.

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. Use the following procedure:

1. Connect the signal to the input connector of the amplifier unit.

2. Set the amplifier unit volts/division switch to display about five divisions of the waveform.

3. Set the Type 3B5 Trigger controls to obtain as stable a display as possible.

4. Set the MANUAL TIME/DIV switch to the fastest sweep rate that displays the pulse.

5. Adjust the amplifier unit position control to move the portion of the pulse where jitter is to be measured to the center horizontal line.

6. Set the DLY'D SWP MAG switch to ×10 or ×100.

7. Set the DELAY control so the pulse is magnified.

8. Pulse jitter is shown by horizontal movement of the pulse (take into account inherent jitter of delayed sweep magnifier). Measure the amount of horizontal movement. Be sure the VARIABLE control is set to CAL.

9. Multiply the distance measured in step 8 by the sweep rate indicated on the readout panel to obtain pulse jitter in time.

Example. Assume that the horizontal movement is 0.5 divisions (see Fig. 2-14), and the indicated sweep rate is .5 μs/DIV (×100 magnification).

Using the formula:

$$\text{Pulse Jitter} = \begin{matrix}\text{horizontal}\\ \text{jitter}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{indicated}\\ \text{sweep}\\ \text{rate}\end{matrix}$$

Substituting the given values:

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

The pulse jitter would be 0.25 microseconds.

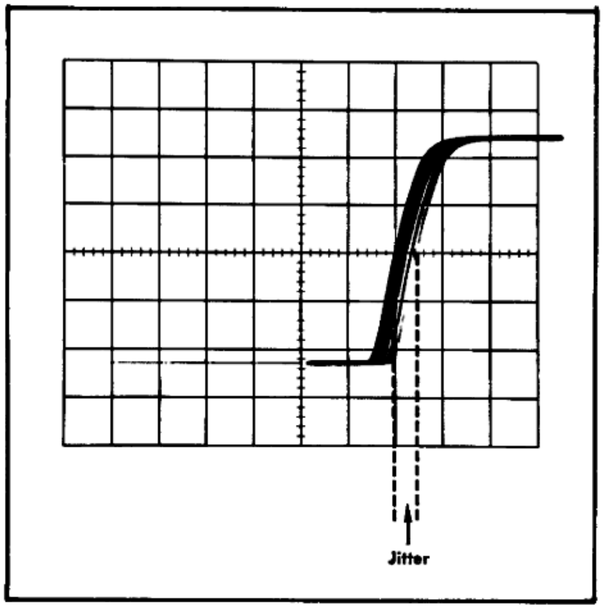


Fig. 2-14. Measuring pulse jitter.

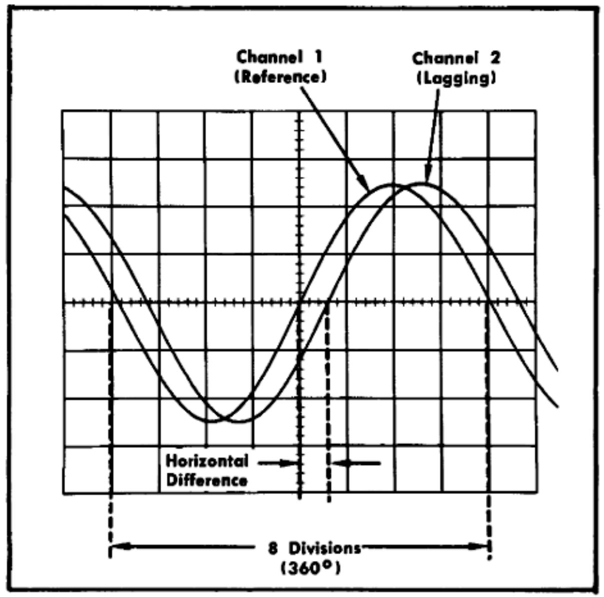


Fig. 2-15. Measuring phase difference.

Multi-Trace Phase Difference Measurements

Phase comparison between two signals of the same frequency can be made using a dual-trace amplifier unit with the Type 3B5. This method of phase difference measurement can be used up to the frequency limit of the amplifier unit. To make the comparison, use the following procedure:

1. Set the amplifier unit input coupling switches to the same position, depending on the type of coupling desired.

2. Set the amplifier unit mode switch to either chopped or alternate. In general, chopped is more suitable for low-frequency signals and alternate is more suitable for high-frequency signals. More information on determining the mode is given in the amplifier unit instruction manual.

3. Connect the reference signal to channel 1 and the comparison signal to channel 2. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signal to the input connectors.

4. If the signals are of opposite polarity, invert the signal on one channel. (Signals may be of opposite polarity due to 180° phase difference; if so, take into account in final calculation.)

5. Set the volts/division switches and the variable volts/division controls so the displays are equal, and about five divisions, in amplitude.

6. Set the Type 3B5 Trigger controls to obtain a stable display (trigger on channel 1 only or external trigger on reference signal).

7. Set the MANUAL TIME/DIV switch to a sweep rate which displays about one cycle of the waveform.

8. Move the waveforms to the center of the graticule with the amplifier unit position controls.

9. Turn the Type 3B5 VARIABLE control until one cycle of the reference signal (channel 1) occupies exactly eight divisions between the first and ninth graticule vertical lines (see Fig. 2-15). Each division of the graticule represents 45° of the cycle (360° ÷ 8 divisions = 45°/division). The sweep rate can be stated in terms of degrees as 45°/division.

10. Measure the horizontal difference between corresponding points on the waveforms.

11. Multiply the measured distance (in divisions) by 45° (sweep rate) to obtain the exact amount of phase difference.

Example. Assume a horizontal difference of 0.6 divisions with a sweep rate of 45°/div as shown in Fig. 2-15

Using the formula:

$$\text{Phase Difference} = \begin{matrix}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{matrix} \times \begin{matrix}\text{sweep rate}\\ \text{(degrees/div)}\end{matrix}$$

Substituting the given values:

$$\text{Phase Difference} = 0.6 \times 45°$$

The phase difference would be 27°.

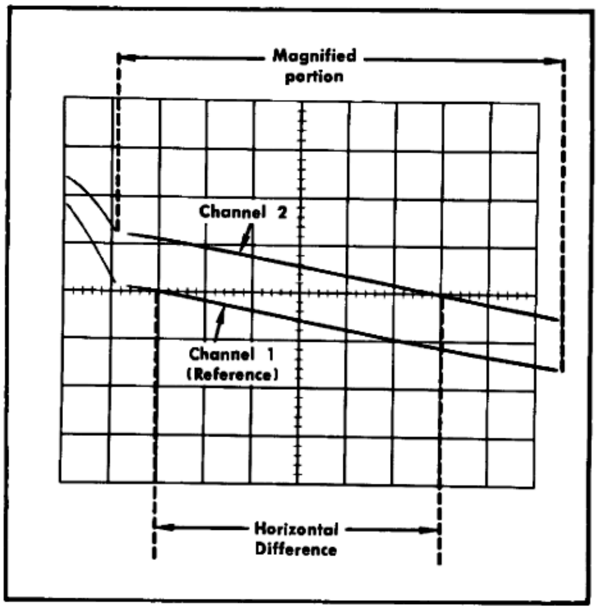


Fig. 2-16. Accurate phase-difference measurement with increased sweep rate.

More Accurate Phase Measurements

More accurate dual-trace phase measurements can be made by increasing the sweep rate (without changing the VARIABLE control setting as established in the preceding method). One of the easiest ways to increase the sweep rate is with the DLY'D SWP MAG switch. The magnified sweep rate is determined by dividing the sweep rate obtained previously by the magnification.

Example. If the sweep rate were increased 10 times with the magnifier, the magnified sweep rate would be 45° ÷ 10 = 4.5°/division. Fig. 2-16 shows the same signals as used in Fig. 2-15 but with the DLY'D SWP MAG switch set to ×10 (DELAY dial set to 0.92). With a horizontal difference of 6 divisions, the phase difference would be:

$$\text{Phase Difference} = \begin{array}{c}\text{horizontal}\\ \text{difference}\\ \text{(divisions)}\end{array} \times \begin{array}{c}\text{magnified sweep}\\ \text{rate (degrees/div)}\end{array}$$

Substituting the given values:

$$\text{Phase Difference} = 6 \times 4.5°$$

The phase difference would be 27°.

SECTION 3
CIRCUIT DESCRIPTION

Introduction

This section of the manual contains an electrical description of the circuitry used in the Type 3B5 Automatic/Programmable Time Base unit. This section begins with a basic block-diagram discussion of the instrument using the simplified block diagram shown in Fig. 3-1. Then, a logic discussion explains which blocks operate in each of the three modes of operation; Manual Mode, Seek Mode and External Mode. In the detailed Circuit Description, a logic block diagram shows the interconnections between the stages in each major circuit and the input and output signals. Also shown is the relationship of the front-panel controls to the individual circuits. A complete block diagram is located in the Diagrams section at the rear of this manual. This block diagram shows the overall relationship between all circuits in this instrument. Complete schematic diagrams of each circuit are also given in the Diagrams section. Refer to these diagram throughout the following circuit description for electrical values and relationship.

BLOCK DIAGRAM DISCUSSION

A simplified block diagram of the Type 3B5 is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block in this block diagram represents a major circuit within the instrument. The number on each block refers to the circuit diagram at the rear of this manual which shows the complete circuit.

The Sweep Trigger circuit produces an output pulse which turns on the Sweep Generator circuit to produce the sweep signal. The output pulse from the Sweep Trigger circuit is derived from the input trigger signal. The input signal can be either an internal signal from the amplifier unit, which is a sample of the vertical deflection signal, or an external signal applied to the EXT TRIG INPUT connector. Trigger slope, level, mode, coupling and source are externally programmable in the External Mode of operation (EXT). For Seek Mode operation (SEEK) a control signal from the Seek Circuit allows the Sweep Trigger circuit to switch to auto triggering if the front-panel controls are incorrectly set or the correct trigger signal is not applied.

The Sweep Generator produces a linear sawtooth signal when triggered by the Sweep Trigger circuit. The slope of the sawtooth produced by the Sweep Generator circuit is controlled by the Delay and Timing Circuit. The output of the Sweep Generator is amplified by the Horizontal Amplifier to produce the horizontal deflection for the indicator oscilloscope CRT. Other signals for horizontal deflection can also be applied to the Horizontal Amplifier through the PROGRAM connector. The horizontal position of the trace can be externally programmed in the External Mode of operation.

The Delay and Timing Circuit provides delayed sweep magnification in addition to selecting the basic sweep rate. The sweep rate is controlled by the MANUAL TIME/DIV switch for Manual Mode operation or by the Counter Circuit for Seek and External Mode operation. The amount of delay before sweep magnification begins is controlled by the front-panel multi-turn DELAY control for Manual and Seek Mode operation, or is externally programmed in the External Mode of operation. The Delayed Sweep Magnifier Control circuit determines the magnification ratio and also provides a correct readout on the readout panel. The magnification ratio (×1, ×10, ×100) is selected by the front-panel DLY'D SWP MAG switch for Manual and Seek Mode operation or it is externally programmed for External Mode operation.

In the Seek Mode of operation, the Seek Circuit produces output pulses which allow the Counter Circuit to select the proper sweep rate for a two to six cycle display (nominal CYCLES/SWEEP adjustment). The Counter Circuit can also be externally programmed to select the sweep rate in the External Mode. The Readout Logic circuit decodes the sweep rate control logic levels from the Counter Circuit and the magnification logic level from the Delayed Sweep Magnifier Control circuit to provide the correct readout panel display in the Seek and External Modes of operation. For Manual Mode operation, the sweep rate and readout-panel display are determined by the MANUAL TIME/DIV switch and the DLY'D SWP MAG switch located in the Readout Logic circuit.

The Readout Board provides the front-panel readout of instrument operation. The bulbs which produce the readout are controlled by the Sweep Generator, Delay and Timing Circuit and the Readout Logic circuit.

The operating mode of the instrument is controlled by the Operating Mode Power circuit. This circuit produces output voltages to control those circuits associated with the Manual Mode, Seek Mode or External Mode functions. External Mode operation can be selected by external program and it has priority over the other modes. The Seek Mode can be selected (when not in the External Mode) by a seek command from the front-panel SEEK button, remote seek command from the amplifier unit or remote seek command through the front-panel PROGRAM connector. The Manual Mode is obtained (except when in External Mode) when the unit is first turned on, when the MAN button is pressed, when the MANUAL TIME /DIV switch setting is changed or when the external program is removed. The Voltage Distribution circuit provides the power supply voltages from the indicator oscilloscope to all of the circuits within this unit. This circuit contains the decoupling networks to provide the decoupled voltages used throughout this unit.

LOGIC DISCUSSION

Manual Mode Operation

Fig. 3-2 shows the circuits in the Type 3B5 which are operative in the Manual Mode. In this mode of operation, the unit operates as a conventional time base with operation determined by the front-panel controls. The Operating Mode Power circuit applies a control level to the other circuits to either lock out the Seek and External Mode functions or to activate Manual Mode functions. The MANUAL

TIME/DIV switch and DLY'D SWP MAG switch provide the correct normal and magnified sweep rate readout on the readout panel.

Seek Mode Operation

The operating circuits for the Seek Mode of operation are shown in Fig. 3-3. This includes all blocks which were operative for Manual Mode (except Manual Operating Mode Power) plus the automatic circuits in the Seek Circuit, Counter Circuit and Readout Logic circuit. The Operating Mode Power circuit applies power to the various circuits to operate the automatic seek functions. The Sweep Trigger circuits operate as determined by the front-panel controls unless the controls are incorrectly set or the applied trigger signal is not correct. Then, the Seek Circuit switches the Sweep Trigger circuit to auto trigger operation and a stable display is presented, if possible. If a trigger signal is not present in the auto trigger mode, the NOT TRIG'D readout comes on and the sweep free runs.

The Seek Circuit resets the sweep to the slowest sweep rate at the start of each seek cycle. Then, the Seek Circuit compares the trigger pulses produced by the Sweep Trigger circuit against a window-gate signal derived from the sawtooth and the sweep gate signal (see Seek Circuit discussion). If trigger pulses occur during the window gate, the Seek Circuit produces an advance pulse which advances the Counter Circuit to the next faster sweep rate and a sweep reset pulse resets the sweep so it starts again at the left side of the graticule at the new sweep rate. Again, the Seek Circuit compares the trigger pulses against the window-gate signal and advances the Counter Circuit if trigger pulses are present. This continues until the sweep rate is fast enough so no trigger pulses occur during the window-gate signal (see Seek Circuit discussion for more complete explanation). The final sweep rate is maintained until another seek command is received or the operating mode is changed. This complete seeking action takes place each time a seek command is received.

Fig. 3-4 shows the logic sequence for Seek Mode operation including a full explanation of operation. The circled numbers on this logic diagram refer to the step in the explanation which describes the action of this individual circuit.

External Mode Operation

The circuits which are operative for External Mode are shown in Fig. 3-5. In this mode of operation, most of the circuits are controlled by external program logic applied to the circuits from an external programmer through the front-panel PROGRAM connector. An E is shown beside each block which is controlled from the programmer. The programmable capabilities of this instrument are the same as the front-panel capabilities (except for variable sweep rate).

The External Mode of operation is established by applying an external mode command to the Operating Mode Power circuit. External Power is then applied to those circuits which control external mode operation and Manual or Seek Mode operation is locked out. Sweep rate, delayed sweep magnification, delay, horizontal position, trigger mode, source, coupling, slope and level are externally programmable.

If auto triggering is programmed, the front-panel LEVEL control determines the starting level of the display.

CIRCUIT DESCRIPTION

Sweep Trigger

General

The Sweep Trigger circuit produces trigger pulses to turn on the Sweep Generator circuit. This trigger pulse is derived either from the vertical input signal or an external signal connected to the EXT TRIG INPUT connector. Control stages in this circuit select the source, coupling, level, mode and slope of the trigger signal. Fig. 3-6 shows a logic block diagram of the Sweep Trigger circuit. A diagram of this circuit is shown on diagram 1 at the rear of this manual.

Trigger Source and Coupling

Relay K3-1 selects the trigger signal either from an internal signal from the amplifier unit or an external signal applied to the EXT TRIG INPUT connector. This relay is controlled by the Trigger Mode Logic stage. When K3 is not energized, internal triggering is provided from the vertical signal. When K3 is energized, K3-1 connects the external trigger signal to the input circuit. Trigger coupling is selected by K4. When K4-1 is open, the trigger signal must pass through coupling capacitor C3. This capacitor blocks the DC component of the trigger signal and attenuates low-frequency AC signals below about 50 Hz. When K4 is energized, K4-1 closes and C3 is by-passed to directly couple all components of the trigger signal to the Input Emitter Follower. DC coupling is provided only in the EXT-DC position of the Trigger Function switch, SW50 or when externally programmed for external DC. More information on how trigger source and coupling are controlled is given under Trigger Mode Logic.

Input Emitter Follower

The Input Emitter Follower, Q23, provides a high input impedance for the trigger signal. It also provides isolation between the Sweep Trigger circuits and the triggering source. The level on the trigger signal at which the trigger circuits respond is controlled by varying the bias level at the base of Q23. The bias level is determined by the LEVEL control, the Auto Trigger P-P Level stage or the external program trigger level. Further information concerning operation of the level control circuit is given under Trigger Level Amplifier. The network D23-D24-D26-C23-C26-R25B in the emitter circuit of Q23 provides stable triggering in the auto trigger mode throughout the complete rotation of the Trigger LEVEL control. This is described in detail under Auto Trigger P-P Level.

The trigger signal at the emitter of Q23 is coupled to the base of Q74 through D62. This diode returns the DC level of the trigger signal to that at the base of Q23 by off-setting the base-emitter voltage drop of Q23. D62 also provides temperature compensation for Q23. The trigger signal at this point follows the level established at the base of Q23 by the trigger signal or the Trigger Level Amplifier circuit.

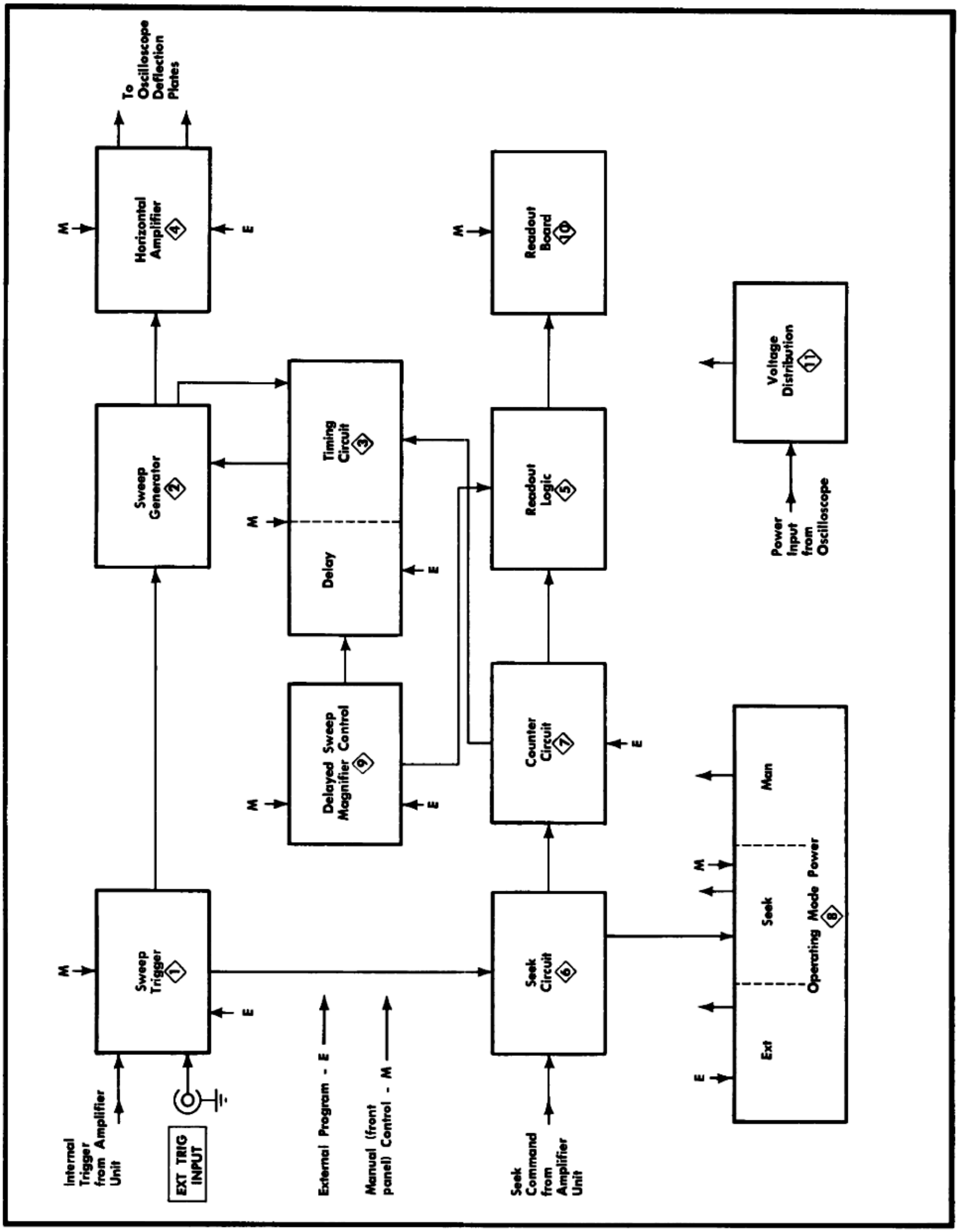


Fig. 3-1. Simplified block diagram of Type 3B5.

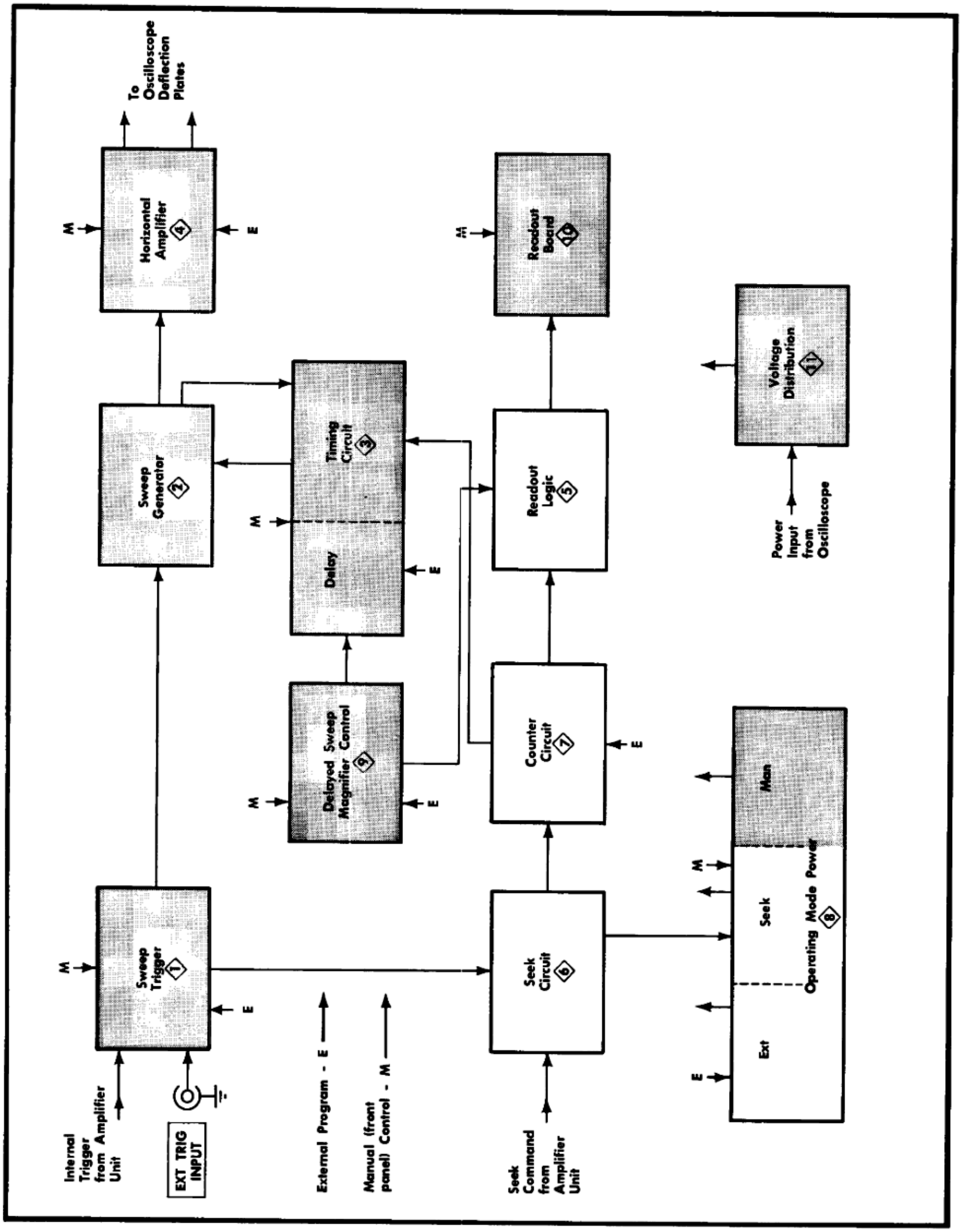


Fig. 3-2. Manual Mode operation (conventional time base). Shaded blocks are operative.

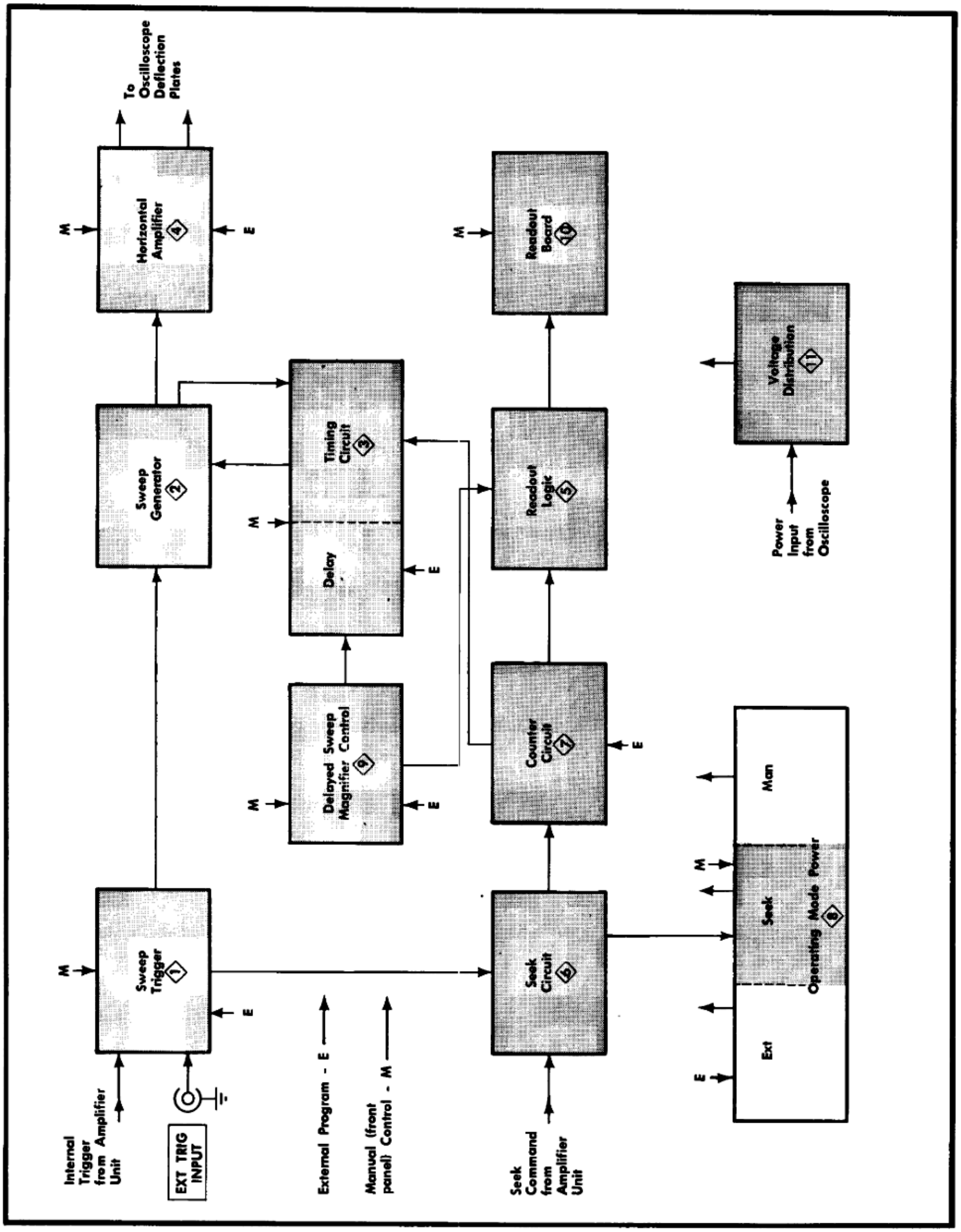
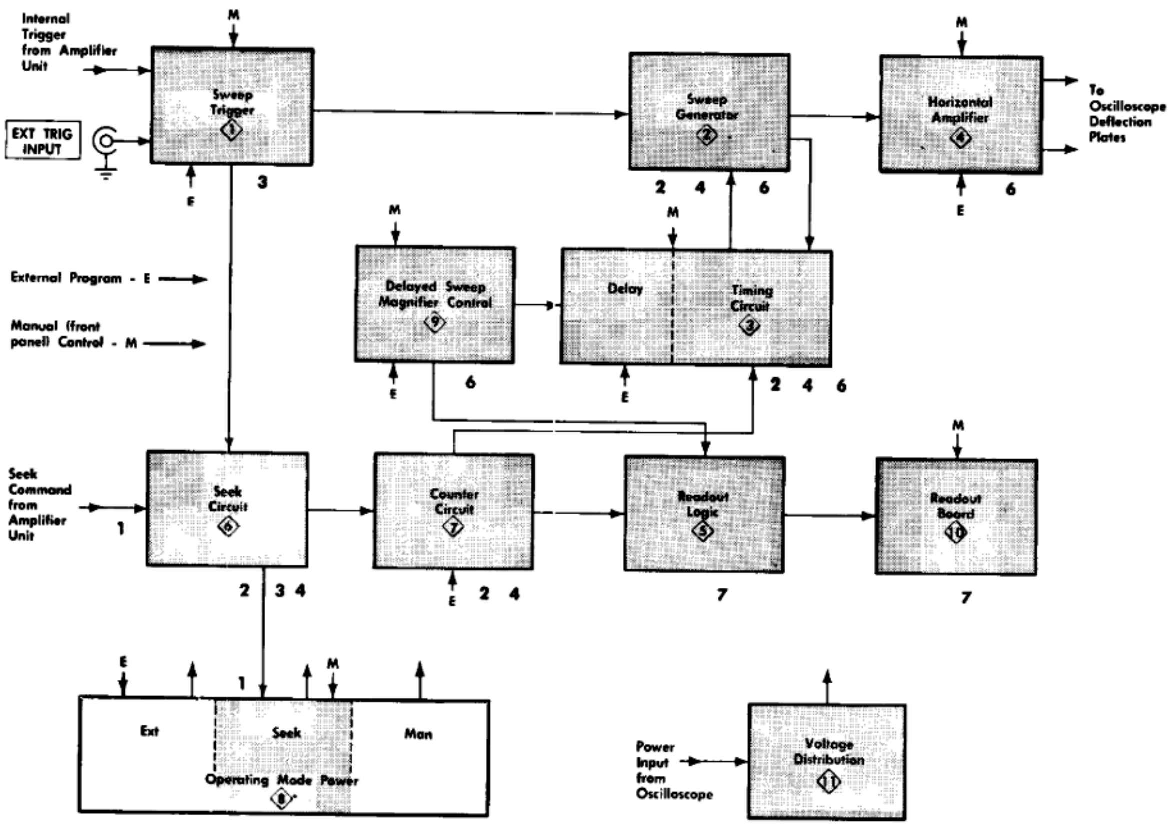


Fig. 3-3. Seek Mode operation (automatic seeking). Shaded blocks are operative.



Seek Mode Logic Sequence

1. Seek command received from front-panel SEEK button, remote seek through PROGRAM connector or remote seek from amplifier unit. Operating Mode Power circuit switches to Seek Power (except when in External Mode).
2. Seek Circuit resets Counter Circuit to five second/division conditions. Counter Circuit in turn produces output levels to select five second/division sweep rate in the Delay and Timing Circuit. Sweep Generator is reset to start sweep at the left side of the graticule.
3. Sweep Trigger circuit operates as set by the front-panel controls. If unit is not correctly triggered with these settings, the Seek Circuit switches unit to auto triggering. Then, if the unit is triggered it operates as described in the next step. If not triggered, the NOT TRIG'D readout comes on. and the sweep free runs (normally at 2 s/DIV sweep rate).
4. Seek Circuit combines sawtooth signal and sweep gate signal to produce a window-gate signal. The duration of this window-gate signal is typically about 20% to 60% of the total sweep duration (10 times sweep rate). Trigger signals from the Sweep Trigger circuit are compared to the window gate. If a trigger pulse occurs during the window gate, an advance pulse is produced which advances the Counter Circuit (and the Delay and Timing Circuit) to the next faster sweep rate and a sweep reset pulse resets the Sweep Generator so it starts over at the left side of the graticule at the new sweep rate.
5. Step 4 is repeated until the Counter Circuit (and the sweep rate) have been advanced until a trigger pulse does not occur during the window-gate. If the .1 μs/DIV sweep rate is reached before this occurs, the Counter Circuit stops and remains at this condition until reset (by next seek command).
6. The Sweep Generator starts to run up at the sweep rate selected by the Counter Circuit. If the Delayed Sweep Magnifier Control circuit is set for ×10 or ×100 magnification, current is added to the Sweep Generator at a point determined by the DELAY control in the Delay and Timing Circuit to magnify a portion of the trace. The final sawtooth at the output of the Sweep Generator circuit is amplified by the Horizontal Amplifier circuit to produce the horizontal deflection.
7. The Readout Logic circuit decodes the sweep-rate logic from the Counter Card and the magnifier logic from the Delayed Sweep Magnifier Control circuit. The output of the Readout Logic circuit is connected to the Readout Board to indicate the sweep rate. If the sweep is magnified, the Readout Board indicates the sweep rate of the magnified portion.

Fig. 3-4. Logic sequence for Seek Mode. Numbers below blocks refer to the step which explains the operation of this block.

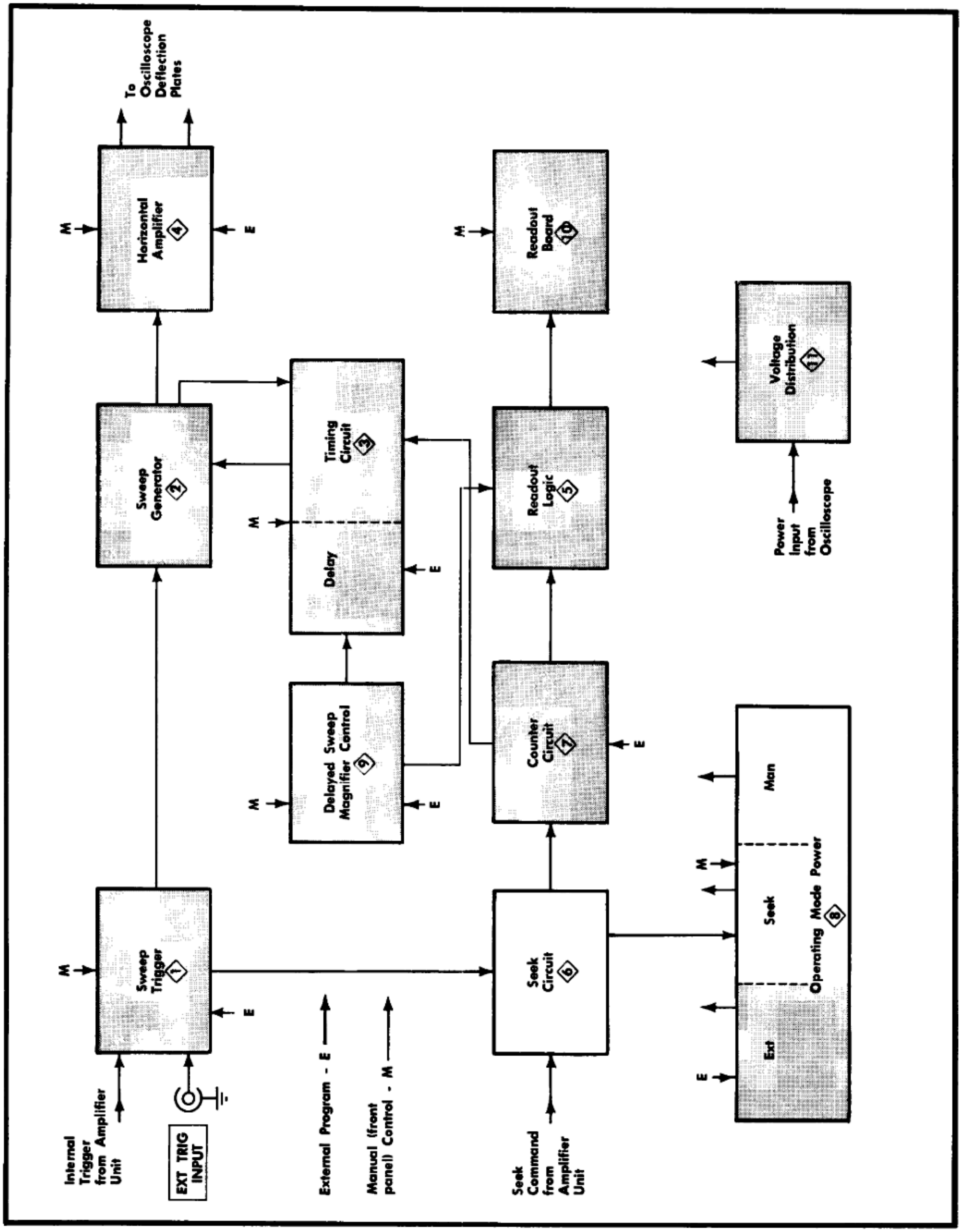


Fig. 3-5. External Mode operation (programmable). Shaded blocks are operative.

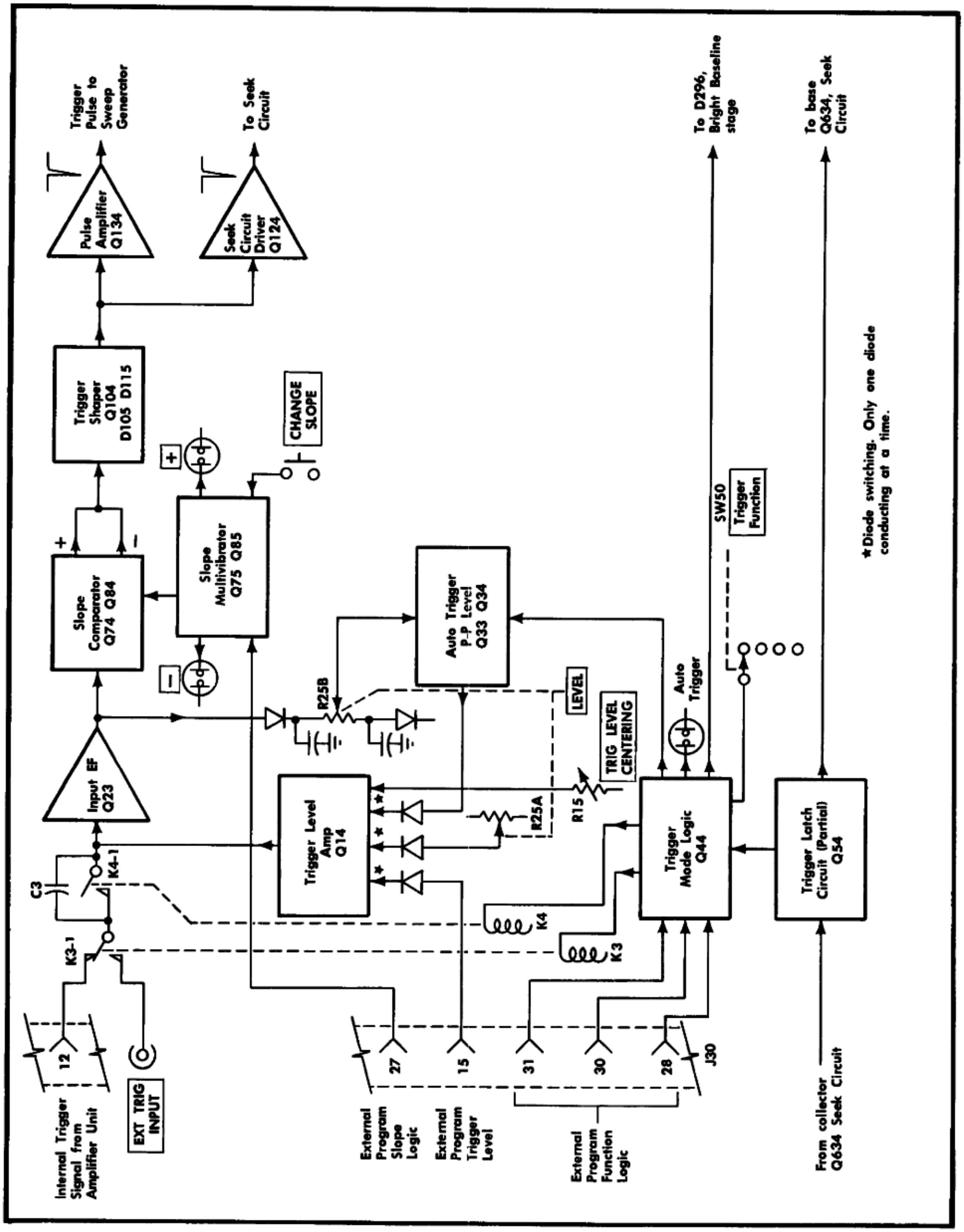


Fig. 3-6. Sweep Trigger logic block diagram.

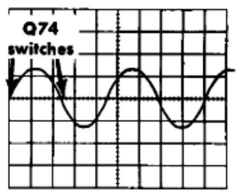
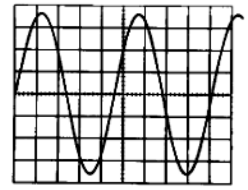
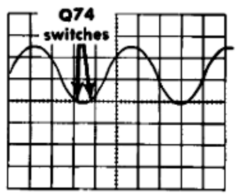
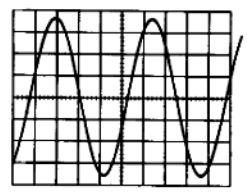
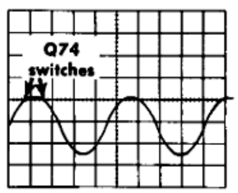
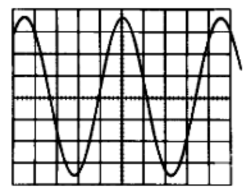
Signal at base of Q74	Condition	CRT display (+ slope)
0 V  (A)	LEVEL control centered. Sweep triggered at midpoint of signal.	
0 V  (B)	LEVEL control counterclockwise from midrange. Sweep triggered on negative portion of signal.	
0 V  (C)	LEVEL control clockwise from midrange. Sweep triggered on positive portion of signal.	

Fig. 3-7. Effect of LEVEL control on AC coupled, symmetrical trigger signal at the base of Q74 for small-signal operation (less than ±5 volts). One kilohertz sine-wave displayed.

Slope Comparator

Q74 and Q84 are connected as a comparator. The comparator is referenced to ground through R94 at the base of Q84. The emitters of Q74 and Q84 are connected together through D91-D92 or C92-R92. Signals with amplitudes higher than about one volt, peak to peak, are DC-coupled between the emitters of Q74 and Q84 through D91 or D92. Smaller signals are AC-coupled through C92 and R92. Since there is very little voltage drop in this coupling between emitters, the voltage at each emitter is essentially the same. Therefore, the transistor which is forward biased controls conduction. For example, assume that the trigger signal applied to the base of Q74 is negative going and it forward biases Q74. The increased current flow through R63 and R93 produces a larger voltage drop and the emitters of both Q74 and Q84 go more negative (less positive). A more negative voltage at the emitter of Q84 reverse biases this transistor and the collector voltage goes negative. At the same time, the collector current of Q74 has increased and its collector goes more positive. Notice that the signal current at the collectors of Q74 and Q84 is opposite in phase. The negative-going signal has been inverted through Q74 but not through Q84. The sweep can be triggered from either the negative-going or positive-going slope of the input signal by producing the trigger pulse from either the inverted signal at the collector of Q74 or the uninverted signal at the collector of Q84. This selection is made by the Slope Multivibrator stage (see Slope Multivibrator discussion).

The DC level of the trigger signal at the emitter of Q23 can be varied by the LEVEL control, the Àuto Trigger P-P Level stage or external program trigger level. This also changes the bias level on Q74 and determines the change in trigger signal necessary to turn Q74 on (or off). For example, when the LEVEL control (also applies to auto trigger or external level) is set near midrange, the base of Q74 is at about zero volts (TRIG LEVEL CENTERING adjustment set correctly). Thèrefore, signal changes around the zero-volt level will turn Q74 on or off (see Fig. 3-7A). If the LEVEL control is set counterclockwise, a more positive level is established at the base of Q74 and this shifts the trigger signal at the base of Q74 to a more positive level (see Fig. 3-7B). Since Q74 still switches near zero volts, it now switches at a more negative point on the trigger signal than when the LEVEL control was centered. This produces an output pulse from the Sweep Triggered circuit at an earlier time, which starts the Sweep Generator sooner. The resultant display shows more of the positive-going edge of the displayed waveform (positive slope triggering). The effect is the opposite when the LEVEL control is set clockwise from midrange (see Fig. 3-7C). The DC level of the waveform is shifted negative and Q74 switches at a later time. Less of the positive-going edge is shown on the displayed waveform (positive slope triggering). The LEVEL control was used to change the trigger level for this explanation. However, the effect will be the same when either the external program level or Auto Trigger P-P Level circuit sets the trigger level.

Slope Multivibrator

The Slope Multivibrator, Q75 and Q85, selects the Slope Comparator output signal which triggers the sweep. This is accomplished by forward biasing either D66 or D96. Q75 and Q85 are connected as a bistable multivibrator. For positive slope triggering, Q85 is biased off and Q75 is conducting. Since the current flow through R82 is reduced with Q85 off, the voltage level at the collector of Q85 rises positive. D82 is reverse biased and the voltage across B82, + SLOPE indicator, ignites it. Meanwhile, on the Q75 side of the multivibrator, the emitter level is at about —7 volts as established by zener diode D86. The base level established by the voltage divider R74-R75-R99 from —12.2 volts to ground is positive enough (less negative) to bias Q75 on and D72 is forward biased. The collector current of Q75 through R72 pulls the collector more negative and B72, — SLOPE indicator, is held off. The negative voltage level at the collector of Q75 reverse biases D66 through D65. This blocks the inverted trigger signal at the collector of Q74 from being passed on to the Trigger Shaper stage. At the same time D96 is forward biased through D95 by the —2 volt level at the cathode of D95 established by divider R74-R75-R99. With D96 forward biased, the trigger signal at the collector of Q84 is coupled to the Trigger Shaper stage to provide positive-slope triggering.

For negative-slope triggering, conditions are reversed. Q75 is off and Q85 is conducting. The collector of Q75 rises positive and B72, —SLOPE indicator, is turned on. D72 is reverse biased and the less negative voltage at the cathode of D65 established by divider R69-R71-R85-R84 forward biases D66 through D65. The inverted trigger signal at the collector of Q74 passes to the Trigger Shaper stage. Q85 is held in conduction by a less negative voltage at its base established by the voltage divider R69-R71-R84-R85 from —12.2 volts to ground. With Q85 conducting, its collector goes negative and B82, + SLOPE indicator, is held off. The negative level at the collector of Q85 reverse biases D96 through D95 and D82 to block the trigger signal from Q84. Q75 is held off by a level of about —6 volts at its base established by divider R74-R75 from —12.2 volts to the collector of Q85.

When the CHANGE SLOPE pushbutton, SW87, is pressed, the slope of the trigger signal changes. The circuit operates as follows to change slope: When SW87 is pressed, the positive level (with respect to negative levels in this circuit) at the base of the on transistor is coupled to the base of the off transistor. This raises the level at the base of the off transistor enough to bring it into conduction and its collector goes negative. The negative-going change at the collector of this transistor is connected to the base of the on transistor to turn it off. The multivibrator switches states and the unit is triggered from the opposite slope. The circuit remains in this condition until the CHANGE SLOPE button is pressed again (or changed by external program).

The trigger slope can be externally programmed through terminal 27 of the front-panel PROGRAM connector, J30. In the External Mode of operation, —12.2 volts is applied to the base of Q85 through D89, R89 and R85 (see Operating Mode Power for explanation of how External Power is obtained). Q85 is reverse biased by this negative voltage at its base and positive-slope triggering is established. Operation of the remainder of the circuit is the same as just described for positive-slope triggering in the Manual Mode. To change the trigger slope to minus, grounding external program slope logic is connected to terminal 27 of J30. This raises the level at the base of Q85 positive to forward bias it. Q85 turns on and establishes negative-slope triggering. Operation of the circuit is the same as described previously for negative-slope triggering. When the grounding level at terminal 27 is removed, the Slope Multivibrator reverts to positive-slope triggering.

Trigger Shaper

The input transistor, Q104, of the Trigger Shaper stage is a low-impedance, current driven amplifier. The base level of Q104 is set at about —4 volts by divider R101-R102 between —12.2 volts and ground. This establishes a level of about —3.5 volts at the emitter. The input signal to this stage is applied through either D66 or D96 as described under Slope Comparator and Slope Multivibrator. When the Slope Multivibrator raises the anode level of either diode above about 3 volts, the corresponding half of the Slope Comparator is connected to the Trigger Shaper stage.

Tunnel diodes[1] D105 and D115 are connected so that when one diode is in its high-voltage state the other diode must be in its low-voltage state. Therefore, when switched by the trigger signal, either D105 or D115 changes to its high-voltage state and the other diode changes to its low-voltage state. Tunnel diodes characteristically switch from the low-voltage state to the high-voltage state very rapidly. However, they are slower when switching back to the low-voltage state. The configuration used in this stage provides both a fast leading edge and a fast trailing edge on the trigger signal.

Circuit operation is as follows: Assume that the signal at the emitter of Q104 is at its most negative level. This also produces a negative level at the collector of Q104 which holds D105 in its low-voltage state and D115 in its high-voltage state. As the Slope Comparator switches, the current through Q104 increases. This increase in collector current switches D105 to its high-voltage state to produce a fast leading edge on the trigger signal. The increase in current through Q104 also depletes enough current from D115 to switch it back to its low-voltage state. L106 opposes the sudden change in current at the collector of Q104 and provides a higher collector load during the transition period to aid in switching the tunnel diodes. The circuit remains in this condition until the Slope Comparator is switched again by the trigger signal applied to the input. Then, the collector current of Q104 decreases and the current through D115 increases. D115 switches to its high-voltage state to produce a fast trailing edge on the trigger signal. Current through D105 decreases and it returns to its low-voltage state. Again L106 aids in switching the tunnel diodes.

The trigger signal at the output of this stage is connected to the Sweep Generator circuit through the Pulse Amplifier and to the Seek Circuit through the Seek Circuit Driver.

Pulse Amplifier

The trigger signal at the output of the Trigger Shaper stage is connected to the base of Q134 through R131. The

[1]See General Electric "Tunnel Diode Manual" for explanation of tunnel diode operation.

trigger signal at this point is basically a rectangular pulse with a fast rise and fall. The width of this pulse depends upon the input signal waveshape and the LEVEL control setting. Q134 is connected as an amplifier with the primary of T140 providing the only collector load. Since transformers respond only to a changing current, the signal at the secondary of T140 consists of negative-going pulses approximately 10 nanoseconds wide, which are coincident with the fall of the positive-going signal at the base of Q134 (inverted by transformer). The secondary of T140 is prevented from going negative by D142. Therefore, only the positive-going trigger pulses are applied to the Sweep Generator. The negative-going trigger pulses at the collector of Q134 are also coupled to the Bright Baseline circuit through D281.

Seek Circuit Driver

The trigger signal at the output of the Trigger Shaper stage is also connected to the base of Q124 through R119. The output signal at the collector of Q124 is connected to the Seek Circuit through terminal 14 of J400.

Trigger Level Amplifier

The Trigger Level Amplifier, Q14, establishes the bias level at the base of the Input Emitter Follower, Q23. The level on the input signal at which the trigger circuit responds is determined by changing this bias level. The base level of Q14 is set at about —6 volts by divider R13-R14 between —12.2 volts and ground. This sets the level at the emitter of Q14 near —6 volts also. The quiescent current through Q14 is adjusted by the TRIG LEVEL CENTERING adjustment, R15, to provide a zero-volt level at the base of Q23 when the LEVEL control is centered. The source of the control current which determines the triggering level is selected by the Trigger Mode Logic stage. Level current may come from the manual LEVEL control, R25A, through D10, the Auto Trigger P-P Level stage through D39 or external program trigger level through D42. The Trigger Mode Logic stage allows current from only one of these sources to pass to the emitter of Q14 (see Trigger Logic discussion).

Auto Trigger P-P Level

The trigger level for auto triggering is established by the Auto Trigger P-P Level stage, Q33 and Q34. The output level from this stage is determined by R25B at the base of Q33. The network D23-D24-D26-C23-C26 around R25B comprises a peak-level sensing network which allows R25B to be adjusted between two voltage levels representing the most negative and positive peaks of the trigger signal. This provides trigger level adjustment for the auto trigger mode over at least a 10% to 90% range of the trigger signal transistion. It also allows the unit to be triggered at all positions of the LEVEL control if the minimum frequency and amplitude specifications are met. This is accomplished as follows: when the trigger signal at the emitter of Q23 rises positive, D23 is forward biased and C23 charges toward this positive level. When the signal goes negative, D23 is reverse biased and D26 is forward biased through D24. C26 charges toward the level of the negative peak. After several cycles, C23 is charged to the level of the positive peaks and C26 to the level of the negative peaks. This effectively places the peak-to-peak voltage of the input signal across R25B at all times. Due to some losses in the circuit, this voltage will be slightly lower than the total this positive level. When the signal goes negative, D23 is peak-to-peak voltage which results in a range of at least 10% to 90% of the trigger signal transition. Therefore, in the auto trigger mode, the trigger level can not be set to a point which does not allow the unit to trigger.

The level selected by R25B is connected to the base of Q33. Q33 and Q34 are connected to operate with very low input current. C31, connected from the collector of Q34 to the base of Q33, slows down the action of the circuit and keeps it from changing the output level too quickly due to a transient change in trigger signal amplitude. The output level at the collector of Q34 is connected to the Trigger Level Amplifier stage through D39 as selected by the Trigger Mode Logic stage.

Trigger Latch Circuit

The Trigger Latch Circuit is comprised of Q54 in the Sweep Trigger circuit and Q634 in the Seek Circuit. A simplified diagram of this circuit is shown in Fig. 3-8. Only the components essential to this explanation are shown on this diagram. Note that the collector of Q634 is connected to the base of Q54 and the collector of Q54 is connected to the base of Q634. Connected in this manner, Q54 and Q634 comprise a latch circuit. When either transistor is on, they are both on and when either transistor is off, they are both off. The output levels from this stage control the Trigger Mode Logic stage and the trigger-level diodes through D9 and D52. The following description explains the condition of this stage in each mode of operation. More information on the operation of this circuit is given under Trigger Mode Logic.

Manual Mode. In the Manual Mode of operation, —12.2 volts Manual Power (see Operating Mode Power discussion) is applied to the base of Q54 through D54 and R54. This negative voltage forward biases Q54 and its collector goes positive to about zero volts. This in turn forward biases Q634 to "latch up" the circuit. (Since Q54 is held on through D54, the unit may be operated without the Logic Card for Manual Mode only operation.) The positive collector level of Q54 also forward biases D52 to allow the Trigger Function switch (or external program) to determine trigger coupling, source and mode (note exception for auto triggering) and reverse biases D9 to allow manual level current to pass through D10. For auto triggering in the Manual Mode of operation, the base of Q54 is connected to ground by SW50 and the Trigger Latch Circuit turns off. When the Trigger Latch Circuit turns off, D9 disconnects the manual level control current and D52 is reverse biased to disconnect the Trigger Function switch. Now the Auto Trigger P-P Level stage determines the trigger level (see Trigger Mode Logic discussion for more information).

Seek Mode. In the Seek Mode, operation of the Trigger Latch Circuit is determined by a voltage level from the Bright Baseline stage (see Bright Baseline discussion) which is connected to the base of Q54 through D299. When a seek command is received, the seek mono pulse produced by Q625 (see Seek Circuit discussion) momentarily forward biases Q634 through D632-C632. If the unit is correctly triggered, the voltage level from the Bright Baseline stage is negative enough to reverse bias D299. This allows Q54 to conduct and the Trigger Latch Circuit remains on. When

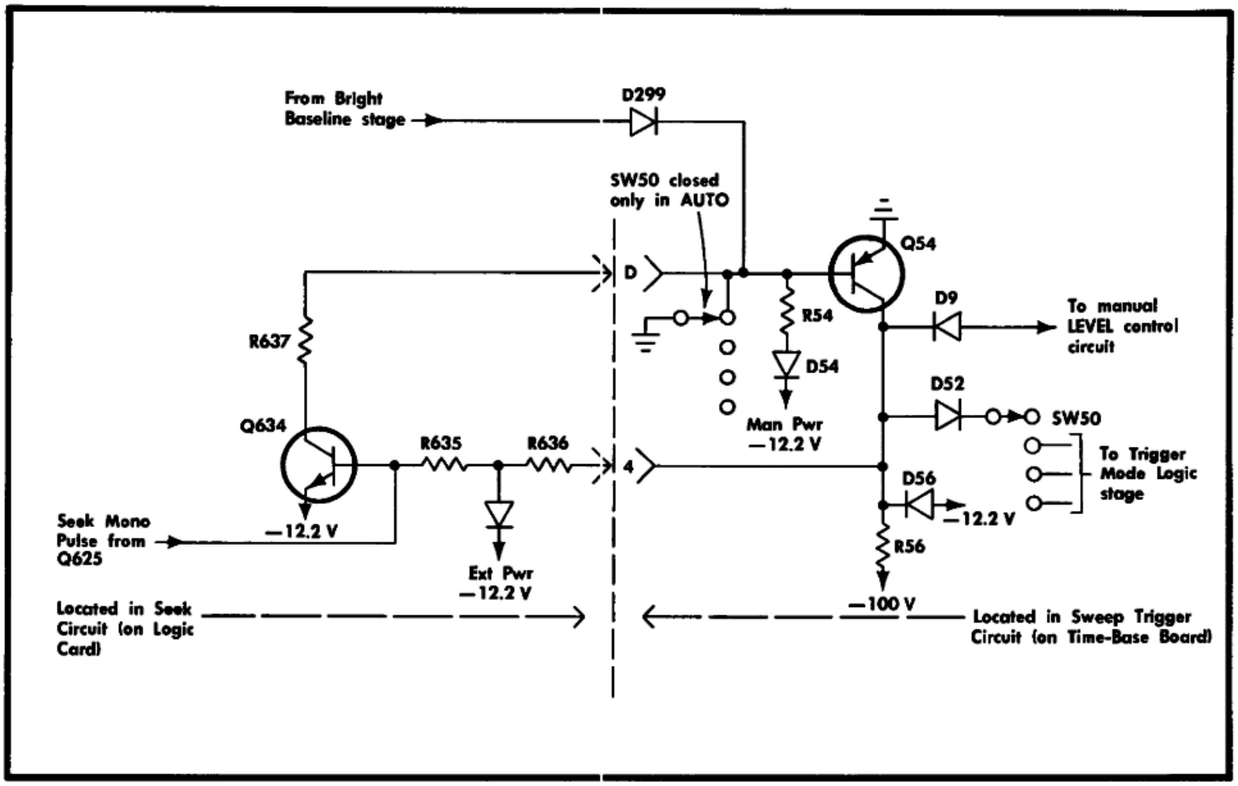


Fig. 3-8. Simplified diagram of Trigger Latch Circuit.

the Trigger Latch Circuit is on, the front-panel trigger controls determine the circuit operation. However, if the unit is not correctly triggered, the output level of the Bright Baseline stage is positive enough to forward bias D299. With D299 forward biased, the base of Q54 rises positive and the Trigger Latch Circuit is shut off. This disconnects the front-panel trigger controls and the Trigger Mode Logic stage switches to auto trigger operation. The operation described here allows the unit to switch to the auto trigger mode, if not correctly triggered, to present a stable display whenever possible in the Seek Mode of operation.

The following logic sequence takes place each time a seek command is received:

TABLE 3-1

Trigger Logic Sequence (Seek Mode)	Visual Indication
I. Seek mono pulse (produced when seek command is received) momentarily turns on Trigger Latch Circuit.	SEEK button lights.
II. Trigger Latch Circuit checks for correct triggering as set by front-panel controls.	
A. Triggered	
1. Trigger Latch Circuit remains on and unit operates as set by the front-panel controls.	Stable CRT display presented.
2. If the unit is no longer correctly triggered after correct triggering has been established as set by the front panel controls (e.g., level of trigger signal changes or external trigger signal is interrupted) the unit reverts to auto triggering (see next step).	
B. Not triggered Trigger Latch Circuit shuts off and Trigger Mode Logic stage switches to auto triggering. Auto Trigger P-P Level stage checks for internal trigger signal.	NOT TRIG'D readout and Auto Trigger light come on.
1. **Triggered.** If auto trigger level can be obtained, sweep rate seeking is performed. Unit remains in auto trigger mode until next seek command is received.	Auto trigger light remains on. NOT TRIG'D readout turns off. Stable CRT display presented.
2. **Still not triggered.** If auto trigger level cannot be obtained, Bright Baseline stage free runs sweep (typically 2 s/DIV sweep rate).	NOT TRIG'D readout and Auto Trigger light remain on. Free running sweep presented.
III. This logic sequence is repeated when the next seek command is received.	

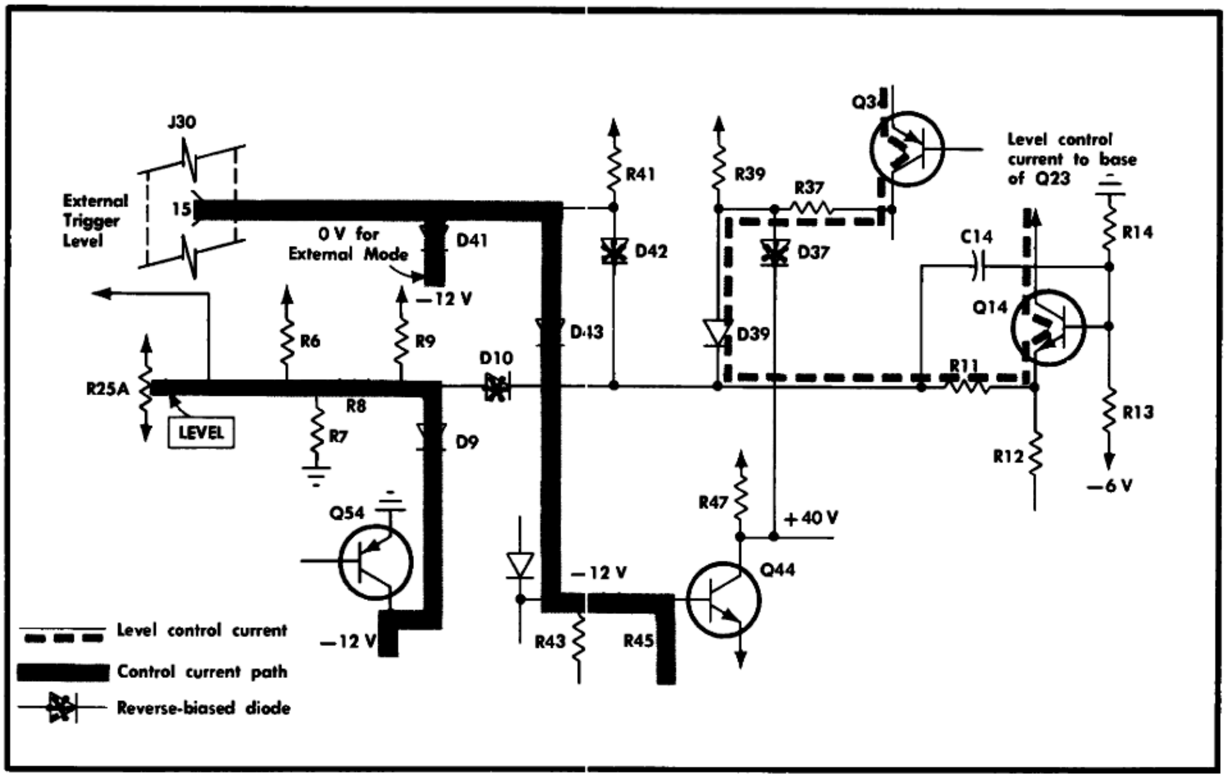


Fig. 3-9. Trigger level current for auto triggering (Manual Mode, Seek Mode or External Mode operation).

External Mode. For External Mode operation, −12.2 volts External Power is applied to the base of Q634 through D635. This holds the Trigger Latch Circuit off and the manual trigger LEVEL control and the Trigger Function switch are disconnected. Now, the operation of the Trigger Mode Logic stage is controlled by the external program function logic connected to J30.

Trigger Mode Logic

General. The Trigger Mode Logic stage selects the trigger mode, coupling and source. For Manual and Seek Mode operation, the Trigger Function switch controls operation (note exception given above for Seek Mode). For External Mode operation, these functions are controlled by external program function logic through J30. In all modes of operation, trigger source, coupling, mode and level are determined by the condition of relays K3 and K4 and diodes D10, D39 and D42. Therefore, the following description is written to relate circuit operation in each mode to these components.

Manual Mode. The Trigger Function switch, SW50, controls Sweep Trigger circuit operation for the Manual Mode of operation. In the INT-AUTO position, D52 is disconnected from the Trigger Mode Logic stage. SW50 also connects the base of Q54 to ground to shut off the Trigger Latch Circuit and the collector of Q54 goes negative. This forward biases D9 and drops the voltage level at the anode of D10 to a level that reverse biases it. Fig. 3-9 shows the condition of the logic diodes for auto triggering. The level-control current from the front-panel LEVEL control is shunted away from the Trigger Level Amplifier. No connections are made to K3 or K4 so no control current flows through either relay and the corresponding switches are not actuated. This means that the applied trigger signal is AC coupled from the internal source. With no current through K3 or K4, the cathode of D46 drops to about −12 volts. D43 is forward biased and D42 reverse biased to divert the external program level current away from the Trigger Level Amplifier. In addition, Seek/Manual Power (see Operating Mode Power discussion) is connected to the cathode of D41 to forward bias it and insure that D42 remains reverse biased. The −12-volt level at the cathode of D46 allows the base of Q44 to go toward −12.2 volts and it is reverse biased. The collector of Q44 rises toward the +125-volt supply and when this voltage reaches the firing potential of B47, Auto Trigger indicator, it comes on to indicate that the trigger circuits are operating in the auto trigger mode. The positive-going potential at the collector of Q44 reverse biases D37 and allows D39 to conduct. This connects the auto trigger level control current from the Auto Trigger P-P Level stage to the emitter of the Trigger Level Amplifier. The collector level of Q44 is also connected to the Bright Baseline stage through D296.

Complete operation is only described for the INT-AC position of normal triggering since operation in the INT-AC, EXT-AC and EXT-DC positions of the Trigger Function switch are basically the same except for control of the current through K3 and K4. Only the differences are given for EXT-AC and EXT-DC. When SW50 is in the INT-AC position,

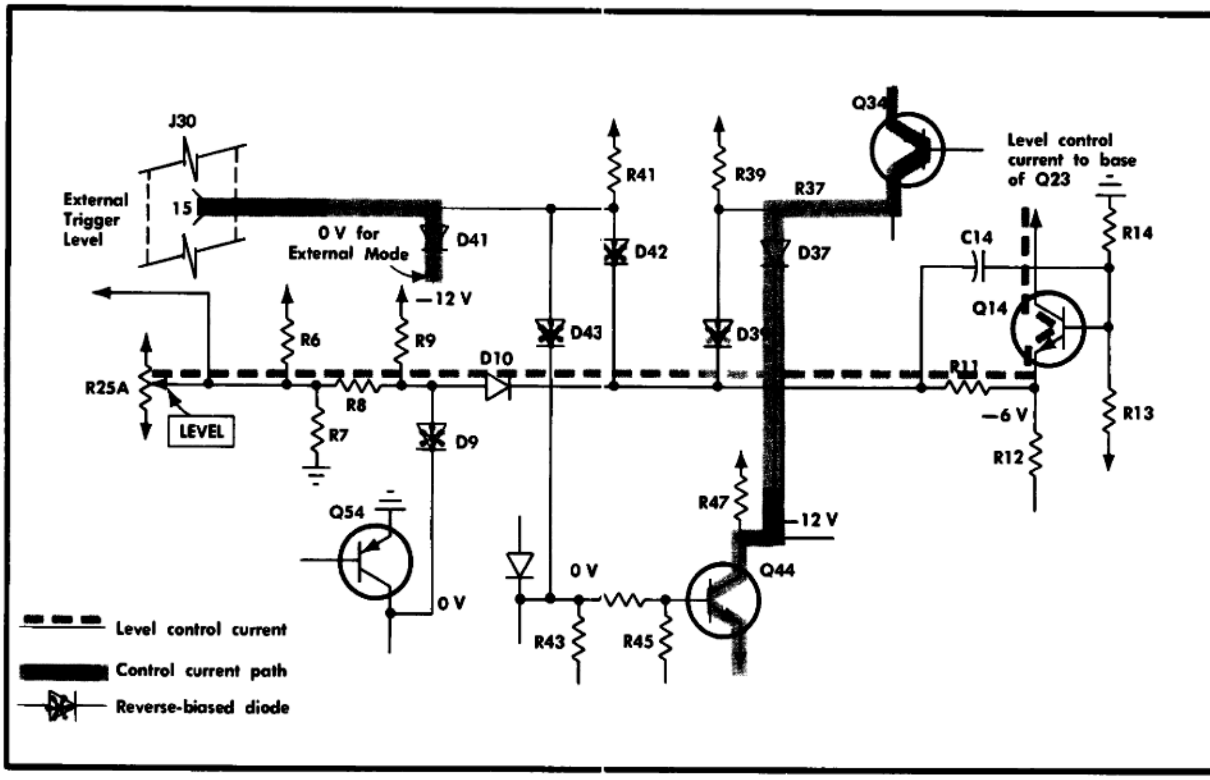


Fig. 3-10. Trigger level current for Manual Mode triggering (non-auto).

the base of Q54 is pulled toward —12.2 volts by the Manual Power applied as previously discussed. The Trigger Latch Circuit turns on and forward biases D52 and reverse biases D9. When D9 is reverse biased, manual level current from the LEVEL control, R25A, is connected to the emitter of Q14 through D10. Fig. 3-10 shows the condition of the logic diodes for manual level operation. The output of the Trigger Latch Circuit rises to about zero volts and this level is connected to the cathode of D46 through D52 and SW50. D46 remains reverse biased and no current flows through either K3 or K4. K3-1 remains in the internal position and K4-1 remains in the AC position. The positive level at the cathode of D46 reverse biases D43. However, the external program level current is still shunted from Q14 by D41 due to the Seek/Manual power applied to it. Q44 is also biased into conduction and its collector goes negative to turn off the Auto Trigger light. With the collector of Q44 negative, D37 is forward biased and the auto trigger level current is shunted.

In the EXT-AC position of SW50, the zero-volt output of the Trigger Latch Circuit is applied to the anode of D46. D45 remains reverse biased and current does not flow through K4. However, current does flow through K3 and K3-1 switches from the internal source to the external. D46 is forward biased and the base of Q44 rises positive to forward bias it. The remainder of the circuit operates as described for INT-AC.

In the EXT-DC position of SW50, the near-ground potential at the collector of Q54 is connected to the anode of D45. Current flows through K4 and K4-1 closes to provide DC-coupling of the signal to the Input Emitter Follower. Also, D45 is forward biased and current flows through K3 to switch K3-1 to the external trigger source. Q44 is turned on through D46 to lock out the auto trigger level current. The remainder of the circuit operates as described for INT-AC.

Seek Mode. In the Seek Mode, operation is determined by the setting of the LEVEL control, Trigger Function switch and the presence (or absence) of a trigger signal. As described in the Trigger Latch Circuit description, Q54 is momentarily turned on each time a seek command is received (except in INT-AUTO). Then, Q54 remains on if the unit is correctly triggered and operation is the same as described for Manual Mode (not auto triggering). However, if the unit is not correctly triggered or SW50 is set to INT-AUTO, Q54 turns off and the instrument switches to auto triggering. Then, operation is the same as described for auto triggering under Manual Mode.

If for some reason the trigger circuit is no longer triggered because, for example, the level of the trigger signal has changed after normal triggering has been established, the output of the Trigger Latch Circuit goes negative. Manual trigger level current is disconnected and the Trigger Mode Logic circuit reverts to auto triggering.

External Mode. In the External Mode of operation, the output of the Trigger Latch Circuit is negative as determined by External Power applied to the circuit (see Trigger Latch Circuit discussion). D9 is forward biased to shunt the manual

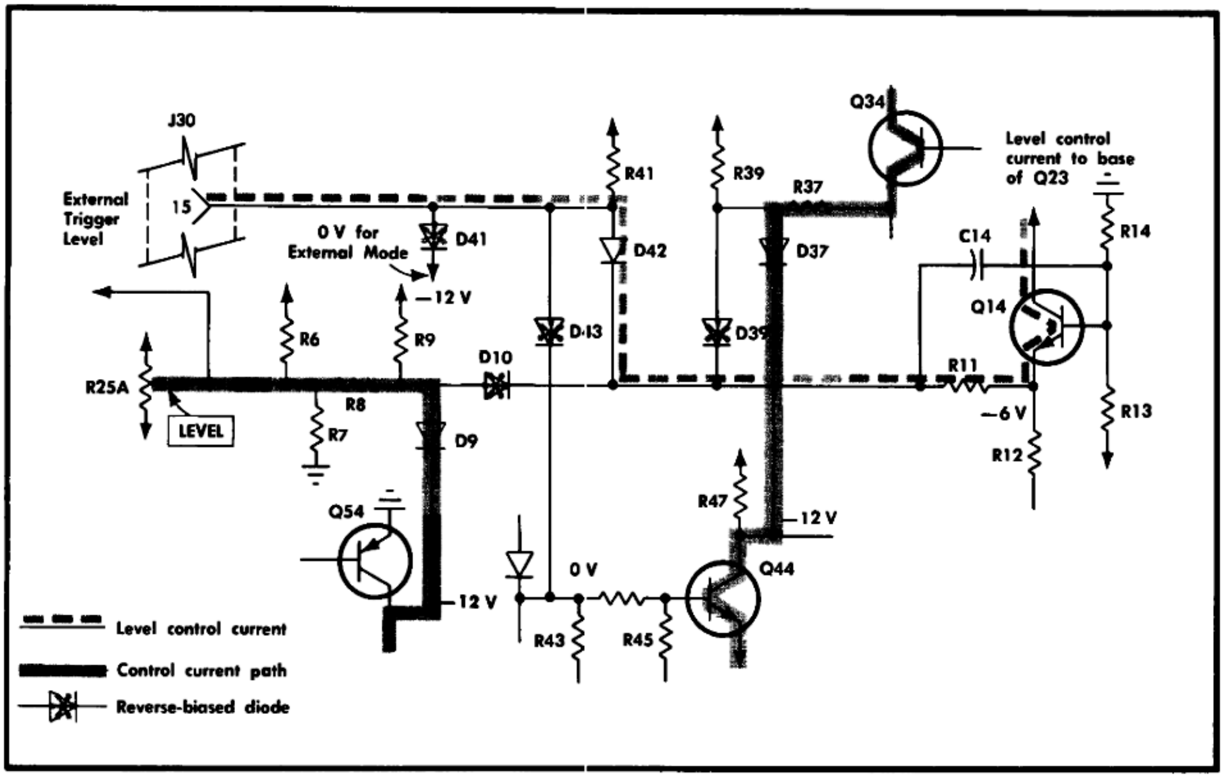


Fig. 3-11. Trigger level current for External Mode triggering (non-auto).

level current and D52 is reverse biased to disconnect the Trigger Function switch. Now, trigger source, coupling and mode are selected by connecting grounding (zero-volt external program function logic to either terminal 28, 30 or 31 of the PROGRAM connector. If no connections are made to these three terminals, the circuit operates in the auto trigger mode. Since there are no connections to the base of Q44, it goes negative and turns off. The Auto Trigger light comes on and D37 is reverse biased to allow auto trigger level current (controlled by the front-panel LEVEL control) to be connected to the Trigger Level Amplifier. Also, D43 is forward biased by the negative potential in the base circuit of Q44 and it shunts the external program level control current away from Q14. The Seek/Manual Power at the cathode of D41 is disconnected in the External Mode of operation so this diode is, in effect, reverse biased.

For Int AC operation, grounding external program function logic is connected to terminal 31 of J30. This places a zero-volt potential at the cathodes of D46 and D43. D46 remains reverse biased and no current flows through either K3 or K4. K3-1 and K4-1 remain in their unactuated positions for AC coupling from the internal trigger signal. However, D43 is reverse biased and the external program level control current is coupled to the Trigger Level Amplifier through D42. Fig. 3-11 shows the condition of the logic diodes for external level control. Zero-volt logic to terminal 31 also raises the potential at the base of Q44 and it conducts. The Auto Trigger light goes out and D37 is forward biased to shunt the auto trigger level current away from the Trigger Level Amplifier.

For Ext AC operation, grounding external program function logic is connected to terminal 30 of J30. This places a zero-volt potential at the anode of D46. D45 remains reverse biased and current does not flow through K4. However, current does flow through K3 and K3-1 is switched from the internal source to the external source. D46 is forward biased and the base of Q44 rises positive enough for it to conduct. Also, D43 is reverse biased by this positive level. The remainder of the circuit operates as described for Int AC.

For Ext DC operation, grounding external program function logic is connected to terminal 28 of J30. This places a zero-volt level at the anode of D45. Current flows through K4 and K4-1 closes to direct couple the signal to the Input Emitter Follower. Also, D45 is forward biased and allows current to flow through K3 to select the external trigger source. D43 is reverse biased and Q44 is turned on through D46 as for Ext AC operation. The remainder of the circuit operates as described for Int AC.

Sweep Generator

General

The Sweep Generator circuit produces a sawtooth voltage to provide horizontal deflection. This output signal is generated on command (trigger pulse) from the Sweep Trigger circuit. The Sweep Generator circuit also produces an unblanking pulse to unblank the CRT to display a signal. In addition, the Sweep Generator circuit can produce a delayed, magnified sweep as controlled by the Delay and Timing Circuit. The Bright Baseline stage allows the Sweep Generator circuit to free-run when a trigger signal is not present for auto triggering. Fig. 3-12 shows a logic block diagram of the Sweep Generator circuit. A diagram of this circuit is shown on diagram 2 at the rear of this manual.

Sweep Gate

The trigger signal at the output of the Sweep Trigger circuit is applied to the Sweep Gate stage through T140. Only the negative-going portions of the trigger signal produce a voltage across the primary of T140 because D142 reflects a minimum impedance back to the primary for the positive-going portions. This produces a positive-going trigger pulse at the secondary of T140. Tunnel diode D145 is quiescently conducting about three milliamps of current which is not enough to switch it to its high-voltage state. The positive-going trigger pulse at the anode of D145 increases its current and it rapidly switches to the high-voltage state where it remains until reset by the Sweep Reset Multivibrator at the end of the sweep. The positive-going level at the anode of D145 forward biases Q144 through R145. When Q144 comes on, its collector rapidly goes negative. This negative-going step is coupled to the output emitter follower Q253 and the Disconnect Emitter Follower, Q153.

Emitter Follower Q253 provides isolation between the Sweep Gate stage and the Unblanking Driver stage. D254 clamps the emitter of Q253 so it does not go more than about 0.5 volts above ground level. The signal at the emitter of Q253 is coupled to the base of the Unblanking Driver stage through R257 and C257. This signal is also coupled to terminal 4 of the interconnecting plug, P21, and to the Seek Circuit. The signal to terminal 4 of P21 is AC coupled by C255 and it provides the alternate trace sync pulse for a multi-trace amplifier unit. The signal to the Seek Circuit is a negative-going sweep gate with an amplitude of about —6 volts. Duration of the sweep gate is the same as the duration of the total displayed sweep.

Disconnect Emitter Follower and Diode

Q153 is quiescently conducting and it forward biases the Disconnect Diode, D155. With D155 conducting, current from the Timing Resistor passes through the Disconnect Diode rather than charging the Timing Capacitor. The negative-going sweep gate at the collector of Q144 turns the Disconnect Emitter Follower, Q153, off and reverse biases the Disconnect Diode. Timing current through the Timing Resistor now begins to charge the Timing Capacitor and the sweep starts to run up. The Disconnect Diode is a low-capacitance, low-leakage, fast turn-off diode to reduce the switching time and improve timing linearity at the start of the sweep.

Sawtooth Sweep Generator, Sweep Output Emitter Follower and Timing Capacitor and Resistor

The basic sweep generator circuit is a Miller Integrator.[2] The Sawtooth Sweep Generator, Sweep Output Emitter Follower and the Timing Capacitor and Resistor stages all operate together to produce the sawtooth for horizontal sweep. When the current flow through the Disconnect Diode is interrupted by the sweep gate signal, the Timing Capacitor begins to charge through the Timing Resistor. The Timing Capacitor and Resistor are changed for the various sweep rates listed on the front panel (see Delay and Timing Circuit discussion). In the 0.1 μs position, variable capacitor C168 is the Timing Capacitor. This capacitor remains in the circuit at all sweep rates and is paralleled by the remaining Timing Capacitors for the slower sweep rates. The charging current to the Timing Capacitor provided by the Timing Resistor is increased 10 times or 100 times to provide delayed sweep magnification (see ×10 and ×100 Magnifier Gates discussion).

As the Timing Capacitor begins to charge toward —100 volts through the Timing Resistor, the grid of V163 goes negative also. This produces a negative-going change at the cathode of V163 which is coupled to the base of Q161. D162 limits the reverse voltage across the Disconnect Diode to protect it during warm up. Q161 amplifies and inverts the voltage change at the cathode of V163 to produce a positive-going signal at its collector. D165 clamps the base of Q161 to protect it during warm up. The positive-going change at the collector of Q161 is coupled to the base of the Sweep Output Emitter Follower, Q174. D172 helps turn Q174 off faster during sweep retrace. The voltage level at the emitter of Q174 is shifted six volts negative by zener diode D173 to provide the correct output DC level without attenuating the signal. The positive-going voltage change at the anode of D173 is the sweep output voltage. This voltage is also connected back to the positive side of the Timing Capacitor. This feedback rises positive at the same rate that the Timing Capacitor charges negative. Therefore, the Timing Capacitor appears to be charging toward the same potential at all times, maintaining a constant charge rate and providing a linear sawtooth output voltage. The output voltage continues to rise positive until the circuit is reset through the Sweep Reset Multivibrator.

The output voltage from the Sweep Output Emitter Follower is connected to the Horizontal Amplifier to produce the horizontal CRT deflection. It is also connected to terminal 18 of the interconnecting plug through R187 to provide a sweep signal current to the amplifier unit and to terminal 16 of the front-panel PROGRAM connector through R189 for sweep output.

Sweep Reset Multivibrator

The positive-going sawtooth voltage at the emitter of Q174 is coupled to the Sweep Reset Multivibrator through R201 and D228. The DC level of the positive-going sweep holds D228 reverse biased during most of the sweep time. However, when the sweep voltage at its anode rises positive enough to forward bias D228, it conducts and Q235 is turned off. The level of the sawtooth at which D228 conducts determines the sweep length. For unmagnified operation, $\overline{\times 1}$ (bar ×1 magnifier) logic from the Delayed Sweep Magnifier Control circuit holds the cathode of D202 near zero volts and the displayed sweep is between 10.3 and 11.3 divisions long. However, for either ×10 or ×100 magnifier operation, the $\overline{\times 1}$ logic level is about —12 volts and D203 is reverse biased. The cathode of D202 is now returned to —12.2 volts through R203. This lowers the

[2] Pulse and Digital Circuits, Millman and Taub, McGraw-Hill, 1956, P.214.

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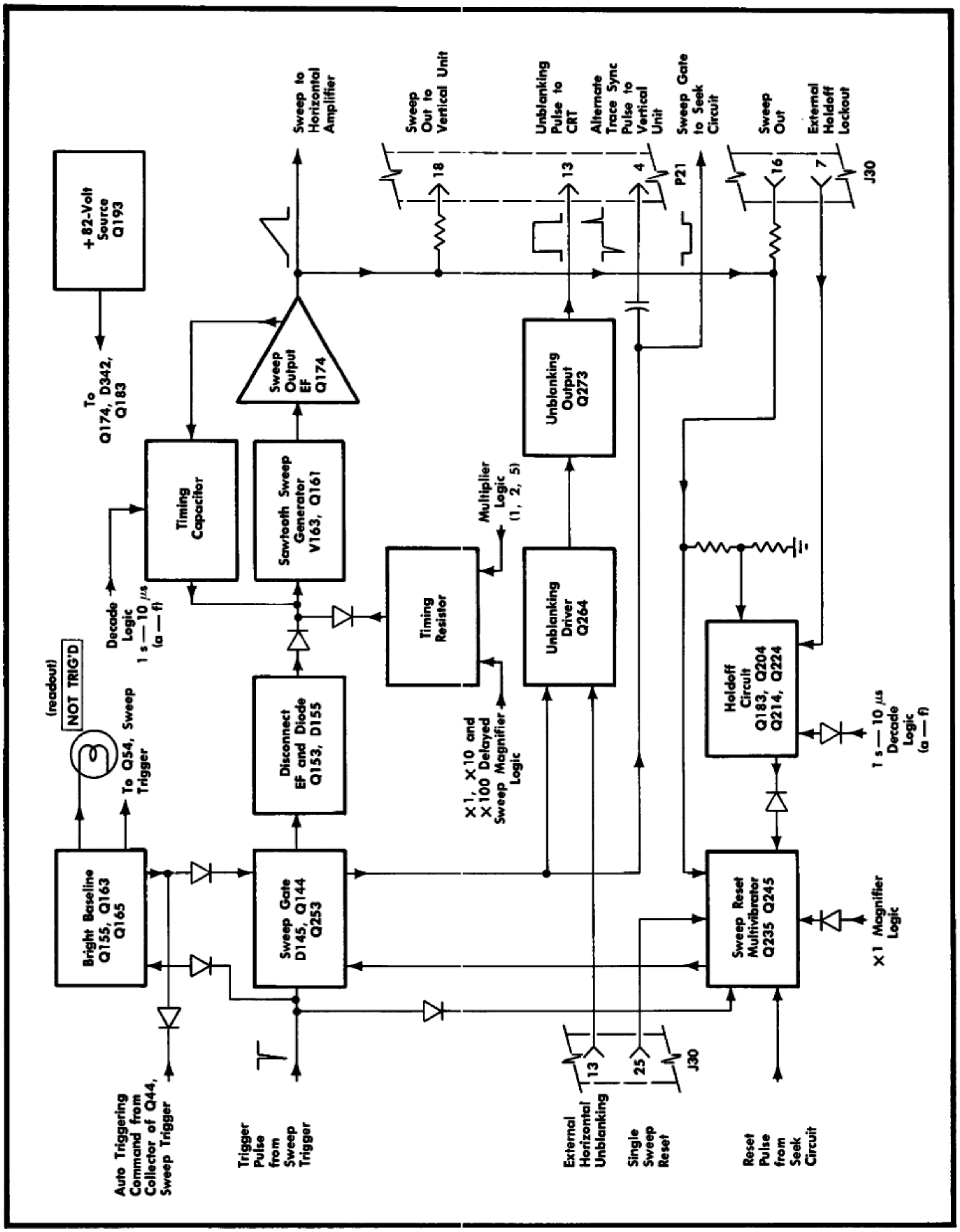

Fig. 3-12. Sweep Generator logic block diagram.

overall sawtooth level and the sawtooth must run up farther to forward bias D228. The effect is a longer sweep of between 12 and 15 divisions for magnified operation.

When the sweep rises positive enough to forward bias D228, it turns Q235 off and Q245 comes on. The Sweep Reset Multivibrator remains in this condition until reset. With Q235 shut off, its collector voltage goes negative. This pulls the anode of the Sweep Gate tunnel diode negative also and D145 reverts to its low-voltage state. D145 is held reverse biased so it cannot accept incoming trigger pulses until the Sweep Reset Multivibrator is reset. The sweep gate output pulse to Q153 and Q253 ends and Q153 and the Disconnect Diode are again forward biased. The Timing Capacitor discharges rapidly through D155 and Q153 until the grid of the Sawtooth Sweep Generator stage is returned to its original level. Now, the Sweep Generator circuit is ready to produce another sweep when the Sweep Reset Multivibrator is reset by the Holdoff Circuit and another trigger is received.

For Seek Mode operation, a positive-going reset pulse is coupled to the base of Q235 each time an advance pulse is produced (see Seek Circuit discussion). This pulse resets the Sweep Generator circuit so it starts over at the next faster sweep rate (faster sweep rate determined by advance pulse to Counter Circuit). A reset pulse can also be applied to this circuit through terminal 25 of J30. This pulse resets the Sweep Generator circuit for single-sweep operation.

Holdoff Circuit

The Holdoff Circuit allows all circuits to return to their original condition before the next sweep is started. The sweep output at the emitter of Q174 is coupled to Q183 through a 2:1 voltage divider, R181-R182. The sawtooth voltage at the emitter of Q183 is connected to the holdoff capacitors through D183 to charge them to one-half the sweep voltage level. C183 is the holdoff capacitor for the fastest sweep ranges and is connected in the circuit at all times. Holdoff capacitors C207, C217 or C227 are connected into the circuit as Q204, Q214 or Q224 are biased into operation by the decade logic level from the Readout Logic circuit. Only one of these transistors is on at a time. When the sweep retraces, D183 is reverse biased since its cathode is held at the charge level of the holdoff capacitor and its anode rapidly goes negative with the sweep retrace voltage. This interrupts the charging current to the holdoff capacitor and it begins to discharge through R183 toward —100 volts (C207, C217 or C227 discharge path includes the associated transistor and related components). When the charge on the holdoff capacitor drops to about zero volts, D229 is forward biased and the base of Q235 goes negative. Q235 comes into conduction and Q245 shuts off. The bias on the Sweep Gate tunnel diode returns to a level that allows it to accept the next trigger pulse.

For fast sweep rates, the network D241-R241-R242 forces the Sweep Reset Multivibrator to reset up to about 10% before the normal holdoff period ends. Positive trigger pulses from the Sweep Trigger circuit are coupled to D241 through T140. These trigger pulses are applied to the base of Q245 and attempt to turn it off and turn Q235 back on. However, Q235 will not come back into conduction unless its base is near the level where it would normally turn on. Then, the positive pulse at the base of Q245 raises the common emitters of Q235 and Q245 positive to bias Q235 on. The circuit is reset and the Sweep Gate tunnel diode returns to a bias level that allows it to switch on the next trigger pulse. A slight current is also added to the Holdoff Circuit from the LEVEL control, R25A, through R185 to change the charge and discharge rate for fast sweep rates and aid in this forced reset. The forced holdoff recovery is only effective at the fastest sweep rates and allows sweep synchronization for less trigger jitter at these faster sweep rates.

For single-sweep operation, a positive voltage can be connected to the Holdoff Circuit through terminal 7 of J30 and R184. This positive voltage prevents the holdoff capacitor from discharging in the normal manner at the end of each sweep. Therefore, the circuit is locked out after each sweep. The next sweep can be produced by resetting the Reset Multivibrator with a positive pulse through terminal 25 of J30. See Single-Sweep Operation in the Operating Instructions section for more information.

Unblanking Driver

The negative-going sweep gate pulse at the emitter of the Sweep Gate emitter follower, Q253, is connected to the base of the Unblanking Driver, Q264 through R257 and C257. C257 improves the response of the circuit to the fast rising and falling portions of the pulse. The emitter level of Q264 is set at about —0.4 volts by D261. Therefore, Q264 is reverse-biased when its base is pulled negative from ground. Quiescently before the sweep is triggered, the base of Q264 rests slightly positive from ground. As the sweep is triggered, the sweep gate signal at the emitter of Q253 drops to about —6 volts. Q264 is reverse biased and its collector rises positive. The DC level change at the collector of Q264 is coupled to Q273 through D265 and R265. Zener diode D265 provides DC voltage matching without a corresponding loss in signal amplitude.

An external unblanking control voltage can be connected to the base of Q264 through terminal 13 of the PROGRAM connector. —12 volts connected to this terminal reverse biases Q264 and unblanks the CRT. This method of unblanking is required for use of the external horizontal input feature.

Unblanking Output

Q273 is connected as an emitter follower. The positive-going level at the collector of Q264 produces a corresponding change at the emitter of Q273. When Q264 is turned off, its collector attempts to rise to +300 volts but is clamped at about +125 volts by D269. This level unblanks the CRT. When the sweep gate signal ends, the emitter of Q273 must be returned to its quiescent level of about +50 volts very rapidly to produce a fast falling edge on the unblanking pulse. However, when the base of Q273 drops negative, Q273 is reverse biased and it does not conduct any of this falling-edge current. D272 is then forward biased and allows the emitter level of Q273 to be pulled back to its original level through C266. This provides a sharp turn off of the trace intensity at the end of the displayed sweep.

+82-Volt Source

Q193 provides +82 volts for operation of Q174, Q183 and D342. The divider R192-R193 from +125 volts to ground sets the base level of Q193 near +82 volts. Since the emitter level follows the base, the voltage at the emitter is about 0.5 volt less positive to establish the desired source voltage.

Bright Baseline

The negative trigger pulses applied to the primary pulses of T140 are also connected to the Bright Baseline stage through D281. Q285 and Q295 are connected as a latch circuit with the collector of Q285 connected to the base of Q295 through R291 and the collector of Q295 connected to the base of Q285 through C284-R284-D282. Negative-going trigger pulses from Q134 in the Sweep Trigger circuit are applied to the base of Q285 to turn it on and its collector goes positive. This positive-going voltage is connected to the base of Q295 and it also turns on. The collector of Q295 goes negative to about −12 volts and C284 begins to charge through R282, D282, and the base-emitter junction of Q285. This charging current holds Q285 in conduction and the circuit is latched up. If only one trigger pulse is applied, the circuit remains latched up for about 50 milliseconds until C284 is near full charge and the charging current can no longer hold Q285 in conduction. Then, the latch circuit shuts off and C284 rapidly discharges through D284 and R294. However, if another trigger pulse (repetitive trigger signal) is applied to the base of Q285 before C284 is near full charge, Q295 quickly discharges C284 and the recharge cycle begins again to hold the circuit latched up.

When the latch circuit is on (unit triggered), the base of Q293 is held negative so current does not flow through B985, NOT TRIG'D readout. The anode of D299 drops to about −6 volts and this level allows the Trigger Latch Circuit to remain on and the unit operates as set by the front-panel controls. When the unit is not triggered, the base of Q293 rises positive to forward bias Q293. The NOT TRIG'D readout, B985, comes on and the anode of D299 rises positive enough so it is forward biased. When D299 conducts it turns the Trigger Latch Circuit off and the unit switches to auto triggering (Seek Mode only). The voltage level at the collector of Q44 in the Sweep Trigger circuit is applied to this stage through D296. This voltage is about −12 volts when the instrument is triggered in the normal trigger mode and it rises to about +40 volts when the unit is in the auto trigger mode. For normal triggering, current flows through D296 or D297 to hold the anode of D148 negative enough to disconnect the Bright Baseline stage from the Sweep Gate stage. However, in the auto trigger mode, D296 is reverse biased and the only current holding D148 reverse biased is through D297 to the Bright Baseline stage. This current is high enough to hold D148 reverse biased when Q293 is off (unit triggered). However, when Q293 comes on (unit not triggered) the cathode of D297 rises to about −5 volts and it is reverse biased. Now, since D296 is also reverse biased for auto triggering, all the current through R149 flows through D149 and D148 to the Sweep Gate tunnel diode. This added current to the tunnel diode automatically switches it to its high-voltage state immediately after it is reset. The result is that the Sweep Generator circuit is automatically retriggered after the end of each holdoff period and a free-running sweep is produced. Since this trace free-runs at the sweep rate produced by the Sweep Generator, it is about the same intensity at all sweep rates.

Delay and Timing Circuit

General

The Delay and Timing Circuit selects a Timing Resistor and Timing Capacitor to determine the sweep rate of the sawtooth produced by the Sweep Generator circuit. The Timing Capacitor is selected by the decade logic and the Timing Resistor is selected by the multiplier logic from the MANUAL TIME/DIV switch or the Counter Circuit. In addition, the ×10 and ×100 Magnifier Gates increase the timing current to provide magnified sweep rates. The Delay Comparator determines the start of the magnified sweep. Fig. 3-13 shows a logic block diagram of the Delay and Timing Circuit. A diagram of this circuit is shown on diagram 3 at the rear of this manual.

Timing Capacitor

The Timing Capacitor determines the decade range of the sweep rate. The Timing Capacitor is selected by coils K310-K315 which actuate corresponding reed relays K310-1 to K315-1. Decade logic from the Readout Logic Circuit (originating at the MANUAL TIME/DIV switch or the Counter Circuit) is applied to the 1 s - 10 μs decade logic lines (a-f). To select one of the timing capacitors, the corresponding decade logic line is dropped to the −12-volt level. The remaining logic lines are held at zero volts. For example to select the 10 μs decade (10, 20 and 50 μs sweep rates), −12 volts is applied to the 10 μs (f) logic line and current passes through K315. K315-1 closes to connect C315 and C316 to the Timing Resistor. The 10, 20 or 50 μs sweep rate within this decade is selected by the multiplier logic applied to the Timing Resistor.

To select the 1 ms and slower sweep decades, K310-1 must be closed in addition to the reed relay which selects the desired Timing Capacitor. For example, to select the 10 ms decade, −12 volts is applied to the 10 ms (c) logic line. Current flows through K312 and K312-1 is actuated. In addition, D304 is forward biased and current flows through K310 to actuate K310-1. For the 1 s (a) decade range, an additional switch is actuated. Current passes through K395 to actuate K395-1 (located in Timing Resistor stage). R394, R395 and R398 are connectd into the Timing Resistor circuit to reduce the timing current through the Timing Resistor 10 times. Since the same Timing Capacitor is used for the 1 s decade as for the 0.1 s decade, the sweep rate is reduced 10 times. The Timing Capacitor for the 1 μs and faster decades is C168 (see Sweep Generator discussion). The ×10 Magnifier Gate stage is used to obtain the 0.1 μs decade and both the ×10 Magnifier Gate stage and a ×10 gain network in the Horizontal Amplifier are used to obtain the 10 ns decade.

When the decade logic to a coil ends, the collapsing magnetic field in the coil produces a reverse inductive voltage. A diode is connected across each of the coils to protect the circuit from this positive-going pulse. D302-D307 provide this protection for K310 and K311. Since all logic lines except one are at zero volts, some of the interconnecting diodes are forward biased for the positive-going pulse

Delay Comparator

The Delay Comparator stage allows selection of the amount of delay before the delayed sweep magnifier is

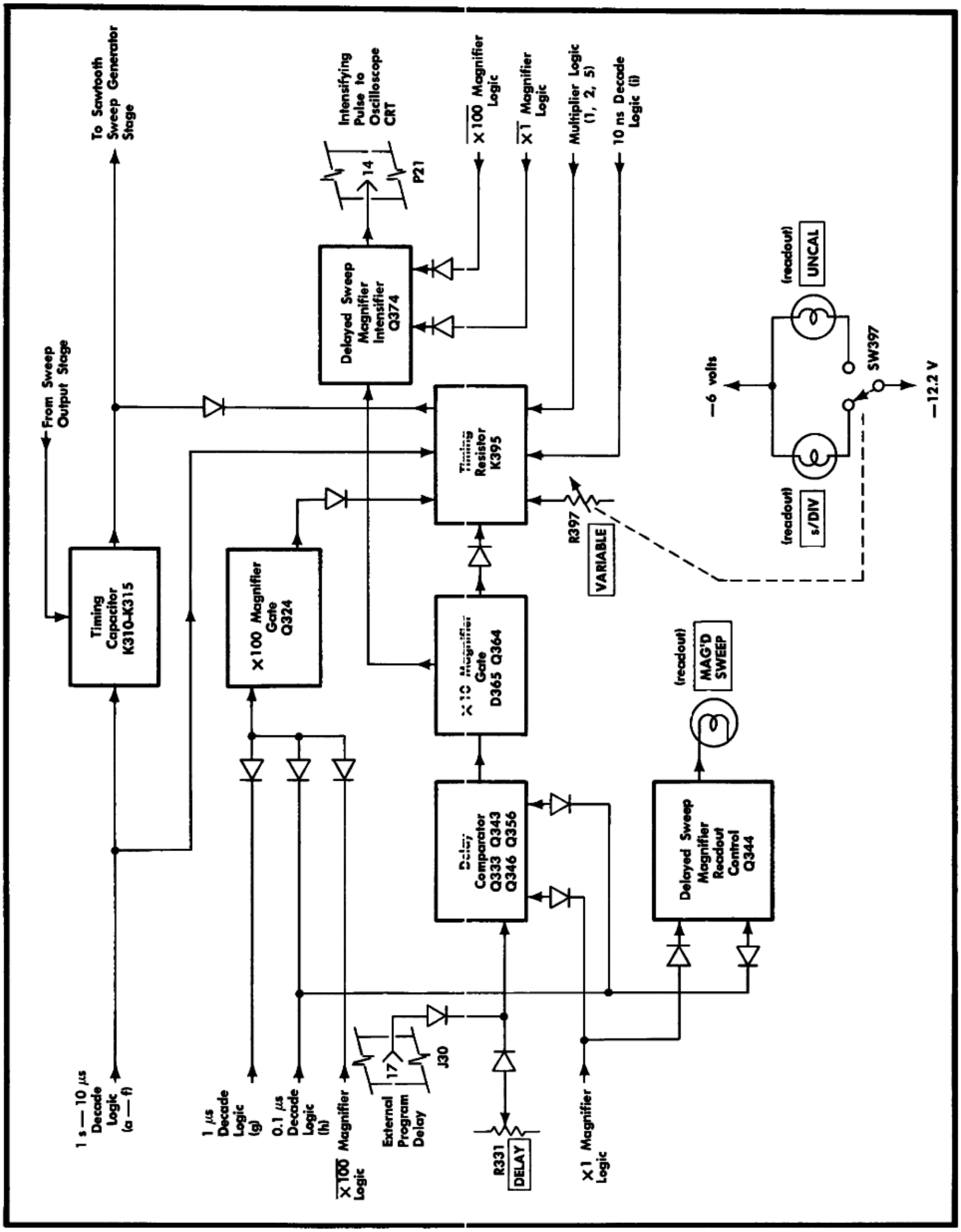

Fig. 3-13. Delay and Timing Circuit logic block diagram.

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turned on. This allows any portion of the sweep to be magnified by selecting, with the DELAY control, the voltage level on the sawtooth where the delayed sweep magnifier is turned on. The DELAY control is calibrated in terms of divisions of display. For example if the DELAY dial is set to 5.00, the delayed sweep magnifier magnifies the portion of the sweep beginning five divisions after the start of the sweep.

For ×1 operation, —7 volt ×1 magnifier logic is connected to the base of Q346 through D348. The base of Q346 goes negative and is clamped at about —6 volts by D349. Q346 is reverse biased and the Delay Comparator stage is locked out so the sweep can not be magnified (note the exception for the 0.1 μs and faster decades). For ×10 and ×100 delayed sweep magnification, the ×1 magnifier logic rises to zero volts to reverse bias D348 and allow the Delay Comparator to switch at the level selected by the DELAY control. This action is as follows: quiescently at the start of the sweep, about two milliamps of current is flowing through R349. Current is also flowing through D338. The current through D338 is a combination of the current supplied by R337 and the current supplied by R336. The current through R336 can be varied between zero and one milliamp by changing the emitter level of Q333 with the DELAY control, R331. R331 is a 10-turn potentiometer to provide precise control of the current through R336. R330 and R333 provide adjustment for the voltage potential across R331. This allows R331 to be accurately calibrated for delay in terms of divisions of CRT display. When R331 is fully counterclockwise (minimum delay), the emitter of Q333 is at its most positive level and little or no current flows through R336. Therefore, there is no additional current at the base of Q346 which must be overcome to switch the comparator. However, in the fully clockwise position (maximum delay) about one milliamp of current flows through R336. This, in effect, adds an additional milliamp of current at the base of Q346 which must be overcome before the comparator can switch.

Quiescently, Q356 is on and controls the conduction of the comparator. The base of Q356 is held at about —3 volts as established by divider R352-R353 from —100 volts to ground. Therefore, the base of Q346 must rise more positive than about —3 volts before it can come on. When Q356 is on, the delayed sweep magnifier circuits are locked out. When Q346 turns on, the delayed sweep magnifier circuits are turned on also.

In addition to the quiescent currents flowing through R336, R337 and R349, the sawtooth voltage is connected to the base of Q346 through R309 and C309. This produces a current change between about zero and one milliamp at the base of Q346 as the sawtooth voltage rises. For minimum delay (zero current through R336) the two milliamp current flow through R349 and R337 holds the base level of Q346 very near its switching level. Then as the sawtooth starts to run up, only a slight level change at the base of Q346 turns it on. The delayed sweep magnifier circuits are turned on at the start of the sweep to magnify the total display. For maximum delay (maximum current through R336) the additional current from Q333 allows the base level of Q346 to go more negative. D349 clamps the base of Q346 at about —6 volts. Now, when the sawtooth starts to run up, it must offset this extra current supplied by Q333 before Q346 can switch. This will be near the positive peak of the sawtooth to turn on the delayed sweep magnifier circuits at the tenth division of display. Only the portion of the trace following the tenth division is magnified (the sweep length is increased several divisions for magnified operation; see the Sweep Generator discussion). Operation of the Delay Comparator for delay between these two extremes is much the same. A precise amount of current as determined by the DELAY control is added to the circuit by Q333. This determines the amount that the sawtooth must run up before the Delay Comparator is switched, thereby determining the point on the sweep where the magnifier is turned on.

In the External Mode of operation, —12.2 volts External Power is applied to the anode of D338 through D337. D338 is reverse biased and the DELAY control and Q333 are disconnected from the Delay Comparator stage. Then, an external program delay current can be supplied through terminal 17 of J30. The stage operates in a similar manner to that described for internal delay. However, since R336 and R337 are disconnected, the external program delay control sets the total quiescent current level in the circuit. Q343 provides 10 times current gain to provide more linear control of the external program delay.

For the 0.1 μs and 10 ns timing decades, the 0.1 μs (h) decade logic line is at —12 volts. This level is connected to the base of Q356 through D354 and R354 to hold Q356 reverse biased, and the magnifier circuit remains on to magnify the total sweep for the 0.1 μs timing decade. In the 10 ns timing decade, 10× gain of the 0.1 μs timing decade is provided by the Horizontal Amplifier. The Delay Comparator stage has no affect upon the turn-on point of the magnified circuits in these timing decades so the total sweep is magnified.

Timing Resistor

The multiplier logic applied to the Timing Resistor determines the sweep rate within the decade established by the Timing Capacitor. Resistor R381-R382-R383 form the "1" timing group, R384-R385-R386 form the "2" timing group and R387-R388-R389 form the "5" timing group. To select a timing group, either D317, D318 or D319 is allowed to conduct by reverse biasing the corresponding logic diode D391, D392 or D393 with the multiplier logic level. This level is —12-volts for the multiplier logic line to the timing group desired and zero volts for the other two logic lines. The timing current through the two timing groups not selected is shunted to the corresponding multiplier logic lines. For example, to select the "2" timing group, —12 volts is applied to the "2" logic line and zero volts to the "1" and "5" logic lines. The anode level of D317, D318 and D319 is at about —3.5 volts. Therefore, the zero-volt multiplier logic level applied to the "1" and "5" logic lines forward biases D391 and D393 to shunt the "1" and "5" timing current. The "2" logic reverse biases D392 and allows the "2" timing current to pass to the Timing Capacitor through D318. Further selection of the specific timing resistor within each timing group provides ×1, ×10 or ×100 sweep magnification. This is explained under ×10 and ×100 Magnifier Gates.

In the 10 ns decade, —12 volts 10 ns (i) decade logic is connected to the timing circuit through R390 and D390. This adds approximately 10% more current to the timing circuit for the 10 ns timing decade to improve timing accuracy.

For all sweep rates, the VARIABLE control, R397, adds additional resistance in series with the Timing Resistor when not in the CAL detent. This provides continuously variable, uncalibrated sweep rates between the 1-2-5 steps. Also note that this control is ganged with SW397 to turn on the UNCAL readout and turn off the s/DIV readout (see s/DIV and UNCAL Readout Control).

s/DIV and UNCAL Readout Control

SW397 is ganged with the VARIABLE control, R397. When the VARIABLE control is in the CAL detent, B999, s/DIV readout, is connected into the circuit. However, whenever the VARIABLE control is turned away from the CAL detent, SW397 turns off B999 and turns on B987, UNCAL readout, to indicate that the sweep rate is not calibrated. The current through B987 or B999 from the −12.2 volts supply provides current to the −6 volt line for the heater of V163. This current is provided in parallel with current supplied by the mode-indicating bulbs in the Operating Mode Power circuit.

×10 and ×100 Magnifier Gates

Q364 is the ×10 Magnifier Gate and Q324 is the ×100 Magnifier Gate. When both of these transistors are on, the sweep magnification is ×1. ×10 delayed sweep magnification is provided when Q364 is off and Q324 remains on. When both Q364 and Q324 are off, the delayed sweep magnification is ×100.

R381, R384 and R387 are the ×1 timing resistors. Only one of these resistors supplies timing current for ×1 sweep magnification as selected by the multiplier logic. For example, Fig. 3-14 shows the timing-current path for a sweep rate of one millisecond/division with ×1 sweep magnification. The 1 ms (d) decade logic actuates K310 and K313 to select the 1 ms decade. D392 and D393 are forward biased by the multiplier logic (approximately zero volts) applied to the "2" and "5" logic lines and the "2" and "5" timing currents are shunted. −12 volts on the "1" logic line reverse biases D391 and allows the "1" timing current to pass to the Timing Capacitor through D317. The ×10 Magnifier Gate is held on by the ×1 magnifier logic applied to the Delay Comparator (see Delay Comparator discussion). This places the collector of Q364 near zero volts and the ×10 timing current is shunted through D367, D366 and Q364. The ×100 Magnifier Gate is held on by the $\overline{\times 100}$ (bar ×100 magnifier) logic. The ×100 timing current is shunted through D327 and Q324. Therefore, only the timing current through R381 charges the Timing Capacitor.

For ×10 delayed sweep magnification, ×10 timing current through R382, R385 or R388 is added to the ×1 timing current. The Delay Comparator switches Q364 off at the sweep level selected by the DELAY control (note exception for 0.1 μs and 10 ns decades; see Delay Comparator discussion). When the comparator switches, the collector of Q356 goes positive. This decreases the current through tunnel diode D365 and it switches from its high-voltage state to its low-voltage state. D365 produces a fast voltage change at the base of Q364 to turn it off quickly. When Q364 turns off, its collector drops to about −12 volts and the ×10 shunt diodes D367-D368-D369 are reverse biased. ×10 timing current is added to the ×1 timing current in the timing group that is charging the Timing Capacitor (as determined by the multiplier logic). The timing current in the other two timing groups is shunted away from the timing capacitor. For example, Fig. 3-15 shows the timing current path for ×10 delayed sweep magnification at a magnified sweep rate of 0.1 millisecond/division. Note that the same Timing Capacitor is used as in the previous example for ×1 magnification. D391 is reverse biased by the multiplier logic applied to the "1"-logic line to allow timing current to charge the Timing Capacitor through D317. The total ×10 timing current is supplied through both R381 and R382. This total timing current is 10 times greater than the ×1 timing current to increase the sweep rate 10 times. The ×100 timing current is shunted by D327 since Q364 is held on by the $\overline{\times 100}$ magnifier logic level.

For ×100 delayed sweep magnification the ×10 Magnifier Gate still controls the starting point of the magnified sweep as described for ×10 operation. The ×100 timing current is a combination of the ×1, ×10 and ×100 timing current. R383, R386 and R389 are the ×100 timing resistors. The ×100 Magnifier Gate is controlled by several logic levels. For the 1 μs timing decade, the 1 μs (g) logic line is at −12 volts. Since its base is held negative, Q324 is conducting and the ×100 timing current is locked out through D327, D328 or D329. In the 0.1 μs and 10 ns timing decades, the 0.1 μs (h) logic line is at −12 volts and the ×100 timing current is similarly locked out. These logic levels prevent sweep rates faster than 10 microseconds/division from being magnified 100 times. In addition, the $\overline{\times 100}$ magnifier logic holds the ×100 Magnifier Gate on for ×1 and ×10 sweep magnification. However, for ×100 sweep magnification the $\overline{\times 100}$ magnifier logic is zero volts and Q324 is reverse biased. The collector of Q324 goes to about −12 volts and the ×100 shunt diodes, D327-D328-D329, are reverse biased. Since the ×10 Magnifier Gate still controls the turn-on point for the delayed sweep magnifier, the ×100 timing current is shunted along with the ×10 timing current. Then, as the ×10 Magnifier Gate is turned on, both the ×10 and ×100 timing current are added to the ×1 timing current to charge the Timing Capacitor. This produces a sweep rate 100 times faster than the basic ×1 sweep rate. Fig. 3-16 shows the timing current path for delayed sweep magnification at a magnified sweep rate of 10 microseconds/division with ×100 magnification. The total ×100 timing current is supplied through R381, R382 and R383. This total current is 100 times greater than the ×1 timing current to increase the sweep rate 100 times.

NOTE

Although the DLY'D SWP MAG switch can be set to ×100 for sweep rates of 1, 2 and 5 μs, only ×10 delayed sweep magnification is provided. Sweep rates between 10 ns and 0.5 μs cannot be magnified with the delayed sweep magnifier.

Delayed Sweep Magnifier Intensifier

Q374 provides an intensifying pulse to the grid circuit of the indicator oscilloscope CRT to compensate for the lower display intensity when the sweep is magnified (due to increased sweep rate.) For ×1 magnification, the $\overline{\times 1}$ magnifier logic level at the anode of D371 is zero volts. This clamps the base of Q374 so it can not go more negative than about zero volts. The $\overline{\times 100}$ magnifier logic level at the anode of D376 is −12 volts. D376 is reverse biased and

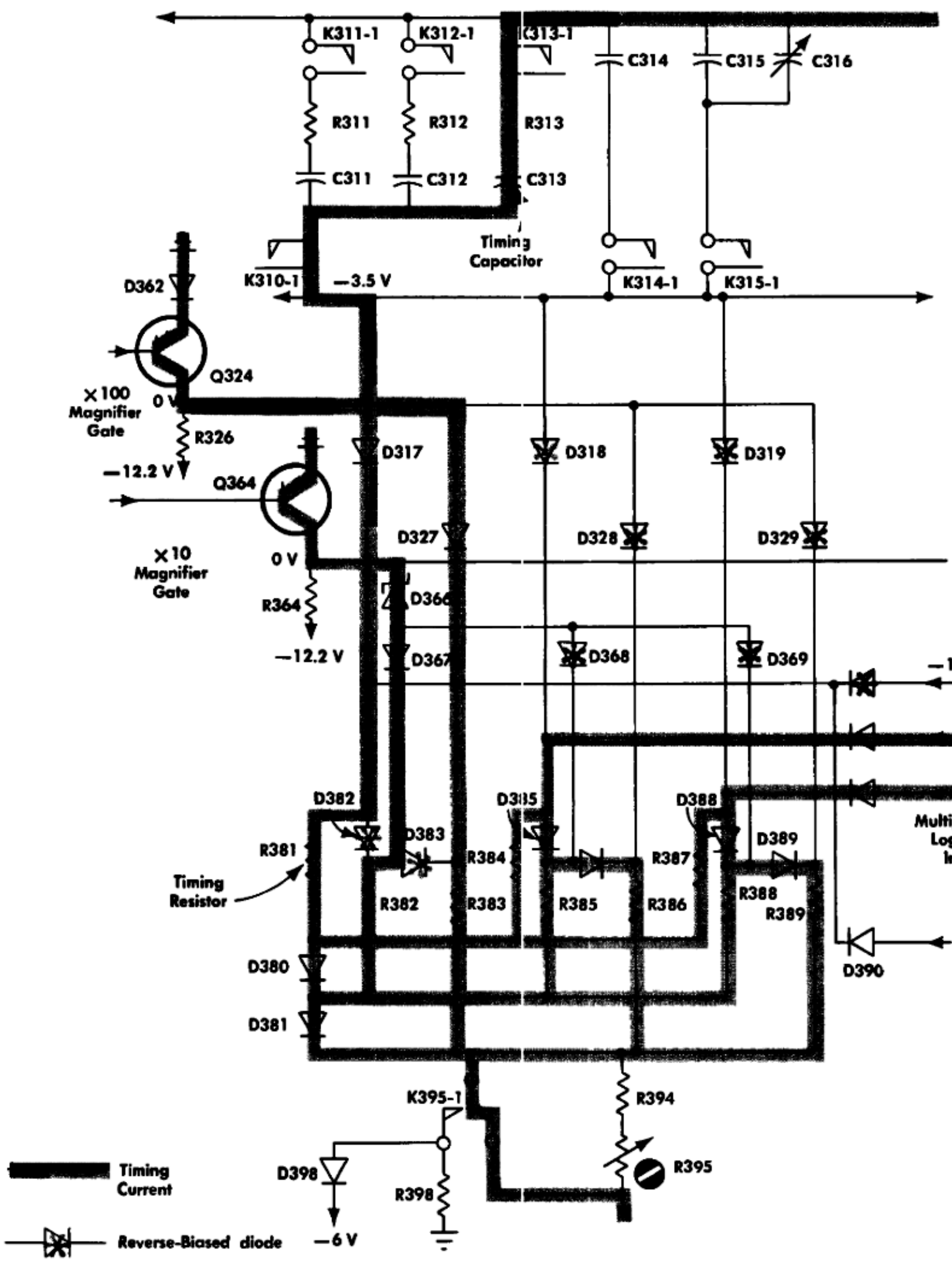

Fig. 3-14. Timing resistor for ×1 magnification (DLY'D SWP MAG switch at OFF). Sweep rate, 1 millisecond/division.

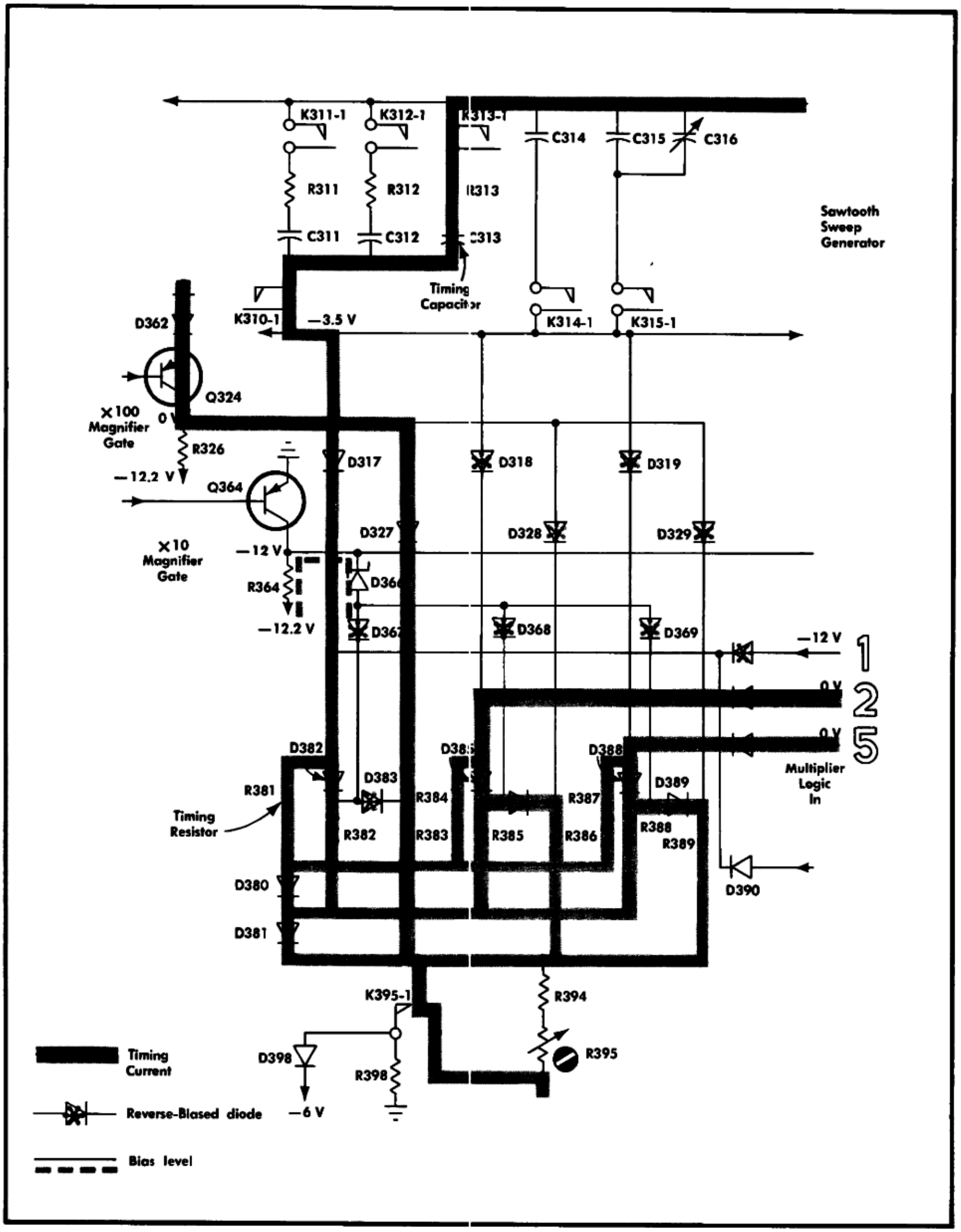

Fig. 3-15. Timing resistor for ×10 delayed sweep magnification. Magnified sweep rate, 0.1 millisecond/division.

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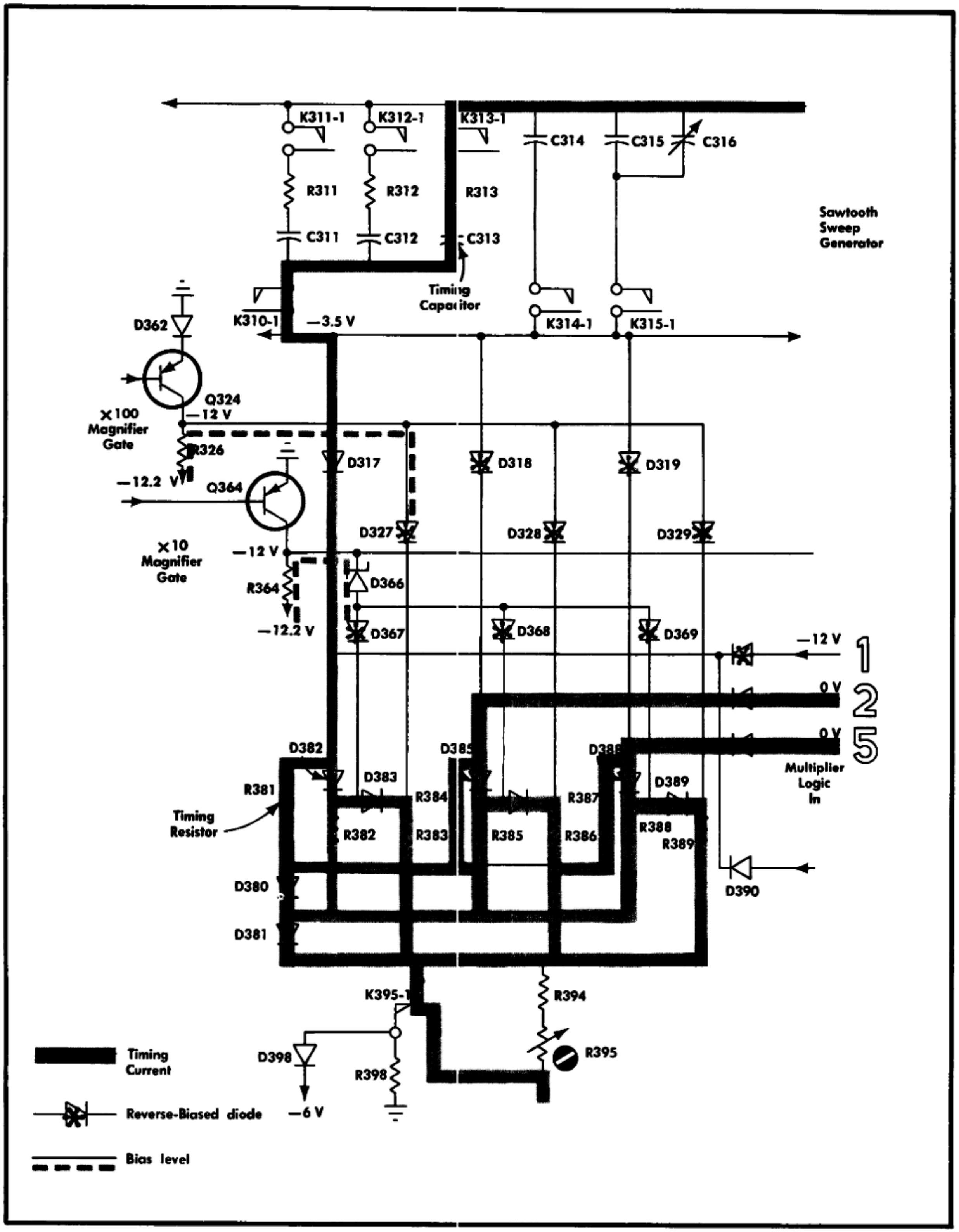


Fig. 3-16. Timing resistor for ×100 delayed sweep magnification. Magnified sweep rate, 10 microseconds/division.

zener diode D375 sets the level at the emitter of Q374 to —6 volts. Since its base is held near zero volts, Q374 is reverse biased. The collector of Q374 goes negative toward the —100-volt supply and is clamped near —12 volts by D374. This voltage level remains constant over the entire sweep for ×1 magnification. This level is coupled to the CRT grid circuit through terminal 14 of the interconnecting plug.

For ×10 delayed sweep magnification, the anode of D371 is held at —12 volts by the $\overline{\times 1}$ magnifier logic and it is reverse biased. The $\overline{\times 100}$ magnifier logic remains at —12 volts and D375 holds the emitter of Q374 at —6 volts. When the ×10 Magnifier Gate stage is turned off by the Delay Comparator, the negative voltage at its collector is connected to the base of Q374 through divider R371-R372-R373. Q374 is forward bisaed and its collector rises positive (less negative) to about —6 volts. This voltage level determines the display intensity for the magnified portion of the trace only.

Operation of the Delayed Sweep Magnifier Intensifier is basically the same for ×100 delayed sweep magnification as for ×10 except that the output is more positive to intensify the trace more. The $\overline{\times 100}$ magnifier logic level to the anode of D376 is zero volts for ×100 delayed sweep magnification. This sets the emitter level of Q374 near zero also. Now as the ×10 Magnifier Gate switches off, the collector of Q374 rises positive to about zero volts. The grid of the indicator oscilloscope CRT is raised more positive to provide a brighter intensity for the magnified portion of the trace only.

Delayed Sweep Magnifier Readout Control

The Delayed Sweep Magnifier Readout Control stage indicates when the basic sweep rate is magnified (except for basic sweep rates of 0.5 microsecond/division and faster). The ×1 magnifier logic level is connected to the base of Q344 through D345 and divider R345-R346-R347. For ×1 sweep magnification, the ×1 magnifier logic level is —12 volts and Q344 is reverse biased. Current does not flow through the readout bulbs. For ×10 and ×100 delayed sweep magnification, the ×1 magnifier logic level is zero volts. Q344 is turned on and its collector goes negative to about —12 volts. Current flows through B982 and B983, MAG'D SWP readout. In the 0.1 μs and 10 ns timing decades, the "h" decade logic line is at —12 volts. This level is connected to the base of Q344 through D344 and divider R346-R347. Q344 is again reverse biased and the indicator bulbs turn off. This logic level over-rides the ×1 magnifier logic level. Since the magnifier is used to provide the basic sweep rate when using the 0.1 μs (h) timing decade, the delayed sweep magnifier is not operable and the MAG'D SWP readout is locked out.

Horizontal Amplifier

General

The Horizontal Amplifier provides the output signal to the left and right deflection plates of the indicator oscilloscope

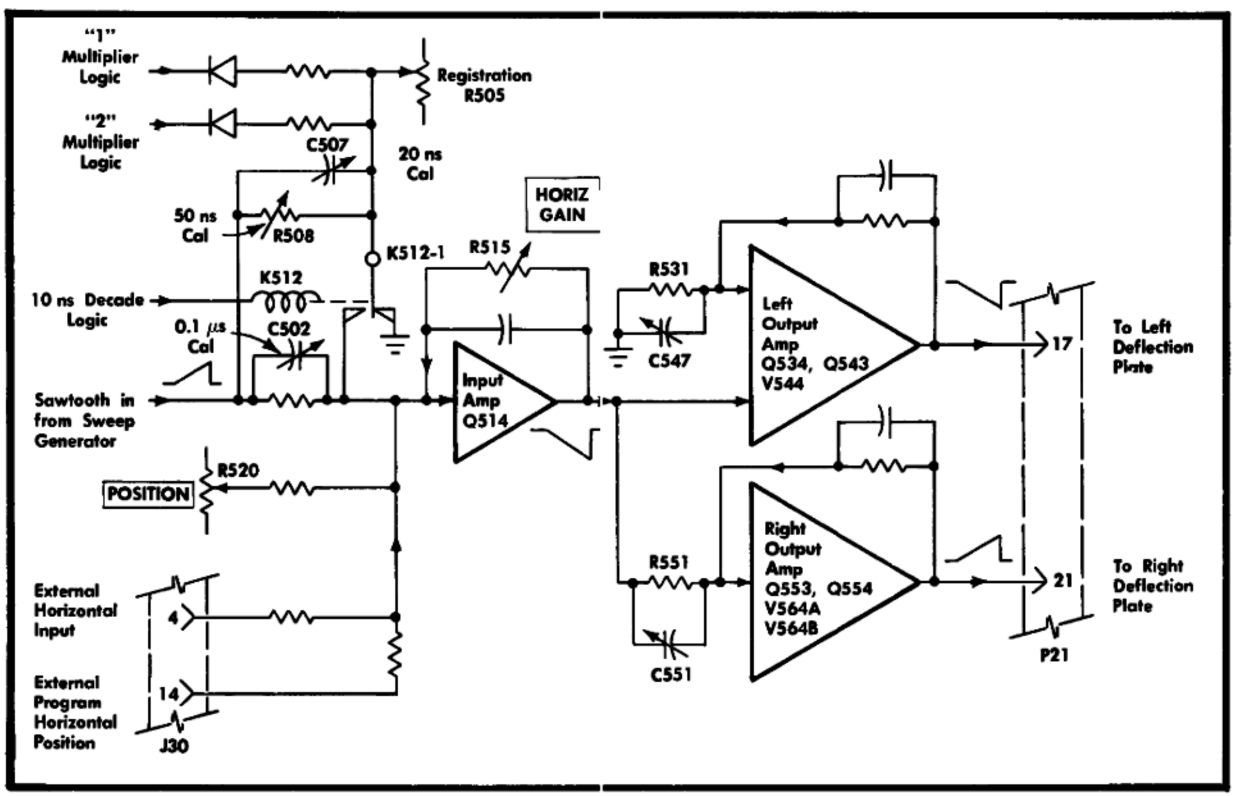


Fig. 3-17. Horizontal Amplifier logic block diagram.

CRT for horizontal deflection. This circuit contains the horizontal positioning network and an adjustment to calibrate the horizontal gain of this unit to the deflection sensitivity of the indicator oscilloscope. An external horizontal deflection signal can be applied to the circuit through terminal 4 of J30 and an external horizontal position level through terminal 14 of J30. A ×10 gain network is connected to the base circuit of the Input Amplifier to provide the correct sweep rate for the 10 ns timing decade (i). Fig. 3-17 shows a logic block diagram of the Horizontal Amplifier. A diagram of this ciruit is shown on diagram 4 at the rear of this manual.

Input Amplifier

The Input Amplifier, Q514, is a feedback (operational) amplifier to provide stable gain and low input impedance. The HORIZ GAIN adjustment, R515, in the feedback loop controls the amount of feedback from the collector to the base, thereby setting the overall gain of the stage. The input impedance of the Input Amplifier is low and it is a current-driven amplifier. For normal operation, the base of Q514 is driven from three current sources: 1) The sawtooth voltage applied through R501-R502-C502 produces a corresponding sawtooth current at the base of Q514; 2) A quiescent bias current is applied to the base of Q514 through R523 and R529; 3) The horizontal POSITION control adds or removes current at the base of Q514.

For the 10 ns timing decade, 10 ns (i) decade logic energizes K512. K512-1 connects the network C507-R507-R508-R509 in parallel with C502-R502 to provide 10 times more sawtooth current to Q514. This produces an output sawtooth which rises 10 times faster to provide the desired 10 times gain increase for the 10 ns timing decade. R505 adds a positioning current to the base circuit for registration in the 10 ns timing decade. This added current allows the trace to start at the same point on the graticule when switching from 0.1 microseconds/division to 50 nanoseconds/division. For the 10 nanosecond and 20 nanosecond sweep rates, an additional positioning current is added by the —12-volt level on either the "1" or "2" logic line.

The Horizontal Amplifier may be used to provide horizontal deflection from sources other than the internal sweep generator by applying the horizontal deflection signal to terminal 4 of J30. The Sweep Generator must be disabled by applying a lockout signal through terminal 7 of J30. An unblanking voltage is also necessary at terminal 13 of J30. See External Horizontal Deflection in Section 2 for complete operating information.

For External Mode operation, the horizontal position of the display can be externally controlled through terminal 14 of J30. In this mode, —12.2 volts External Power is applied to the anode of D526 to reverse-bias it. Then, the current through R528, which normally flows through D526 and R525, is connected through D528 and R523 to establish a negative bias level at the base of Q514. By adding current through terminal 14, the desired external program horizontal position can be established. Notice that the front-panel POSITION control is not disconnected for External Mode operation. The external program position level operates as a vernier for the front-panel POSITION control.

Left Output Amplifier

Q534, Q543 and V544 are connected as a feedback amplifier for gain stabilization and linear output to the CRT deflection plates. The output signal at the plate of V544 is in phase with the negative-going signal applied to the base of Q534. Negative feedback is provided from the plate of V544 to the emitter of Q534 through R546 and C546. Diodes D531 and D532 connected between the emitter and collector of Q534 protect this transistor from excess input voltage. In addition, they improve the recovery time of Q534 when driven by a large signal, particularly for magnified operation at fast sweep rates. The negative-going deflection signal at the plate of V544 is connected to the left CRT deflection plate through terminal 17 of P21.

Right Output Amplifier

The Right Output Amplifier is basically the same as the Left Output Amplifier except that it produces an output signal 180° out of phase with the input signal. The negative-going signal at the collector of Q514 is connected to the base of Q553 through the compensated voltage divider C551-R551-R552. C551 provides high-frequency compensation for the Horizontal Amplifier. Q553, Q554, V564A and V564B are connected as a feedback amplifier. Negative feedback is provided from the cathode of V564B to the base of Q553 through R567 and C567. The input signal is inverted through Q553-Q554 but is not inverted through the remainder of the circuit to produce a positive-going output signal. This positive-going deflection signal is connected to the right CRT deflection plate through terminal 21 of P21

Readout Logic

General

The Readout Logic circuit determines the decade and multiplier readout on the front panel of the unit. For manual operation, the MANUAL TIME/DIV and DLY'D SWP MAG switches determine the logic to control the readout panel. For Seek or External Mode operation, the readout is controlled by the decade, multiplier and magnifier logic applied from the Counter Circuit and the Delayed Sweep Magnifier Control circuit. The decade logic and multiplier logic is distributed from this circuit to the Sweep Generator, Delay and Timing Circuit and the Horizontal Amplifier circuits. Fig. 3-18 shows a logic block diagram of the Readout Logic circuit. A diagram of this circuit is shown on diagram 5 at the rear of this manual.

Multiplier and Decade Readout

The Multiplier and Decade Readout stages provide the front-panel readout of the sweep rate. These stages are controlled by the Manual Readout Decoding stage for Manual Mode operation or the decade and multiplier logic from the Counter Circuit for Seek and External Mode Operation.

Manual Readout Decoding

The MANUAL TIME/DIV switch, SW450, and the DLY'D SWP MAG switch, SW940, determine the readout panel

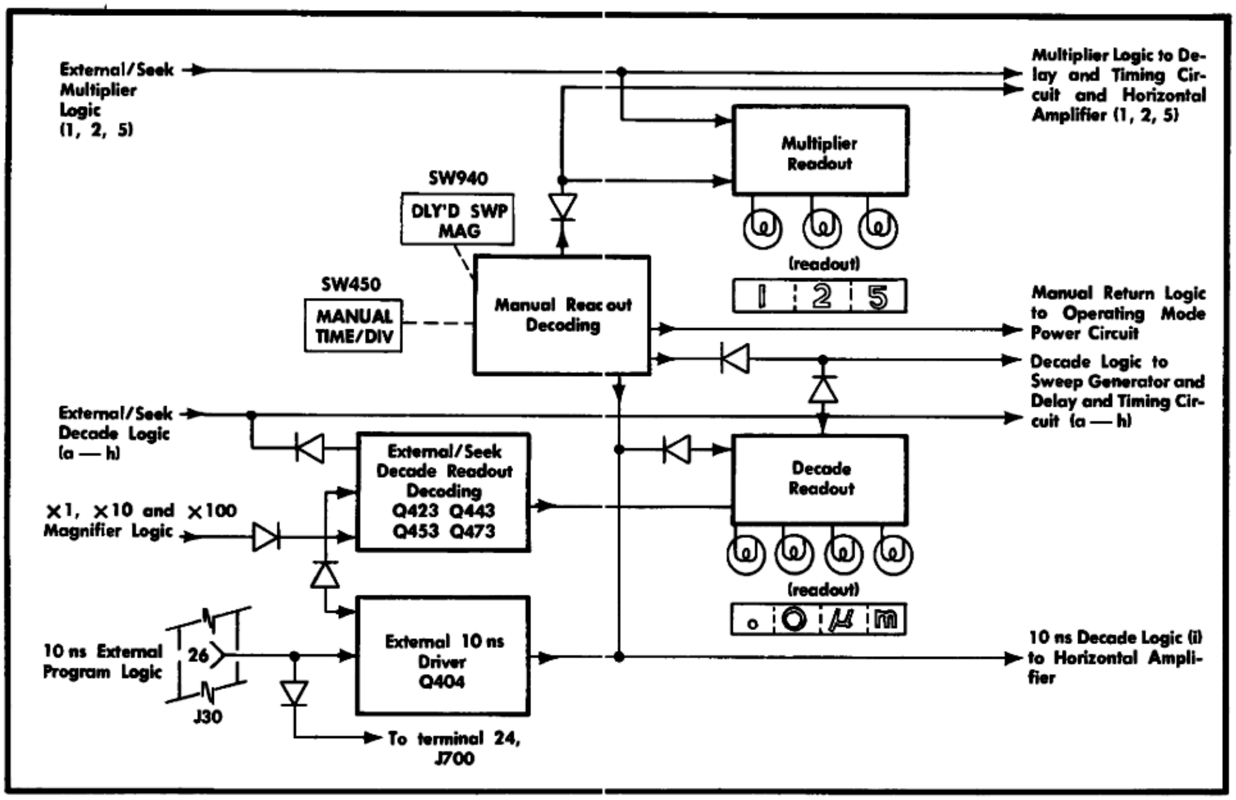


Fig. 3-18. Readout Logic block diagram.

indications for Manual Mode operation. The wiper contacts of these switches are connected to Manual Power through diodes. In the Manual Mode of operation, —12.2 volts Manual Power is applied and the diodes are forward biased. For Seek or External Mode operation, Manual Power is disconnected from the diodes and the setting of these switches does not affect operation of this circuit. Wafer 3F of SW450 determines the Manual Mode multiplier logic to the 1, 2, 5 readout bulbs. This logic is —12 volts for the desired multiplier. The Manual Mode multiplier logic sequence is 5-2-1 throughout the rotation of the switch. This wafer also provides the Manual Mode multiplier logic to the Sweep Generator and the Delay and Timing Circuit.

Wafer 3R of SW450 provides the Manual Mode decade logic to the Sweep Generator and the Delay and Timing Circuit. A —12 volt level is connected to one of the 1 s - 0.1 μs (a-h) decade logic lines to select the timing decade. In the last three clockwise positions (10, 20 and 50 ns), D404 applies —12 volts to the 0.1 μs (h) logic line to hold this decade on. The 10 ns (i) logic level established in these positions turns on the "0", "m", "μ" readout through diodes D485, D486 and D487. The 10 ns logic is also connected to the Horizontal Amplifier circuit.

Wafers 1R, 2F and 2R provide the decade readout for the Manual Mode. Only one of these wafers is returned to —12.2 volts Manual Power through the DLY'D SWP MAG switch, SW940. These two switches in combination provide Manual Mode magnifier decoding. For example, when the MANUAL TIME/DIV switch is in the 5 s position and the DLY'D SWP MAG switch is set to ×1, there is no output from the decade readout. The 5 and s/DIV readouts are on as controlled by other circuits previously discussed. For ×10 delayed sweep magnification, the DLY'D SWP MAG switch applies —12 volts to wafer 2F. This logic level turns on the "." readout to indicate a magnified sweep rate of 0.5 seconds/division. In the ×100 position of SW940, Manual Power is applied to wafer 2R. The "0" and "m" readouts are turned on through diodes D491 and D492 to indicate a magnified sweep rate of 50 milliseconds/division.

Wafer 1F provides manual-return logic to the Operating Mode Power circuit. As the MANUAL TIME/DIV switch position is changed, this wafer opens the ground return to the Seek Mode Control stage and the unit returns to Manual Mode operation (see Operating Mode Power for more information).

External/Seek Decade Readout Decoding

Decade logic from the Counter Circuit and ×1, ×10 and ×100 magnifier logic from the Delayed Sweep Magnifier Control circuit are applied to the External/Seek Decade Readout Decoding stage to determine the decade readout in the Seek and External Modes of operation. The decade logic level applied is —12 volts for the decade logic line that is on and zero volts for the remaining lines. Magnifier Logic Level is —12 volts[3] for the delayed sweep magnifica-

[3]The magnifier logic level may be as low as —5.5 volts or, on the ×100 logic line (×100 magnifier logic) it may drop to zero under certain conditions; see Delayed Sweep Magnifier Control circuit discussion for explanation. However, these differing levels do not affect operation.

tion desired and zero volts for the other two lines. These logic levels are connected through the diode matrix to control the readout driver transistors, Q423-Q443-Q453-Q473. These transistors in turn control the ".", (Q423), "0" (Q443), "m" (Q453) and "μ" (Q473) readouts on the front panel.

Figs. 3-19, 3-20 and 3-21 show current flow and diode conditions in the diode matrix and driver transistors to illustrate the operation of this circuit. For convenience in explaining this circuit, only part of the diagram is reproduced in these figures. Also, conditions are explained with only one basic sweep decade (one millisecond decade) with the changes in circuit conditions shown for ×1, ×10 and ×100 delayed sweep magnification of this basic sweep rate. Condition of components not essential to this explanation is omitted.

Fig. 3-19 shows circuit conditions for ×1 sweep magnification at sweep rates of 1, 2 and 5 milliseconds/division. The 1 ms (d) decade logic line is at —12 volts and the remaining decade logic lines are at zero volts. The ×1 logic line is at about —7 volts and the ×10 and ×100 magnifier logic lines are at zero volts. The decade logic level to the "." readout driver, Q423, is shunted by the zero volt ×10 magnifier logic at the anode of D421. D422 is reverse biased and the "." readout remains off. The decade logic level connected to the "0" readout driver, Q443, is shunted by the zero-volt ×100 magnifier logic at the anode of D431. D432 is reverse biased and the "0" readout remains off. The decade logic level connected to the base circuit of the "μ" readout driver, Q473, is shunted by the zero-volt ×100 magnifier logic at the anode of D471 and the "μ" readout remains off. The decade logic is also connected to the base circuit of the "m" readout driver through both R463 and R466. The current through R463 is shunted by the ×10 magnifier logic through D463. However, the decade logic is applied to the base of Q453 through D467 because the —7 volts ×1 magnifier logic reverse biases shunt diode D466. The base of Q453 drops to about —6 volts and it is forward biased. Current passes through B997 and the "m" readout comes on. This logic combination provides a readout of ____ms/DIV, with the multiplier provided by the Multiplier Readout stage.

Circuit conditions for ×10 delayed sweep magnification of the same basic sweep rate described above are shown in Fig. 3-20. The 1 ms decade logic is still —12 volts. However, the ×10 magnifier logic line is at —12 volts and the ×1 and ×100 lines are at zero volts. The decade logic applied to the base circuit of the "." readout driver is allowed to pass to the base of Q423 because the shunt diode D421 is held reverse biased by the —12-volt ×10 magnifier logic level. Current passes through B991 and the "." readout comes on. The decade logic to the "0" readout driver, Q443, is shunted by D431. Decade logic to the "m" readout driver, Q453, biases this transistor on since the shunt diode D463 is reverse biased by the —12-volt ×10 magnifier logic level. Current through the parallel path to Q453 is shunted through D466 to the ×1 magnifier logic line. The "μ" readout driver, Q473, remains off because the decade logic current is shunted by D471. This logic combination provides a readout of .____ms/DIV, with the multiplier provided by the Multiplier Readout stage.

×100 delayed sweep magnification of the basic 1, 2 or 5 millisecond sweep rate is shown in Fig. 3-21. Decade logic to the 1 ms logic line remains at —12 volts. Magnifier logic to the ×100 magnifier logic line is now —12 volts and zero volts to the ×1 and ×10 lines. Decade logic to the base of Q423 is shunted to the ×10 magnifier logic line by D421. The —12 volt level on the anode of D431 holds it reverse biased and allows the decade logic level to turn Q443 on. Current flows through B995 and the "0" readout comes on. Decade logic to the "m" readout driver is shunted because the ×1 magnifier logic level forward biases D466 and the ×10 magnifier logic level forward biases D463. D471 is held reverse biased by the —12-volt ×100 magnifier logic and the decade logic biases Q473 on. Current flows through B998 and the "μ" readout comes on. This logic combination provides a readout of ____0 μs/DIV, with the multiplier provided by the Multiplier Readout stage.

"1" multiplier and 0.1 μs decade (h) logic levels are connected to the Seek Circuit to lock out the Seek circuit when the 0.1 microsecond sweep rate is reached (see Advance Gate discussion). In the Seek Mode of operation, the 0.1 microsecond position is the only sweep rate when both of these logic levels are —12 volts.

External 10 Nanosecond Driver

To select the 10 ns decade (i) for External Mode operation, zero-volts external program logic is applied to terminal 26 of J30. The base of Q404 rises positive enough to bias it on and its collector goes negative to about —12 volts. This places —12 volts on the 10 ns decade logic line and the "0", "m", "μ" readouts are turned on through diodes D485, D486 and D487. D403 couples the 10 ns external program logic to pin 24 of J700 to turn on the 0.1 μs timing decade (h) to provide the correct sweep rate. The 10 ns logic level is also connected to the Horizontal Amplifier circuit.

In addition to turning on Q404 and the 0.1 μs timing decade, the 10 ns external program logic at terminal 26 of J30 locks out the "." readout driver, Q423, through D447 and the "μ" readout driver, Q473, through D470 to prevent parallel currents to the readout bulbs.

Seek Circuit

General

The Seek Circuit initiates the automatic time-base and trigger seeking functions of the Type 3B5 upon receipt of a seek command. This circuit provides reset and advance pulses to the Counter Circuit to automatically select sweep rate and, in conjunction with the Trigger Circuit, select auto triggering if the front-panel Trigger controls are incorrectly set or a trigger signal is not applied. Fig. 3-22 shows a logic block diagram of the Seek Circuit. A diagram of this circuit is shown on diagram 6 at the rear of this manual. Fig. 3-23 shows operating waveforms from the Seek Circuit to aid in this explanation.

Seek Input Circuit

The seek command to actuate this circuit can come from one of three sources: 1) front-panel SEEK button, SW604; 2) remote seek through terminal 12 of the front-panel PROGRAM connector, J30; 3) remote seek through the amplifier unit from a remote-seeking probe or the amplifier unit program connector. The remote seek command from the amplifier

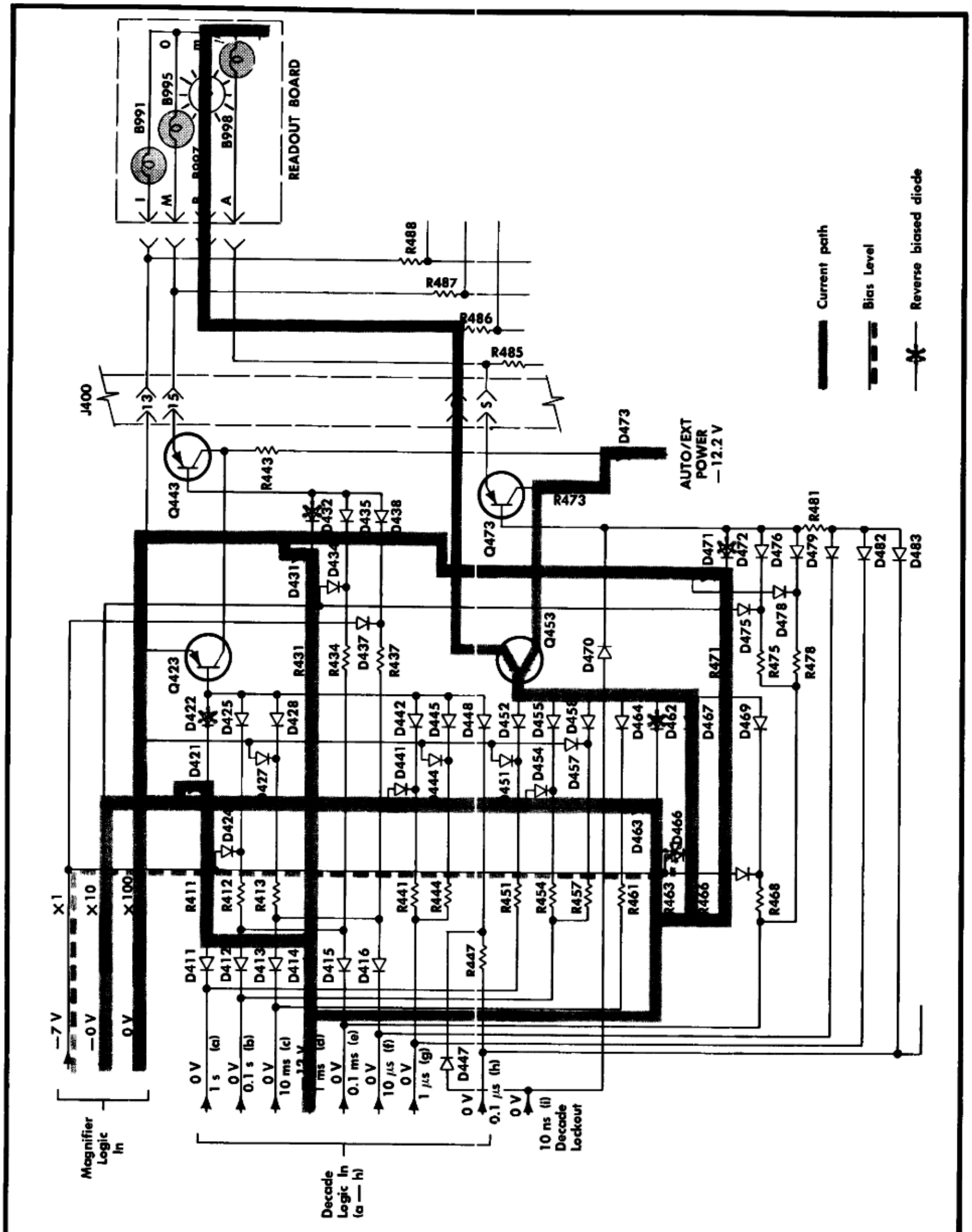


Fig. 3-19. Decade readout current for 1, 2 and 5 millisecond sweep rates (×1 sweep magnification).

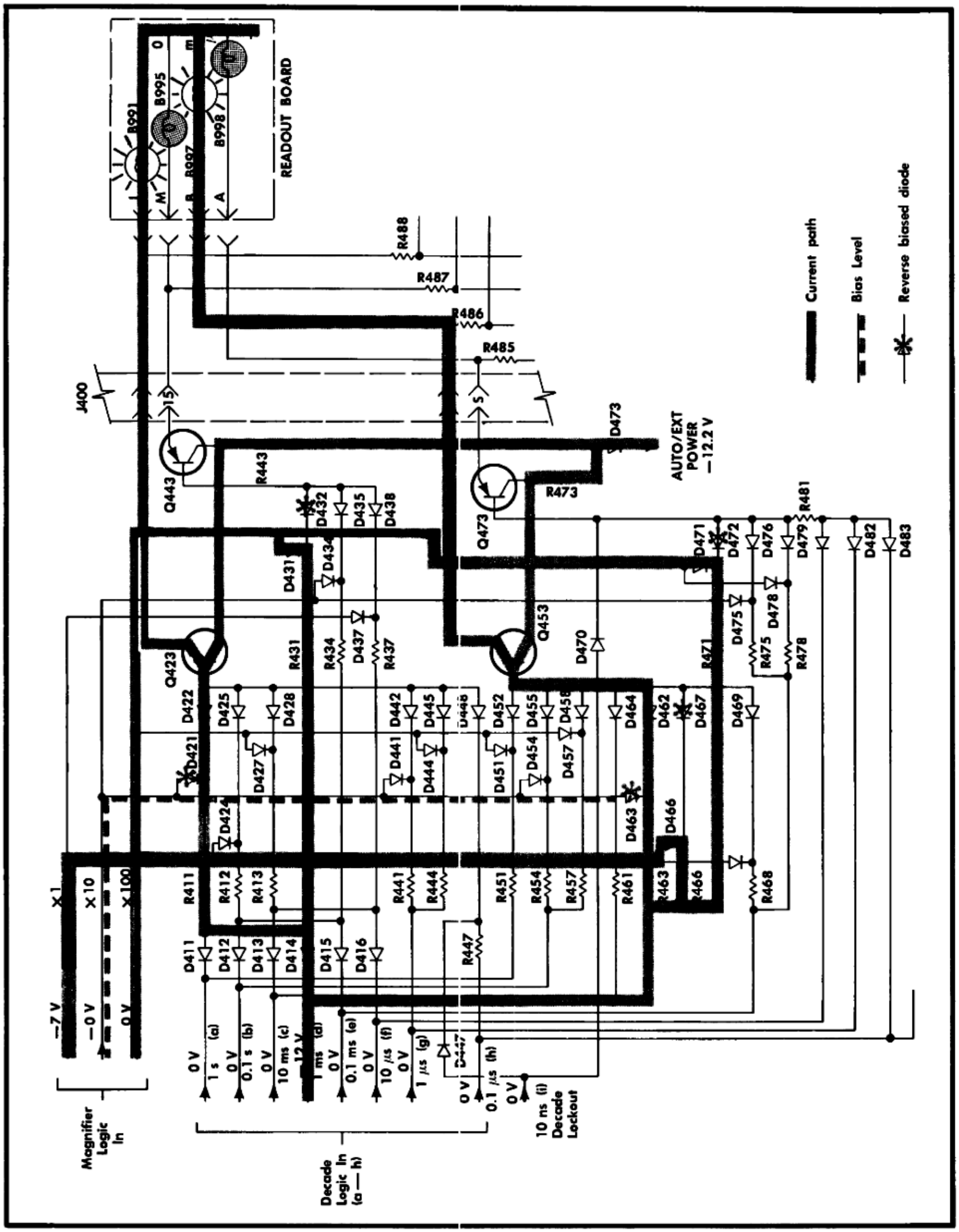


Fig. 3-20. Decade readout current for 0.1, 0.2 and 0.5 millisecond magnified sweep rates (×10 delayed sweep magnification).

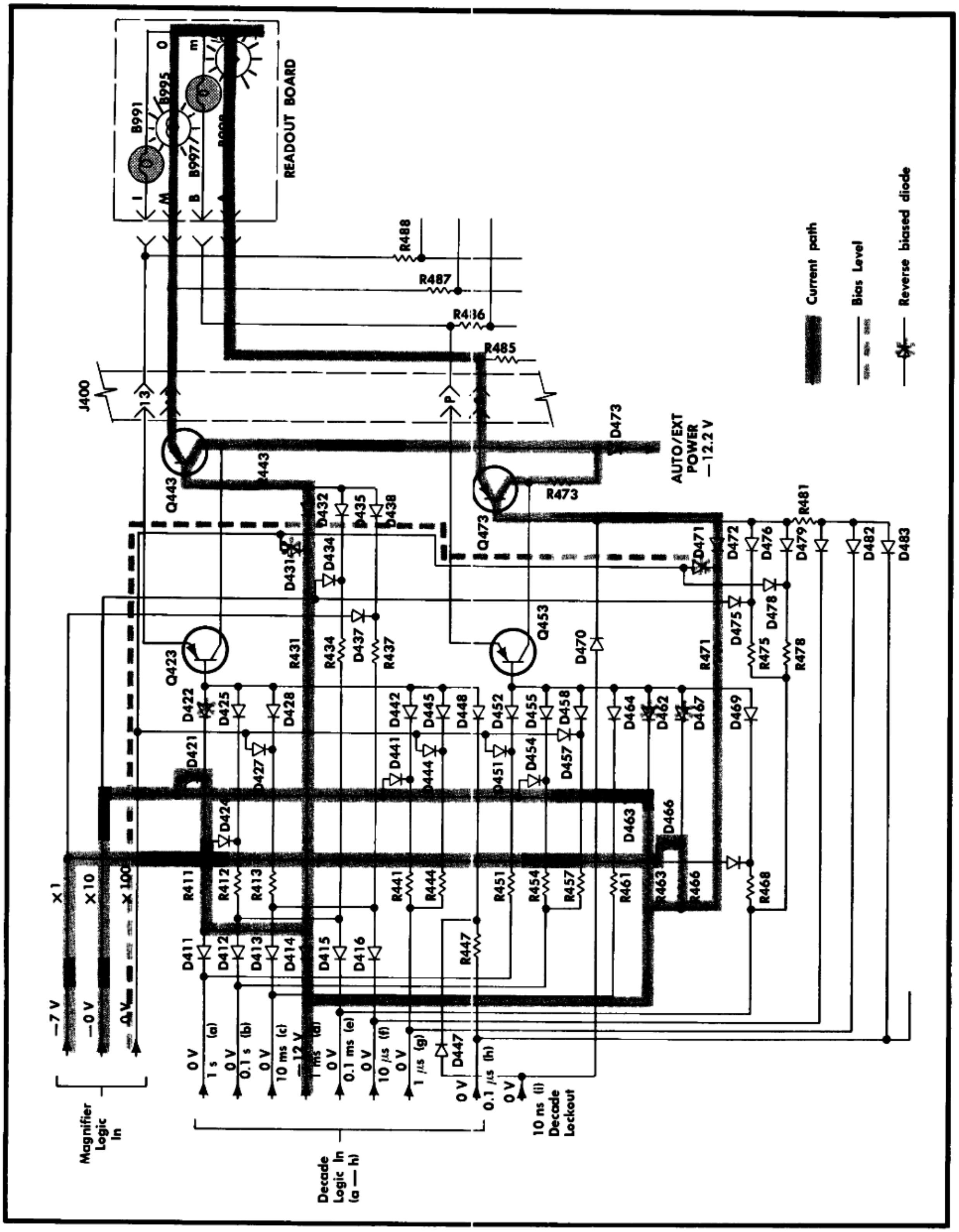


Fig. 3-21. Decade readout current for 10, 20 and 50 microsecond magnified sweep rates (×100 delayed sweep magnification).

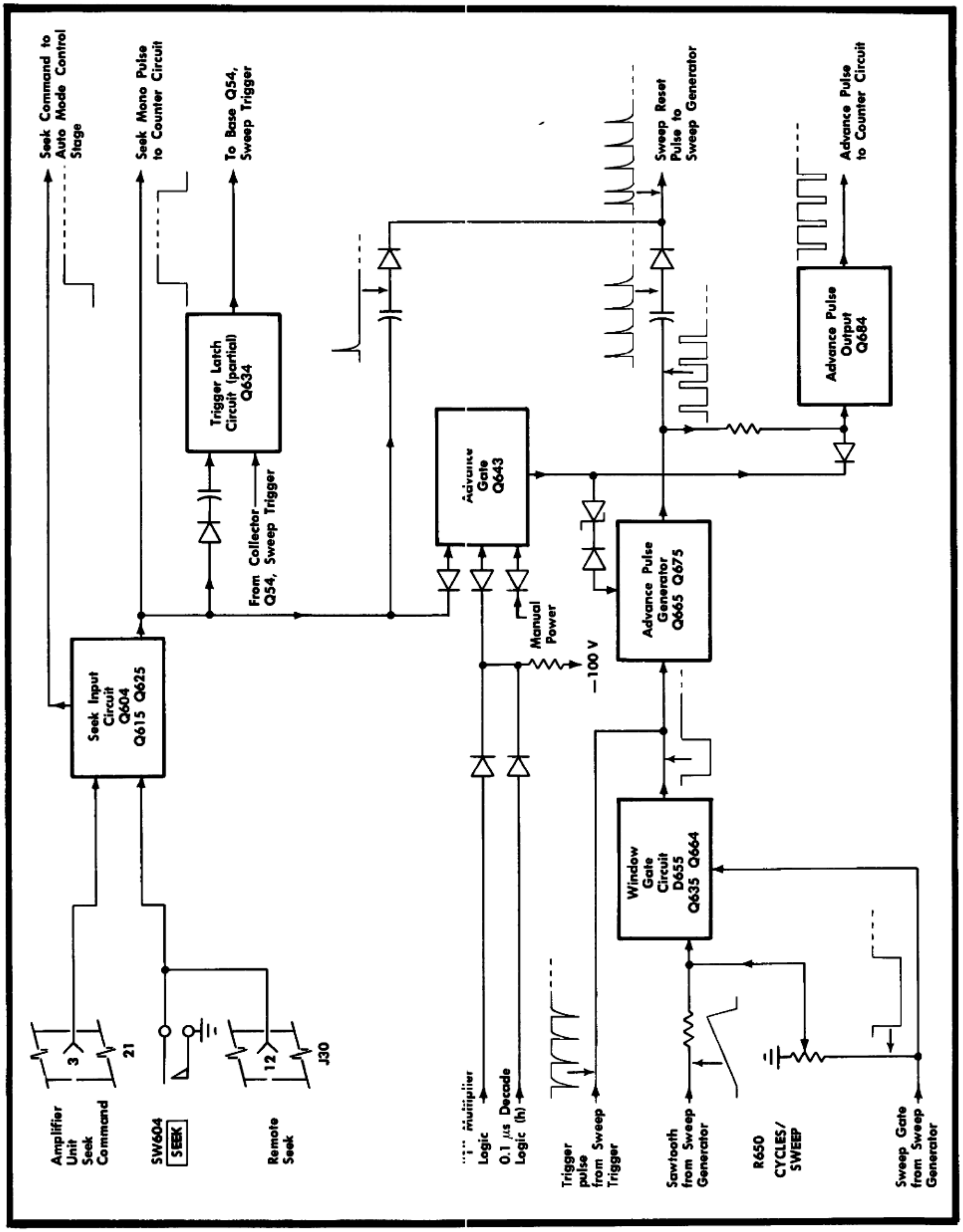
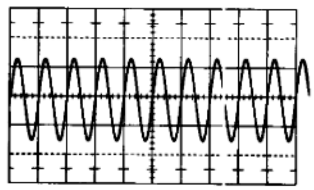
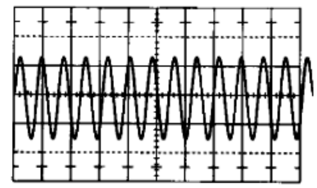
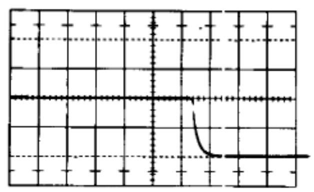
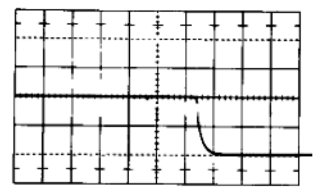
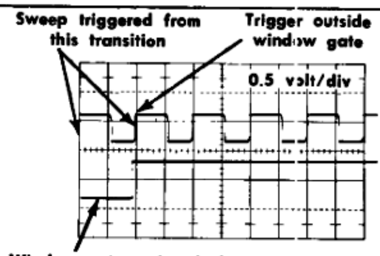
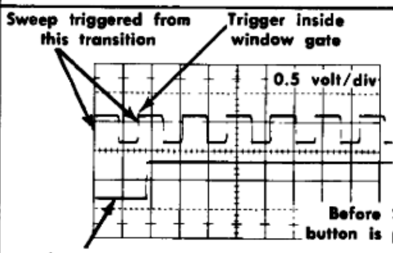
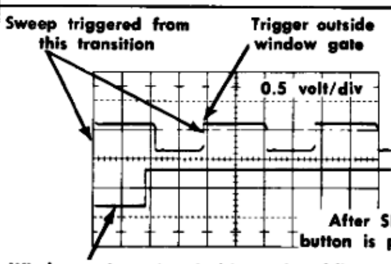
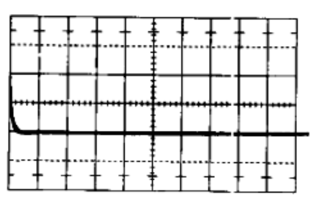
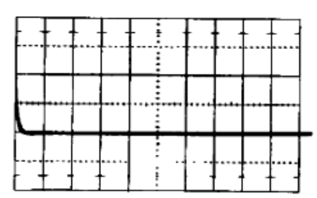
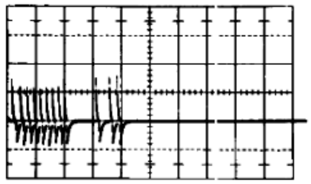
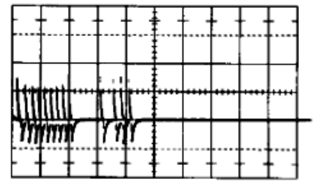
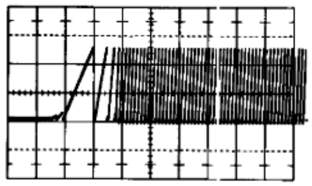
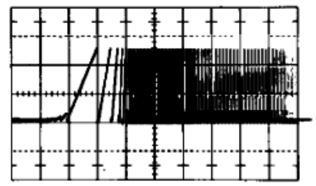
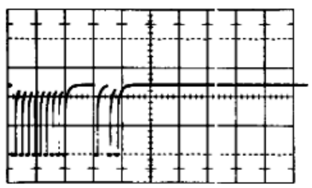
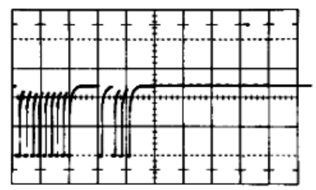
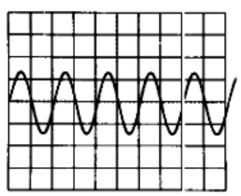
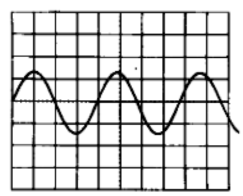


Fig. 3-22. Seek Circuit Logic block diagram

SEEK CIRCUIT OPERATION

Waveform Source	1 kHz sine-wave signal applied, 3B5 seeks to 0.5 ms/DIV (CYCLES/SWEEP adjustment set according to Calibration procedure).	1.3 kHz sine-wave signal applied, 3B5 seeks to 0.2 ms/DIV (CYCLES/SWEEP adjustment set according to Calibration procedure).
Input Signal.	 2 volts/div, 1 ms/div	 2 volts/div, 1 ms/div
Seek mono pulse at pin 8 of J400.	 5 volts/div, 0.2 s/div	 5 volts/div, 0.2 s/div
Trigger pulse (at junction of D105 and D115) and window-gate (at TP664) coincidence shown on dual-trace display.	 2 volts/div, 0.5 ms/div	 2 volts/div, 0.5 ms/div
		 2 volts/div, 0.2 ms/div
Sweep reset pulse at anode of D629.	 5 volts/div, 50 ms/div	 5 volts/div, 50 ms/div

Ⓐ

Seek Circuit Operation (cont)		
Sweep reset pulse at anode of D681[1].	 5 volts/div, 50 ms/div	 5 volts/div, 50 ms/div
Sawtooth sweep signal at TP500[1].	 20 volts/div, 50 ms/div	 20 volts/div, 50 ms/div
Advance pulses at pin 11 of J400[1].	 5 volts/div, 50 ms/div	 5 volts/div, 50 ms/div
Resultant CRT display.	 2 volts/div, 0.5 ms/div	 2 volts/div, 0.2 ms/div

[1]Repetition rate of these waveforms is a function of sweep range, CYCLES/SWEEP adjustment and holdoff time.

Fig. 3-23. Seek Circuit waveforms showing circuit operation when SEEK button is pressed. External triggering was used to indicate overall time relationship.

unit is connected to this unit through terminal 3 of the interconnecting plug and the interconnecting cables in the indicator oscilloscope. The network D601-D602-R601-R602-R603-C602-C603-C604 eliminates all signals at the base of Q604 except the seek command to prevent a false seek command to the Seek Circuit. A remote seek command from the amplifier unit turns on Q604 and its collector rises positive to about zero volts. Likewise, the front-panel seek command or the remote seek command through J30 raises the circuit potential to zero volts. The seek command may either be momentary or it may be a continuous seek command. The seek command is connected to the base of Q615 to produce the seek mono pulse and to the Operating Mode Power circuit through D605 (see Seek Mode Control discussion) to switch the instrument to the Seek Mode of operation.

Q615 and Q625 are connected as an AC-coupled multivibrator. Quiescently, Q615 is held on by the negative potential at its base established by the —12.2 volt level at the collector of Q604 (no seek command applied). The base of Q625 is clamped at about +0.5 volts by D619 and Q625 is held off. When a seek command is received, the base of Q615 rises positive and it turns off. Its collector goes negative toward —100 volts and is clamped when it reaches about —12 volts by D614. C616 begins to charge and this charge current flows through R616 to pull the base of Q625 negative and turn it on. The collector of Q625 rises positive to produce the seek mono pulse. This pulse is connected to the Counter Circuit, Trigger Latch Circuit and the Advance Gate stage. It also provides a sweep reset pulse to the Sweep Generator circuit through C629 and D629.

The circuit remains in this condition until C616 is fully charged. Then, the current through R616 returns to its quiescent level and Q625 is turned off again. Its collector goes negative to about —8 volts to end the seek mono pulse. This negative change is coupled back to the base of Q615 through R626-R627-C627. If the seek command has ended, this feedback has no effect on circuit operation. However, if a seek command still holds the base of Q615 near zero volts, this feedback pulls the base of Q615 negative enough to turn it on again and produce another seek mono pulse. As long as a seek command is applied, Q615 and Q625 act as a free-running multivibrator.

Trigger Latch Circuit

Q634 operates in conjunction with Q54 in the Trigger Circuit to provide auto triggering if the front-panel controls are incorrectly set or a trigger signal is not applied (Seek Mode operation only). Full operation of this circuit is explained under Trigger Latch Circuit in the Sweep Trigger discussion

Advance Gate

The Advance Gate stage produces an output level which either locks out or enables the Advance Pulse Generator and the Advance Pulse Output stage. For Manual Mode operation, the Advance Gate output level is held at —12 volts by Manual Power applied to the base of Q643 through D644. This holds both Q665 and Q684 reverse biased to lock out any advance pulses. In the Seek Mode of operation, the output level from the Advance Gate depends upon the input levels. D640 and D641 comprise an "and" gate for the "1" multiplier and 0.1 μs decade (h) logic levels. When both of these logic levels are —12 volts, the base of the Advance Gate stage goes negative and succeeding advance pulses are locked out. This condition is met only in the 0.1 microsecond sweep rate when the "1" logic connected to D640 and the 0.1 μs logic connected to D641 are both at —12 volts. Current then flows through R641, D642 and R643 and the base of Q643 goes negative. This lock-out action prevents the Counter Circuit from returning to the 5 s sweep rate on fast signals.

When a seek mono pulse is received at the base of Q643, its emitter rises positive to about zero volts. The duration of the output pulse at the collector is the same as the duration of the seek mono pulse at the base unless the 0.1 microsecond sweep rate is reached. This positive output level enables the Advance Pulse Generator and the Advance Pulse Output stages to allow advance and sweep reset pulses to be produced.

Window Gate and Advance Pulse Generator

The Window Gate circuit turns on the Advance Pulse Generator circuit to produce advance pulses for the Counter Circuit. When an Advance Gate enable pulse is applied to the emitter of Q665 through D666 and D665 (only in Seek Mode with seek command applied), its emitter level rises to about —2.5 volts as set by D668 and zener diode D669. Therefore, the base of Q665 must go below about —3.0 volts before Q665 can be biased on. Trigger pulses from the Seek Circuit Driver stage in the Sweep Trigger circuit are connected to the base of Q665 through T660 and D661. However, these negative-going trigger pulses are only about 1.5 volts in amplitude so they do not turn Q665 on. An additional negative level must be provided by the collector level of Q664 to turn Q665 on. The time duration of this negative window-gate signal from Q664 is controlled by the CYCLES/SWEEP adjustment, R650, to determine the number of cycles in the CRT display.

Circuit operation is as follows: the sawtooth produced by the Sweep Generator circuit is connected to the base of Q653 through R186. The bias level of Q653 is set by the sweep gate connected to the base through R650 and R651 (only during a sweep). This bias level can be adjusted by the CYCLES/SWEEP adjustment, R650; the setting of R650 determines the amount that the sawtooth must run up before it turns Q653 on. At the start of the sweep, both Q653 and Q664 are biased off. The sweep gate signal also provides the collector supply for Q664. Since Q664 is biased off at the start of the sweep, its collector goes negative toward —6 volts and is clamped at about —2.5 volts by divider R657-R658 and D657. This collector level allows the trigger pulses to turn on Q665. However, when the sawtooth overcomes the bias level at the base of Q653 as set by R650, Q653 turns on and its collector goes negative. D655 switches to its high-voltage state and Q664 turns on very rapidly. The collector of Q664 rises to about zero volts to end the window-gate signal. This locks out any further trigger pulses at the base of Q665.

At the start of each seek cycle, the sweep rate is reset to 5 seconds/division by the seek mono pulse to the Counter Circuit and the sweep is reset to the left side of the graticule by the sweep reset pulse produced by the Advance Pulse Generator stage. The sawtooth at the base of Q653 starts to run up at this sweep rate. The Advance Pulse Generator is not turned on by the trigger pulse which starts the sweep, due to normal delay time designed into this circuit. However, if the next trigger pulse is applied to Q665 before the sawtooth turns the Window Gate circuit on (i.e., collector of Q664 still negative), the Advance Pulse Generator, Q665 and Q675, is turned on. When Q665 turns on, its collector rises positive to bias Q675 on. The resulting negative-going change at the collector of Q675 holds Q665 in conduction through C671-R671 until the charge on C671 equalizes. When C671 is charged, the base of Q665 rises positive and it turns off. The signal at the collector of Q665 provides the advance pulse to the Advance Pulse Output stage. It also provides a sweep reset pulse to the Sweep Generator circuit through C681-D681 so the sweep restarts with each advance pulse. Each time a trigger signal produces an advance pulse during the window-gate signal (before the sawtooth biases Q653 on), the sawtoooth starts to run up again at the next faster sweep rate (advance pulse increases sweep rate; see Counter Circuit discussion). This action continues each time Q665 is triggered until the sweep rate is fast enough to turn Q653 on (to end window-gate signal) before a trigger can produce an advance pulse.

The amount that the sawtooth must run up before it turns Q653 on is set by the CYCLES/SWEEP adjustment. Since voltage level on the sawtooth is related to divisions on the CRT, the setting of this control determines the number of cycles in the CRT display. For example, assume a constant input signal produces a three-cycle display in the Seek Mode when R650 is set to midrange. Then, when R650 is set clockwise, the base of Q653 is less negative and the sawtooth must overcome less of the sweep gate current to turn Q653 on. Therefore, fewer advance pulses are produced before the sweep rate is advanced enough so that Q653 turns on before Q655 can be triggered. With fewer advance pulses to the Counter Circuit, a slower sweep rate is produced to display more cycles of the signal. On the other hand, if the CYCLES/SWEEP adjustment is set counterclockwise, the sawtooth must overcome more sweep-gate current and run up farther to turn Q653 on. More advance pulses are produced before the sawtooth reaches the level where it turns Q653 on before Q665 can be triggered. More advance pulses to the Counter Circuit produce a faster sweep rate which results in less cycles in the display.

Advance Pulse Output

Q684 provides amplification for the advance pulses produced by the Advance Pulse Generator stage and couples them to the Counter Circuit. This stage only produces an output when enabled by the Advance Gate stage through D682. Locking this stage out in addition to locking out the Advance Pulse Generator circuit insures that all advance pulses are locked out after the 0.1 microsecond sweep rate has been reached. It also prevents the Counter Circuit from being advanced by noise or other extraneous pulses in the Seek Circuit when a seek command is not present.

Fig. 3-23 shows operating waveforms from the Seek Circuit. The first set of waveforms shows circuit conditions with a 1-kHz sine wave applied (CYCLES/SWEEP adjustment set according to Calibration Procedure). The second set of waveforms shows circuit conditions with a 1.3 kHz sine-wave signal.

Counter Circuit

General

The Counter Circuit produces the multiplier and decade logic levels for the Seek and External modes of operation. In the Seek Mode, the output of this circuit is controlled by the seek mono pulse and advance pulses produced by the Seek Circuit. For external Mode operation, the output of this circuit is controlled by external program logic levels applied through the front-panel PROGRAM connector. Fig. 3-24 shows a logic block diagram of the Counter Circuit. A diagram of this circuit is shown on diagram 7 at the rear of this manual.

Multiplier Counter

The three-state Multiplier Counter produces the 1-2-5 logic to select the sweep-rate multiplier within the timing decade selected by the Decade Counter stage. Fig. 3-25 shows circuit conditions for "5" output. The positive-going seek mono pulse from the Seek Circuit turns on Q705 at the start of each seek cycle through C731, D731 and R731. The collector level of Q705 is coupled to Q715 and Q725 through D713 and D723 to hold them off. The first advance pulse produced by the Seek Circuit is coupled to the base of Q705 through C704 and D704. Q705 turns off and its collector rises positive. This level change turns Q715 on through C709.

Fig. 3-26 shows circuit conditions for "2" multiplier output. Q715 turns on when Q705 is turned off by the advance pulse. Then, the collector level of Q715 holds Q705 and Q725 off through D703 and D723. The second advance pulse produced by the Seek Circuit is coupled to the base of Q715 through C714 and D714. This negative-going pulse turns Q715 off and its collector rises positive. C719 couples this change to the base of Q725 to turn it on.

"1" multiplier logic is produced by Q725 as shown in Fig. 3-27. Q725 is turned on by Q715. As it turns on, the collector level of Q725 goes negative to hold Q705 and Q715 off through D702 and D712. The third advance pulse produced by the Seek Circuit is connected to the base of Q725 through C724 and D724. Q725 turns off and its collector rises positive. This positive level change turns Q705 back on through C729. As Q705 comes back on, the negative-going change at its collector produces an advance command level to the Enable Multivibrator stage. The action described starts over and repeats until the Seek Circuit stops producing advance pulses. One advance command to the Enable Multivibrator is produced for each three advance pulses produced by the Seek Circuit.

For External Mode operation grounding (zero-volt) external multiplier program logic is applied to the Multiplier Counter circuit through either terminal 2, 3 or 5 of J30. This external program logic biases on the associated transistor to produce the desired multiplier logic output. The transistor which is turned on by the external program logic holds the other transistors off and this transistor remains on until the external program logic is removed.

For Manual Mode operation, —12.2-volt Seek/External Power to the Counter Circuit is disconnected. This enables the entire circuit in this mode and the output levels of this circuit rise to about zero volts.

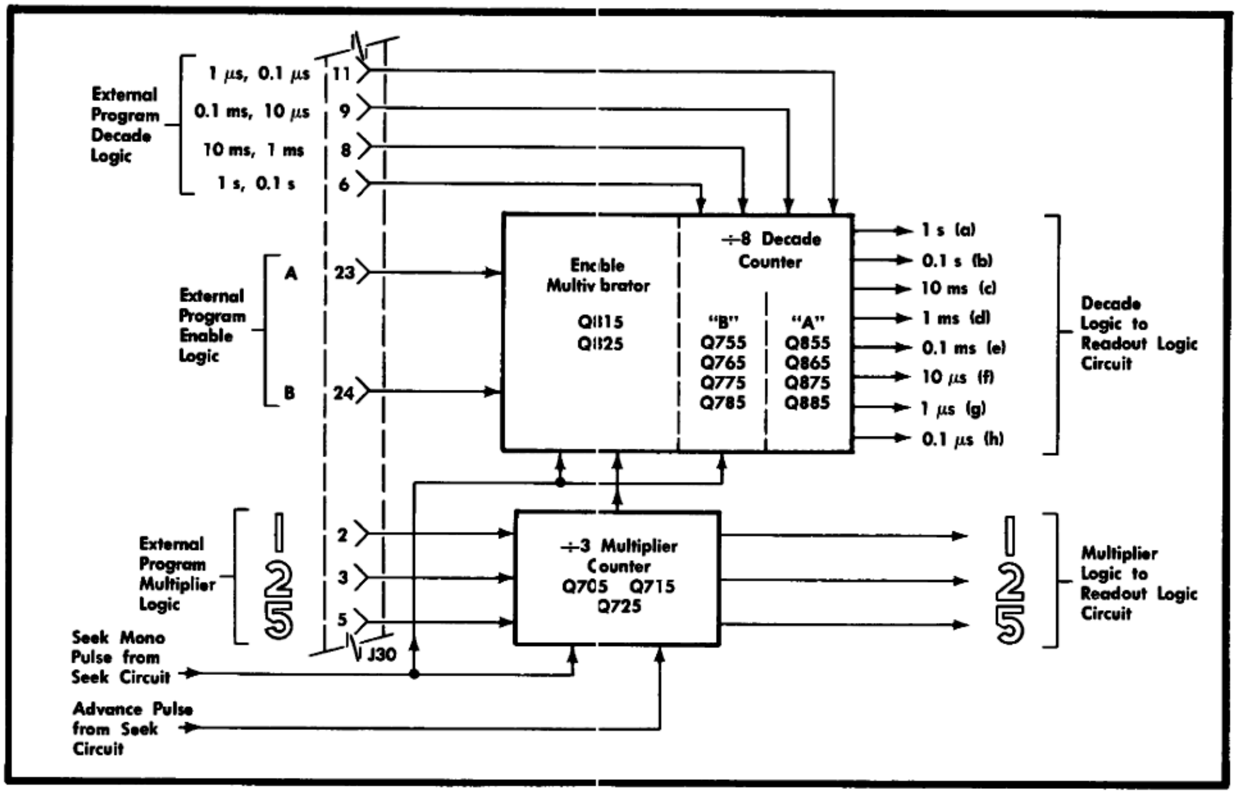


Fig. 3-24. Counter Circuit Logic block diagram.

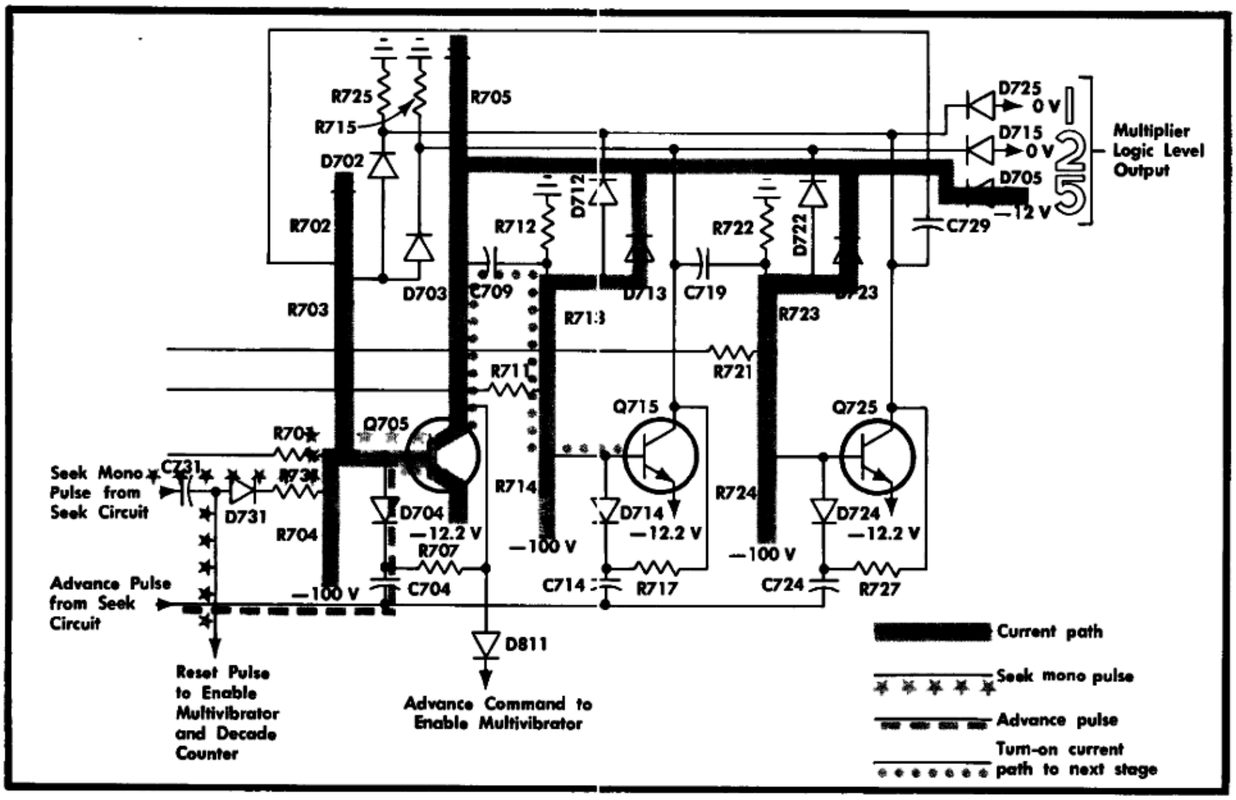


Fig. 3-25. Multiplier Counter circuit conditions for "5" output.

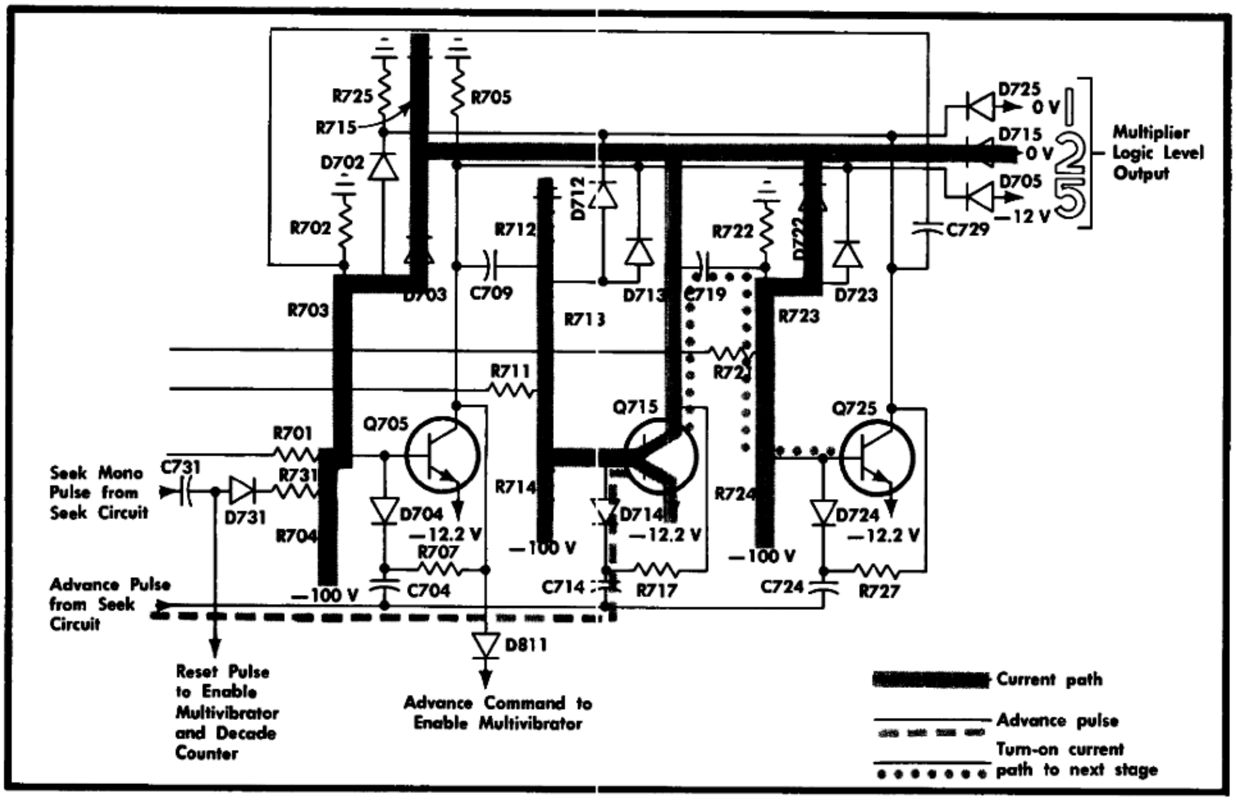


Fig. 3-26. Multiplier Counter circuit conditions for "2" output.

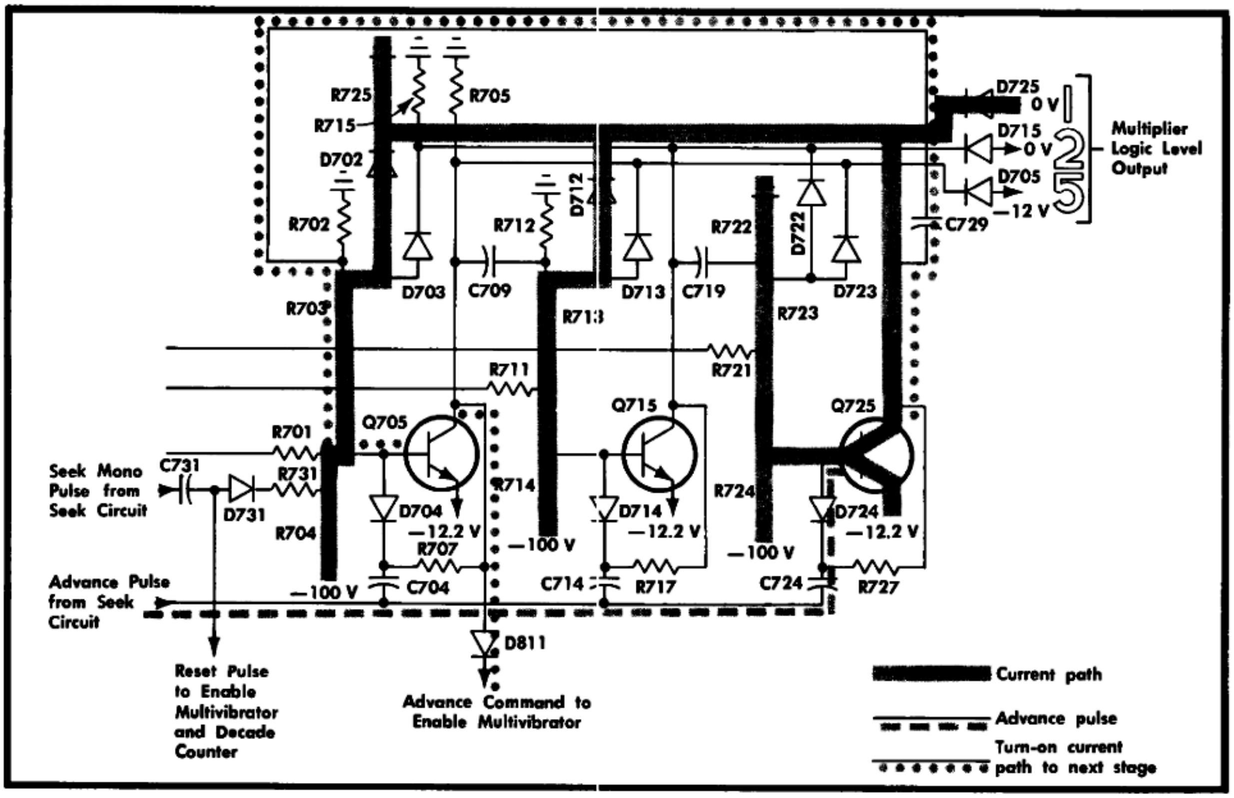


Fig. 3-27. Multiplier Counter circuit conditions for "1" output.

Enable Multivibrator

For Seek Mode operation, Q815 and Q825 are coupled as a bistable multivibrator. The multivibrator switches each time an advance command is received from the Multiplier Counter stage. The collector level of Q815 and Q825 determines which group of transistors in the Decade Counter can conduct. At the start of the seek cycle, the seek mono pulse from the Seek Circuit turns Q815 on through D818 and R818. The collector of Q815 goes negative and the base level of transistors Q755, Q765, Q775 and Q785 (B group) is pulled negative to hold them off. The collector of Q825 rises positive and Q855, Q865, Q875 and Q885 (A group) are enabled. Only one of the transistors in the A group conducts, however (see Decade Counter discussion).

The third advance pulse from the Seek Circuit produces an advance command to the Enable Multivibrator through D811. This advance command turns off the on transistor. For example, the first advance command (third advance pulse) after the circuit has been reset is connected to the base of Q815 through C812 and D814. Q815 turns off and Q825 comes on. Now the B group transistors are enabled and the A group is locked out. With the sixth advance pulse to the Multiplier Counter circuit, the Enable Multivibrator returns to the original condition and the A group transistors are enabled. The Enable Multivibrator switches with each third advance pulse produced by the Seek Circuit.

For External Mode operation, either Q815 or Q825 is held on by the grounding external program enable logic applied through terminal 23 or 24 of J30. This holds the associated transistor on and locks out the corresponding group of Decade Counter transistors. For example, external program enable logic applied to terminal 23 (A logic line) holds Q815 on. The collector level of Q815 goes negative to lock out the B group transistors and allow the A group transistors to conduct.

Decade Counter

The Decade Counter is an eight-state (alternate four-four) ring counter which provides the decade logic levels in the Seek and External Modes of operation. The transistors in the Decade Counter are divided into two groups; Q755, Q765, Q775 and Q785 form group B and Q855, Q865, Q875 and Q885 form group A. Only one of these transistor groups can conduct at one time as enabled by the Enable Multivibrator. Furthermore, only one transistor within the enabled group conducts as determined by the ring-counter action.

The seek mono pulse from the Seek Circuit biases Q855 on. Also the Enable Multivibrator is reset as described previously to allow the A group transistors to conduct. When Q855 conducts, its collector level goes negative and it reverse biases transistors Q865, Q875 and Q885 through D862, D872 and D882. The 1 s decade (a) logic line drops to —12 volts to select the 1 s timing decade. The Decade Counter remains in this condition until the Enable Multivibrator is switched by the advance command from the Multiplier Counter (every third advance pulse from Seek Circuit). Then, the opposite group of transistors is enabled; in this example, the B group. As Q855 turns off, the positive-going level change at its collector is coupled to the base of Q755 through C856 and R753. The collector of Q755 goes negative to lock out the remaining transistors in the B group. The decade logic output on the 0.1 s decade (b) logic line (0.1 second timing decade) is —12 volts. This action continues each time an advance command switches the Enable Multivibrator. As the on transistor is switched off by the Enable Multivibrator, it turns on the next transistor in the opposite group. Decade logic from the output of the Decade Counter is connected to the Readout Logic circuit. The alternate four-four ring counter configuration just described is used to insure that the ring counter does not free run as sometimes occurs in conventional counters with this number of states.

For External Mode operation, external program decade logic connected to terminals 6, 8, 9 or 11 of J30 controls the Decade Counter. The grounding external program decade logic is connected to the bases of the corresponding transistors in both groups A and B. Only the transistor in the group which is enabled by the Enable Multivibrator conducts. For example, if the external program logic is connected to terminals 9 and 23 of J30 (0.1 ms or 10 ms decade logic and A enable logic) the external program decade logic is connected to both Q775 and Q875. However, the A external program enable logic connected to the Enable Multivibrator locks out the B group transistors so only Q875 can turn on. The decade logic output is on the 0.1 ms decade (e) logic line to select the 0.1 ms timing decade.

Operating Mode Power

General

The Operating Mode Power circuit provides Seek/Manual Power, Manual Power, Seek/External Power and External Power to the unit. The output power from this circuit is changed to control the operating mode. For example in the Seek Mode of operation, Seek/Manual and Seek/External Power output is available and in the External Mode of operation Seek/External and External Power output is available. Fig. 3-28 shows a logic block diagram of the Operating Mode Power circuit. A diagram of this circuit is shown on diagram 8 at the rear of this manual.

Manual Mode Control

In the Manual Mode of operation, Q915 determines the output of this circuit. Fig. 3-29 shows circuit conditions for Manual Mode operation. Q915 is forward biased by the level at its base established by divider R911-R912-R913. This level is more positive than the level at the base of Q905 so that Q915 comes on when the unit is first turned on to provide Manual Mode operation (except when programmed for External Mode). The collector current of Q915 flows through B915 and the MAN pushbutton lights up. This bulb drops about 6 volts of the —12-volt level at the collector of Q915 to provide current to the —6-volt line for the heater of V163. This current is supplied in parallel with the current from the s/DIV and UNCAL Readout Control stage. Current also flows through K915 and K915-1 is actuated to connect —12.2 volts to the Manual Power line. Seek/Manual Power output is provided through D919. The collector level of Q915 is connected to the Seek Mode Control stage through D901 to lock it off during Manual Mode operation

The Manual Mode of operation can be selected by pressing the MAN button or by changing the sweep rate with the MANUAL TIME/DIV switch. When the MAN button is

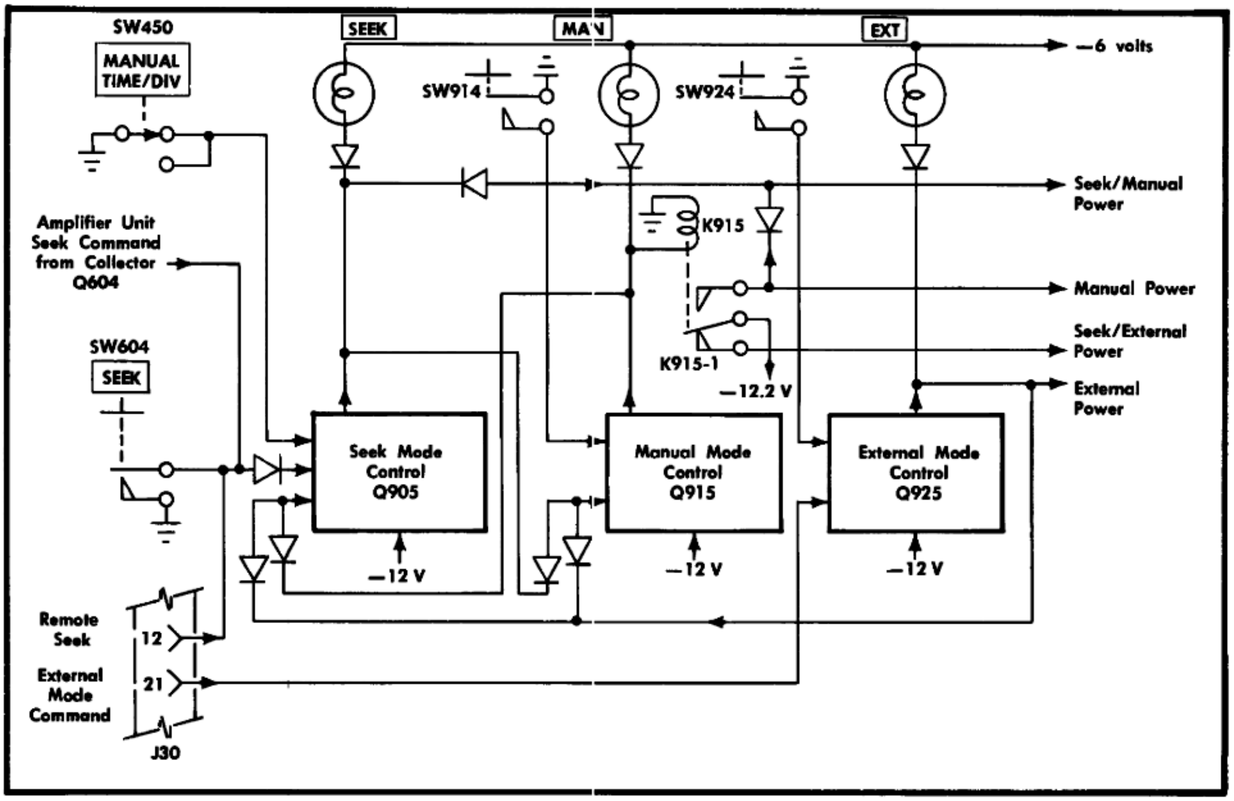


Fig. 3-28. Operating Mode Power logic block diagram.

pressed, SW914 raises the base of Q915 positive enough to turn it on and its collector goes negative. Q905 is turned off through D901 and Q915 controls the circuit (except in External Mode; see External Mode Control discussion). Changing the MANUAL TIME/DIV switch returns the unit to the Manual Mode of operation when in the Seek Mode. The base level of Q905 is established by a divider to ground through the MANUAL TIME/DIV switch (note that only part of this switch is shown on this diagram; see diagram 5 for complete switch). As this switch is rotated between steps, the ground connection for the divider is momentarily opened. The base of Q905 goes negative and it shuts off. Then, Q915 comes on and locks off Q905 to establish Manual Mode operation. Divider R911-R912-R913 holds the base of Q915 slightly more positive than the base of Q905 to return the unit to Manual Mode operation when the external mode command is disconnected.

Seek Mode Control

Fig. 3-30 shows circuit conditions for the Seek Mode of operation. In this mode of operation, Q905 determines the output from this circuit. Q905 is forward biased by the level at its base established by divider R901-R902-R903. This bias level is interrupted to return the unit to Manual Mode operation when the MANUAL TIME/DIV switch is rotated (see Manual Mode Control discussion). The collector current of Q905 flows through B905 and the SEEK pushbutton lights up. This bulb drops about six volts of the —12-volt level at the collector of Q905 to provide current to the —6-volt output line

Current also flows through D909 to provide Seek/Manual Power output and through D911 to lock Q915 off. With Q915 off, K915-1 connects —12.2 volts to the Seek/External Power output.

The Seek Mode of operation can be obtained from four sources; front-panel SEEK button, remote seek command through the front-panel PROGRAM connector, seek command from a remote-seeking probe through an automatic/programmable amplifier unit and remote seek command through the amplifier unit program connector. When the Type 3B5 front-panel SEEK button is pressed, SW604 raises the base of Q905 positive enough to turn it on and its collector goes negative. Q915 is turned off through D911 and Q905 controls the circuit (except in External Mode; see External Mode Control discussion). The seek command from the amplifier unit or the remote seek command similarly raises the base level of Q905 to allow it to come into conduction.

External Mode Control

External Mode operation is provided only when the EXT button is held depressed or when an external mode command is applied through the PROGRAM connector. The circuit is connected so that this stage over-rides the other two control stages. Fig. 3-31 shows circuit conditions for External Mode operation. Q925 is on when the base is held positive enough to forward bias the transistor either by holding the EXT button depressed or by external mode command through terminal 21 of J30. When Q925 is on, col

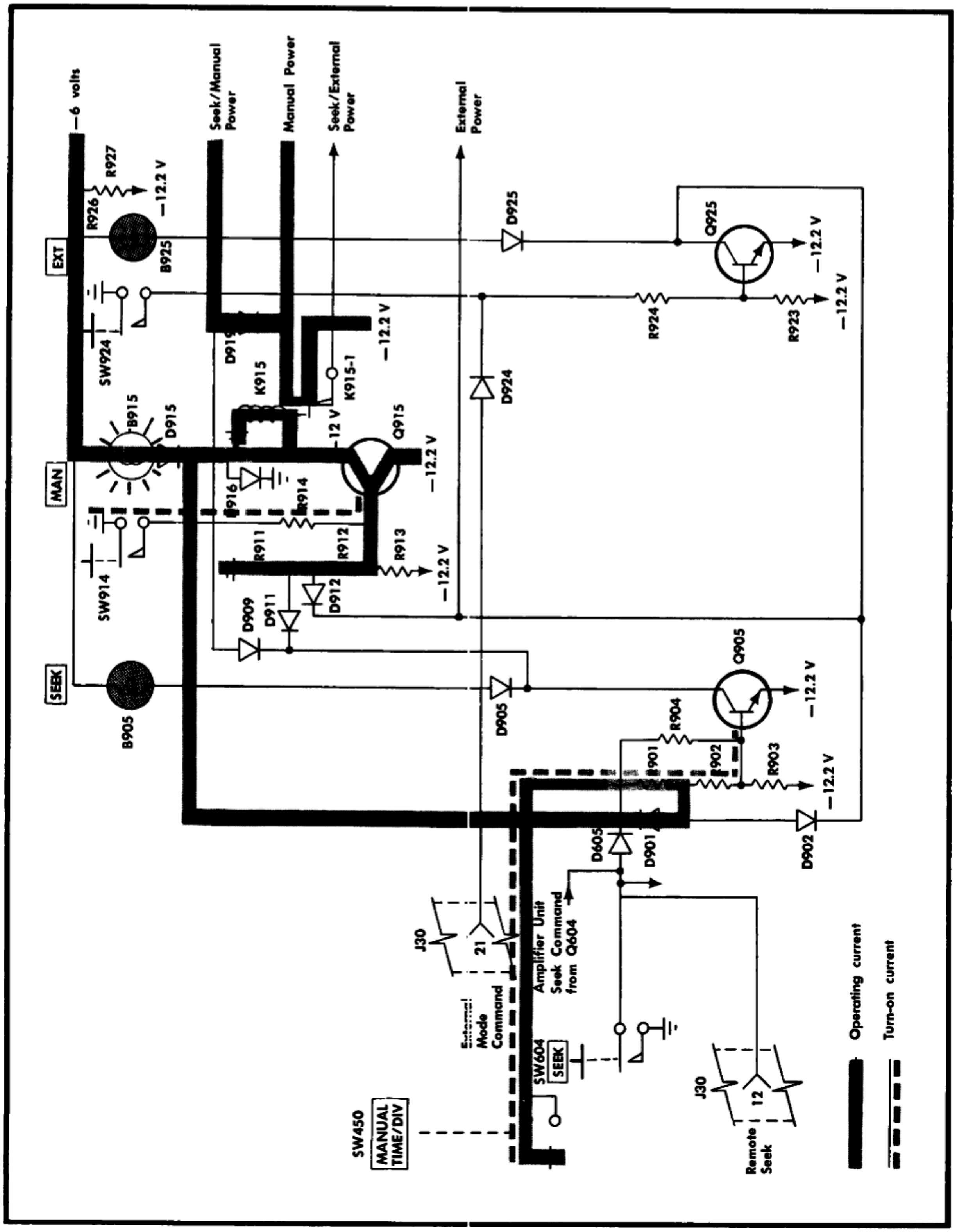


Fig. 3-29. Circuit conditions for Manual Mode operation.

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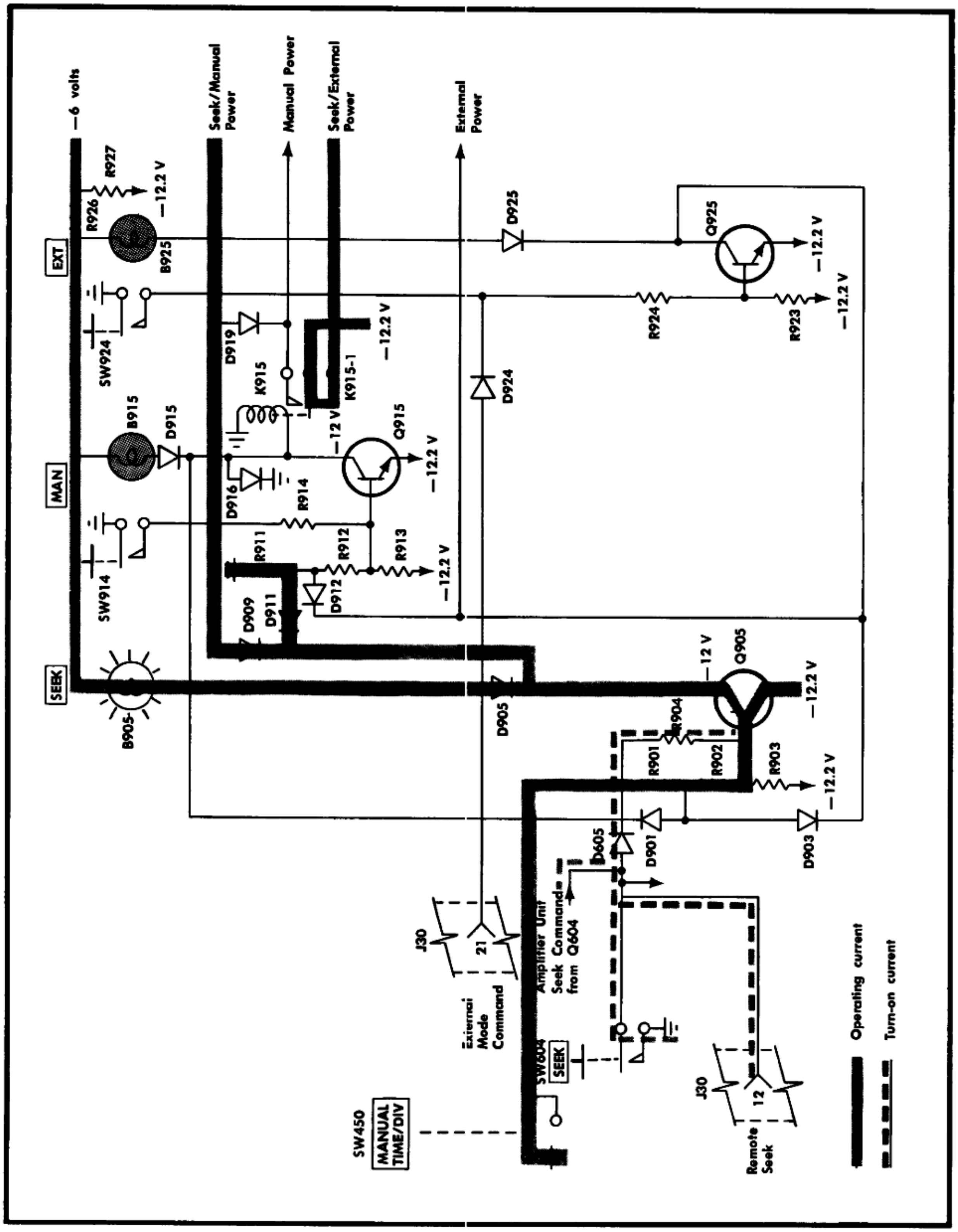


Fig. 3-30. Circuit conditions for Seek Mode operation.

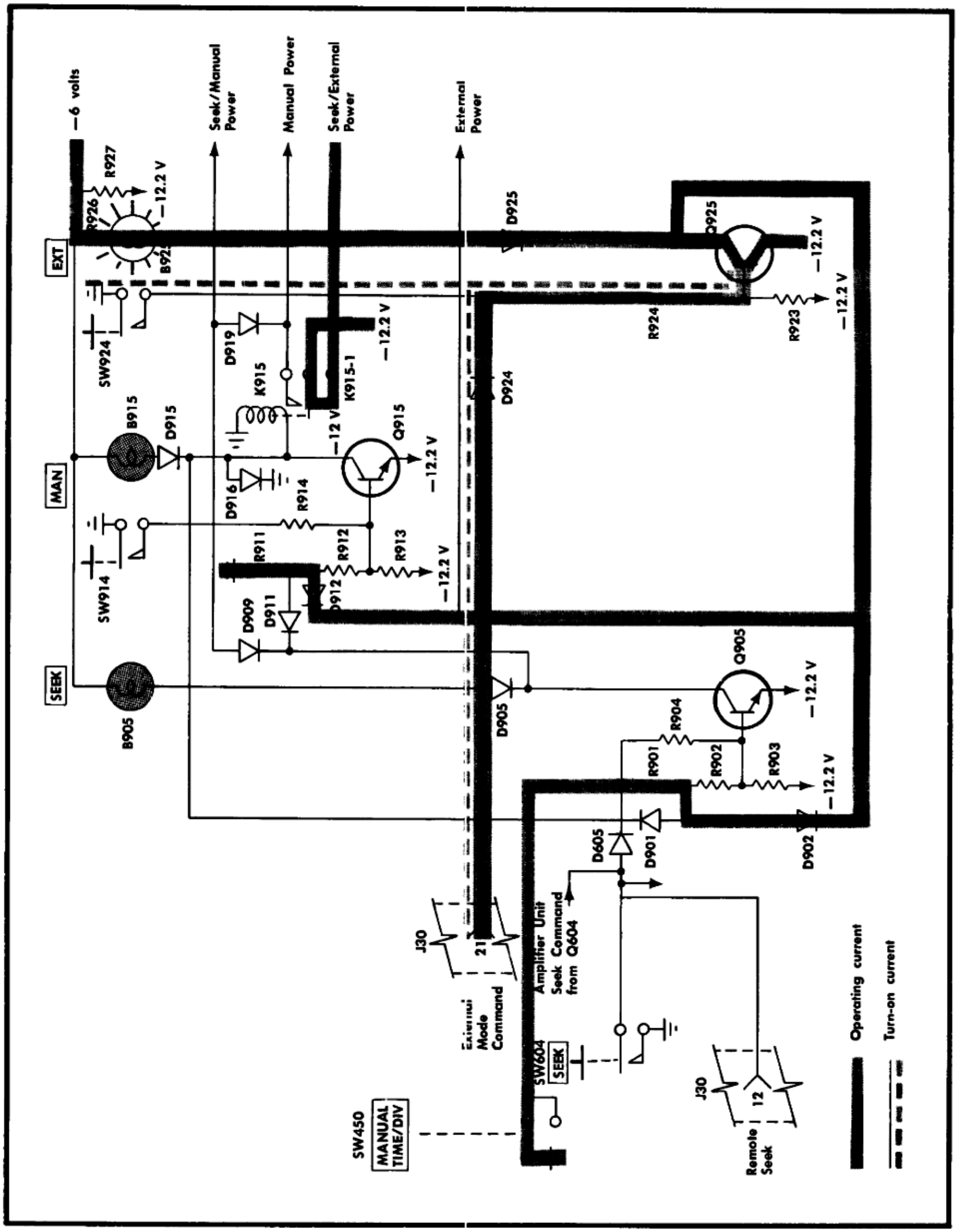


Fig. 3-31. Circuit conditions for External Mode operation.

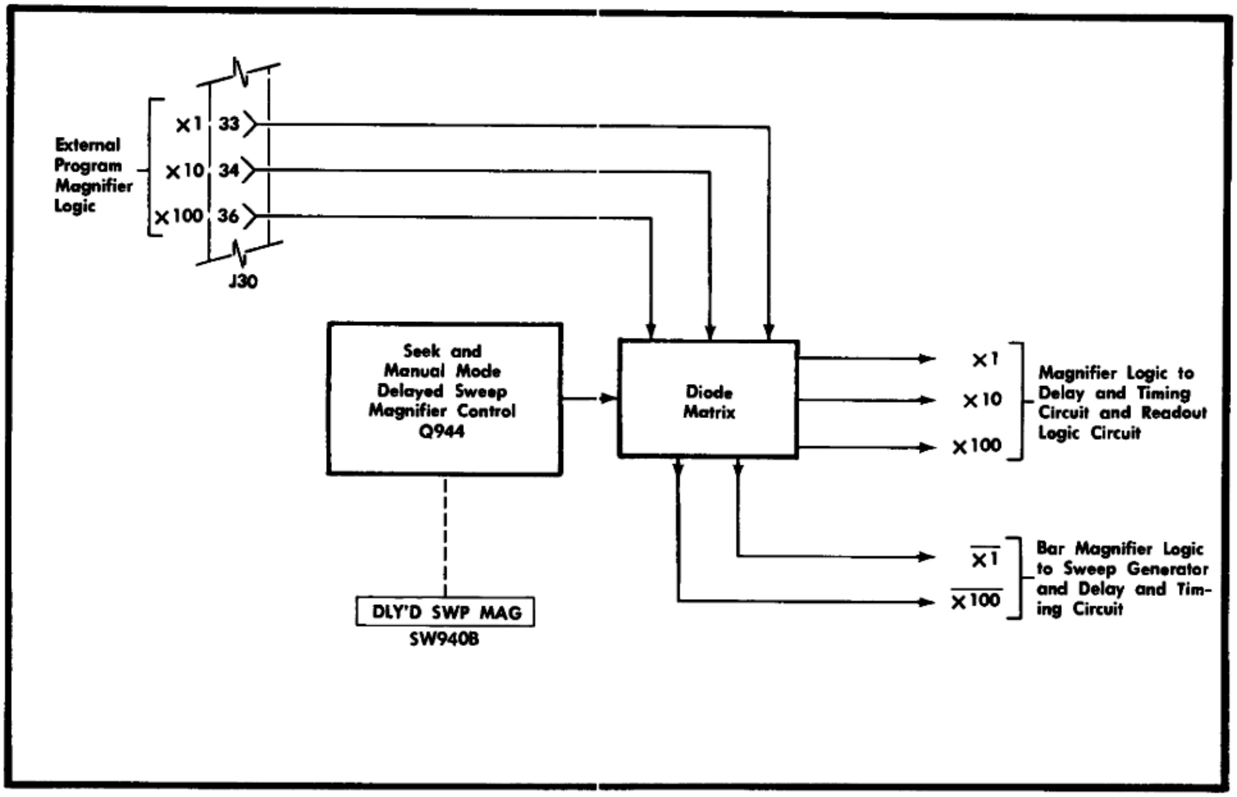


Fig. 3-32. Delayed Sweep Magnifier Control circuit logic block diagram.

lector current flows through B925 and the EXT light comes on. This bulb drops about six volts of the —12-volt level at the collector of Q925 to provide current to the —6-volt output line. The collector level of Q925 provides the External Power output. In addition, the collector level of Q925 is connected to Q905 through D902 and to Q915 through D912 to lock out the Seek and Manual Mode Control circuits. Since Q915 is held off, K915-1 connects —12.2 volts to the Seek/External Power output.

Interconnecting Diagram

General

Diagram 9 shows the interconnections between Interconnecting Plug P21, PROGRAM connector J30, Logic Card connector J400 and Counter Card connector J700. Although these interconnections are shown in part on other diagrams, this diagram gives an overall view of the interconnections. This diagram also includes the Delayed Sweep Magnifier Control circuit which is described below.

Delayed Sweep Magnifier Control

Fig. 3-32 shows a block diagram of the Delayed Sweep Magnifier Control circuit. This circuit is controlled by Q944 and the DLY'D SWP MAG switch in Seek and Manual Mode operation. For External Mode operation, the bias level is disconnected from Q944 and the circuit is controlled by external program magnifier logic through terminal 33, 34 or 36 of J30. However, circuit operation is the same regardless of the mode of operation. Table 3-1 lists the typical logic output levels on the magnifier logic lines.

For ×1 magnification, the anodes of D947 and D949 are held at zero volts by Q944 or the external program ×1 magnifier logic at terminal 33 of J30. This holds the $\overline{\times 1}$ (bar ×1 magnifier) logic line at zero volts along with the ×10 and ×100 logic lines through D947 and D949. The ×1 magnifier logic level drops to about —7 volts where it is clamped by D348 and D349 in the Delay and Timing Circuit. The $\overline{\times 100}$ (bar ×100 magnifier) logic level is also set at about —7 volts through D944.

For ×10 delayed sweep magnification, the anodes of D946 and D948 are held at zero volts by the input level which also holds the ×1 and ×100 magnifier logic lines at zero through D946 and D948. The ×10 magnifier logic line is pulled to —12 volts through resistor R949 and both the $\overline{\times 1}$ and $\overline{\times 100}$ magnifier logic lines are held at about —12 volts through D945 and D947.

×100 delayed sweep magnification places zero volts on the $\overline{\times 100}$ magnifier logic line. The ×1 and ×100 magnifier logic lines are held at zero volts through D944 and D945. D947 is reverse biased and the $\overline{\times 1}$ magnifier logic line drops to about —12 volts through R204 (Sweep Generator circuit). D949 is reverse biased and the ×100 magnifier logic line rests at about —5.5 volts as established by the shunt diodes in the Readout Logic circuit. (The ×100 magnifier logic level may be zero volts for ×100 magnification in some positions of the MANUAL TIME/DIV switch.)

TABLE 3-1

Magnifier and Bar Magnifier Logic Output Levels

Magnification Ratio (switch position or external program logic)	Logic output Level on Logic Lines				
	×1	×10	×100	$\overline{\times 1}$	$\overline{\times 100}$
×1 (OFF)	−7 V	0 V	0 V	0 V	−7 V
×10	0 V	−12 V	0 V	−12 V	−12 V
×100	0 V	0 V	−12 V[1]	−12 V	0 V

[1]Normally −12 volts. May vary between zero and −12 volts since there is no "pull-down" resistor on the ×100 magnifier logic line.

Readout Board

The Readout Board circuit shown on diagram 10 shows the connection to this board and the bulbs which produce the readout-panel display. The function of the bulbs and the operating circuitry is described in the Sweep Generator, Delay and Timing Circuit and the Readout Logic discussions

Voltage Distribution

Diagram 11 shows the distribution of the voltage from the indicator oscilloscope through connector P21 to the boards and connectors in this instrument. The decoupling networks which provide decoupled operating voltages are shown in this diagram and are not repeated on the individual circuit diagrams.

SECTION 4
MAINTENANCE

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 3B5.

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 3B5 is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

Cleaning

The Type 3B5 should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The covers of the indicator oscilloscope minimize the amount of dust which reaches the interior of the Type 3B5. Operation of the system without covers in place necessitates more frequent cleaning. When the Type 3B5 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 front panel of the Type 3B5 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 should not be used.

Interior. Dust in the interior of the unit 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 or for cleaning ceramic terminal strips and circuit boards.

Lubrication

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

Visual Inspection

The Type 3B5 should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors or nuvistors, damaged circuit boards 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 recurrence of the damage.

Transistor and Nuvistor Checks

Periodic checks of the transistors and nuvistors in the Type 3B5 are not recommended. The best check of transistor or nuvistor performance is its actual operation in the instrument. More details on checking transistor and nuvistor operation is given under Troubleshooting.

Recalibration

To assure accurate measurements, check the calibration of this instrument after each 500 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 the Calibration section.

The 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 recalibration.

TROUBLESHOOTING

Introduction

The following information, is provided to facilitate troubleshooting of the Type 3B5, if trouble develops. Information contained in other sections of this manual should be used along with the following information to aid in locating the defective component. 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 9. The component number and electrical value of each component in this instrument are shown on the diagrams. Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the Type 3B5 and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams. The portions of the circuit mounted on circuit boards or cards are enclosed with a blue line.

Switch Wafer Identification. Switch wafers shown on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters F and R indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

TABLE 4-1

Component Numbers

Component Numbers on Diagrams	Circuit
1-139	Sweep Trigger
140-299	Sweep Generator
300-399	Delay and Timing Circuit
400-499	Readout Logic
500-599	Horizontal Amplifier
600-699	Seek Circuit
700-899	Counter Circuit
900-939	Operating Mode Power
940-969	Delayed Sweep Magnifier Control
970-999	Readout Board

Circuit Boards and Cards. Fig. 4-6 through 4-13 show the circuit boards and cards used in the Type 3B5. Fig. 4-5 shows the location of each board within the instrument. Each electrical component on the boards is identified by its circuit number. The circuit boards and cards are also outlined on the diagrams with a blue line. These pictures used along with the diagrams will aid in locating the components mounted on the circuit boards and cards.

Wiring Color-Code. All insulated wire and cable used in the Type 3B5 is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using the EIA resistor color code. A white background color indicates a positive voltage and a tan background indicates a negative voltage. Table 4-2 gives the wiring color-code for the power-supply voltages used in the Type 3B5.

Resistor Color-Code. In addition to the brown composition resistors, some metal-film resistors (identifiable by their gray or blue body color) and some wire-wound resistors (usually light blue or gray-green) are used in the Type 3B5. 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 the 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.

TABLE 4-2

Power Supply Wiring Color-Code

Supply	Background Color	1st Stripe	2nd Stripe	3rd Stripe
+300 volt	white	orange	black	violet
+125 volt	white	brown	red	brown
−12.2 volt	tan	brown	red	black
−100 volt	tan	brown	black	brown

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 3B5 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 and identifies the Tektronix Part Number using the resistor color-code system (e.g., a diode color-coded blue-brown-gray-green indicates diode type 6185 with Tektronix Part Number 152-0185-00). The cathode and anode end of metal-encased diodes can be identified either by the diode symbol marked on the body or by the flared end at the anode.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 3B5.

1. Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer or equivalent.

Purpose: To test semiconductors used in this instrument.

2. Volt-ohmmeter

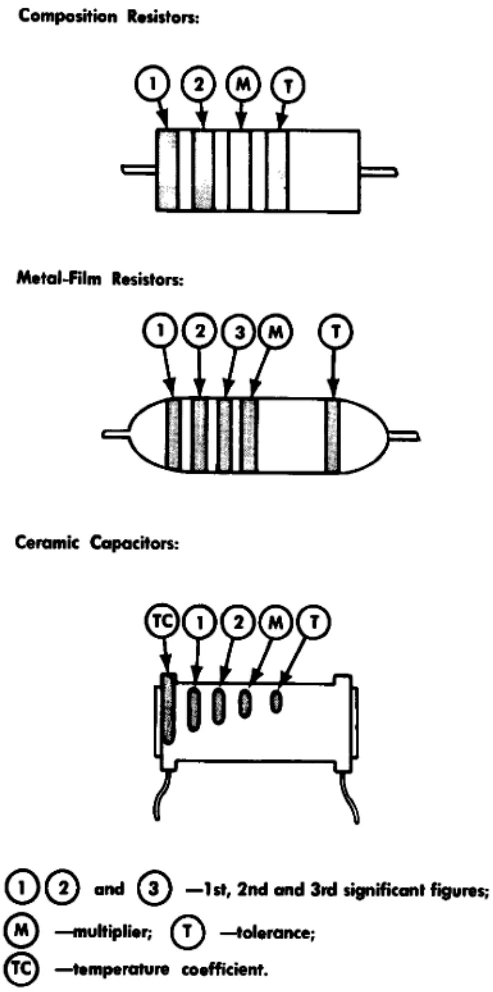
Description: 20,000 ohms/volt. 0—500 volts DC. Accurate within 3%. Test prods must be well insulated.

Purpose: To check voltages and for general troubleshooting in this instrument.

3. Test Oscilloscope

Description: DC to 20 MHz, 50 millivolts to 50 volts/division with 10× probe.

Purpose: To check waveforms in this instrument.



Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier		Tolerance	Temperature Coefficient
		Resistors	Capacitors		
Silver	- - -	10^{-2}	- - -	10%	- - -
Gold	- - -	10^{-1}	- - -	5%	±0
Black	0	1	1	20% or 2 pF†	—0.033 parts/million
Brown	1	10	10	1% or 0.1 pF†	—0.075 parts/million
Red	2	10^{2}	10^{2}	2%	- - -
Orange	3	10^{3}	10^{3}	2.5%	- - -
Yellow	4	10^{4}	10^{4}	- - -	—0.330 parts/million
Green	5	10^{5}	10^{5}	5% or 0.5 pF†	- - -
Blue	6	10^{6}	10^{6}	- - -	- - -
Violet	7	- - -	- - -	- - -	- - -
Gray	8	- - -	10^{-2}	0.25 pF	- - -
White	9	- - -	10^{-1}	10% or 1 pF†	General purpose-1
(none)	- - -	- - -	- - -	20%	- - -

†For values less than 10 pF.

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

4. Plug-In Extension

Description: 24-pin rigid extender. Tektronix Part No 013-0034-00.

Purpose: Permits operation of the unit outside the plug-in compartment for better accessibility. (A flexible extender may be used for DC voltage checks and slower sweep rates only.)

5. Circuit-Card Extender

Description: 56-terminal rigid extender. Tektronix Part No. 012-0078-00.

Purpose: Permits access to the circuit cards in this unit.

Troubleshooting Techniques

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

2. Check Associated Equipment. Before proceeding with troubleshooting of the Type 3B5, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. The indicator oscilloscope and amplifier unit can be checked for proper operation by substituting another time-base plug-in unit which is known to be operating properly (preferably another Type 3B5 or similar unit). If the trouble persists after substitution, the indicator oscilloscope or amplifier unit are defective.

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

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 circuit boards, damaged components, etc.

5. Isolate Trouble to a Circuit. To isolate a trouble to a circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. For example, no sawtooth output indicates that the Sweep Generator circuit is probably at fault. When trouble symptoms appear in more than one circuit, check all affected circuits by taking voltage and waveform readings.

Table 4-3 can be used to locate the defective circuit. This table provides setup information to insure that the controls are not incorrectly set. Following the setup information, a series of checks is provided to isolate the trouble to a particular circuit within the instrument.

After the defective circuit has been located, proceed with steps 6—8 to locate the defective component(s).

6. Check Circuit Board Interconnections. If the trouble has been isolated to a particular circuit, check the pin connectors on the circuit board for correct connection. Figs. 4-6 through 4-13 show the correct connections for each board.

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

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 test conditions in the Diagram section.

TABLE 4-3

Circuit Isolation Troubleshooting Guide

Preliminary setup

1. Remove the Counter Card and Logic Card.
2. Replace the unit into the plug-in compartment and turn on the indicator oscilloscope power.
3. Center the amplifier unit position control.
4. Set the indicator oscilloscope intensity control to midrange.
5. Set the Trigger Function switch to INT-AUTO.

CHECK	PROCEDURE
1. Trace present	YES: Apparent trouble may have been due to incorrect control settings; if a stable, triggered display still cannot be obtained, check the Sweep Trigger circuit. NO: Turn indicator oscilloscope intensity control to maximum; still no trace, proceed to next step.
2. Check that all readout bulbs are good	Replace any defective readout bulbs before proceeding.
A. Check that MAN light is on.	YES: Proceed to next check. NO: Check Operating Mode Power circuit.
B. Check that the NOT TRIG'D and s/DIV readouts are on.	YES: Proceed to next check. NO: Check Bright Baseline stage (Q293, Q295 and Q296) or the s/DIV and UNCAL Readout Control stage.
C. Rotate the CAL control and check that the s/DIV readout goes off and the UNCAL readout comes on (return to CAL).	YES: Proceed to next check. NO: Check s/DIV and UNCAL Readout Control stage.
D. Set the DLY'D SWP MAG switch to ×10 and check that the MAG'D SWP readout comes on (return to OFF).	YES: Proceed to next check. NO: Check Delayed Sweep Magnifier Readout Control stage.
E. Rotate the MANUAL TIME/DIV switch throughout its range and check that the ".", "5", "1", "2", "0", "m" and "μ" readouts come on.	YES: Proceed to next step. NO: Check Multiplier and Decade Readout stages.
3. Check for sweep at TP173 (Time-Base Board) with test oscilloscope.	YES: Proceed to step 5. NO: Proceed to next step.
4. Check DC level at TP173	GREATER THAN 40 VOLTS: Check Sawtooth Sweep Generator stage (Q153, D155, Q161, V163 and Q174). LESS THAN 5 VOLTS: Check Sweep Gate stage (Q144, D145, and associated circuitry).
5. Check for sweep at deflection plates with test oscilloscope.	YES: Check Unblanking Circuit. NO: Check Horizontal Amplifier circuit.
6. Replace Counter Card and Logic Card. Check that correct display can be obtained in Seek and External Modes of operation.	YES: Trouble corrected. NO: Check Seek Circuit, Counter Circuit and Operating Mode Power circuit.

8. Check Individual Components. The following procedures describe methods of checking indivdual components in the Type 3B5. Components which are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurements due to the effects of surrounding circuitry.

A. TRANSISTORS AND NUVISTORS. The best check of transistor or nuvistor operation is actual performance under operating conditions. If a transistor or nuvistor 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 or nuvistor might also be damaged. If substitute transistors or nuvistors are not available, use a dynamic tester (such as Tektronix Type 570 or 575). Static-type testers are not recommended, since they do not check operation under simulated operating conditions.

B. 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 about 1.5 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. Do not measure tunnel diodes or the special clip-in diode (sweep disconnect diode) with an ohmmeter; use a dynamic tester (such as a Tektronix Type 575 Transistor-Curve Tracer). The clip-in diode can also be damaged by static-discharge.

C. RESISTORS. Resistors can be checked wih 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 is in excess of the specified tolerance.

D. 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 (roll-off).

E. REED-DRIVE COILS. The reed-drive coils can be checked for correct operation as follows (the coils have four mounting leads for rigidity; make measurements between the two leads on either end of the coil): 1) Check the DC resistance of the coil with an ohmmeter (protective diodes are connected across the coils; take diodes and other circuitry into account on resistance measurements; typical resistance values are given in the Electrical Parts List). 2) Check the DC voltage drop across the coil when the actuating level is applied. 3) If both the resistance and voltage are correct, the coil can be assumed to be correct; check the reed relay position and continuity. 4) If the resistance is incorrect (take into account surrounding circuitry), disconnect the coil and check the resistance again. 5) If the voltage across the coil is incorrect but the coil resistance is correct, check the circuit originating the actuating level.

F. CAPACITORS. A leaky or shorted capacitor can best be detected by checking 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.

9. Repair and Readjust the Circuit. If any defective parts are located, follow the replacement procedures which follow. Be sure to check the performance of any circuit that has been repaired or has had 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 3B5 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 lists 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 its 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 3B5. 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 and Cards. Use ordinary 60/40 solder and a 35- to 40-watt pencil type soldering iron on the circuit boards and cards. The tip of the iron should be clean and properly tinned for best heat transfer to the solder joint. A higher wattage soldering iron may separate the wiring from the base material.

The following technique should be used to replace a component on a circuit board or card. Most components can be replaced without removing the boards from the instrument. The cards should be removed to replace components (see Circuit Card Replacement in this section).

1. Grip the component lead with long-nose pliers. Touch the soldering iron to the lead at the solder connection. Do not lay the iron directly on the board as it may damage the board.

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

3. Bend the leads of the new component to fit the holes in the board. If the component is replaced while the board is mounted in the instrument, cut the leads long enough so they just protrude through the board. Insert the leads into the holes in the board so the component is firmly seated against the board (or as positioned originally). If it does not seat properly, heat the solder and gently press the component into place.

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

5. Clip the excess lead that protrudes through the board.

6. Clean the area around the solder connection with a flux-remover solvent. Be careful not to remove information printed on the board.

Ceramic Terminal Strips. Solder used on the ceramic terminal strips should contain about 3% silver. Use a 40- to 75-watt soldering iron with a 1/8-inch wide wedge-shaped tip. Ordinary solder can be used occasionally without damage to the ceramic terminal strips. However, if ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond may be broken.

Solder containing 3% silver is usually available locally or it can be purchased from Tektronix in one-pound rolls; order by Tektronix Part Number 251-0514-00.

Observe the following precautions when soldering to ceramic terminal strips.

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.

2. Maintain a clean, properly tinned tip.

3. Avoid putting pressure on the ceramic terminal strip.

4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.

5. Clean the flux from the terminal strip with a flux-remover solvent.

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

Observe the following precautions when soldering metal terminals:

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

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

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

4. Clean the flux from the solder joint with a flux-remover solvent.

Component Replacement

WARNING

Disconnect the instrument from the power source before replacing components.

Ceramic Terminal Strip Replacement. A complete ceramic terminal strip assembly is shown in Fig. 4-2. Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be re-used if they are not damaged. The applicable Tektronix Part Numbers for the ceramic strips and spacers used in this instrument are given in the Mechanical Parts List.

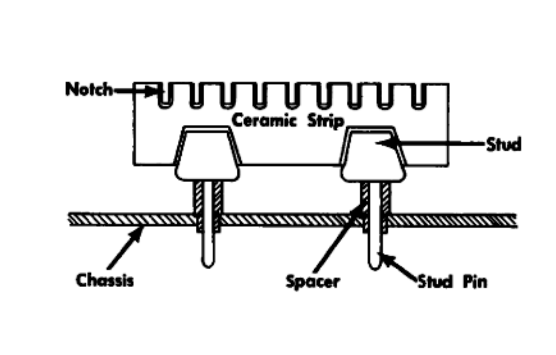


Fig. 4-2. Ceramic terminal strip assembly

To replace a ceramic terminal strip, use the following procedure:

REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch to show location of the components and connections.

2. Pry or pull the damaged strip from the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

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REPLACEMENT:

1. Place the spacers in the chassis holes.

2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft mallet and tap lightly, directly over the stud, to seat the strip completely.

3. If the stud extends through the spacers, cut off the excess.

4. Replace all components and connections. Observe the soldering precautions given under Soldering Techniques in this section.

Circuit Board Replacement. If a circuit board is damaged beyond repair, either the entire assembly including all soldered-on components, or the board only, can be replaced. Part numbers are given in the Mechanical Parts List for either the completely wired or the unwired board. Most of the components mounted on the circuit boards can be replaced without removing the boards from the instrument. (The components mounted on the rear of the Time-Base Board can be reached by removing the Counter and Logic Cards.)

Most of the connections to the circuit boards are made with pin connectors. However, several connections are soldered to the rear side of the Time-Base Board. Unsolder these connections before removing this board.

Use the following procedure to remove a circuit board:

1. Disconnect all pin connectors from the board and unsolder any soldered connections.

2. Remove all screws holding the board to the chassis.

3. Lift the circuit board out of the instrument. Do not force or bend the board.

4. To replace the board, reverse the order of removal. Correct location of the pin connectors is shown in Figs. 4-6 through 4-13. Replace the pin connectors carefully so they mate correctly with the pins. If forced into place incorrectly positioned, the pin connectors may be damaged.

Circuit Card Replacement. If one of the plug-in circuit cards is damaged and cannot be repaired, it should be replaced with a new circuit card. Replacement cards are available with or without the soldered-on components in place. Part numbers are given in the Mechanical Parts List for either the completely wired or the unwired card. The circuit cards are held in the instrument by a spring clip which fits in a notch on the side of each card. To remove the card, hold the spring clip out of the notch while disengaging the card from the connector. When replacing the circuit cards, install each card in the correct connector (see Fig. 4-5) with the components facing the right direction.

Transistor and Nuvistor Replacement. Transistors and nuvistors 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 or nuvistors may affect the calibration of this instrument. When transistors or nuvistors are replaced, check the operation of that part of the instrument which may be affected.

Replacement transistors or nuvistors 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 and nuvistors used in this instrument. This view is as seen from the bottom of the transistor or nuvistor. Notice that there are two different lead configurations for plastic-case transistors. When replacing these transistors, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the basing used for metal-case transistors.

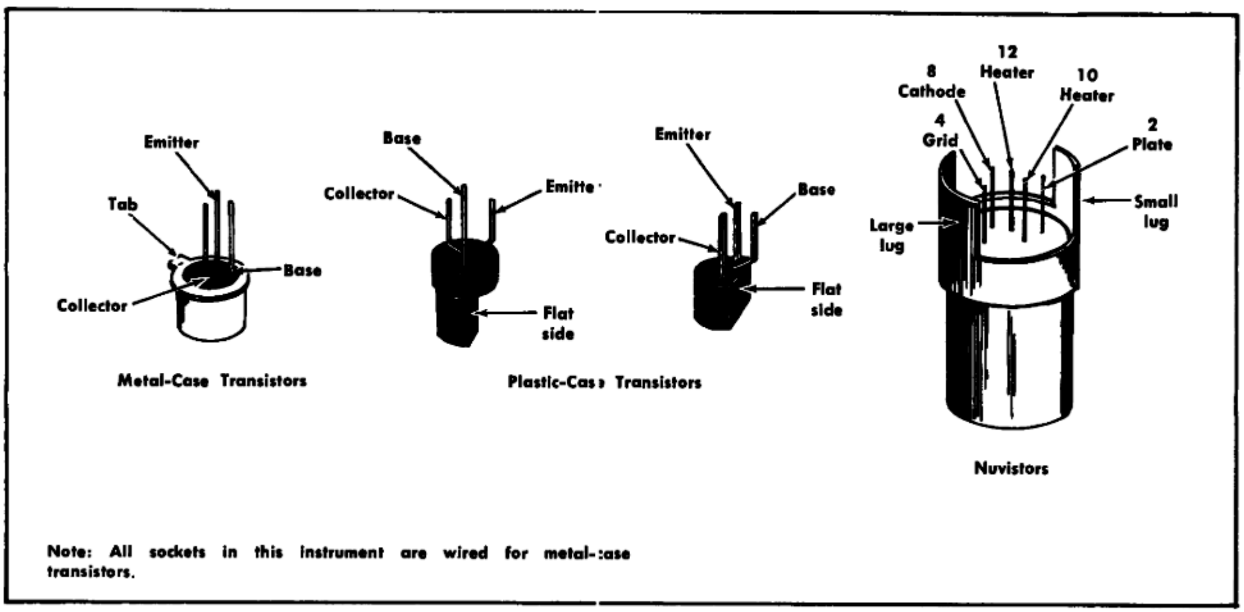


Fig. 4-3. Electrode configuration for transistors and nuvistors in this instrument (as viewed from bottom of transistor or nuvistor)

Glass Reed-Relay Replacement. The glass reed-relays used in this instrument are pressurized. Therefore, safety glasses should be worn to protect the eyes when replacing these relays. To avoid damage to the reed-relays, do not apply stress to the metal-glass bond. When it is necessary to bend a lead, use two pair of long-nose pliers. Before replacing a reed-relay, be sure the actuating circuit is not at fault. See the Troubleshooting procedure for methods of checking the circuit. It is important that the replacement reed-relay be correctly positioned within the drive coil assembly with about the same lead length as the original to provide similar magnetic characteristics.

REMOVAL:

1. Observe the physical position of the leads and glass bulb of the old reed-relay.

2. Cut the leads of the old reed-relay at the bend in the lead. This leaves a solder post for installation of the new reed-relay (those which have three leads already have two solder posts on one end; unsolder the leads from these posts).

3. Pull the old reed-relay out of the drive coil.

REPLACEMENT:

1. Slip the new reed-relay into the drive coil. If the reed-relay has three leads, slip the single lead in first.

2. Position the new reed-relay in exactly the same physical position as the old one.

3. Position the leads correctly and solder the new reed-relay to the solder posts (old reed-relay leads). Avoid excessive heat on the reed-relay; use a heat-sink on the leads if soldering close to the glass body.

4. Clip off the excess lead length beyond the solder posts. Do not clip the leads closer than 1/4 inch from the glass body.

Rotary Switches. Individual wafers or mechanical parts of rotary switches are normally not replaceable. If a switch is defective, replace the entire assembly. Replacement switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

When replacing a switch, tag the leads and switch terminals with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method is to draw a sketch of the switch layout and record the wire color at each terminal. When soldering to the new switch be careful that the solder does not flow beyond the rivets on the switch terminals. Spring tension of the switch contact can be destroyed by excessive solder.

Access to Parts Mounted on Subpanel. Many of the components mounted on the subpanel cannot be reached easily for repair or removal when the instrument is fully

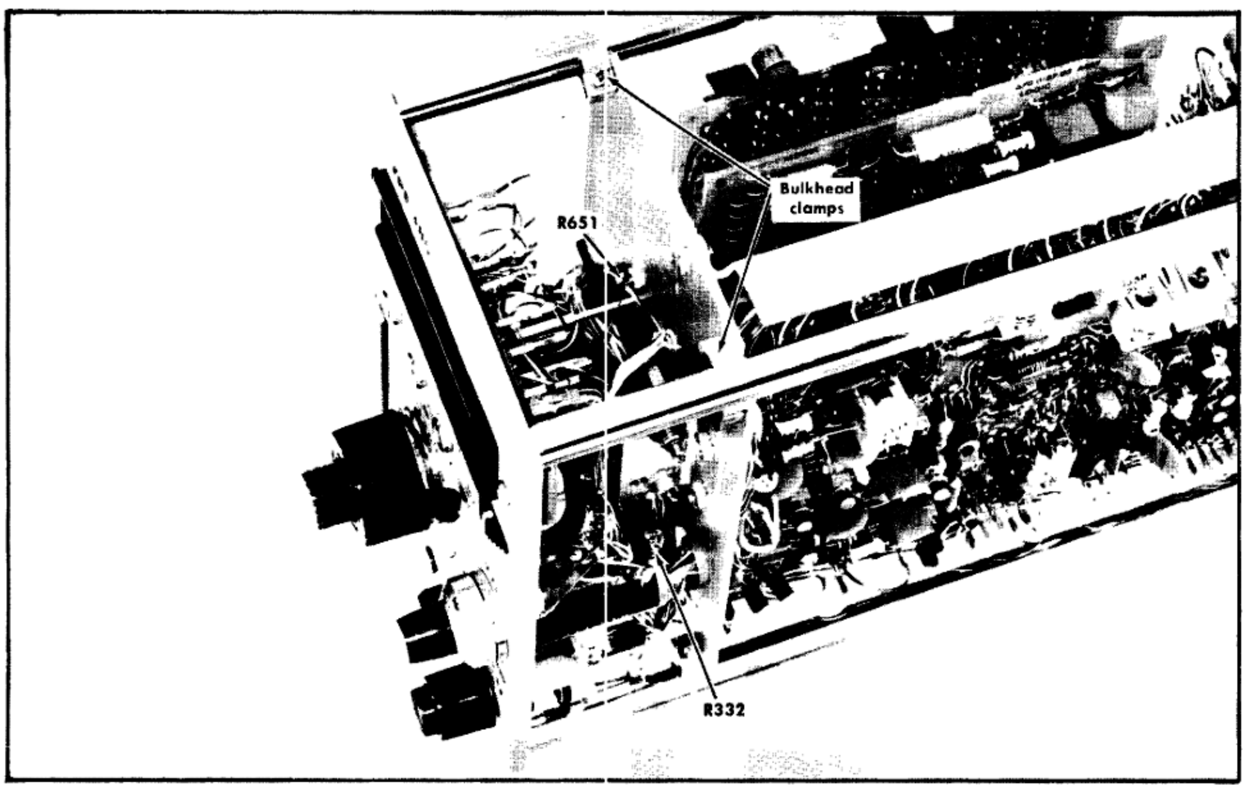


Fig. 4-4. Partial disassembly of the Type 3B5 to allow access to components mounted on the subpanel.

assembled. Better access is provided by partially disassembling the unit as follows:

1. Unsolder one end of R332 and R651 (see Fig. 4-4 for location).

2. Remove the VARIABLE control knob.

3. Loosen the four clamps which hold the center bulkhead to the support rods (see Fig. 4-4).

4. Remove the four screws which hold the rear plate to the support rods.

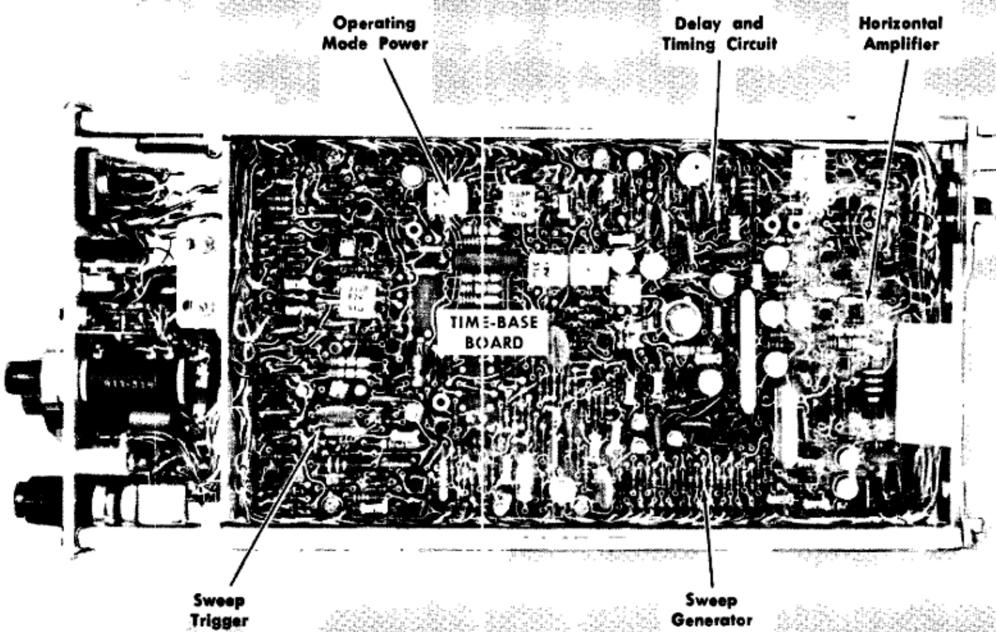
5. Hold the front panel with one hand and slide the entire assembly to the rear as far as the cabling allows.

6. Reverse the order of removal to reassemble the unit. Guide the CAL adjustment extension into the front-panel bushing while pushing the unit together.

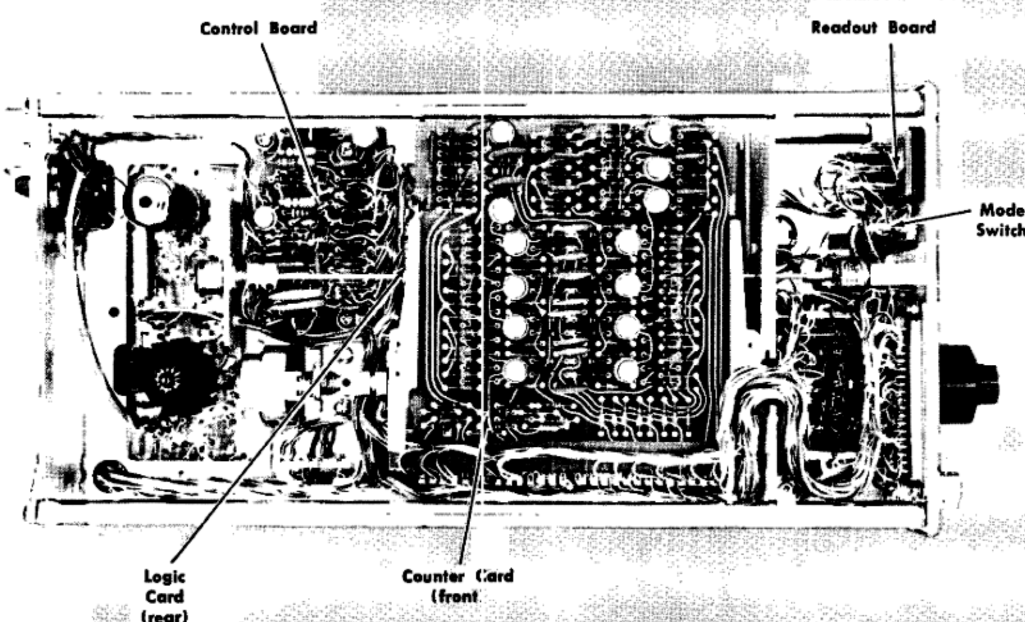
Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. The Performance Check procedure in Section 5 provides a quick and convenient means of checking instrument operation.

NOTES



(A) Right-side view showing general location of individual circuits on Time-Base Board.



(B) Left-side view.

Fig. 4-5. Location of circuit boards (and cards) in the Type 3B5 (see Figs. 4-6 to 4-13 for component location).

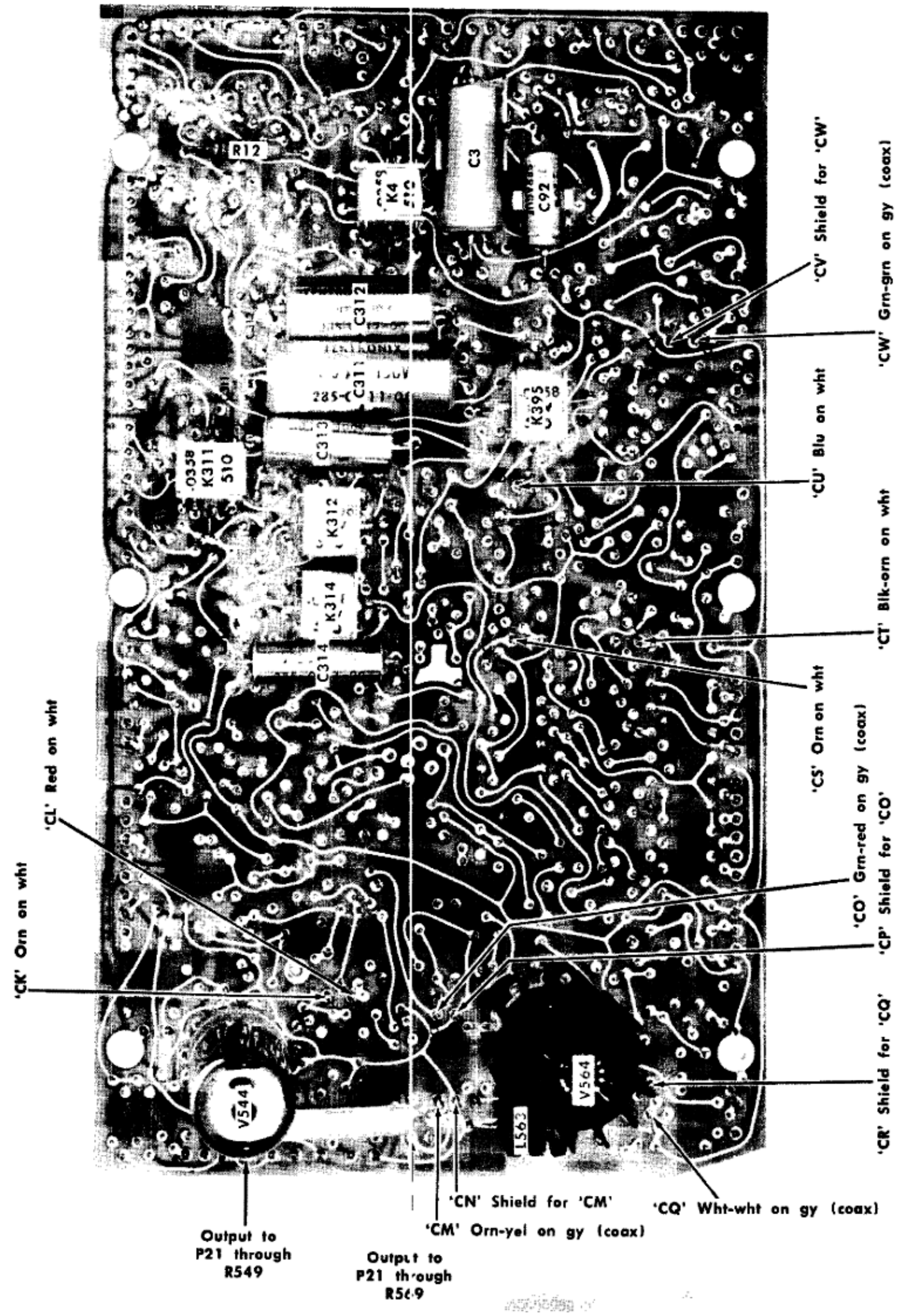


Fig. 4-6. Location of components on rear of Time-Base circuit board

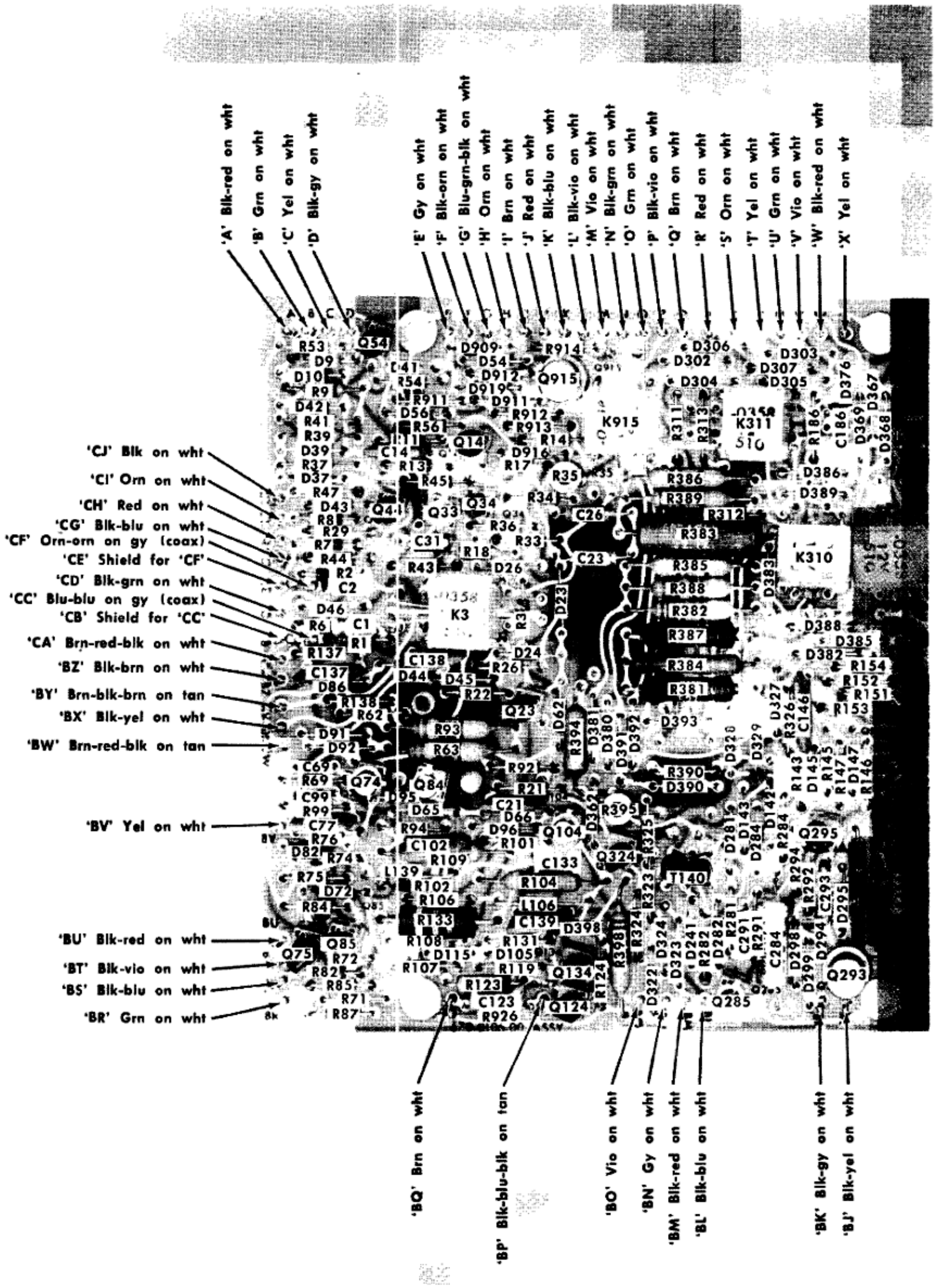


Fig. 4-7. Location of components on Time-Base circuit board (partial). (Sweep Trigger, partial Operating Mode Power and partial Delay and Timing Circuit shown.)

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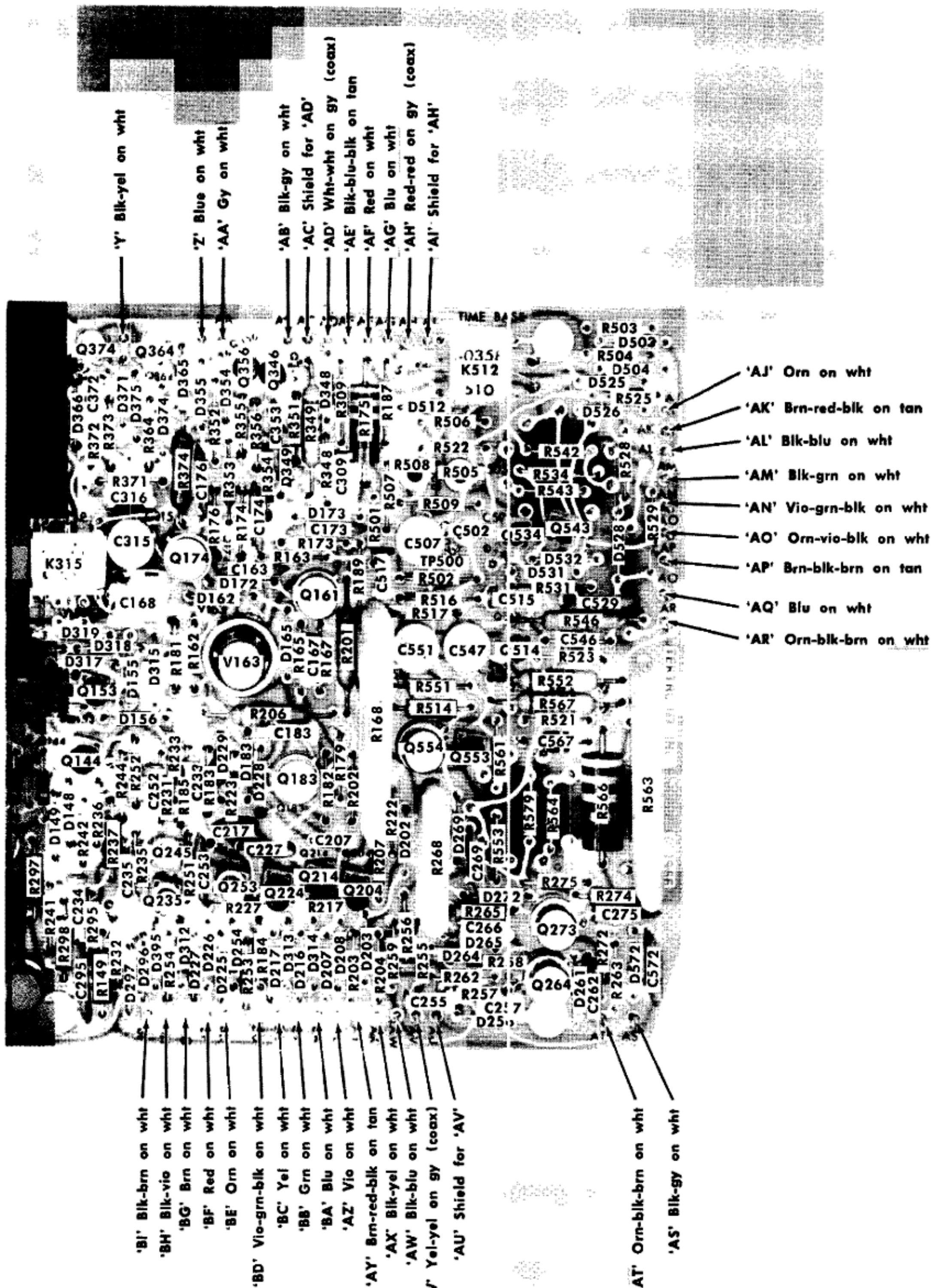

Fig. 4-8. Location of components on Time-Base circuit board (partial). (Partial Delay and Timing Circuit, Sweep Generator and Horizontal Amplifier shown.)

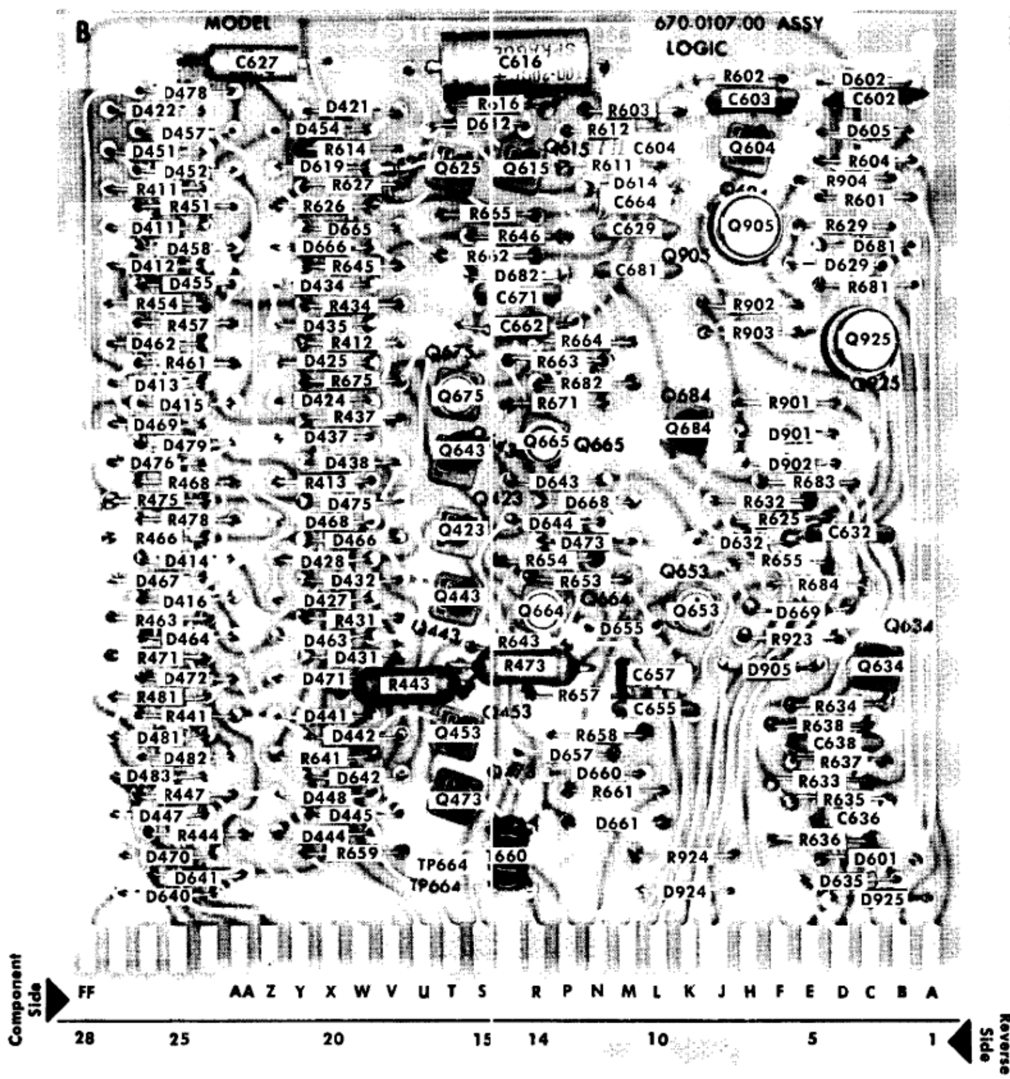

Fig. 4-9. Location of components on Logic Card.

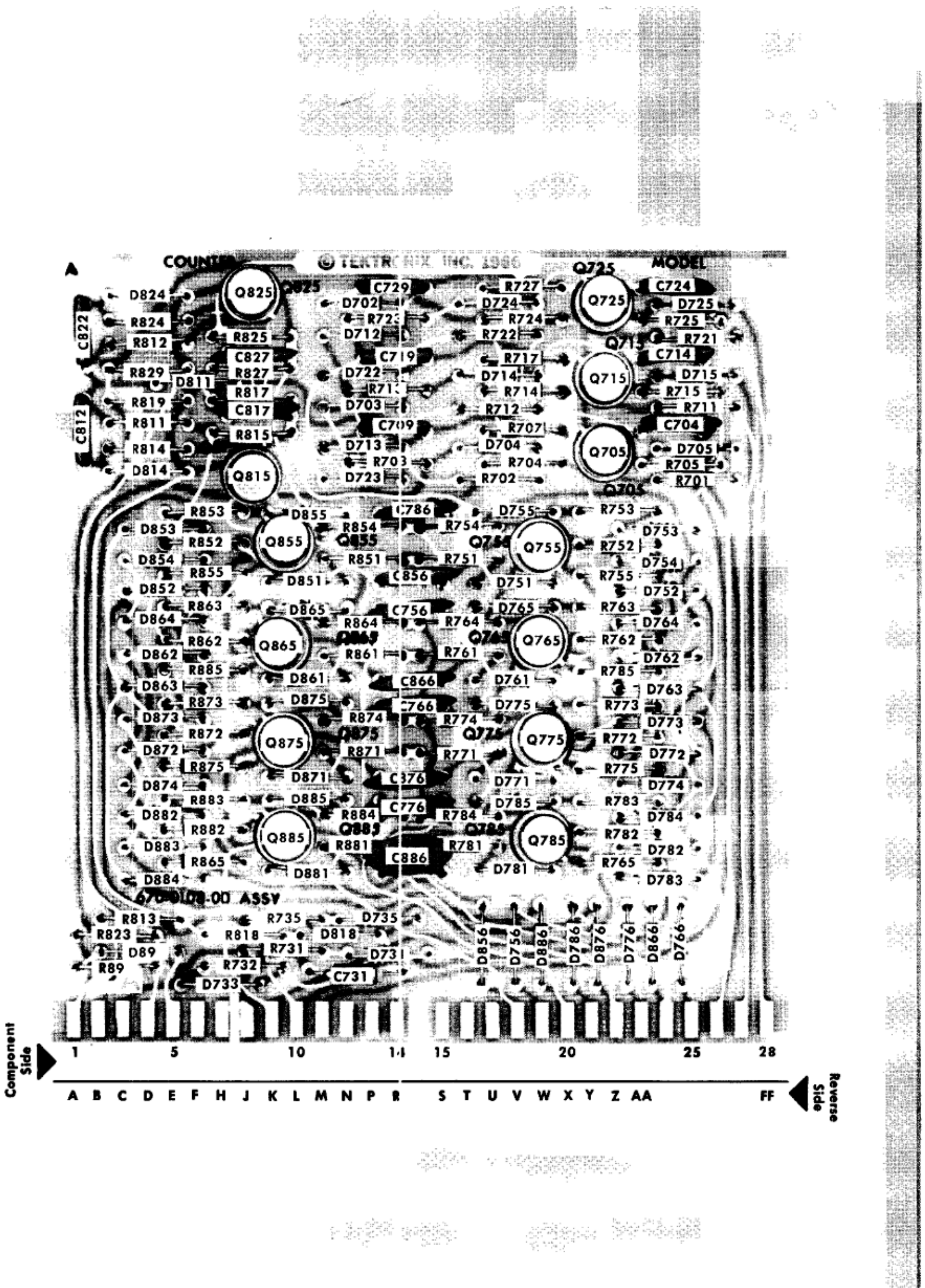

Fig. 4-10. Location of components on Counter Card.

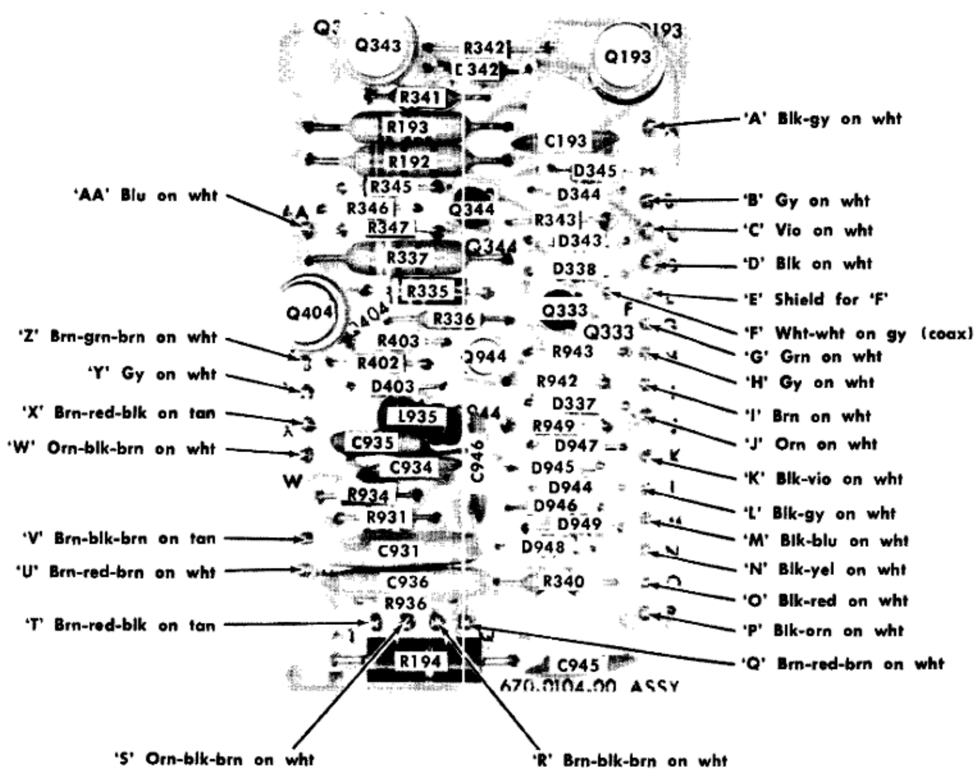

Fig. 4-11. Location of ccmponents on Control Board.

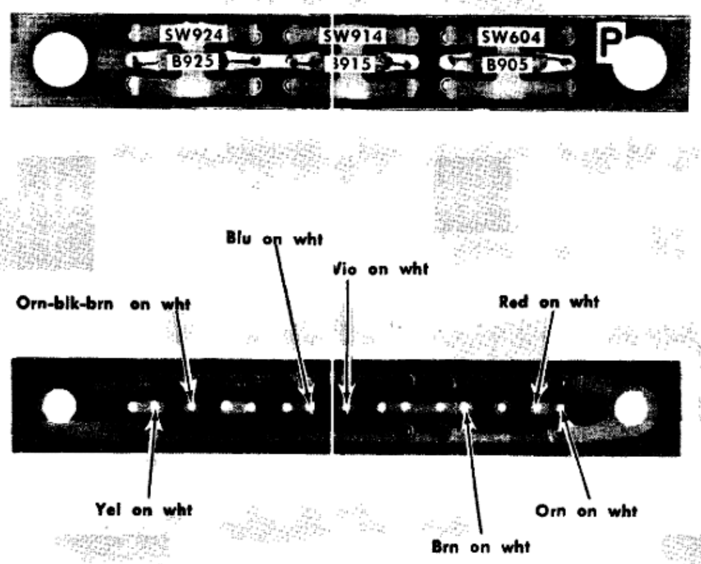

Fig. 4-12. Mode Switch circuit board.

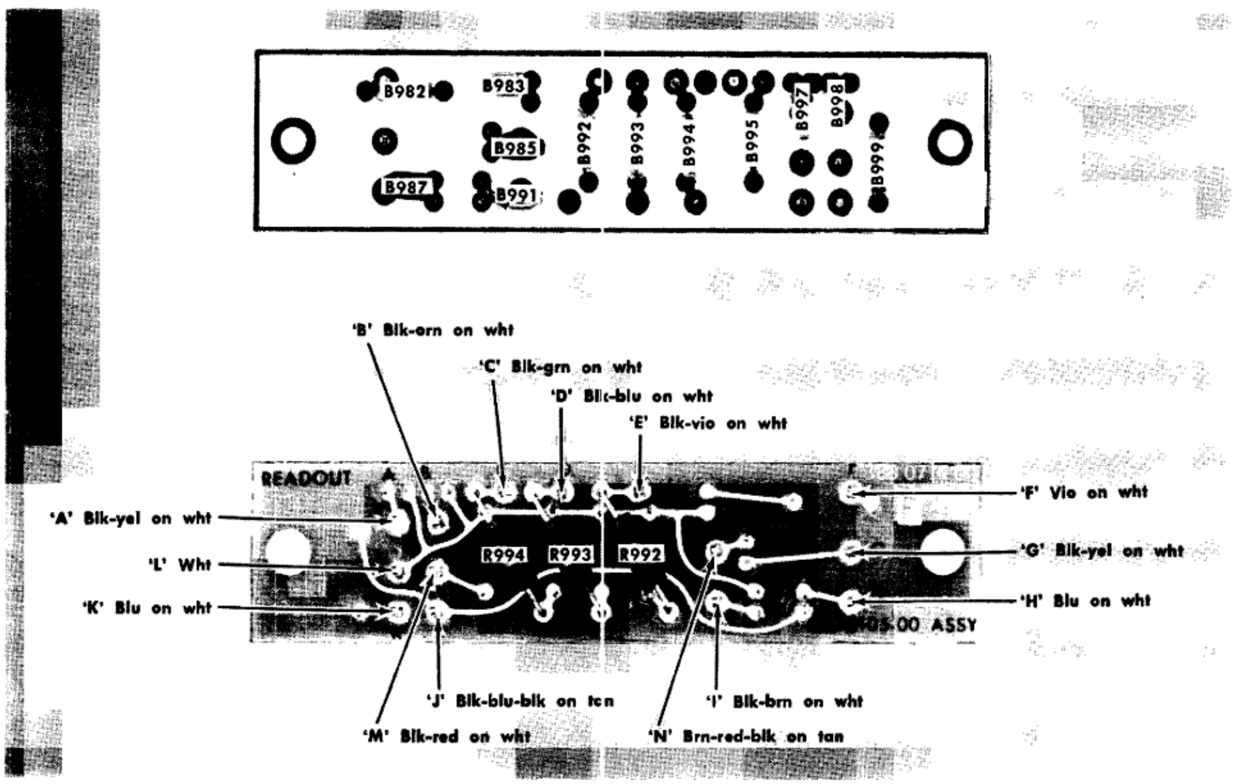

Fig. 4-13. Location of components on Readout Board

NOTES

SECTION 5
PERFORMANCE CHECK

Introduction

This section of the manual provides a procedure for rapidly checking the performance of the Type 3B5. This procedure checks the operation of the instrument without making internal adjustments. However, screwdriver adjustments which are located on the front panel are adjusted in this procedure.

If the instrument does not meet the performance requirements given in this procedure, internal checks and/or adjustments are required. See the Calibration section. All performance requirements given in this section correspond to those given in the Characteristics section.

NOTE

All waveforms shown in this section are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Recommended Equipment

The following equipment is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

1. Indicator oscilloscope. Must be compatible with the Type 3B5 and must be capable of supplying the necessary power. Tektronix Type 561A Oscilloscope recommended.

2. Automatic/programmable amplifier unit. Must be compatible with the indicator oscilloscope and the Type 3B5. (A standard amplifier plug-in unit may be used although some steps may not apply). Tektronix Type 3A5 Automatic/Programmable Amplifier recommended.

3. Remote-seeking probe. Tektronix P6030 recommended.

4. Constant amplitude sine-wave generator. Frequency, 50 kHz and 350 kHz to 20 MHz; output amplitude, 0.5 to 5 volts peak to peak into 50 ohms; amplitude accuracy, within ±3% from 50 kHz to above 20 MHz. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

5. Low-frequency sine-wave generator. Frequency, 10 Hz to 2 MHz; output amplitude, 0.5 to 40 volts peak to peak; amplitude accuracy, within ±3% from 10 Hz to 2 MHz. For example, General Radio 1310-A Oscillator.

6. Time-mark generator. Marker outputs, 5 seconds to 20 nanoseconds; accuracy, within ±0.1%. Tektronix Type 184 Time-Mark Generator recommended.

7. Test oscilloscope system. Frequency response, DC to 25 MHz; minimum deflection factor, 0.05 volts/division (without probe). Tektronix Type 543B Oscilloscope with a Type 1A2 Plug-In Unit and a P6008 10× probe recommended.

8. Cable. Impedance, 50 ohms; type, RG-8A/U; electrical length, five nanoseconds (for use with Type 191); connectors, GR874. Tektronix Part No. 017-0502-00.

9. In-line termination. Impedance, 50 ohms; wattage rating, two watts; accuracy, ±3%; connectors, GR874 input with BNC male output. Tektronix Part No. 017-0083-00.

10. Cable (two). Impedance, 50 ohms; type, RG-58A/U; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-00.

11. Termination. Impedance 50 ohms; accuracy, ±3%; connectors, BNC. Tektronix Part No. 011-0049-00.

12. BNC T connector. Tektronix Part No. 103-0030-00.

13. DC voltmeter. Minimum sensitivity, 20,000 ohms/volt; accuracy, within ±3% at −12, −100 and +125 volts; range zero to 150 volts. For example, Simpson Model 262.

14. Adapter. Connectors, BNC female and two alligator clips. Tektronix Part No. 013-0076-00.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, control settings or test equipment connections should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information. Type 3B5 front-panel control titles referred to in this procedure are capitalized (e.g., MANUAL TIME/DIV).

The following procedure uses the equipment listed under Recommended Equipment. If equipment is substituted, control settings or setup may need to be altered to meet the requirements of the equipment used.

Preliminary Procedure

1. Connect the indicator oscilloscope to a power source which meets its voltage and frequency requirements.

2. Insert the amplifier unit into the left (vertical) plug-in compartment.

3. Insert the Type 3B5 into the right (horizontal) plug-in compartment.

4. Set the front-panel controls as follows:

Control Settings

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	1.00
MANUAL TIME/DIV	.5 ms

VARIABLE	CAL
Trigger Function	EXT-AC
LEVEL	Midrange
SLOPE	+

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	10 Volts
Mode	Manual

Indicator Oscilloscope

Focus	See step 1
Intensity	See step 1
Calibrator	10 Volts
Power	On

5. Set the indicator oscilloscope power switch to on. Allow at least five minutes warm up at 25° C, ±5°, for checking the instrument to the given accuracy.

1. Check Trigger Level Centering

REQUIREMENTS— + and —20 volt sine-wave signal centered within the LEVEL control range (EXT-AC).

a. Connect the low-frequency sine-wave generator to the amplifier unit input connector through the BNC cable and the BNC T connector (use the BNC to alligator clips adapter to connect the generator ouput to the BNC cable). Connect the output of the BNC T connector to the Type 3B5 EXT TRIG INPUT connector with a BNC cable.

b. Set the low-frequency sine-wave generator for a four-division CRT display (40 volts peak to peak) at one kilohertz.

c. Set the indicator oscilloscope intensity control for a visible display.

d. Set the indicator oscilloscope focus control for a focused display.

e. Turn the LEVEL control fully counterclockwise.

f. ADJUST—TRIG LEVEL CENTERING adjustment, R15 (on front panel), to setting where unit does not trigger (no trace and NOT TRIG'D readout on) for both + and — slope.

g. Turn the LEVEL control fully clockwise.

h. ADJUST—TRIG LEVEL CENTERING adjustment, R15, to setting where unit does not trigger for both + and — slope triggering. Then, set the adjustment midway between the setting obtained in step f for this setting

i. Recheck steps e through h and readjust if necessary. The display must not be triggered (no trace) at either end of rotation for both + and — slope triggering when correctly adjusted. (This step also checks EXT-AC trigger LEVEL range for at least + and — 20 volts.)

2. Check Trigger Level Control Range

REQUIREMENT—EXT-AC, checked as part of step 1; EXT-DC, at least + and — 10 volts.

a. Set the LEVEL control to midrange.

b. Set the low-frequency sine-wave generator for a two-division CRT display (20 volts peak to peak) at one kilohertz.

c. Set the Trigger Function switch to EXT-DC.

d. CHECK—NOT TRIG'D readout off (unit triggered).

e. Turn the LEVEL control fully counterclockwise.

f. CHECK—CRT display not triggered (no trace) and the NOT TRIG'D readout is on for both + and — slope triggering (indicates at least —10 volt LEVEL control range).

g. Turn the LEVEL control fully clockwise.

h. CHECK—CRT display not triggered and the NOT TRIG'D readout is on for both + and — slope triggering (indicates at least +10 volt LEVEL control range).

3. Check Auto Trigger Centering

REQUIREMENT—Stable auto triggering on a 0.5-division display throughout the rotation of the LEVEL control.

a. Change the following control settings:

Trigger Function	INT-AUTO
LEVEL	Midrange
Volts/Division (amplifier unit)	1 Volt

b. Set the low-frequency sine-wave generator for a 0.5-division CRT display (0.5 volt peak to peak) at one kilohertz.

c. Turn the LEVEL control fully counterclockwise.

d. CHECK—Stable CRT display for both + and — slope triggering. Auto Trigger light must be on.

e. Turn the LEVEL control fully clockwise.

f. CHECK—Stable CRT display for both + and — slope triggering.

4. Check Low-Frequency Triggering Operation

REQUIREMENT—Correct triggering with minimum deflection or minimum input voltage in all positions of the Trigger Function switch.

a. Change the following control settings:

MANUAL TIME/DIV	20 ms
Trigger Function	EXT-AC
LEVEL	Midrange
SLOPE	+

b. Set the low-frequency sine-wave generator for a one-division CRT display (one volt peak to peak) at 50 hertz.

c. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

d. Set the Trigger Function switch to EXT-DC.

e. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

f. Without changing the output amplitude, set the low-frequency sine-wave generator to 10 hertz.

g. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

h. Set the Trigger Function switch to INT-AC.

i. Set the low-frequency sine-wave generator for a 0.5 division CRT display (0.5 volt peak to peak) at 50 hertz.

j. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

k. Set the Trigger Function switch to INT-AUTO.

l. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering throughout the complete rotation of the LEVEL control.

5. Check Trigger Slope Operation and Coupling

REQUIREMENT—Stable triggering on correct slope of input signal and indication of correct trigger coupling.

a. Connect the indicator oscilloscope calibrator output to the amplifier unit input connector and the EXT TRIG INPUT connector with the BNC T connector and two BNC cables.

b. Change the following control settings:

MANUAL TIME/DIV	2 ms
LEVEL	Midrange
Trigger Function	INT-AUTO
Volts/Division (amplifier unit)	2 Volts

c. If the + slope light is not on, press the CHANGE SLOPE button.

d. CHECK—CRT display starts on the positive slope of the signal (see Fig. 5-1) and the + slope light is on.

e. Press the CHANGE SLOPE button.

f. CHECK—CRT display starts on the negative slope of the signal (see Fig. 5-1) and the — slope light is on.

g. Set the Trigger Function switch to EXT-DC.

h. Press the CHANGE SLOPE button to provide + slope triggering.

i. Turn the LEVEL control clockwise until the display is not triggered (NOT TRIG'D readout on). Then turn the LEVEL control counterclockwise slightly until the CRT display is stable.

j. Without changing the LEVEL control setting, set the Trigger Function switch to EXT-AC.

k. CHECK—NOT TRIG'D readout comes on to indicate that unit is not correctly triggered. This check indicates that the trigger circuit has blocked the DC level of the calibrator signal to AC couple the trigger signal to the trigger circuit.

l. Disconnect all test equipment.

6. Check High-Frequency Triggering Operation

REQUIREMENT—Correct triggering at 50 kilohertz and 20 megahertz with minimum deflection or minimum input voltage in all positions of Trigger Function switch.

a. Change the following control settings:

MANUAL TIME/DIV	20 ms
Trigger Function	INT-AC
SLOPE	+
Volts/Division (amplifier unit)	1 Volt

b. Connect the constant-amplitude sine-wave generator to the amplifier unit input connector through the five-nanosecond GR cable, 50-ohm in-line termination and the BNC T connector. Connect the output of the BNC T connector to the Type 3B5 EXT TRIG INPUT connector with a 50-ohm BNC cable.

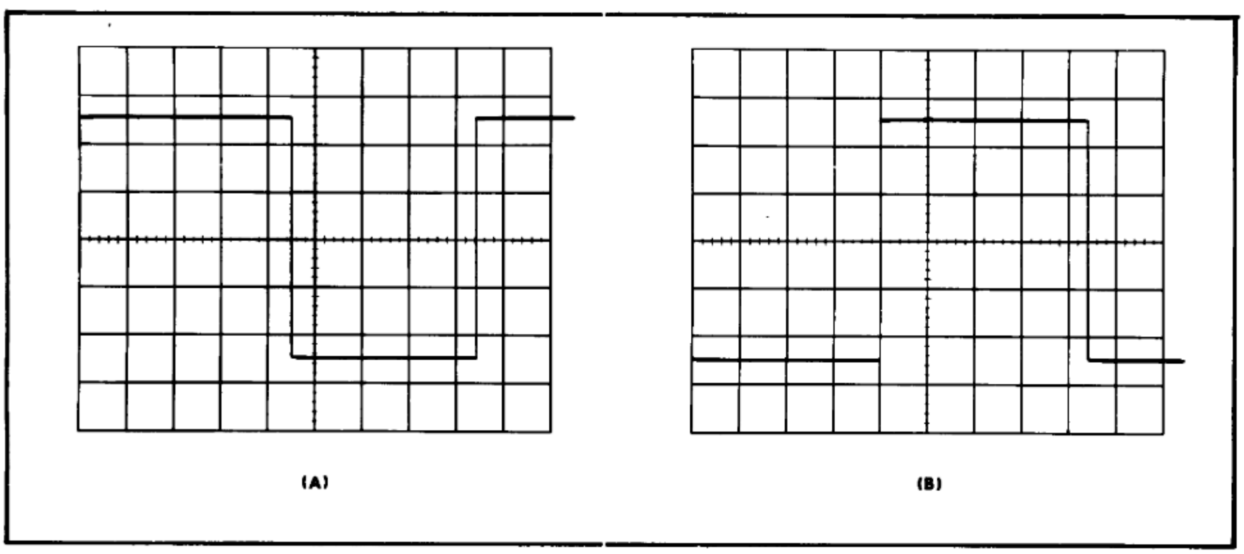

Fig. 5-1. Typical CRT display when checking trigger slope operation. (A) + slope; (B) — slope.

c. Set the constant-amplitude generator for a 0.5-division CRT display (0.5 volt peak to peak) at 50 kilohertz.

d. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

e. Set the constant-amplitude generator for a 0.5 division display at 20 megahertz (this check can be made only with an amplifier unit which has a bandpass of at least 15 MHz).

f. Set the MANUAL TIME/DIV switch to .1 μs.

g. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

h. Set the Trigger Function switch to INT-AUTO.

i. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering. The Auto Trigger light must be on.

j. Set the Trigger Function switch to EXT-AC.

k. Set the constant-amplitude generator for a one-division CRT display (one volt peak to peak) at 50 kilohertz.

l. Set the MANUAL TIME/DIV switch to 20 μs.

m. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

n. Set the Trigger Function switch to EXT-DC.

o. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

p. Without changing the output amplitude, set the constant-amplitude generator to 20 megahertz.

q. Set the MANUAL TIME/DIV switch to .1 μs.

r. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

s. Set the Trigger Function switch to EXT-AC.

t. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

u. Disconnect all test equipment.

7. Check Basic Timing

REQUIREMENT—Correct timing at 1 ms/DIV.

a. Change the following control settings:

MANUAL TIME/DIV	1 ms
Trigger Function	INT-AUTO
LEVEL	Midrange
SLOPE	+
Volts/Division (amplifier unit)	0.5 Volt

b. Connect the time-mark generator to the amplifier unit input connector through the 50-ohm BNC cable and a 50-ohm BNC termination.

c. Set the time-mark generator for one millisecond markers.

d. Position the second marker to the first graticule line with the POSITION control.

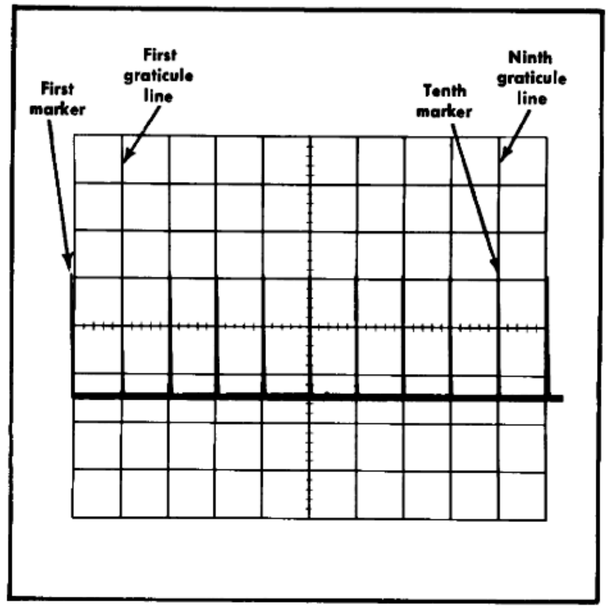

Fig. 5-2. Typical CRT display showing correct basic timing.

e. CHECK—CRT display for one marker each division between the first and ninth vertical graticule lines (see Fig. 5-2).

NOTE

Unless otherwise noted, use the middle eight horizontal divisions when checking timing (see Fig. 2-4, Operating Instructions section).

f. ADJUST—CAL adjustment, R515 (on front-panel), for one marker each division. (This adjustment should be checked and readjusted as necessary when the Type 3B5 is inserted into a plug-in compartment other than the one in which it was calibrated.)

8. Check Variable Control Range

REQUIREMENT—At least 2.5:1.

a. Set the time-mark generator for 10-millisecond markers.

b. Position the markers to the far left and right vertical graticule lines with the POSITION control.

c. Turn the VARIABLE control fully counterclockwise.

d. CHECK—CRT display for four-division maximum spacing between markers (2.5:1 range, see Fig. 5-3). UNCAL readout must come on and s/DIV readout must be off when VARIABLE control is out of the CAL position.

e. Return the VARIABLE control to the CAL position.

9. Check Sweep Length

REQUIREMENT—Normal sweep, 10.3 to 11.3 divisions; magnified sweep, 12 to 15 divisions.

Ⓐ

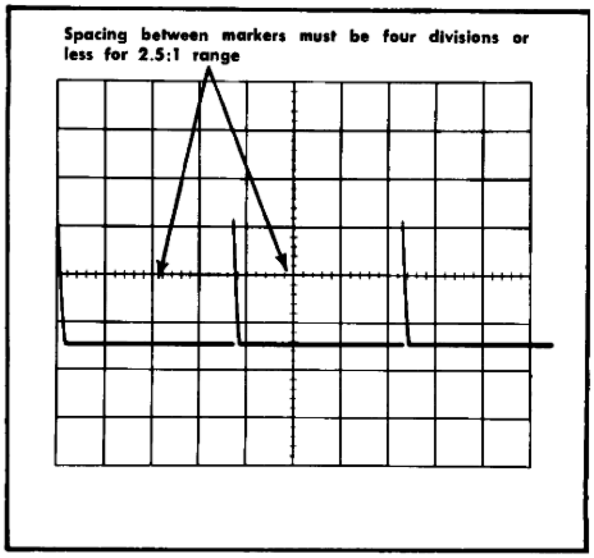

Fig. 5-3. Typical CRT display when checking VARIABLE control range

a. Set the time-mark generator for one-millisecond and 0.1-millisecond marker output.

b. Position the eleventh one-millisecond marker to the center vertical line with the POSITION control.

c. CHECK—CRT display for sweep length between 10.3 and 11.3 divisions as shown by 0.3 to 1.3 divisions of display to the right of the center vertical line (see Fig. 5-4A). Large markers in the display indicate divisions and small markers indicate 0.1 division (unmagnified only).

d. Set the DLY'D SWP MAG switch to ×10.

e. CHECK—CRT display for sweep length between 12 and 15 divisions as shown by two to five divisions of display to the right of the center vertical line (see Fig. 5-4B).

f. Set the DLY'D SWP MAG switch to ×100.

g. CHECK—CRT display shows same sweep length as in step e.

10. Check Delay Dial Accuracy

REQUIREMENT—Within ±1.5% of full scale at 1 ms/DIV; within ±3% of full scale at all other sweep rates (includes incremental linearity).

NOTE

See Section 6, steps 10 and 11 for verification of DELAY dial incremental linearity.

a. Set the time-mark generator for one-millisecond markers.

b. Set the DELAY dial to 1.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the second marker (see Fig. 5-5).

c. CHECK—DELAY dial setting 1.00, ±7.5 minor dial divisions (±1.5% of full scale).

d. Repeat this check at each major dial division between 2.00 and 9.00. Check for ±7.5 minor dial divisions, or less, deviation between the major dial divisions and the dial setting which produces the correct display.

e. Set the MANUAL TIME/DIV switch to 2 ms (sweep readout 20 μs/DIV).

f. CHECK—Set the DELAY dial to each major dial division between 1.00 and 9.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the applicable marker (two markers/division). Check for ±15 minor dial divisions, or less deviation between the major dial divisions and the dial setting which produces the correct display (±3% of full scale).

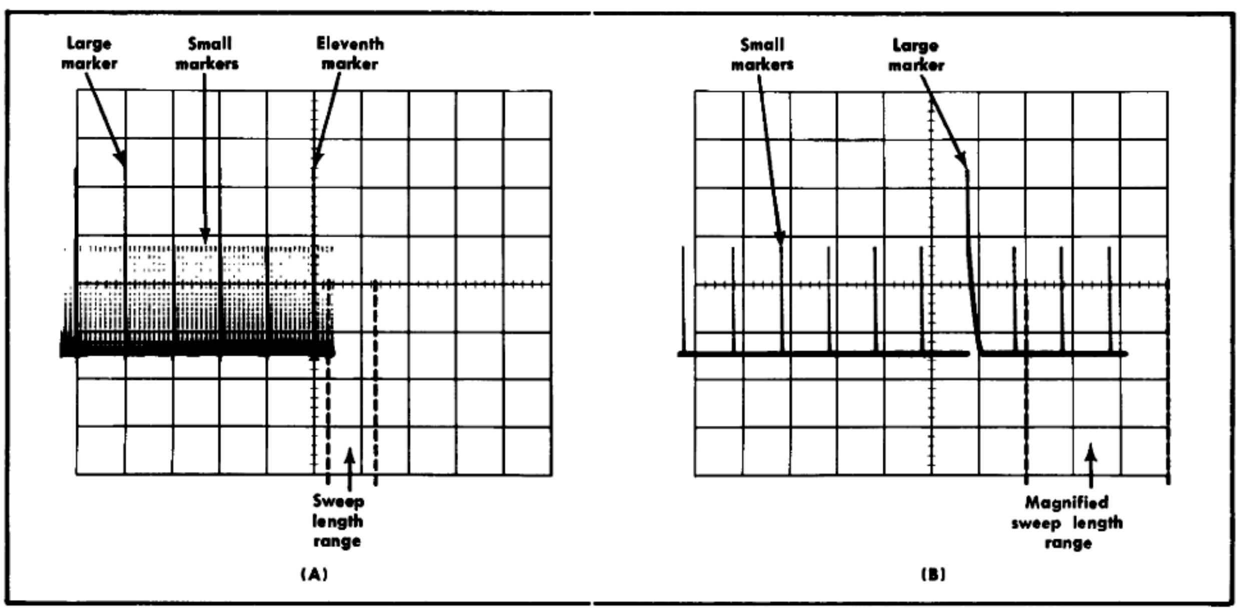

Fig. 5-4. Typical CRT display when checking sweep length. (A) Unmagnified, (B) ×10 magnification.

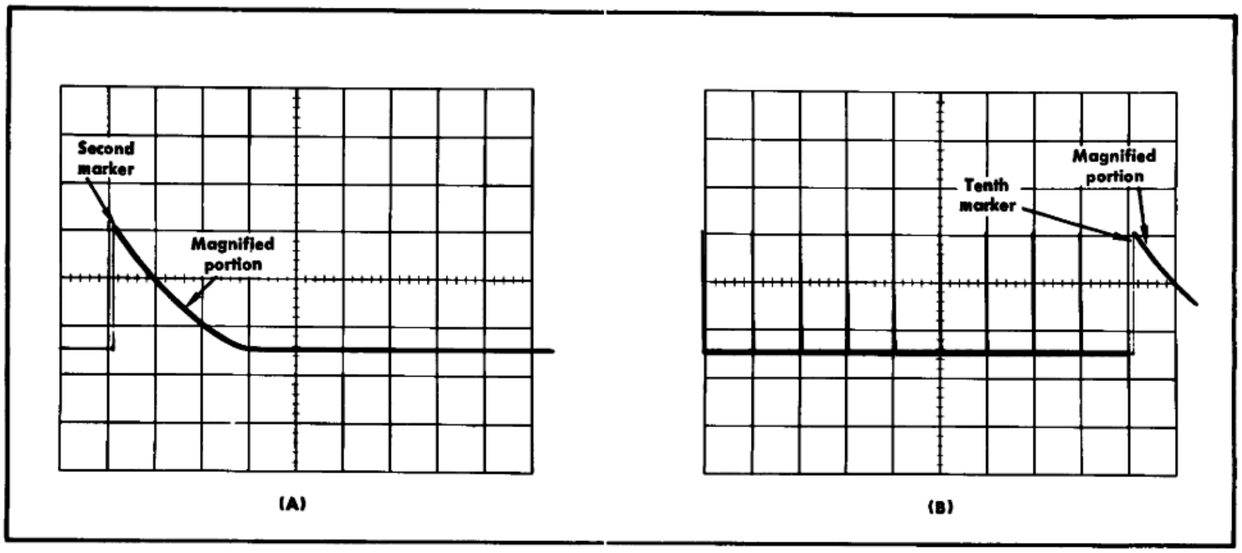

Fig. 5-5. Typical CRT display showing correct position of the magnified portion. (A) DELAY dial near 1.00, (B) DELAY dial near 9.00.

g. Set the MANUAL TIME/DIV switch to 5 ms (sweep readout 50 μs/DIV).

h. Set the time-mark generator for five-millisecond markers.

i. CHECK—Set the DELAY dial to each major dial division between 1.00 and 9.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the applicable marker. Check for ±15 minor dial divisions, or less, deviation between the major dial division and the dial setting which produces the correct display (±3% of full scale).

11. Check Delayed Sweep Magnifier Jitter

REQUIREMENT—3 parts or less per 10,000.

a. Set the time-mark generator for one-millisecond markers.

b. Set the MANUAL TIME/DIV switch to 1 ms.

c. Set the DELAY dial to 1.00 and then rotate the dial as necessary to position the magnified second marker to the center vertical line.

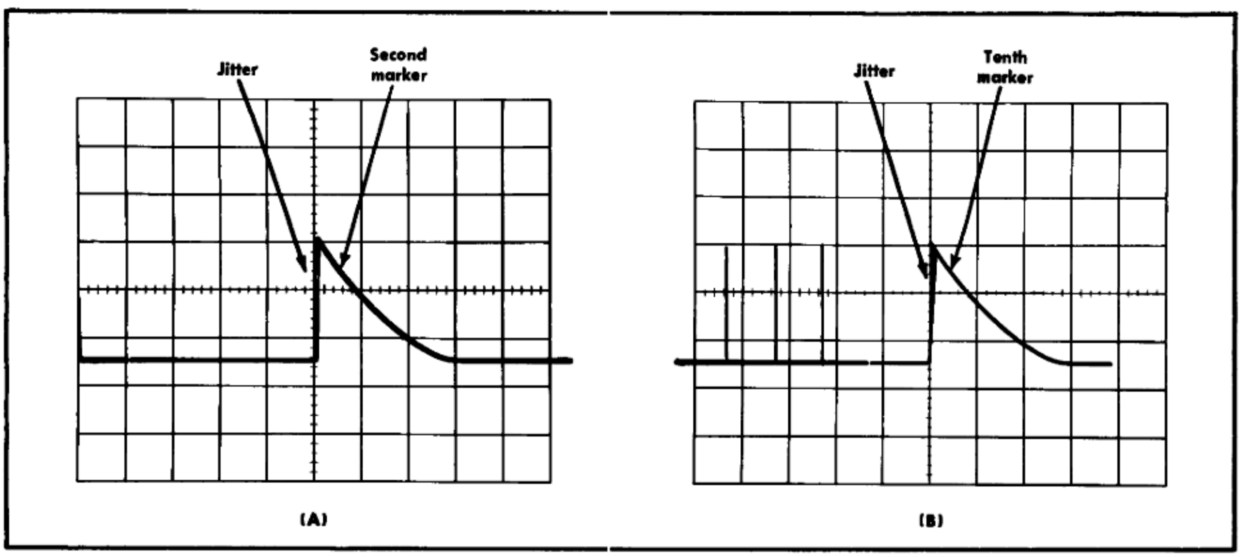

Fig. 5-6. Typical CRT display showing delayed magnifier jitter. (A) DELAY dial near 1.00, (B) DELAY dial near 9.00.

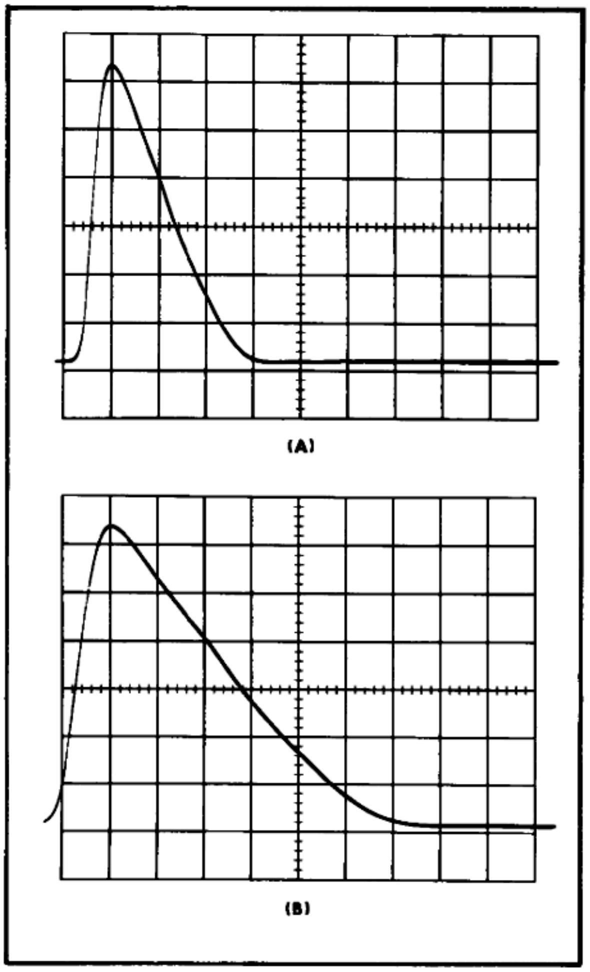

Fig. 5-7. Typical CRT display showing correct registration. (A) MANUAL TIME/DIV switch set to .1 μs; (B) MANUAL TIME/DIV switch set to 50 ns.

d. CHECK—Jitter on the leading edge of the magnified marker does not exceed 0.3 division (3 parts or less per 10,000; see Fig. 5-6A). Ignore slow drift.

e. Set the Delay dial to 9.00 and then rotate the dial and POSITION control to move the magnified tenth marker to the center vertical line.

f. CHECK—Jitter on the leading edge of the magnified marker does not exceed 0.3 division (3 parts or less per 10,000; see Fig. 5-6B).

12. Check Registration

REQUIREMENT—Less than one division shift when changing from 0.1 μs/DIV to 50 ns/DIV.

a. Change the following control settings:

MANUAL TIME/DIV	.1 μs
Trigger Function	INT-AC
LEVEL	Triggered display
Volts/Division (amplifier unit)	0.2 Volts

b. Set the time-mark generator for five-microsecond markers.

c. Move the marker to the first graticule line with the POSITION control (see Fig. 5-7A).

d. Set the MANUAL TIME/DIV switch to 50 ns.

e. CHECK—Marker should remain within ±1 division of the first graticule line (see Fig. 5-7B).

13. Check Normal and Magnified Timing Accuracy

REQUIREMENT—Normal sweep: 1 s to 10 ns, within ±3% with correct readout-panel indication; 5 s and 2 s, within ±5% with correct readout-panel indication.

a. Connect the time-mark generator trigger output connector to the EXT TRIG INPUT connector with a 50-ohm BNC cable.

b. Change the following control settings:

DELAY	0.00
MANUAL TIME/DIV	10 μs
Trigger Function	EXT-DC
LEVEL	Stable display

c. Move the start of the trace to the left vertical graticule line with the POSITION control.

d. Set the time-mark generator for 20-nanosecond markers (this check can be made only with an amplifier unit which has a bandpass of at least 15 MHz).

e. Set the MANUAL TIME/DIV switch to 10 ns.

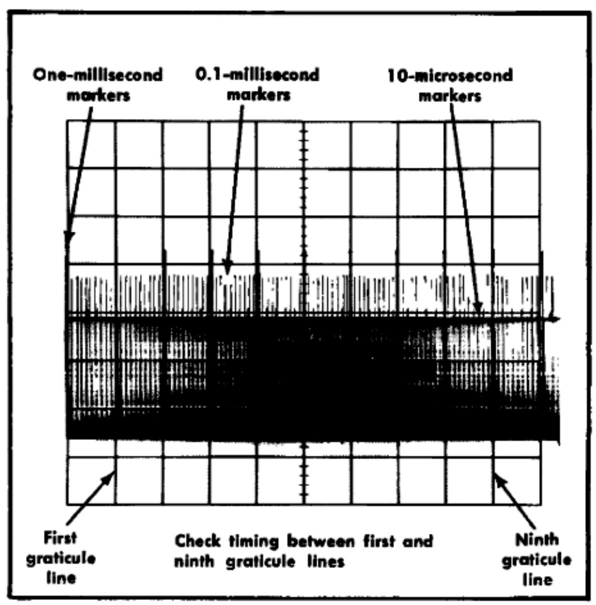

Fig. 5-8. Typical CRT display when checking timing accuracy (1 μs to 50 ms). Waveform shown was taken with MANUAL TIME/DIV switch set at 1 ms and DLY'D SWP MAG switch set to OFF.

f. Move the nearest marker to the vertical graticule line.

g. CHECK—Normal and magnified timing accuracy and correct readout-panel indications in all positions of the MANUAL TIME/DIV switch. Switch settings, time-mark generator output, readout-panel indications and tolerances are given in Table 5-1. First, check timing and readout with the DLY'D SWP MAG switch at OFF, then at ×10 and ×100 (readjust LEVEL control as necessary to maintain a stable

TABLE 5-1

TIMING CHECK (Normal and Magnified)

MANUAL TIME/DIV Switch Setting	Time-Mark Generator Output		Readout-Panel Indication With DLY'D SWP MAG Switch Set At			CRT Display (Markers/ Division)	Accuracy (measured between first and ninth graticule lines; see Fig. 5-8)
	Markers	Trigger	OFF	×10	×100		
10 ns	20 ns	1 μs	10 mμs/DIV	10 mμs/DIV	10 mμs/DIV	1 marker/ 2 divisions	±3% (±0.24 div)[1]
20 ns	20 ns	1 μs	20 mμs/DIV	20 mμs/DIV	20 mμs/DIV	1	±3%[1]
50 ns	50 ns	1 μs	50 mμs/DIV	50 mμs/DIV	50 mμs/DIV	1	±3%[1]
.1 μs	0.1 μs	1 μs	.1 μs/DIV	.1 μs/DIV	.1 μs/DIV	1	±3%
.2 μs	0.1 μs	1 μs	.2 μs/DIV	.2 μs/DIV	.2 μs/DIV	2	±3%
.5 μs	0.5 μs	1 μs	.5 μs/DIV	.5 μs/DIV	.5 μs/DIV	1	±3%
1 μs	1 μs, 0.1 μs	1 μs	1 μs/DIV	.1 μs/DIV	.1 μs/DIV	1	±3%
2 μs	1 μs, 0.1 μs	1 μs	2 μs/DIV	.2 μs/DIV	.2 μs/DIV	2	±3%
5 μs	5 μs, 0.5 μs	1 μs	5 μs/DIV	.5 μs/DIV	.5 μs/DIV	1	±3%
10 μs	10 μs, 1 μs, 0.1 μs	10 μs	10 μs/DIV	1 μs/DIV	.1 μs/DIV	1	±3%
20 μs	10 μs, 1 μs, 0.1 μs	10 μs	20 μs/DIV	2 μs/DIV	.2 μs/DIV	2	±3%
50 μs	50 μs, 5 μs, 0.5 μs	10 μs	50 μs/DIV	5 μs/DIV	.5 μs/DIV	1	±3%
.1 ms	0.1 ms, 10 μs, 1 μs	0.1 ms	.1 ms/DIV	10 μs/DIV	1 μs/DIV	1	±3%
.2 ms	0.1 ms, 10 μs, 1 μs	0.1 ms	.2 ms/DIV	20 μs/DIV	2 μs/DIV	2	±3%
.5 ms	0.5 ms, 50 μs, 5 μs	0.1 ms	.5 ms/DIV	50 μs/DIV	5 μs/DIV	1	±3%
1 ms	1 ms, 0.1 ms, 10 μs	1 ms	1 ms/DIV	0.1 ms/DIV	10 μs/DIV	1	±3%
2 ms	1 ms, 0.1 ms, 10 μs	1 ms	2 ms/DIV	0.2 ms/DIV	20 μs/DIV	2	±3%
5 ms	5 ms, 0.5 ms, 50 μs	1 ms	5 ms/DIV	0.5 ms/DIV	50 μs/DIV	1	±3%
10 ms	10 ms, 1 ms, 0.1 ms	10 ms	10 ms/DIV	1 ms/DIV	.1 ms/DIV	1	±3%
20 ms	10 ms, 1 ms, 0.1 ms	10 ms	20 ms/DIV	2 ms/DIV	.2 ms/DIV	2	±3%
50 ms	50 ms, 5 ms, 0.5 ms	10 ms	50 ms/DIV	5 ms/DIV	.5 ms/DIV	1	±3%
.1 s (OFF)	0.1 s	.1 s	.1 s/DIV	- -	- -	1	±3%
.1 s (×10)	10 ms	10 ms	- -	10 ms/DIV	- -	1	±3%
.1 s (×100)	1 ms	10 ms	- -	- -	1 ms/DIV	1	±3%
.2 s (OFF)	0.1 s	0.1 s	.2 s/DIV	- -	- -	2	±3%
.2 s (×10)	10 ms	10 ms	- -	20 ms/DIV	- -	2	±3%
.2 s (×100)	1 ms	10 ms	- -	- -	2 ms/DIV	2	±3%
.5 s (OFF)	0.5 s	1 s	.5 s/DIV	- -	- -	1	±3%
.5 s (×10)	50 ms	0.1 s	- -	50 ms/DIV	- -	1	±3%
.5 s (×100)	5 ms	0.1 s	- -	- -	5 ms/DIV	1	±3%
1 s (OFF)	1 s	1 s	1 s/DIV	- -	- -	1	±3%
1 s (×10)	0.1 s	0.1 s	- -	0.1 s/DIV	- -	1	±3%
1 s (×100)	10 ms	0.1 s	- -	- -	10 ms/DIV	1	±3%
2 s (OFF)	1 s	1 s	2 s/DIV	- -	- -	2	±5% (±0.4 div)
2 s (×10)	0.1 s	0.1 s	- -	0.2 s/DIV	- -	2	±5%
2 s (×100)	10 ms	0.1 s	- -	- -	20 ms/DIV	2	±5%
5 s (OFF)	5 s	1 s	5 s/DIV	- -	- -	1	±5%
5 s (×10)	0.5 s	0.1 s	- -	0.5 s/DIV	- -	1	±5%
5 s (×100)	50 ms	0.1 s	- -	- -	50 ms/DIV	1	±5%

[1]10, 20 and 50 ns accuracy applies only when checked according to procedure.

display. Also check that the MAG'D SWP readout is on when the DLY'D SWP MAG switch is set to ×10 or ×100. Check timing accuracy between the first and ninth graticule lines. A typical CRT display is shown in Fig. 5-8.

CAUTION

To prevent permanent damage to the CRT phosphor, either reduce the trace intensity at slow sweep rates to a level which does not produce a halo around the spot or position the baseline of the marker display below the viewing area.

h. Disconnect the trigger cable.

14. Check Operating Mode

REQUIREMENT—Instrument operates correctly in the mode selected by the EXT, MAN and SEEK buttons.

a. Change the following control settings:

DLY'D SWP MAG	OFF
MANUAL TIME/DIV	1 ms
Trigger Function	INT-AUTO
Volts/Division (amplifier unit)	0.5 Volts

b. Connect the time-mark generator to the amplifier unit input connector through a 50-ohm BNC cable and a 50-ohm BNC termination.

c. Set the time-mark generator for one-millisecond markers.

d. Press the SEEK button.

e. CHECK—SEEK button lights and a stable display is presented

f. Press the EXT button momentarily.

g. CHECK—EXT button lights as long as it is held depressed.

h. Release the EXT button.

i. CHECK—MAN button lights and a stable display is presented.

15. Check Cycles/Sweep

REQUIREMENT—Two to six cycles displayed in Seek Mode.

a. Press the SEEK button.

b. CHECK—CRT display for two to six cycles (nominal CYCLES/SWEEP adjustment).

c. ADJUST—Hold the SEEK button depressed and adjust the CYCLES/SWEEP adjustment (on front panel) for the desired number of cycles in the display (this adjustment selects a nominal range of operation; exact number of cycles displayed for a particular signal will vary due to the sweep rate selected by the Seek Circuit). Allow the seek circuits time to recycle between adjustments (about one to two seconds).

d. Disconnect the time-mark generator.

16. Check Seek Mode Operation

REQUIREMENT—Correct operation with seek command from remote-seeking probe, amplifier unit program connector, front-panel SEEK button and Type 3B5 PROGRAM connector. Does not seek when amplifier unit seek button is pressed.

a. Connect the remote-seeking probe to the automatic/programmable amplifier unit input connector.

b. Connect the probe tip to the indicator oscilloscope calibrator output connector.

c. Press the seek button on the remote-seeking probe.

d. CHECK—Both the amplifier unit and the Type 3B5 seek a stable CRT display showing between two and six cycles horizontally and two to six divisions vertically (may vary due to calibration of front-panel adjustments).

e. Connect a jumper lead (#18 or #20 wire) between terminals 4 and 22 of the amplifier unit program connector.

f. CHECK—Both the amplifier unit and the Type 3B5 seek a stable CRT display (units continuously recycle approximately every two to four seconds).

g. Disconnect the jumper lead.

h. Press the front-panel seek button on the amplifier unit.

i. CHECK—Only the amplifier unit seeks.

j. Press the front-panel SEEK button on the Type 3B5.

k. CHECK—Only the Type 3B5 seeks a stable display.

l. Connect a jumper lead between terminals 12 and 22 of the Type 3B5 PROGRAM connector.

m. CHECK—Only the Type 3B5 seeks a stable display (unit continuously recycles every one to two seconds).

17. Check Seek Mode Frequency Response

REQUIREMENT—Correct Seek Mode operation from 30 hertz to 20 megahertz.

a. Connect the low-frequency sine-wave generator to the amplifier unit input connector through the BNC cable (use the BNC to alligator clips adapter to connect the generator output to the BNC cable).

b. Set the low-frequency sine-wave generator for about two-volts output at 30 hertz.

c. Set the Test Function switch to EXT-DC

d. CHECK—Slowly increase the output frequency of the low-frequency sine-wave generator and check that the unit progressively seeks the next faster sweep rate presenting a stable display (leave on continuous seek) as the frequency is increased. Allow time for the seek circuits to recycle (about one to two seconds) before increasing the frequency. Check from 30 hertz to 2 megahertz.

e. Disconnect the low-frequency sine-wave generator and connect the time-mark generator to the amplifier unit through the 50-ohm BNC cable and the 50-ohm BNC termination.

f. Set the time-mark generator for 50-nanosecond markers (20 megahertz sine wave; this check can only be made with an amplifier unit which has a bandpass of at least 15 MHz).

g. CHECK—A stable CRT display is presented (20 cycles displayed; readout-panel indication, .1 μs/DIV) before the seek circuits recycle.

h. Disconnect the jumper lead and set the Trigger Function switch to INT-AUTO.

18. Check Multitrace Sync Pulse Output

REQUIREMENT—Multitrace unit operates correctly with the Type 3B5.

a. If a multitrace 3-series plug-in unit is available, remove the amplifier unit and insert the multitrace unit in the left plug-in compartment,

b. Connect the indicator oscilloscope calibrator output to both amplifier unit inputs with the BNC T connector and two BNC cables.

c. Set the multitrace unit for multiple trace operation

d. Set both volts/division switches of the amplifier unit so the display is about two divisions in amplitude.

e. Set the MANUAL TIME/DIV switch to 2 ms.

f. CHECK—CRT display alternates between traces.

g. Remove the multitrace unit and replace the automatic/programmable amplifier unit.

19. Check Delayed Sweep Magnifier Intensifier Levels

REQUIREMENT—Trace intensity increased for ×10 and ×100 magnified operation.

a. Set the MANUAL TIME/DIV switch to 0.1 ms.

b. Reduce the intensity setting until the trace is just visible.

c. Set the DLY'D SWP MAG switch to ×10.

d. CHECK—Trace intensity increases so magnified portion of trace is easily seen.

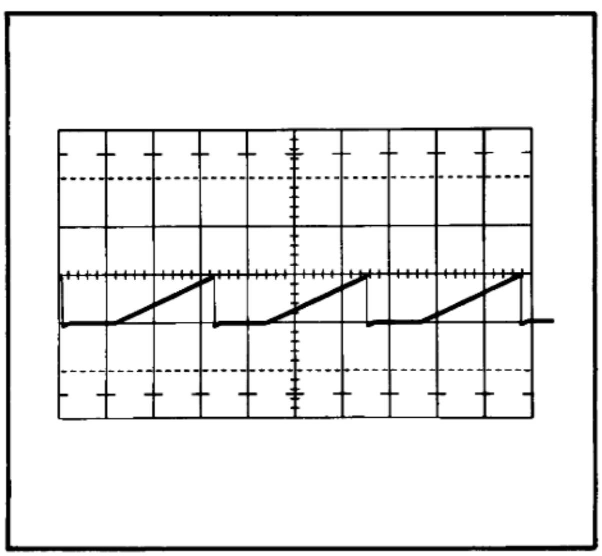

Fig. 5-9. Typical test oscilloscope display when checking sawtooth output.

e. Set the DLY'D SWP MAG switch to ×100.

f. CHECK—Trace intensity of magnified portion about the same as for ×10.

20. Check Sawtooth Output Through Program Connector

REQUIREMENT—Approximately 0.05 milliamp/division at 0.1 ms/DIV (0.05 volt/division of sweep into 1 kΩ).

a. Set the DLY'D SWP MAG switch to OFF.

b. Connect the 10× probe to the test oscilloscope input.

c. Set the test oscilloscope for a vertical deflection of 0.05 volt/division (0.5 volt/division including 10× probe) and a sweep rate of 0.5 millisecond/division.

d. Connect a 1 kΩ, ½ watt, 1% resistor between terminals 16 and 22 of the PROGRAM connector.

e. Connect the 10× probe tip to terminal 16 of the PROGRAM connector.

f. CHECK—Test oscilloscope display for about three cycles of the sawtooth signal and a vertical deflection of one division, ±0.1 division; see Fig. 5-9 (0.05 milliamp/division, ±10%, output from Type 3B5).

21. Check Front-Panel Output Voltages

REQUIREMENT—Terminal 1, approximately −12.2 volts; terminal 18, approximately +125 volts; terminal 19, approximately −100 volts.

a. Connect the DC voltmeter from terminal 1 of the PROGRAM connector to chassis ground.

b. CHECK—Meter reading approximately −12.2 volts.

c. Connect the DC voltmeter from terminal 18 of the PROGRAM connector to chassis ground.

d. CHECK—Meter reading approximately +125 volts.

e. Connect the DC voltmeter from terminal 19 of the PROGRAM connector to chassis ground.

f. CHECK—Meter reading approximately −100 volts.

NOTE

The special single sweep, external horizontal circuit shown in Fig. 2-6 provides the most convenient method of checking steps 22 and 23. It is recommended that this circuit be constructed if these features are to be checked frequently. However, the following procedure provides a method for checking these steps either with or without the special circuit.

22. Check External Horizontal Input

REQUIREMENT—Deflection factor about five volts/division.

a. Connect a jumper lead (#18 or #20 solid wire) between terminals 1 and 13 of the PROGRAM connector and

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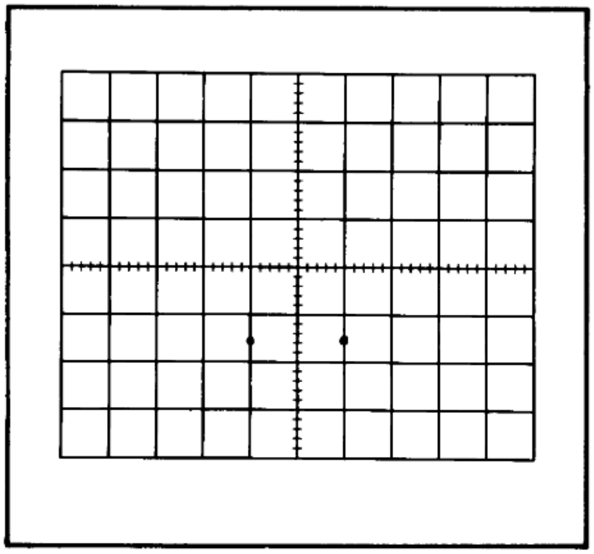

Fig. 5-10. Typical CRT display when checking external horizontal operation.

connect a 20-kΩ, ½-watt resistor between terminals 14 and 22. Connect a jumper lead (wire) from the indicator oscilloscope calibrator output connector to terminal 4 of the PROGRAM connector (10 volts calibrator output). (If using the special circuit, connect a BNC cable from the calibrator output connector to the external horizontal input connector and switch to external horizontal.)

b. CHECK—Two dots displayed on screen about two divisions apart (deflection factor about 5 volts/division, see Fig. 5-10).

c. Disconnect all connections to the PROGRAM connector (special circuit may be left in place).

23. Check Single Sweep Operation

REQUIREMENT—Single sweep display presented each time circuit is reset.

a. Set the MANUAL TIME/DIV switch to 20 ms and the Trigger Function switch to INT-AC.

b. Connect the indicator oscilloscope calibrator output to the amplifier unit input connector with a BNC cable.

c. Set the amplifier unit for about four divisions of vertical deflection.

d. Set the LEVEL control for a stable display.

e. Connect a jumper lead (wire) between terminals 7 and 18 (Caution; +125 volts) of the PROGRAM connector. (If using special circuit, set switch to single sweep.)

f. CHECK—A trace is not displayed but the NOT TRIG'D readout remains off.

g. Connect a jumper lead to terminal 25 of the PROGRAM connector. Momentarily touch the other end of the jumper lead to terminal 1. (Disregard this step for special circuit.)

h. CHECK—A single display (one sweep only) is presented each time the circuit is reset by touching the jumper lead to terminal 1 (there will be more than one sweep if the jumper lead is connected to terminal 1 throughout the entire sweep.) If using the special circuit, check that a single display is presented each time the reset button is pressed.

i. Disconnect all test equipment.

24. Check External Programmed Operation

No test procedure is given here for checking the external programmed operation of this unit. If a Tektronix external programmer is used, a complete checkout procedure for the programmable functions is given in the Instruction Manual for that unit. To check external programmed operation without a programmer, use the external program information given in Section 2.

This completes the performance check procedure for the Type 3B5. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

NOTES

SECTION 6
CALIBRATION

Introduction

Complete calibration information for the Type 3B5 Automatic/Programmable Time Base is given in this section. This procedure calibrates the instrument to the performance requirements listed in the Characteristics section. The Type 3B5 can be returned to original performance standards by completion of each step in this procedure. If it is desired to merely touch up the calibration, perform only those steps entitled "Adjust . . .". A short-form calibration, procedure is also provided in this section for the convenience of the experienced calibrator.

The Type 3B5 should be checked, and recalibrated if necessary, after each 500 hours of operation, or every six months if used infrequently, to assure correct operation and accuracy. The Performance Check section of this manual provides a complete check of instrument performance without making internal adjustments. Use the performance check procedure to verify the calibration of the Type 3B5 and determine if recalibration is required.

EQUIPMENT REQUIRED

General

The following test equipment, or its equivalent, is required for complete calibration of the Type 3B5 (see Fig. 6-1). Specifications given are the minimum necessary for accurate calibration of this instrument. 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.

1. Indicator oscilloscope. Must be compatible with the Type 3B5 and must be capable of supplying the necessary power. Tektronix Type 561A Oscilloscope recommended.

2. Automatic/programmable amplifier unit. Must be compatible with the indicator oscilloscope and the Type 3B5. (A standard amplifier plug-in unit may be used although some steps may not apply.) Tektronix Type 3A5 Automatic/Programmable Amplifier recommended.

3. Remote seeking probe. Tektronix P6030 recommended.

4. Constant amplitude sine-wave generator. Frequency, 50 kHz and 350 kHz to 20 MHz; output amplitude, 0.5 to 5 volts peak to peak into 50 ohms; amplitude accuracy, within ±3% from 50 kHz to above 20 MHz. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

5. Low-frequency sine-wave generator. Frequency, 10 Hz to 2 MHz; output amplitude, 0.5 to 40 volts peak to peak; amplitude accuracy, within ±3% from 10 Hz to 2 MHz. For example, General Radio 1310-A Oscillator.

6. Time-mark generator. Marker outputs, 5 seconds to 20 nanoseconds; accuracy within ±0.1%. Tektronix Type 184 Time-Mark Generator recommended.

7. Test oscilloscope system. Frequency response, DC to 25 MHz; minimum deflection factor, 0.05 volts/division (without probe). Tektronix Type 543B Oscilloscope with a Type 1A2 Plug-In Unit and a P6008 10× probe recommended.

8. Cable. Impedance, 50 ohms; type, RG-8A/U; electrical length, five nanoseconds (for use with Type 191); connectors, GR874. Tektronix Part No. 017-0502-00.

9. In-line termination. Impedance, 50 ohms; wattage rating, two watts; accuracy, ±3%; connectors, GR874 input with BNC male output. Tektronix Part No. 017-0083-00.

10. Cable (two). Impedance, 50 ohms; type, RG-58A/U; length, 42 inches: connectors. BNC. Tektronix Part No. 012-0057-00.

11. Termination. Impedance 50 ohms; accuracy, ±3%; connectors, BNC. Tektronix Part No. 011-0049-00.

12. BNC T connector. Tektronix Part No. 103-0030-00.

13. Rigid plug-in extender, 24-pin. Tektronix Part No. 013-0034-00.

14. Circuit-card extender, 56-terminal. Tektronix Part No 012-0078-00.

15. DC voltmeter. Minimum sensitivity, 20,000 ohms/volt; accuracy, within ±1% at −12, −100, +125 and +180 volts; range, zero to 200 volts. For example, Simpson Model 262.

16. Adapter. Connectors, BNC female and two alligator clips. Tektronix Part No. 013-0076-00.

17. Insulated screwdriver. 1½-inch shaft, non-metallic. Tektronix Part No. 003-0000-00.

18. Screwdriver. Three-inch shaft. Tektronix Part No. 003-0192-00.

CALIBRATION RECORD AND INDEX

This short-form calibration procedure is provided to aid in checking the operation of the Type 3B5. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristics section.

Type 3B5, Serial No. ____________________

Calibration Date ____________________

Calibration Technician ____________________

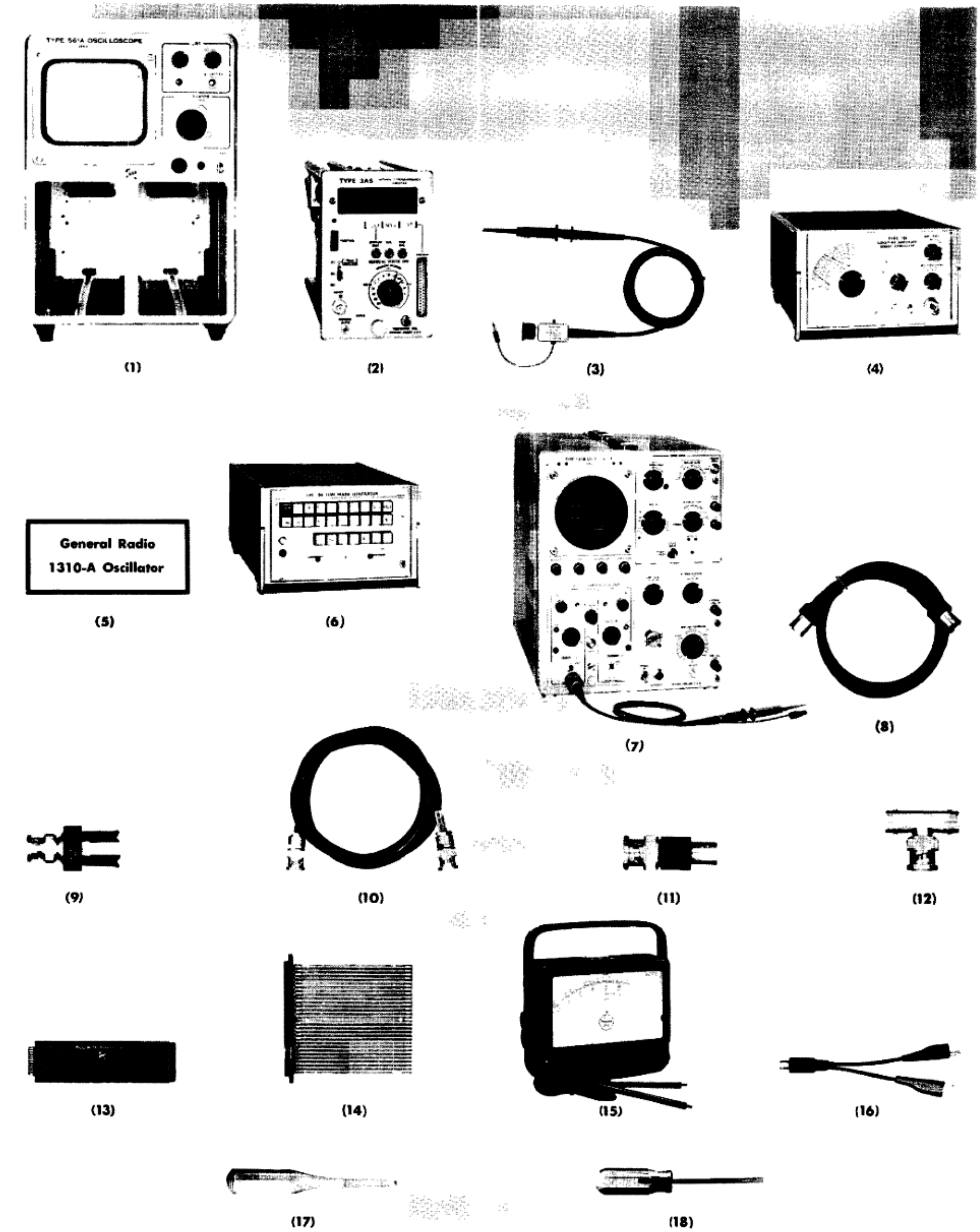

Fig. 6-1. Recommended calibration equipment.

☐ 1. Adjust Trigger Level Centering (R15). Page 6-5.
+ and — 20 volt sine-wave signal centered within the LEVEL control range (EXT-AC).

☐ 2. Check Trigger Level Control Range. Page 6-6.

EXT-AC	Checked as part of step 1
EXT-DC	At least + and — 10 volts

☐ 3. Adjust Auto Triggering Centering (R35). Page 6-6.
Stable auto triggering on a 0.5-division display throughout the rotation of the LEVEL control.

☐ 4. Check Low-frequency Triggering Operation. Page 6-7.
Correct triggering with minimum deflection or minimum input voltage in all positions of the Trigger Function switch.

☐ 5. Check Trigger Slope Operation and Coupling. Page 6-7.
Stable triggering on correct slope of the input signal and indication of correct trigger coupling.

☐ 6. Check High-Frequency Triggering Operation. Page 6-8.
Correct triggering at 50 kilohertz and 20 megahertz with minimum deflection or minimum input voltage in all positions of the Trigger Function switch.

☐ 7. Adjust Basic Timing (R515). Page 6-10.
Correct timing is 1 ms/DIV.

☐ 8. Check Variable Control Range. Page 6-11.
At least 2.5:1.

☐ 9. Check Sweep Length. Page 6-11.

Normal sweep	10.3 to 11.3 divisions
Magnified sweep	12 to 15 divisions

☐ 10. Adjust Delay Start and Stop (R330 and R333). Page 6-12.
Alignment of DELAY dial indication with corresponding markers in CRT display.

☐ 11. Check Delay Dial Incremental Linearity and Accuracy Page 6-12.
Incremental linearity, within ±0.4%. Accuracy, within ±0.4% of full scale at 1 ms/DIV (with step 10 correctly adjusted and line voltage held constant); within ±3% of full scale at all other sweep rates

☐ 12. Check Delayed Sweep Magnifier Jitter. Page 6-13.
3 parts or less per 10,000.

☐ 13. Adjust One-Second Timing (R395). Page 6-13.
Correct timing at 1 s/DIV.

☐ 14. Adjust One-Microsecond Timing (C168). Page 6-13.
Correct timing at 1 μs/DIV.

☐ 15. Adjust 10-Microsecond Timing (C315). Page 6-14.
Correct timing at 10 μs/DIV.

☐ 16. Adjust 0.1-Microsecond Timing (C502). Page 6-15.
Correct timing at 0.1 μs/DIV.

☐ 17. Adjust High-Frequency Compensation (C547 and C551). Page 6-17.
Optimum horizontal amplifier response at 50 ns/DIV

☐ 18. Adjust Registration (R505). Page 6-18.
No display shift at first graticule line when changing from 0.1 μs/DIV to 50 ns/DIV.

☐ 19. Adjust 50-Nanosecond and 20-Nanosecond Timing (R508 and C507). Page 6-19.
Correct timing at 50 ns/DIV and 20 ns/DIV.

☐ 20. Adjust 10-Nanosecond Timing (C547 and C551). Page 6-19.
Correct timing at 10 ns/DIV.

☐ 21. Check Normal and Magnified Timing Accuracy Page 6-20.

1 s to 10 ns	Within ±3% with correct readout-panel indication.
5 s and 2 s	Within ±5% with correct readout-panel indication.

☐ 22. Check Operating Mode. Page 6-23.
Instrument operates correctly in the mode selected by the EXT, MAN and SEEK buttons.

☐ 23. Check Seek Mono Pulse Width and Seek Cycling Time. Page 6-23.

Seek mono pulse width	One second to 1.8 seconds.
Seek cyling time	One to two seconds.

☐ 24. Adjust Cycles/Sweep (R650). Page 6-24.
Nominal CYCLES/SWEEP setting.

☐ 25. Check Seek Mode Operation. Page 6-24.
Correct operation with seek command from remote-seeking probe, amplifier unit program connector, front-panel SEEK button and the Type 3B5 PROGRAM connector. Does not seek when amplifier unit seek button is pressed.

☐ 26. Check Seek Mode Frequency Response. Page 6-25.
Correct Seek Mode operation from 30 hertz to 20 megahertz.

☐ 27. Check Multitrace Sync Pulse. Page 6-25.
About five-volt pulses to amplifier unit.

☐ 28. Check Delayed Sweep Magnifier Intensifier Levels. Page 6-25.
Following voltage levels to indicator oscilloscope:

DLY'D SWP MAG switch OFF	About —12 volts
DLY'D SWP MAG switch at ×10	About —6 volts during magnified sweep time
DLY'D SWP MAG switch at ×100	About zero volts during magnified sweep time

☐ 29. Check Sawtooth Output Through Program Connector. Page 6-26.

0.05 milliamp/division, ±10%, at 0.1 ms/DIV (0.05 volt/division of sweep into 1 kΩ).

☐ 30. Check Sawtooth Output to Amplifier Unit. Page 6-27.

About 50 volts at 0.1 ms/DIV

☐ 31. Check Front-Panel Output Voltages. Page 6-28.

Terminal 1	About −12.2 volts
Terminal 18	About +125 volts
Terminal 19	About −100 volts

☐ 32. Check Output DC Level. Page 6-29.

+180 volts, ±10 volts.

☐ 33. Check External Horizontal Input. Page 6-29.

Deflection factor about five volts/division.

☐ 34. Check Single Sweep Operation. Page 6-29.

Single sweep display presented each time circuit is reset.

☐ 35. Check External Programmed Operation. Page 6-30.

Use procedure given in external programmer Instruction Manual or information given in Section 2 of this manual.

CALIBRATION PROCEDURE

General

The following procedure is arranged in a sequence which allows the Type 3B5 to be calibrated with the least interaction of adjustments and reconnection of equipment. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts of the instrument. When a step interacts with others, the steps which need to be checked are noted in the "INTERACTION- . . ." step.

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section.

The "Adjust . . . ◐" steps in the following procedure provide a check of instrument performance, whenever possible, before the adjustment is made. The symbol ◐ is used to identify the steps in which an adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met. However, when performing a complete calibration, best overall performance will be provided if each adjustment is made to the exact setting, even if the "CHECK - . . ." is within the allowable tolerance.

In the following procedure, a test equipment setup picture is shown for each major group of adjustments and checks. Beneath each setup picture is a complete list of front-panel control settings for the Type 3B5 and associated amplifier unit and indicator oscilloscope. To aid in locating individual controls which have been changed during complete calibration, these control names are printed in bold type. If only a partial calibration is performed, start with the nearest setup preceding the desired portion. Type 3B5 front-panel control titles referred to in this procedure are capitalized (e.g., DELAY). Internal adjustment titles are initial capitalized only (e.g., Start).

The following procedure uses the equipment listed under Equipment Required. If equipment is substituted, control settings or test equipment setup may need to be altered to meet the requirements of the equipment used.

NOTE

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Preliminary Procedure

1. Remove the right side cover from the indicator oscilloscope.

2. Connect the indicator oscilloscope to a power source that meets its voltage and frequency requirements.

3. Insert the amplifier unit into the left (vertical) plug-in compartment.

4. Insert the Type 3B5 into the right (horizontal) plug-in compartment.

5. Set the indicator oscilloscope power switch to on. Allow at least five minutes warm up at 25° C, ±5° for checking the instrument to the given accuracy.

NOTES

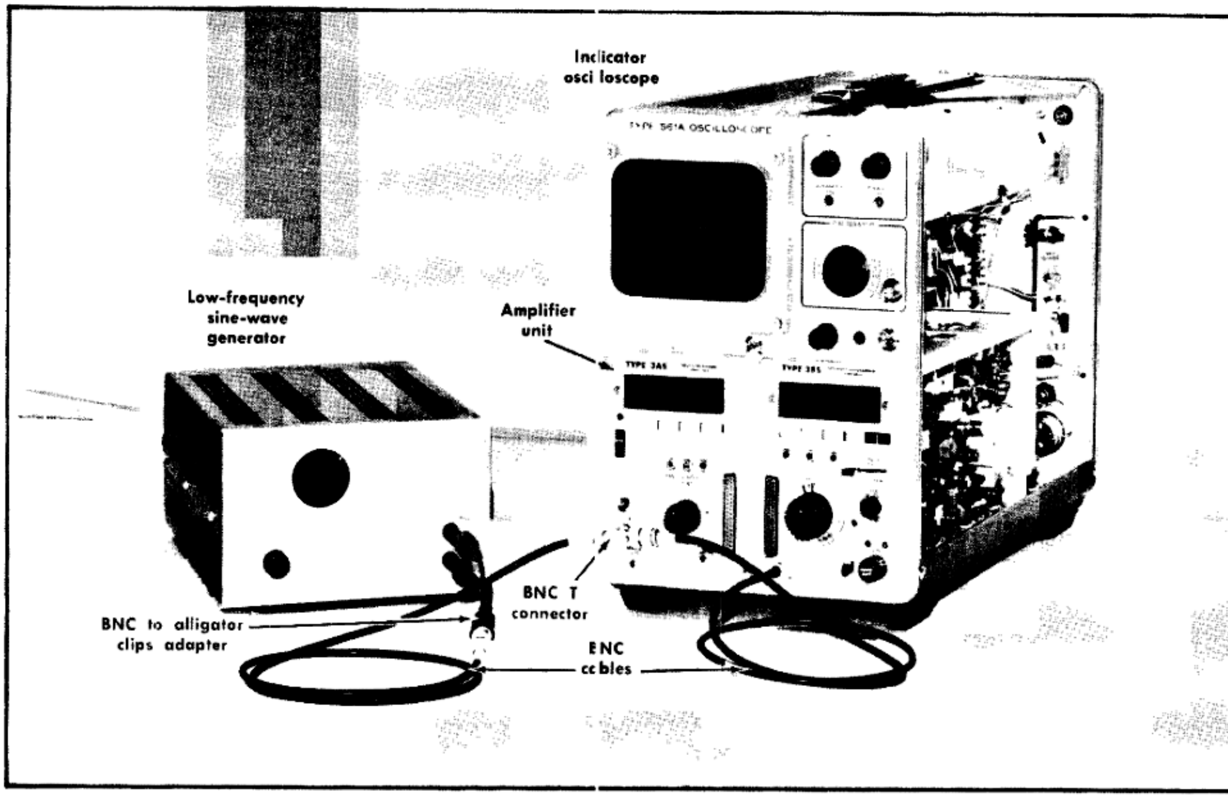

Fig. 6-2. Initial equipment setup for steps 1—5.

Control Settings

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	1.00
MANUAL TIME/DIV	.5 ms
VARIABLE	CAL
Trigger Function	EXT-AC
LEVEL	Midrange
SLOPE	+

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	10 Volts
Mode	Manual

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Visible display
Calibrator	10 Volts
Power	On

1. Adjust Trigger Level Centering ⓪

a. Test equipment setup is shown in Fig. 6-2.

b. Connect the low-frequency sine-wave generator to the amplifier unit input connector through the BNC cable and the BNC T connector (use the BNC to alligator clips adapter to connect the generator output to the BNC cable). Connect the output of the BNC T connector to the Type 3B5 EXT TRIG INPUT connector with a BNC cable.

c. Set the low-frequency sine-wave generator for a four-division CRT display (40 volts peak to peak) at one kilohertz.

d. Turn the LEVEL control fully counterclockwise.

e. ADJUST—TRIG LEVEL CENTERING adjustment, R15, (see Fig. 6-3), to setting where unit does not trigger (no trace and NOT TRIG'D readout on) for both + and — slope.

f. Turn the LEVEL control fully clockwise.

g. ADJUST—TRIG LEVEL CENTERING adjustment, R15, to setting where unit does not trigger for both + and — slope triggering. Then, set the adjustment midway between the setting obtained in step e and this setting.

h. Recheck steps d through g and readjust if necessary. The display must not be triggered (no trace) at either end of rotation for both + and — slope triggering when correctly adjusted. (This step also checks EXT-AC trigger LEVEL range for at least + and — 20 volts.)

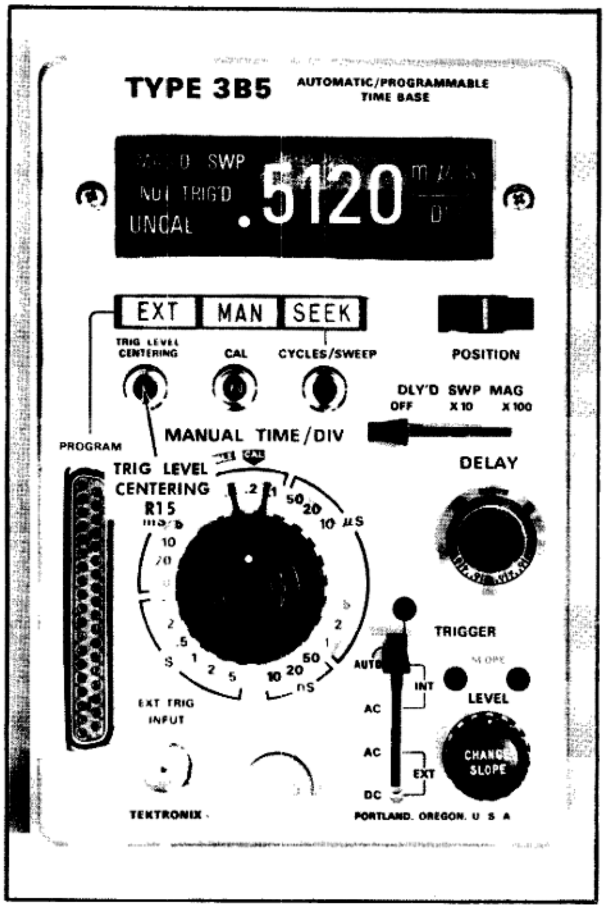

Fig. 6-3. Location of TRIG LEVEL CENTERING adjustment (front panel).

2. Check Trigger Level Control Range

a. Set the LEVEL control to midrange.

b. Set the low-frequency sine-wave generator for a two-division CRT display (20 volts peak to peak) at one kilohertz.

c. Set the Trigger Function switch to EXT-DC.

d. CHECK—NOT TRIG'D readout off (unit triggered).

e. Turn the LEVEL control fully counterclockwise.

f. CHECK—CRT display not triggered (no trace) and the NOT TRIG'D readout is on for both + and — slope triggering (indicates at least —10 volt LEVEL control range).

g. Turn the LEVEL control fully clockwise.

h. CHECK—CRT display not triggered and the NOT TRIG'D readout is on for both + and — slope triggering (indicates at least +10 volt LEVEL control range).

3. Adjust Auto Trigger Centering ⓿

a. Change the following control settings:

Trigger Function	INT-AUTO
LEVEL	Midrange
Volts/Division (amplifier unit)	1 Volt

b. Set the low-frequency sine-wave generator for a 0.5-division CRT display (0.5 volt peak to peak) at one kilohertz. (If the amplifier unit is other than a Type 3A5, monitor the voltage at pin CC of the Time-Base Board with the test oscilloscope and adjust the low-frequency sine-wave generator for 0.7 volts, peak to peak).

c. Turn the LEVEL control fully counterclockwise.

d. CHECK—Stable CRT display for both + and — slope triggering. Auto Trigger light must be on.

e. ADJUST—Auto Trigger Centering adjustment, R35 (see Fig. 6-4), for a stable CRT display for both + and — slope triggering.

f. Turn the LEVEL control fully clockwise.

g. CHECK—Stable CRT display for both + and — slope triggering.

h. ADJUST—Auto Trigger Centering adjustment, R35, for stable CRT display of both + and — slope triggering.

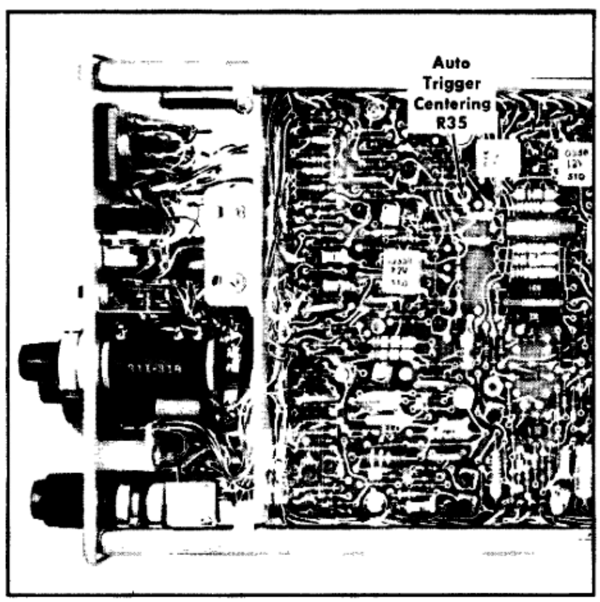

Fig. 6-4. Location of Auto Trigger Centering adjustment (right side).

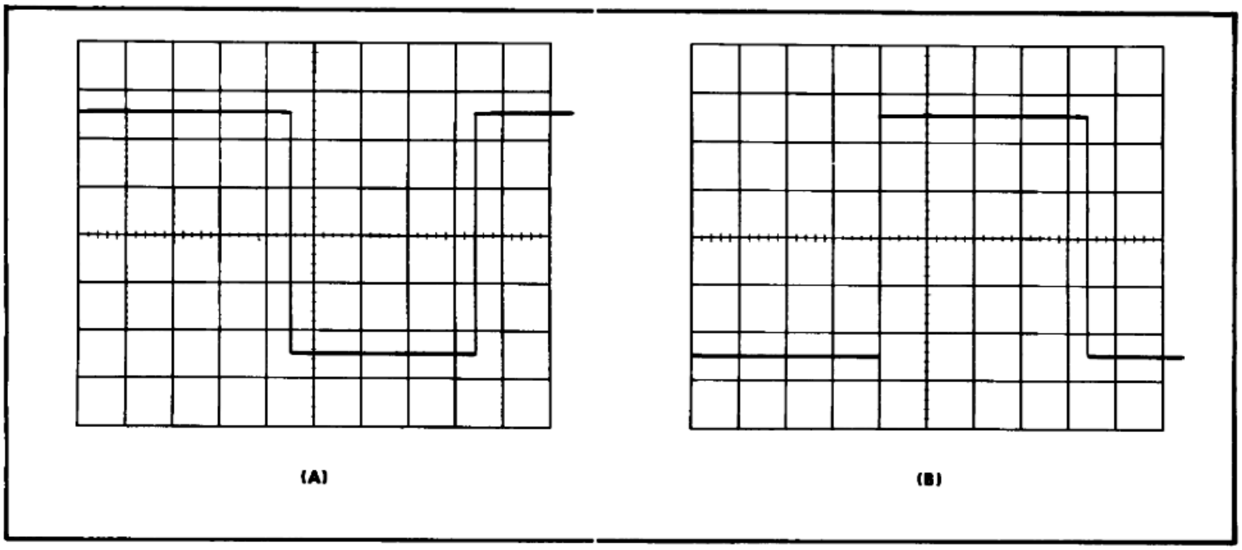

Fig. 6-5. Typical CRT display when checking trigger slope operation (A) + slope; (B) — slope.

i. Recheck steps c through h and readjust as necessary. A compromise setting must be established which provides correct triggering for both checks d and g.

4. Check Low-Frequency Triggering Operation

a. Change the following control settings:

MANUAL TIME/DIV	20 ms
Trigger Function	EXT-AC
LEVEL	Midrange
SLOPE	+

b. Set the low-frequency sine-wave generator for a one-division CRT display (one volt peak to peak) at 50 hertz.

c. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

d. Set the Trigger Function switch to EXT-DC.

e. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

f. Without changing the output amplitude, set the low-frequency sine-wave generator to 10 hertz.

g. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

h. Set the Trigger Function switch to INT-AC.

i. Set the low-frequency sine-wave generator for a 0.5 division CRT display (0.5 volt peak to peak) at 50 hertz (0.7 volts, peak to peak, at pin CC of the Time-Base Board for units other than the Type 3A5).

j. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

k. Set the Trigger Function switch to INT-AUTO.

l. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering throughout the complete rotation of the LEVEL control.

5. Check Trigger Slope Operation and Coupling

a. Connect the indicator oscilloscope calibrator output to the amplifier unit input connector and the EXT TRIG INPUT connector with the BNC T connector and two BNC cables.

b. Change the following control settings:

MANUAL TIME/DIV	2 ms
LEVEL	Midrange
Trigger Function	INT-AUTO
Volts/Division (amplifier unit)	2 Volts

c. If the + slope light is not on, press the CHANGE SLOPE button.

d. CHECK—CRT display starts on the positive slope of the signal (see Fig. 6-5A) and the + slope light is on.

e. Press the CHANGE SLOPE button.

f. CHECK—CRT display starts on the negative slope of the signal (see Fig. 6-5B) and the — slope light is on.

g. Set the Trigger Function switch to EXT-DC.

h. Press the CHANGE SLOPE button to provide + slope triggering.

i. Turn the LEVEL control clockwise until the display is not triggered (NOT TRIG'D readout on). Then turn the LEVEL control clockwise slightly until the CRT display is stable.

j. Without changing the LEVEL control setting, set the Trigger Function switch to EXT-AC.

k. CHECK—NOT TRIG'D readout comes on to indicate that unit is not correctly triggered. This check indicates that the trigger circuit has blocked the DC level of the calibrator signal to AC couple the trigger signal to the trigger circuit.

l. Disconnect all test equipment.

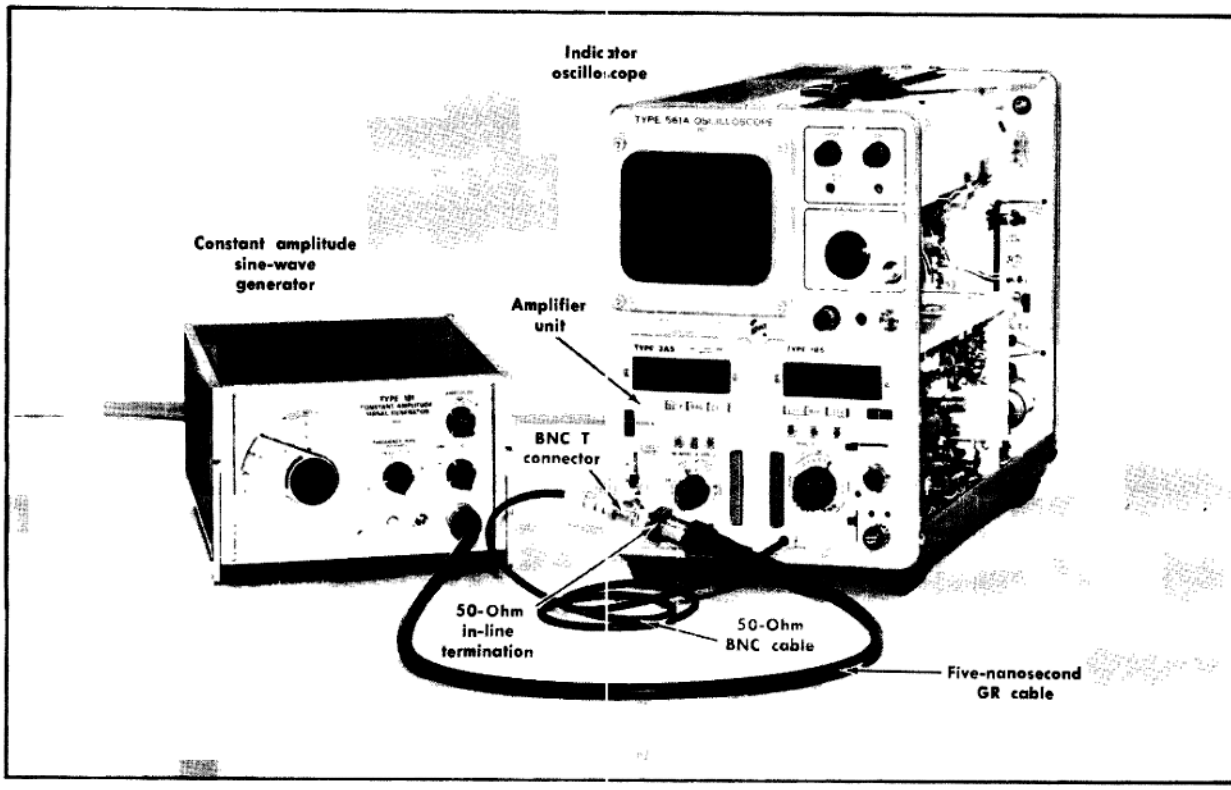

Fig. 6-6. Test equipment setup for step 6.

Control Settings

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	1.00
MANUAL TIME/DIV	**20 ms**
VARIABLE	CAL
Trigger Function	**INT-AC**
LEVEL	Midrange
SLOPE	**+**

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	**1 Volt**
Mode	Manual

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Visible display
Calibrator	10 Volts
Power	On

6. Check High-Frequency Triggering Operation

a. Test equipment setup is shown in Fig. 6-6.

b. Connect the constant-amplitude sine-wave generator to the amplifier unit input connector through the five-nanosecond GR cable, 50-ohm in-line termination and the BNC T connector. Connect the output of the BNC T connector to the Type 3B5 EXT TRIG INPUT connector with a 50-ohm BNC cable.

c. Set the constant-amplitude generator for a 0.5-division CRT display (0.5 volt peak to peak) at 50 kilohertz (0.7 volt peak to peak at pin CC of the Time-Base Board for units other than the Type 3A5).

d. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

e. Set the constant-amplitude generator for a 0.5 division display at 20 megahertz (this check can be made only with an amplifier unit which has a bandpass of at least 15 MHz).

f. Set the MANUAL TIME/DIV switch to .1 μs.

g. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

h. Set the Trigger Function switch to INT-AUTO.

i. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering. The Auto Trigger light must be on.

j. Set the Trigger Function switch to EXT-AC.

k. Set the constant-amplitude generator for a one-division CRT display (one volt peak to peak) at 50 kilohertz.

l. Set the MANUAL TIME/DIV switch to 20 μs.

m. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

n. Set the Trigger Function switch to EXT-DC.

o. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

p. Without changing the output amplitude, set the constant-amplitude generator to 20 megahertz.

q. Set the MANUAL TIME/DIV switch to .1 μs.

r. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

s. Set the Trigger Function switch to EXT-AC.

t. CHECK—Stable CRT display can be obtained with the LEVEL control for both + and — slope triggering.

u. Disconnect all test equipment.

NOTES

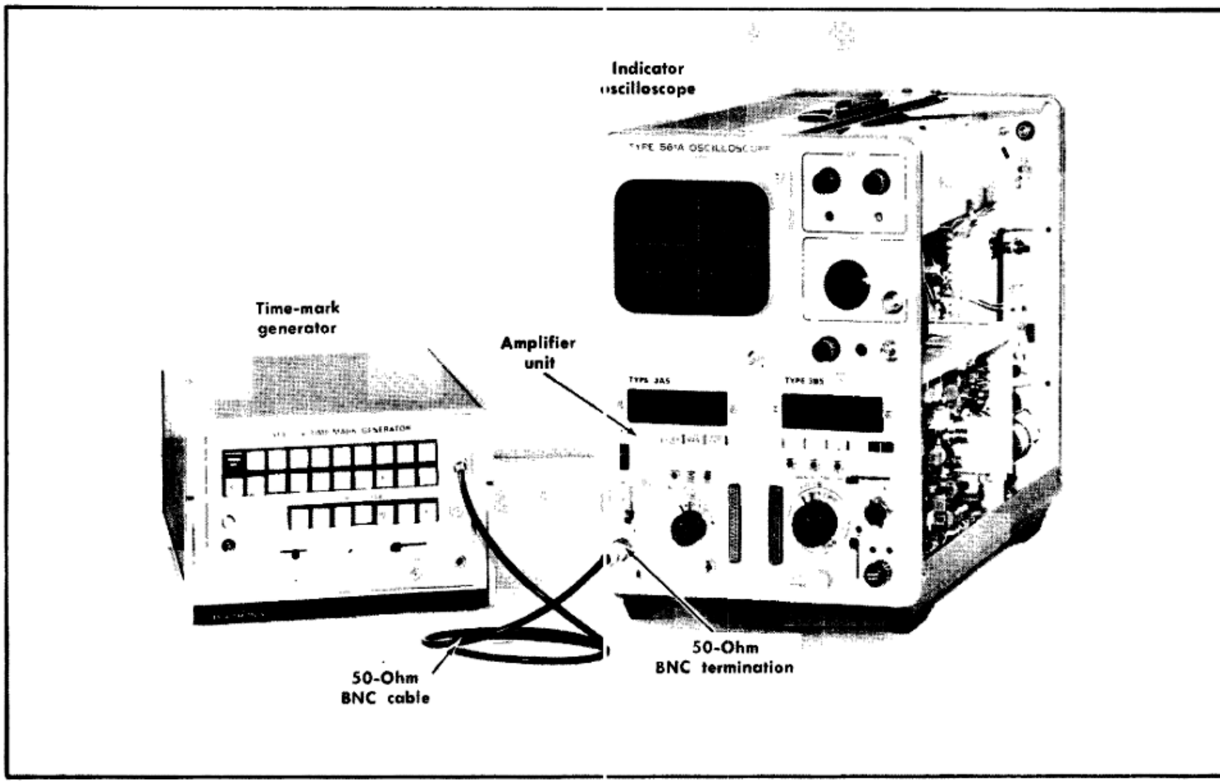

Fig. 6-7. Initial test equipment setup for steps 7—16.

Control Settings

Type 3B5	
Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	1.00
MANUAL TIME/DIV	**1 ms**
VARIABLE	CAL
Trigger Function	**INT-AUTO**
LEVEL	**Midrange**
SLOPE	**+**
Amplifier Unit	
Position	Midrange
Input Coupling	DC
Volts/Division	**0.5 Volts**
Mode	Manual
Indicator Oscilloscope	
Focus	Adjust for correct display
Intensity	Visible Display
Calibrator	10 Volts
Power	On

7. Adjust Basic Timing 0

a. Test equipment setup is shown in Fig. 6-7.

b. Connect the time-mark generator to the amplifier unit input connector through the 50-ohm BNC cable and a 50-ohm BNC termination.

c. Set the time-mark generator for one-millisecond markers.

d. Position the second marker to the first graticule line with the POSITION control.

e. CHECK—CRT display for one marker each division between the first and ninth graticule lines (see Fig. 6-8A).

NOTE

Unless otherwise noted, use the middle eight horizontal divisions when checking or adjusting timing (see Fig. 2-4, Operating Instructions section).

f. ADJUST—CAL adjustment, R515 (see Fig. 6-8B), for one marker each division.

g. INTERACTION—Check steps 10—21. (This adjustment should be checked and readjusted as necessary when the Type 3B5 is inserted into a plug-in compartment other than the one in which it was calibrated.)

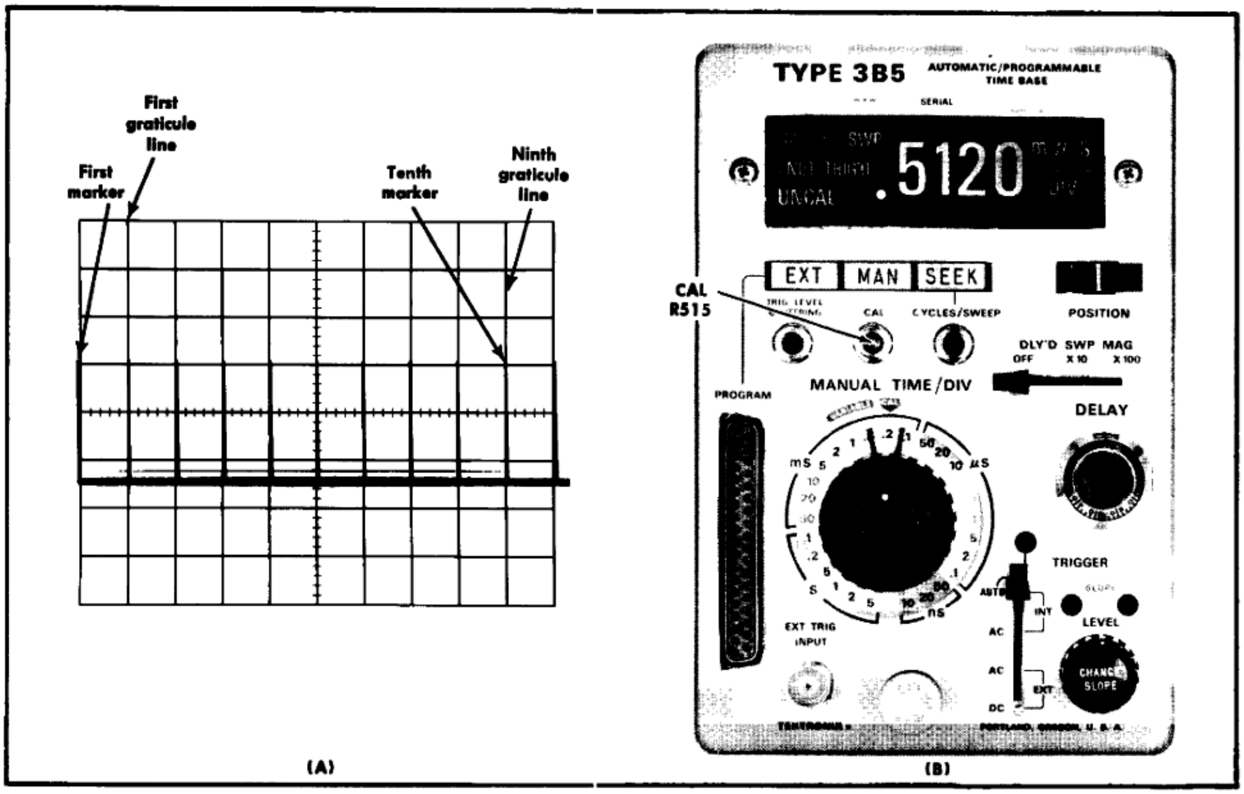

Fig. 6-8. (A) Typical CRT display showing correct basic timing; (B) location of CAL adjustment (front panel)

8. Check Variable Control Range

a. Set the time-mark generator for 10-millisecond markers.

b. Position the markers to the far left and right vertical graticule lines with the POSITION control.

c. Turn the VARIABLE control fully counterclockwise.

d. CHECK—CRT display for four-division maximum spacing between markers (2.5:1 range; see Fig. 6-9). UNCAL readout must come on and s/DIV readout must be off when VARIABLE control is out of the CAL position.

e. Return the VARIABLE control to the CAL position.

9. Check Sweep Length

a. Set the time-mark generator for one-millisecond and 0.1-millisecond marker output.

b. Position the eleventh one-millisecond marker to the center vertical line with the POSITION control.

c. CHECK—CRT display for sweep length between 10.3 and 11.3 divisions as shown by 0.3 to 1.3 divisions of display to the right of the center vertical line (see Fig. 6-10A). Large markers in the display indicate divisions and small markers indicate 0.1 division (unmagnified only).

d. Set the DLY'D SWP MAG switch to ×10.

e. CHECK—CRT display for sweep length between 12 and 15 divisions as shown by two to five divisions of display to the right of the center vertical line (see Fig. 6-10B).

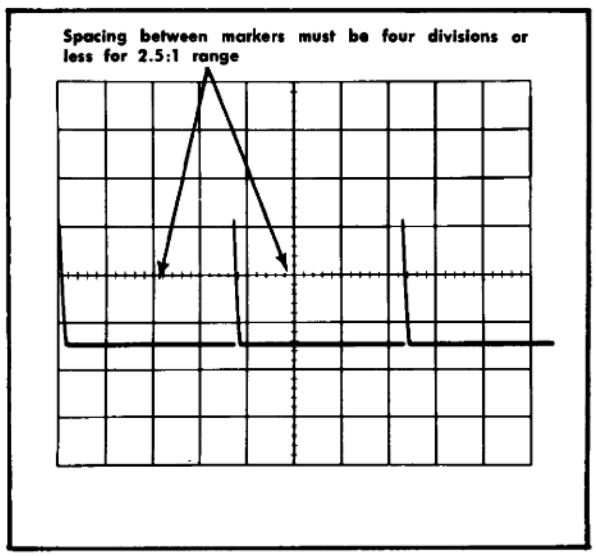

Fig. 6-9. Typical CRT display when checking VARIABLE control range.

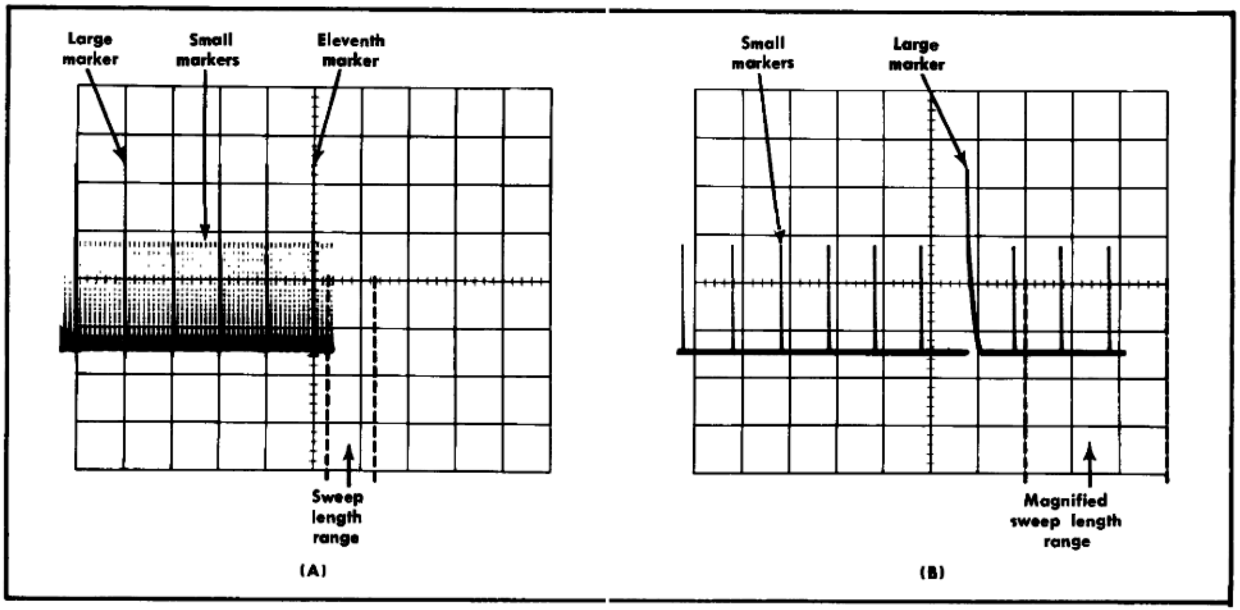

Fig. 6-10. Typical CRT display when checking sweep length. (A) Unmagnified, (B) ×10 magnification.

f. Set the DLY'D SWP MAG switch to ×100.

g. CHECK—CRT display shows same sweep length as step e.

10. Adjust Delay Start and Stop

a. Set the DLY'D SWP MAG switch to OFF.

b. Position the first marker to the left vertical graticule line.

c. Return the DLY'D SWP MAG switch to ×100.

d. Set the time-mark generator for one-millisecond markers.

e. CHECK—Magnified portion of CRT display starts at the leading edge of the second marker (see Fig. 6-11A).

f. ADJUST—Start adjustment, R330 (see Fig. 6-11B), so the magnified portion of the display starts at the leading edge of the second marker.

g. Set the DELAY dial to 9.00.

h. CHECK—Magnified portion of CRT display starts at the leading edge of the tenth marker (see Fig. 6-11C).

i. ADJUST—Stop adjustment, R333 (see Fig. 6-11B), so the magnified portion of the display starts at the leading edge of the tenth marker.

j. Recheck steps e through i and readjust if necessary until the magnified portion is positioned correctly for both checks.

11. Check Delay Dial Incremental Linearity and Accuracy

a. Set the DELAY dial to 2.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the second marker.

b. CHECK—DELAY dial setting 2.00, ±2 minor dial divisions (incremental linearity within ±0.4% of full scale; this check applies only when step 10 is correctly adjusted).

NOTE

Line voltage must be held constant for steps 10 and 11 for given incremental linearity tolerance to apply.

c. Repeat this check at each major dial division between 2.00 and 9.00. Check for ±2 minor dial divisions, or less, deviation between the major dial division and the dial setting which produces the correct display.

d. Set the MANUAL TIME/DIV switch to 2 ms (sweep readout 20 μs/DIV).

e. CHECK—Set the DELAY dial to each major dial division between 1.00 and 9.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the applicable marker (two markers/division). Check for ±15 minor dial divisions, or less, deviation between the major dial division and the dial setting which produces the correct display (±3% of full scale).

f. Set the MANUAL TIME/DIV switch to 5 ms (sweep readout 50 μs/DIV).

g. Set the time-mark generator for five-millisecond markers.

h. CHECK—Set the DELAY dial to each major dial division between 1.00 and 9.00 and then rotate the dial as necessary so the magnified portion starts at the leading edge of the applicable markers. Check for ±15 minor dial divisions, or less, deviation between the major dial division and the dial setting which produces the correct display (±3% of full scale).

12. Check Delayed Sweep Magnifier Jitter

a. Set the time-mark generator for one-millisecond markers.

b. Set the MANUAL TIME/DIV switch to 1 ms.

c. Set the DELAY dial to 1.00 and then rotate the dial as necessary to position the magnified second marker to the center vertical line.

d. CHECK—Jitter on the leading edge of the magnified marker does not exceed 0.3 division (3 parts or less per 10,000; see Fig. 6-12A). Ignore slow drift.

e. Set the DELAY dial to 9.00 and then rotate the dial and POSITION control to move the magnified tenth marker to the center vertical line.

f. CHECK—Jitter on the leading edge of the magnified marker does not exceed 0.3 division (3 parts or less per 10,000; see Fig. 6-12B).

13. Adjust One-Second Timing

a. Set the time-mark generator for one-second markers.

b. Change the following control settings:

DLY'D SWP MAG	OFF
MANUAL TIME/DIV	1 s
Trigger Function	INT-AC
LEVEL	Triggered display

CAUTION

To prevent permanent damage to the CRT phosphor, either reduce the trace intensity to a level which does not produce a halo around the spot or position the baseline of the marker display below the viewing area.

c. CHECK—CRT display for one marker each division between the first and ninth vertical graticule lines (see Fig. 6-13A).

d. ADJUST—1 s Cal adjustment, R395 (see Fig. 6-13B), for one marker each division.

14. Adjust One-Microsecond Timing

a. Set the time-mark generator for one-microsecond markers.

b. Set the MANUAL TIME/DIV switch to 1 μs.

c. CHECK—CRT display for one marker each division between the first and ninth vertical graticule lines (see Fig. 6-14A).

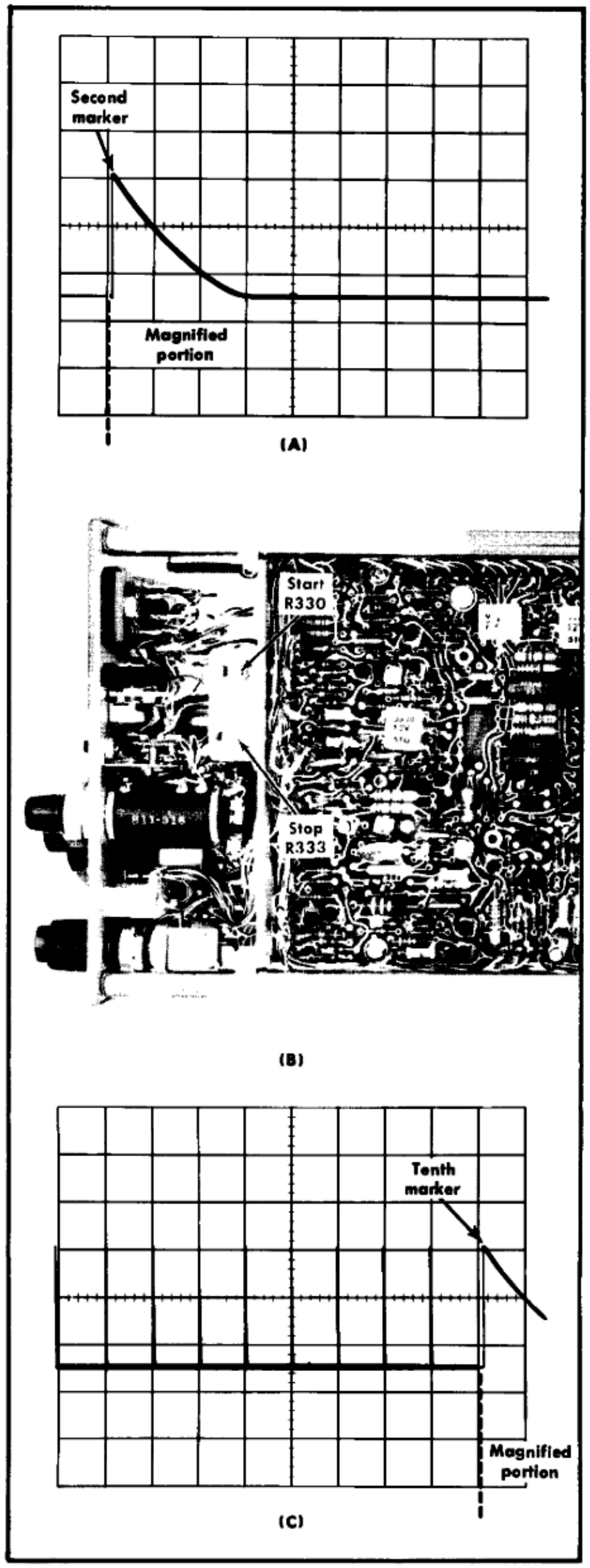

Fig. 6-11. (A) Typical CRT display showing correct delay Start adjustment, (B) Location of Start and Stop adjustments (right side), (C) Typical CRT display showing correct delay Stop adjustment.

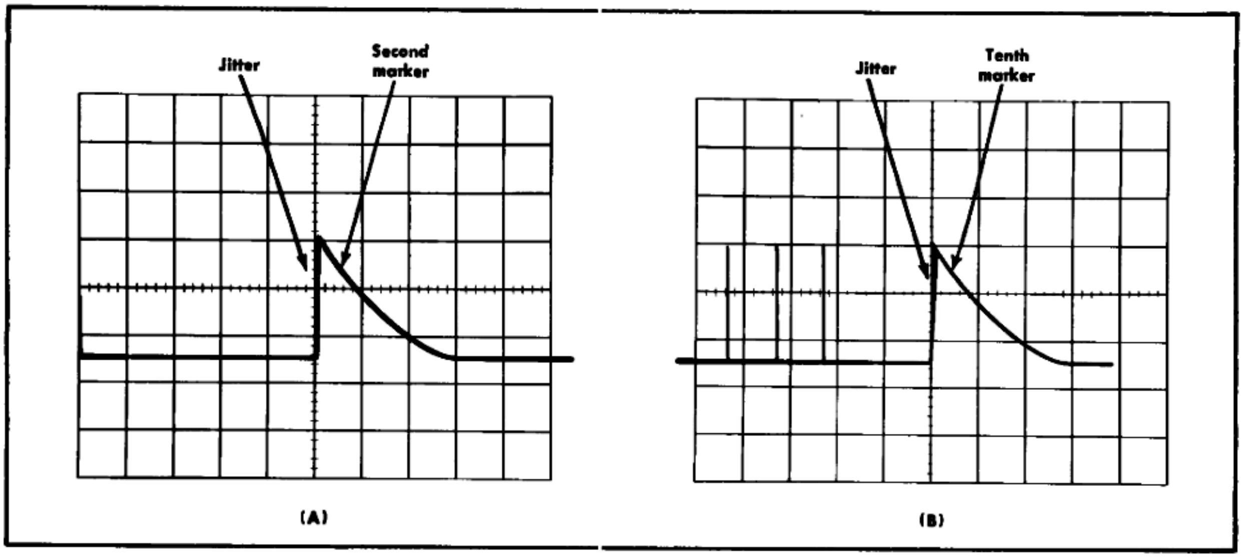

Fig. 6-12. Typical CRT display showing delayed sweep magnifier jitter. (A) DELAY dial near 1.00, (B) DELAY dial near 9.00.

d. ADJUST—1 μs Cal adjustment, C168 (see Fig. 6-14B), for one marker each division.

e. INTERACTION—Check steps 15—20.

15. Adjust 10-Microsecond Timing

a. Set the time-mark generator for 10-microsecond markers.

b. Set the MANUAL TIME/DIV switch to 10 μs.

c. CHECK—CRT display for one marker each division between the first and ninth vertical graticule lines (see Fig. 6-15A).

d. ADJUST—10 μs Cal adjustment, C315 (see Fig. 6-15B), for one marker each division.

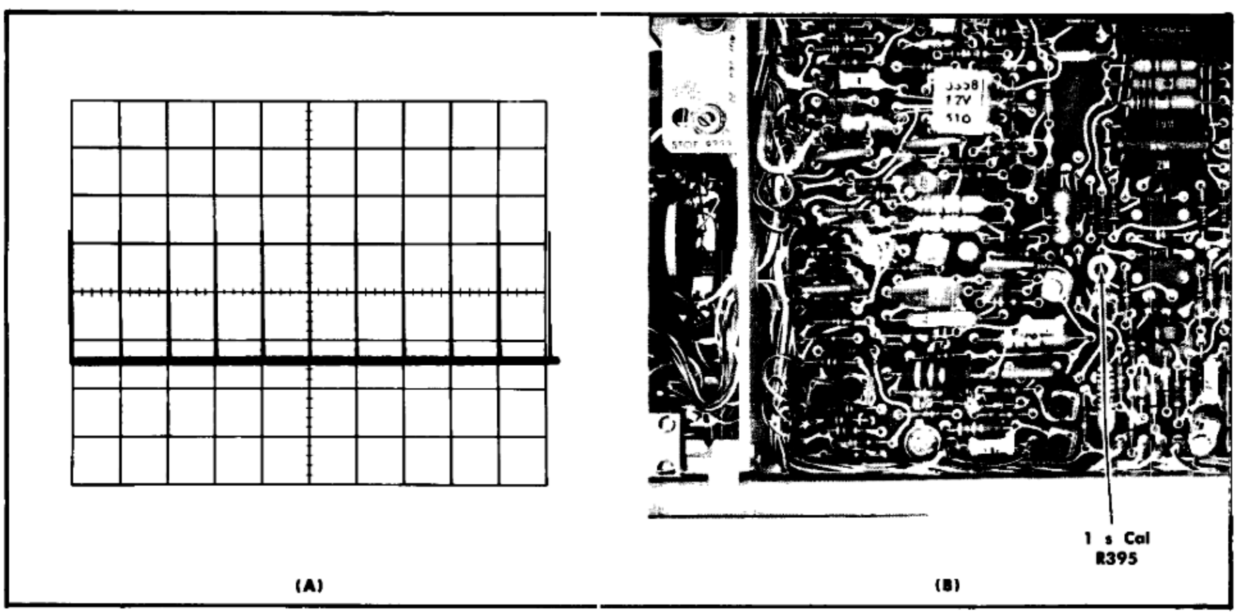

Fig. 6-13. (A) Typical CRT display showing correct one-second timing, (B) Location of 1 s Cal adjustment (Time-Base Board).

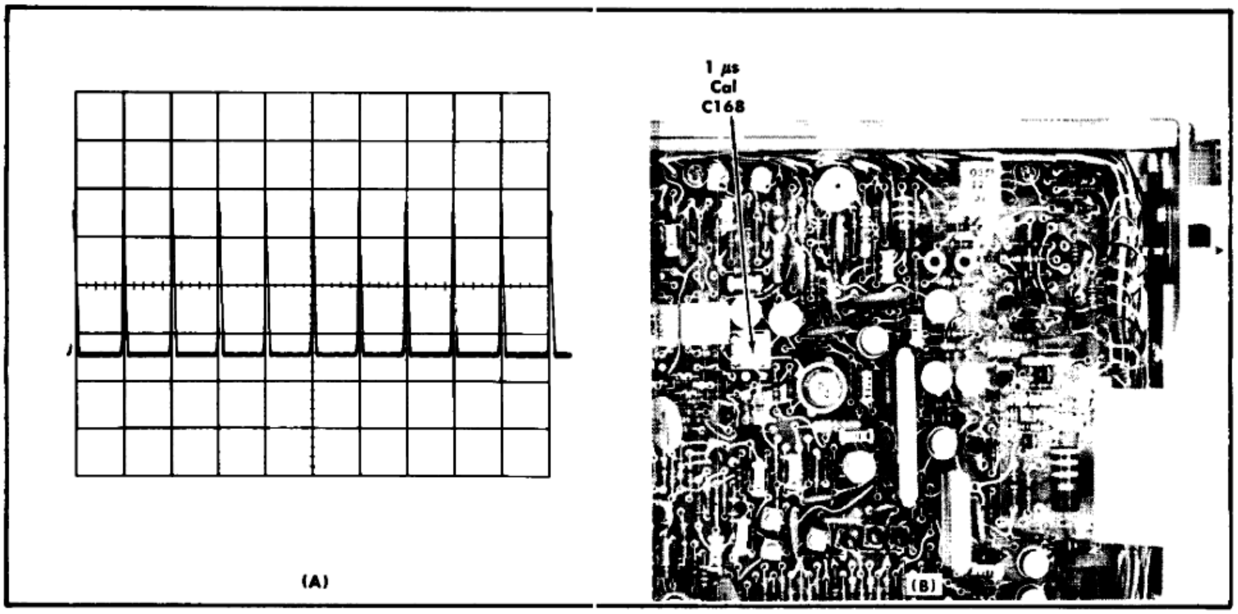

Fig. 6-14. (A) Typical CRT display showing correct one-microsecond timing, (B) Location of 1 μs Cal adjustment (Time-Base Board).

16. Adjust 0.1-Microsecond Timing

a. Set the time-mark generator for 0.1-microsecond markers.

b. Set the MANUAL TIME/DIV switch to 0.1 μs.

c. Set the LEVEL control for a triggered display.

d. CHECK—CRT display for one marker each division between the first and ninth vertical graticule lines (second and tenth marker; see Fig. 6-16A).

e. ADJUST—0.1 μs Cal adjustment, C502 (see Fig. 6-16B), for one marker each division.

f. INTERACTION—Check steps 17—20.

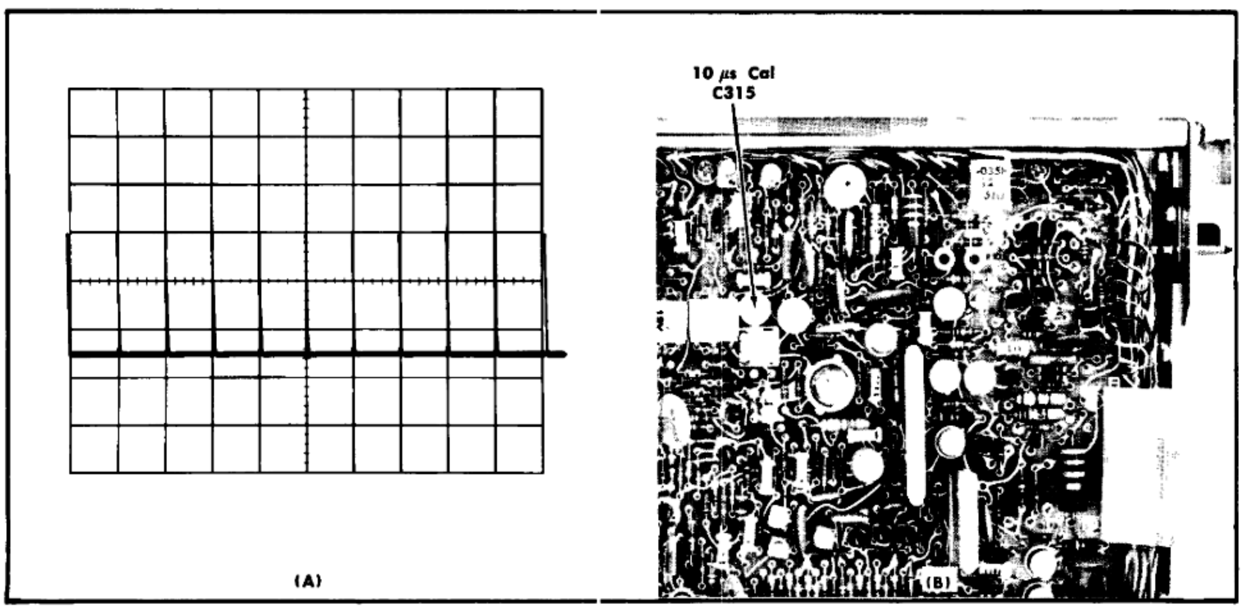

Fig. 6-15. (A) Typical CRT display showing correct 10-microsecond timing, (B) Location of 10 μs Cal adjustment (Time-Base Board).

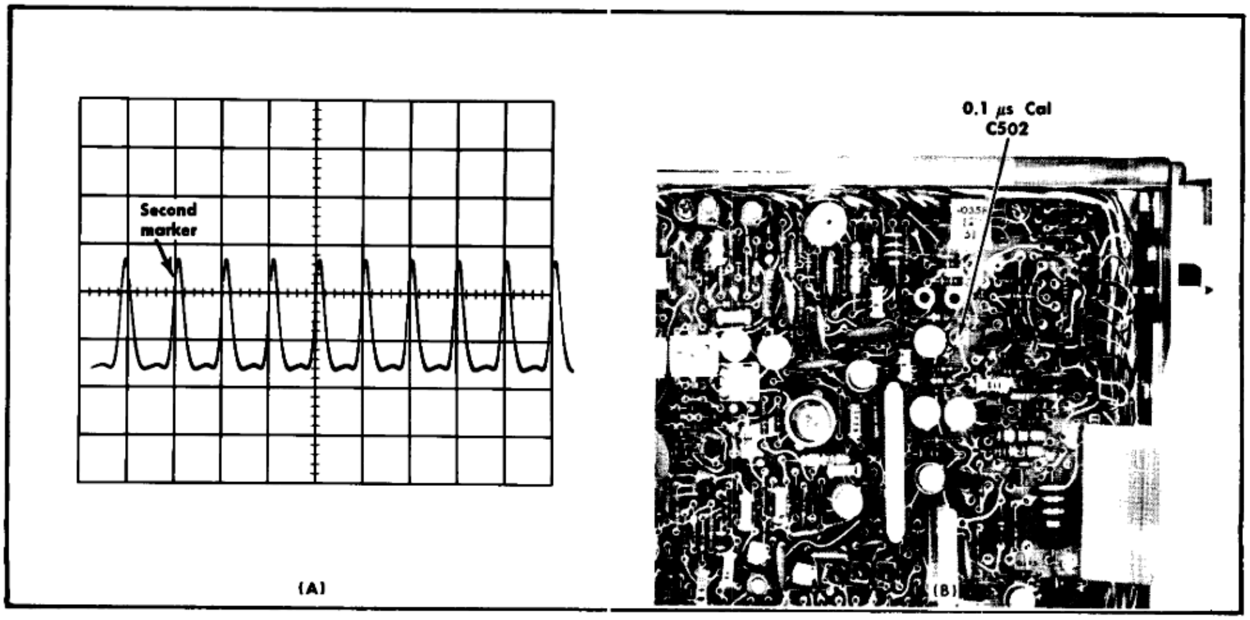

Fig. 6-16. (A) Typical CRT display showing correct 0.1-microsecond timing, (B) Location of 0.1 μs Cal adjustment (Time-Base Board).

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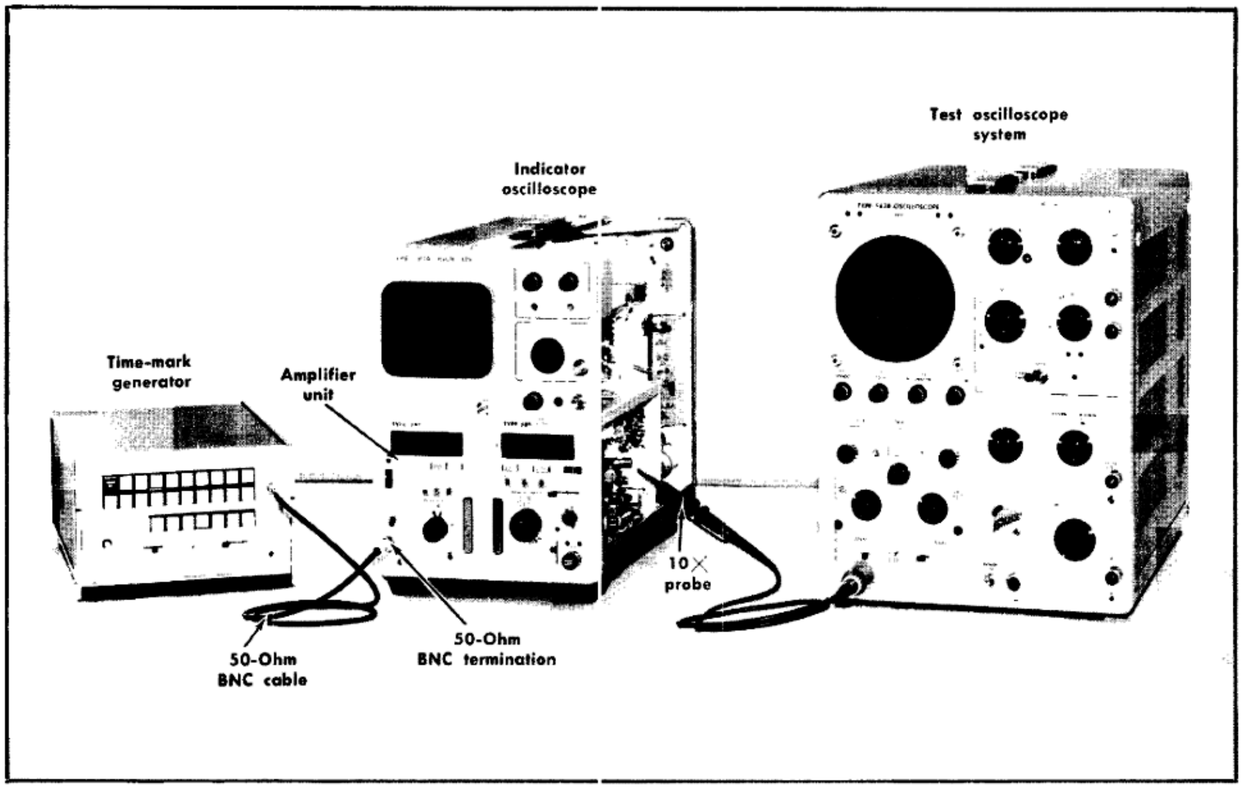

Fig. 6-17. Initial test equipment setup for steps 17—21.

Control Settings

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	**0.00**
MANUAL TIME/DIV	**50 ns**
VARIABLE	CAL
Trigger Function	INT-AC
LEVEL	Triggered display
SLOPE	+

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	**0.2 Volts**
Mode	Manual

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Visible display
Calibrator	10 Volts
Power	On

17. Adjust High-Frequency Compensation ⓘ

NOTE

The Type 3B5 must not be on an extender for steps 17 through 21. Also, the amplifier unit must have a bandpass of at least 10 MHz to check these steps.

a. Test equipment setup is shown in Fig. 6-17.

b. Connect the time-mark generator to the amplifier unit input connector through a 50-ohm BNC cable and a 50-ohm BNC termination.

c. Connect the 10× probe (compensated) to the input of the test oscilloscope system.

d. Set the test oscilloscope for a vertical deflection of five volts/division (50 volts/division including 10× probe) and the sweep rate to two microseconds/division.

e. Connect the probe tip to the test point for C547 (see Fig. 6-18A).

f. Set the time-mark generator for 50-nanosecond markers.

g. Set the test oscilloscope triggering controls for a stable display.

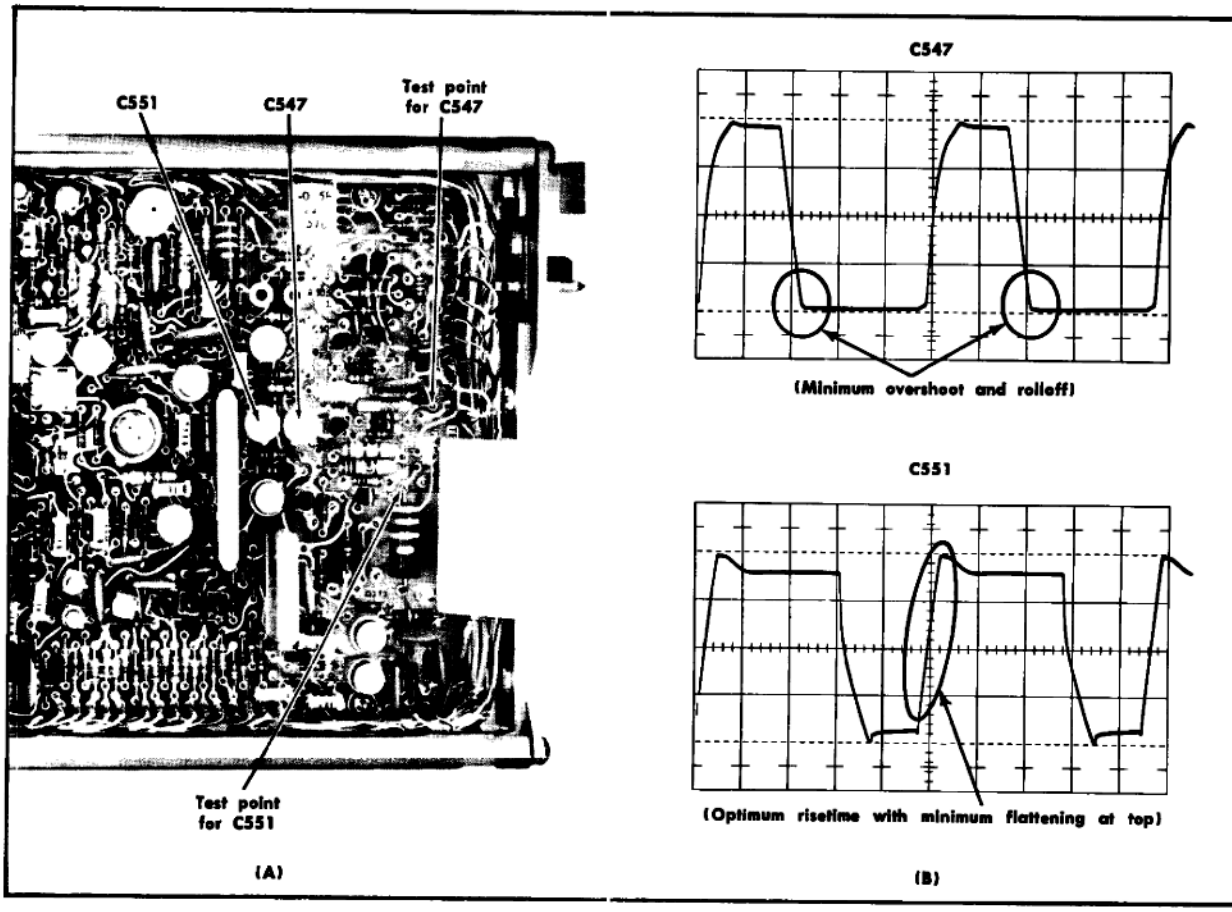

Fig. 6-18. (A) Location of high-frequency test points and adjustment: (Time-Base Board), (B) Typical test oscilloscope display showing correct adjustment.

h. CHECK—Test oscilloscope display for optimum square corner at the lower, trailing edge of the waveform (see Fig. 6-18B).

i. ADJUST—C547 (see Fig. 6-18A) for minimum overshoot and rolloff at the lower trailing edge of the waveform (optimum square corner). A typical test oscilloscope display is shown in Fig. 6-18B.

j. Move the probe tip to the test point for C551 (see Fig. 6-18A).

k. CHECK—Test oscilloscope display for optimum risetime with minimum flattening out at the top of the waveform (see Fig. 6-18B).

l. ADJUST—C551 (see Fig. 6-18A) for optimum risetime with minimum flattening out at the top of the waveform. A typical test oscilloscope display is shown in Fig. 6-18B.

NOTE

This is a preliminary adjustment for optimum high-frequency response. Further adjustment to provide correct timing and linearity may be necessary when checking 10-nanosecond timing in step 20.

m. Disconnect the 10× probe tip.

18. Adjust Registration

a. Set the time-mark generator for five-microsecond markers.

b. Set the MANUAL TIME/DIV switch to .1 μs.

c. Move the marker to the first vertical graticule line with the POSITION control (see Fig. 6-19A).

d. Set the MANUAL TIME/DIV switch to 50 ns.

e. CHECK—Marker should remain at the first vertical graticule line (see Fig. 6-19B).

f. ADJUST—Registration adjustment, R505 (see Fig. 6-19C), to move the marker to the first graticule line.

g. INTERACTION—Check steps 19 and 20

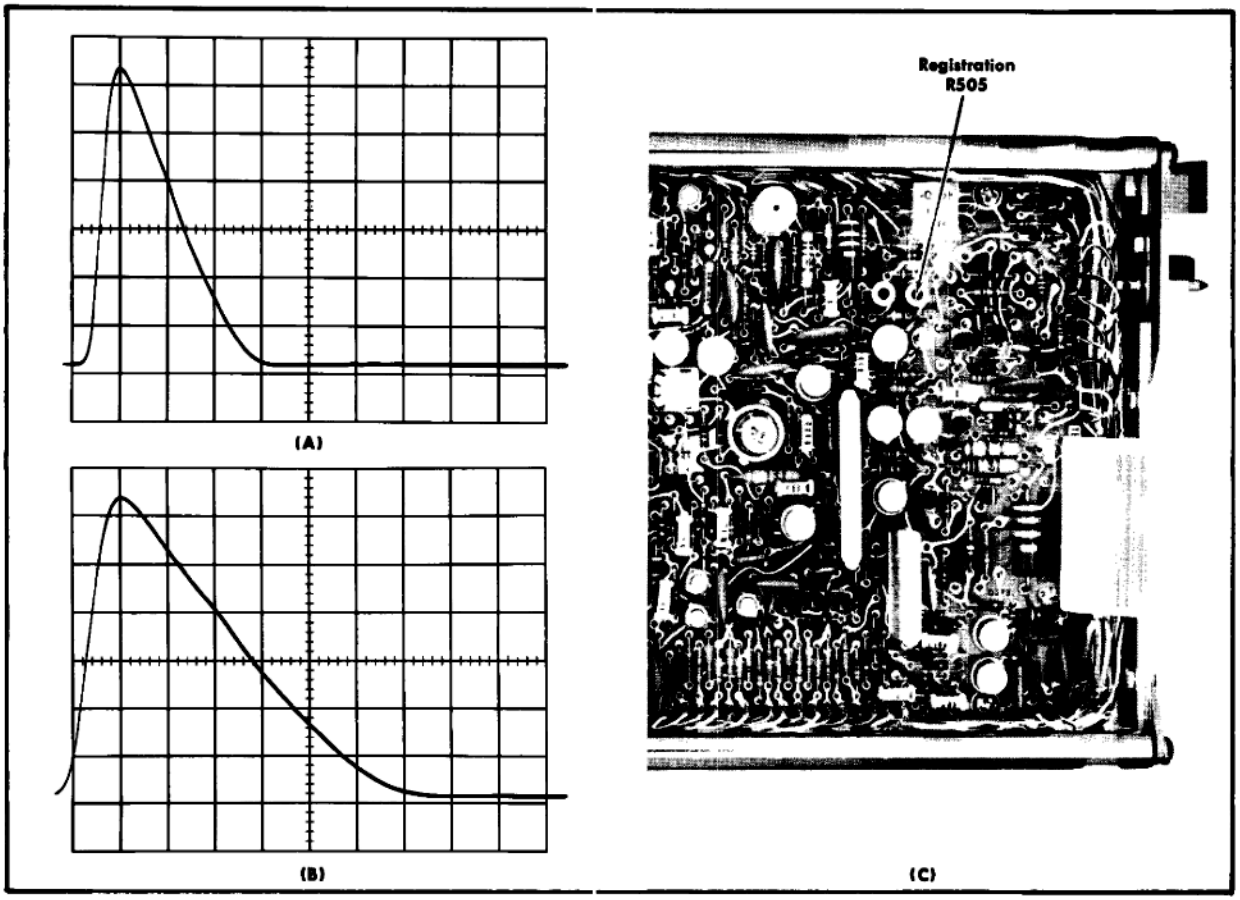

Fig. 6-19. Typical CRT display showing correct registration. (A) MANUAL TIME/DIV switch set to .1 μs, (B) MANUAL TIME/DIV switch set to 50 ns, (C) Location or Registration adjustment (Time-Base Board).

19. Adjust 50-Nanosecond and 20-Nanosecond Timing

a. Set the MANUAL TIME/DIV switch to 10 μs.

b. Move the start of the trace to the left vertical graticule line with the POSITION control.

c. Set the time-mark generator for 50-nanosecond markers.

d. Set the MANUAL TIME/DIV switch to 50 ns.

e. Move the nearest marker to the first vertical graticule line.

f. CHECK—CRT display for one marker each division between the first and ninth graticule lines (see Fig. 6-20A).

g. ADJUST—50 ns Cal adjustment, R508 (see Fig. 6-20B), for one marker each division.

h. Set the time-mark generator for 20-nanosecond markers.

i. Set the MANUAL TIME/DIV switch to 20 ns.

j. Move the nearest marker to the first vertical graticule line.

k. CHECK—CRT display for one marker each division between the first and ninth graticule lines (see Fig. 6-20C).

l. ADJUST—20 ns Cal adjustment, C507 (see Fig. 6-20B), for one marker each division.

m. Repeat steps a through l and readjust if necessary.

n. Recheck step 18 and readjust if necessary.

o. INTERACTION—Check step 20.

20. Adjust 10-Nanosecond Timing

a. Set the MANUAL TIME/DIV switch to 10 ns.

b. CHECK—CRT display for one marker each two divisions (see Fig. 6-21) with the fifth marker within ±0.24 division of the ninth vertical graticule line (timing within ±3%). (If timing error is greater than 5%, replace V544 and repeat steps 17 to 20.)

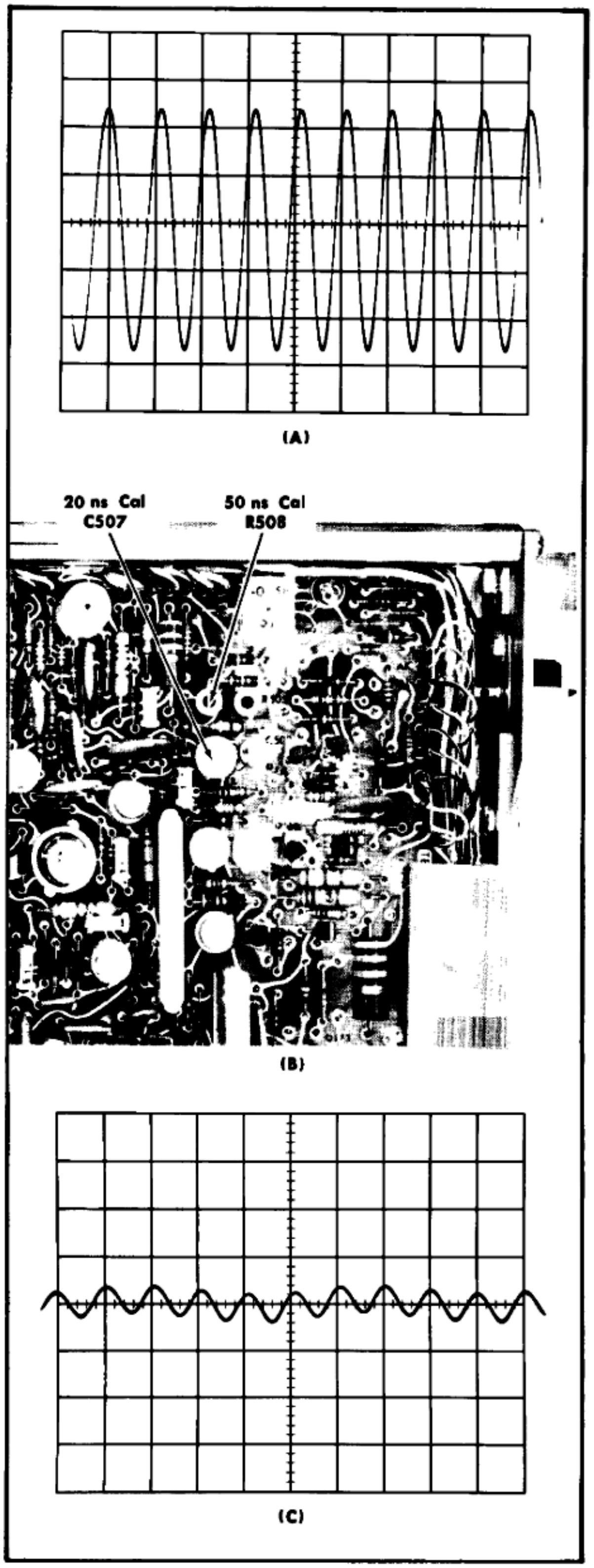

Fig. 6-20. (A) Typical CRT display showing correct 50-nanosecond timing, (B) Location of 50 and 20 ns adjustments (Time-Base Board), (C) Typical CRT display showing correct 20-nanosecond timing.

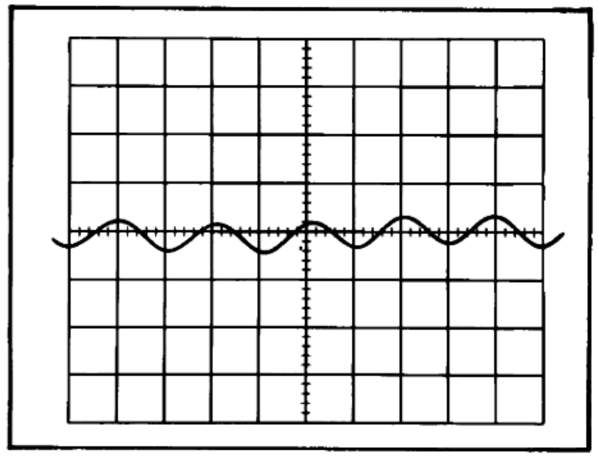

Fig. 6-21. Typical CRT display showing correct 10-nanosecond timing.

c. ADJUST—C547 and C551 (see Fig. 6-18A) slightly for optimum timing and linearity. (Note: readjust only if outside the tolerances listed in step b).

d. If adjustments are made, recheck step 19.

21. Check Normal and Magnified Timing Accuracy

a. Connect the time-mark generator trigger output connector to the EXT TRIG INPUT connector with a 50-ohm BNC cable.

b. Set the DELAY dial to 0.00.

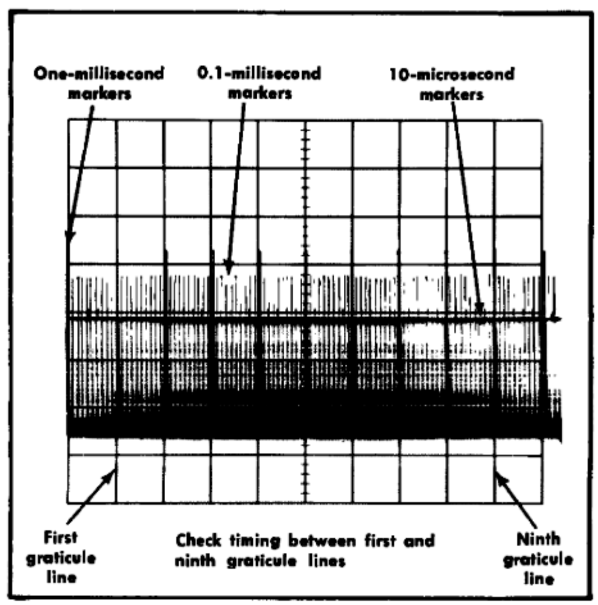

Fig. 6-22. Typical CRT display when checking timing accuracy (1 μs to 50 ms). Waveform shown was taken with MANUAL TIME/DIV switch set at 1 ms and DLY'D SWP MAG switch set to OFF.

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TABLE 6-1

TIMING CHECK (Normal and Magnified)

MANUAL TIME/DIV Switch Setting	Time-Mark Generator Output		Readout-Panel Indication With DLY'D SWP MAG Switch Set At:			CRT Display (Markers/Division)	Accuracy (measured between first and ninth graticule lines; see Fig. 6-22)
	Markers	Trigger	OFF	×10	×100		
10 ns	20 ns	1 μs	10 mμs/DIV	10 mμs/DIV	10 mμs/DIV	1 marker/ 2 divisions	±3% (±0.24 div)[1]
20 ns	20 ns	1 μs	20 mμs/DIV	20 mμs/DIV	20 mμs/DIV	1	±3%[1]
50 ns	50 ns	1 μs	50 mμs/DIV	50 mμs/DIV	50 mμs/DIV	1	±3%[1]
.1 μs	0.1 μs	1 μs	.1 μs/DIV	.1 μs/DIV	.1 μs/DIV	1	±3%
.2 μs	0.1 μs	1 μs	.2 μs/DIV	.2 μs/DIV	.2 μs/DIV	2	±3%
.5 μs	0.5 μs	1 μs	.5 μs/DIV	.5 μs/DIV	.5 μs/DIV	1	±3%
1 μs	1 μs, 0.1 μs	1 μs	1 μs/DIV	.1 μs/DIV	.1 μs/DIV	1	±3%
2 μs	1 μs, 0.1 μs	1 μs	2 μs/DIV	.2 μs/DIV	.2 μs/DIV	2	±3%
5 μs	5 μs, 0.5 μs	1 μs	5 μs/DIV	.5 μs/DIV	.5 μs/DIV	1	±3%
10 μs	10 μs, 1 μs, 0.1 μs	10 μs	10 μs/DIV	1 μs/DIV	.1 μs/DIV	1	±3%
20 μs	10 μs, 1 μs, 0.1 μs	10 μs	20 μs/DIV	2 μs/DIV	.2 μs/DIV	2	±3%
50 μs	50 μs, 5 μs, 0.5 μs	10 μs	50 μs/DIV	5 μs/DIV	.5 μs/DIV	1	±3%
.1 ms	0.1 ms, 10 μs, 1 μs	0.1 ms	.1 ms/DIV	10 μs/DIV	1 μs/DIV	1	±3%
.2 ms	0.1 ms, 10 μs, 1 μs	0.1 ms	.2 ms/DIV	20 μs/DIV	2 μs/DIV	2	±3%
.5 ms	0.5 ms, 50 μs, 5 μs	0.1 ms	.5 ms/DIV	50 /s/DIV	5 μs/DIV	1	±3%
1 ms	1 ms, 0.1 ms, 10 μs	1 ms	1 ms/DIV	0.1 ms/DIV	10 μs/DIV	1	±3%
2 ms	1 ms, 0.1 ms, 10 μs	1 ms	2 ms/DIV	0.2 ms/DIV	20 μs/DIV	2	±3%
5 ms	5 ms, 0.5 ms, 50 μs	1 ms	5 ms/DIV	0.5 ms/DIV	50 μs/DIV	1	±3%
10 ms	10 ms, 1 ms, 0.1 ms	10 ms	10 ms/DIV	1 ms/DIV	.1 ms/DIV	1	±3%
20 ms	10 ms, 1 ms, 0.1 ms	10 ms	20 ms/DIV	2 ms/DIV	.2 ms/DIV	2	±3%
50 ms	50 ms, 5 ms, 0.5 ms	10 ms	50 ms/DIV	5 ms/DIV	.5 ms/DIV	1	±3%
.1 s (OFF)	0.1 s	.1 s	.1 s/DIV	- -	- -	1	±3%
.1 s (×10)	10 ms	10 ms	- -	10 ms/DIV	- -	1	±3%
.1 s (×100)	1 ms	10 ms	- -	- -	1 ms/DIV	1	±3%
.2 s (OFF)	0.1 s	0.1 s	.2 s/DIV	- -	- -	2	±3%
.2 s (×10)	10 ms	10 ms	- -	20 ms/DIV	- -	2	±3%
.2 s (×100)	1 ms	10 ms	- -	- -	2 ms/DIV	2	±3%
.5 s (OFF)	0.5 s	1 s	.5 s/DIV	- -	- -	1	±3%
.5 s (×10)	50 ms	0.1 s	- -	50 ms/DIV	- -	1	±3%
.5 s (×100)	5 ms	0.1 s	- -	- -	5 ms/DIV	1	±3%
1 s (OFF)	1 s	1 s	1 s/DIV	- -	- -	1	±3%
1 s (×10)	0.1 s	0.1 s	- -	0.1 s/DIV	- -	1	±3%
1 s (×100)	10 ms	0.1 s	- -	- -	10 ms/DIV	1	±3%
2 s (OFF)	1 s	1 s	2 s/DIV	- -	- -	2	±5% (±0.4 div)
2 s (×10)	0.1 s	0.1 s	- -	0.2 s/DIV	- -	2	±5%
2 s (×100)	10 ms	0.1 s	- -	- -	20 ms/DIV	2	±5%
5 s (OFF)	5 s	1 s	5 s/DIV	- -	- -	1	±5%
5 s (×10)	0.5 s	0.1 s	- -	0.5 s/DIV	- -	1	±5%
5 s (×100)	50 ms	0.1 s	- -	- -	50 ms/DIV	1	±5%

[1] 10, 20 and 50 ns accuracy applies only if trace position is not moved from setting in steps 19 and 20. Otherwise, check accuracy within ±5%.

c. Set the Trigger Function switch to EXT-DC.

d. Set the LEVEL control for a stable display.

e. CHECK—Normal and magnified timing accuracy and correct readout-panel indications in all positions of the MANUAL TIME/DIV switch. Switch settings, time-mark generator output, readout-panel indications and tolerances are given in Table 6-1. First check timing and readout with the DLY'D SWP MAG switch at OFF; then at ×10 and ×100 (readjust LEVEL control as necessary to maintain a stable display). Also check that the MAG'D SWP readout is on when the DLY'D SWP MAG switch is set to ×10 or ×100. Check timing accuracy between the first and ninth graticule lines. A typical CRT display is shown in Fig. 6-22.

CAUTION

To prevent permanent damage to the CRT phosphor, either reduce the trace intensity at slow sweep rates to a level which does not produce a halo around the spot, or position the baseline of the marker display below the viewing area.

f. Disconnect the trigger cable.

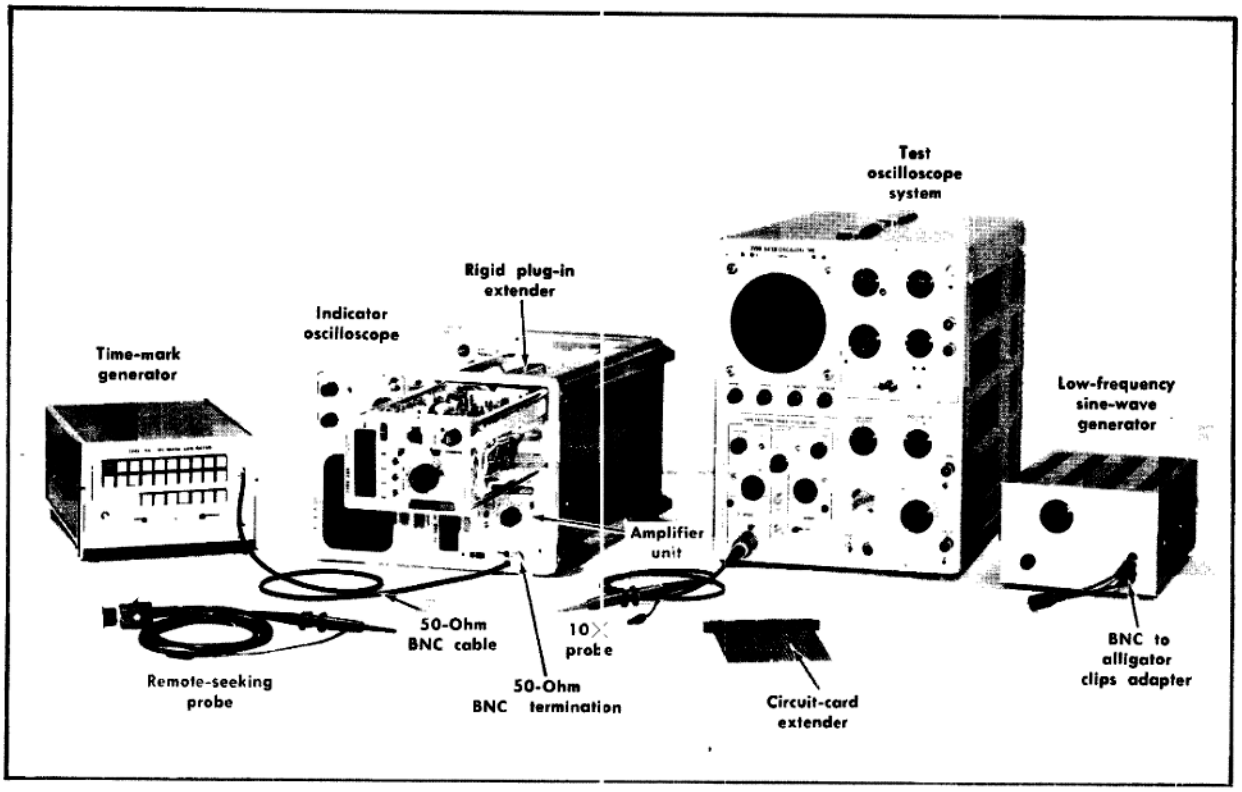

Fig. 6-23. Initial test equipment setup for steps 22—30.

Control Settings

Type 3B5

MODE	MAN
POSITION	Midrange
DLY'D SWP MAG	**OFF**
DELAY	0.00
MANUAL TIME/DIV	**1 ms**
VARIABLE	CAL
Trigger Function	**INT-AUTO**
LEVEL	Midrange
SLOPE	+

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	**0.5 Volts**
Mode	Manual

Ⓐ

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Visible display
Calibrator	10 Volts
Power	On

22. Check Operating Mode

a. Test equipment setup is shown in Fig. 6-23.

b. Remove the Type 3B5 from the indicator oscilloscope and reconnect using the rigid plug-in extender (turn indicator oscilloscope power off while removing and reconnecting the Type 3B5). Lay the indicator oscilloscope on its left side.

c. Connect the time-mark generator to the amplifier unit input connector through a 50-ohm BNC cable and a 50-ohm BNC termination.

d. Set the time-mark generator for one-millisecond markers.

e. Press the SEEK button.

f. CHECK—SEEK button lights and a stable display is presented.

g. Press the EXT button momentarily.

h. CHECK—EXT button lights as long as it is held depressed.

i. Release the EXT button.

j. CHECK—MAN button lights and a stable display is presented.

23. Check Seek Mono Pulse Width and Seek Cycling Time

a. Connect the 10× probe to the test oscilloscope system and connect the probe tip to pin 8 of J400 (Logic Card; see Fig. 6-24A).

b. Set the test oscilloscope for a vertical deflection of 0.5 volt/division (5 volts/division including 10× probe) at a sweep rate at 0.2 second/division. Set the trigger slope switch to + and the LEVEL control slightly clockwise from midrange.

c. CHECK—Press the SEEK button and release. Check test oscilloscope display for a positive pulse between five and

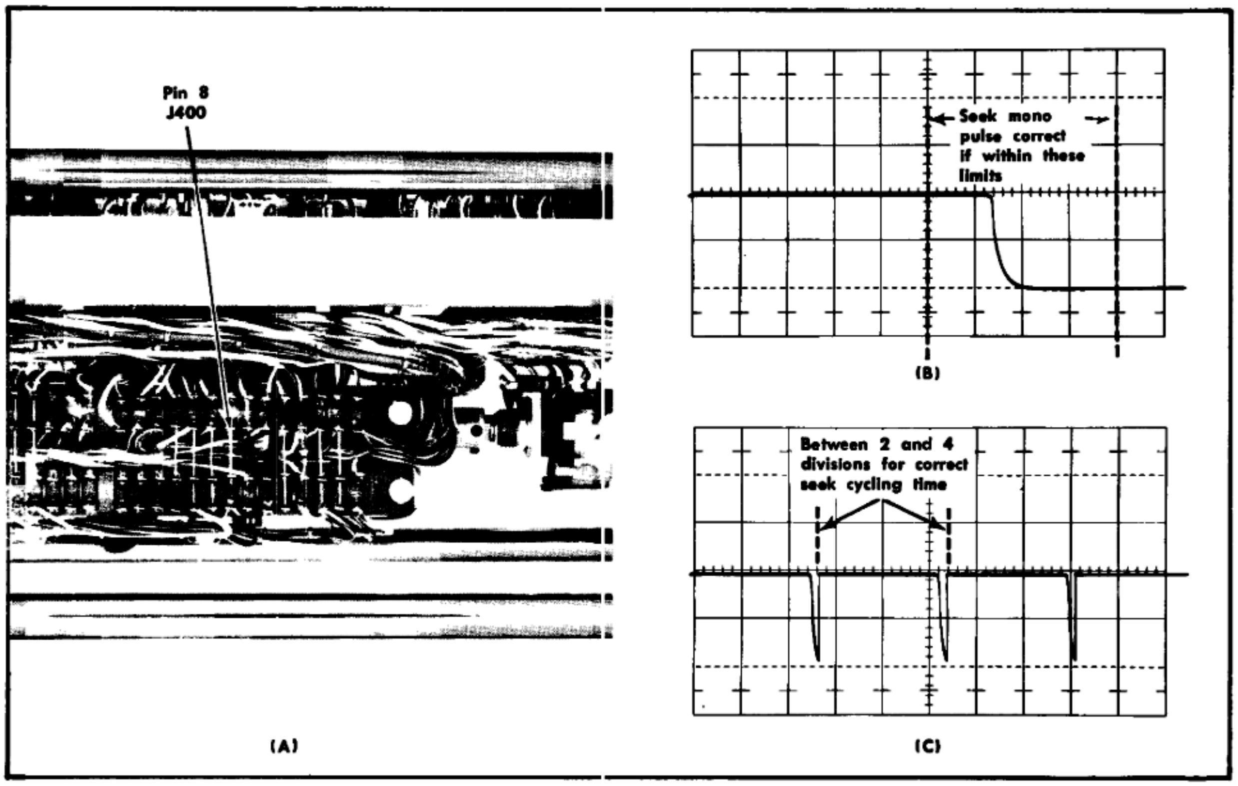

Fig. 6-24. (A) Location of Pin 8, J400 (bottom), (B) Typical test oscilloscope display when checking seek mono pulse duration, (C) Typical test oscilloscope display when checking seek cycling time.

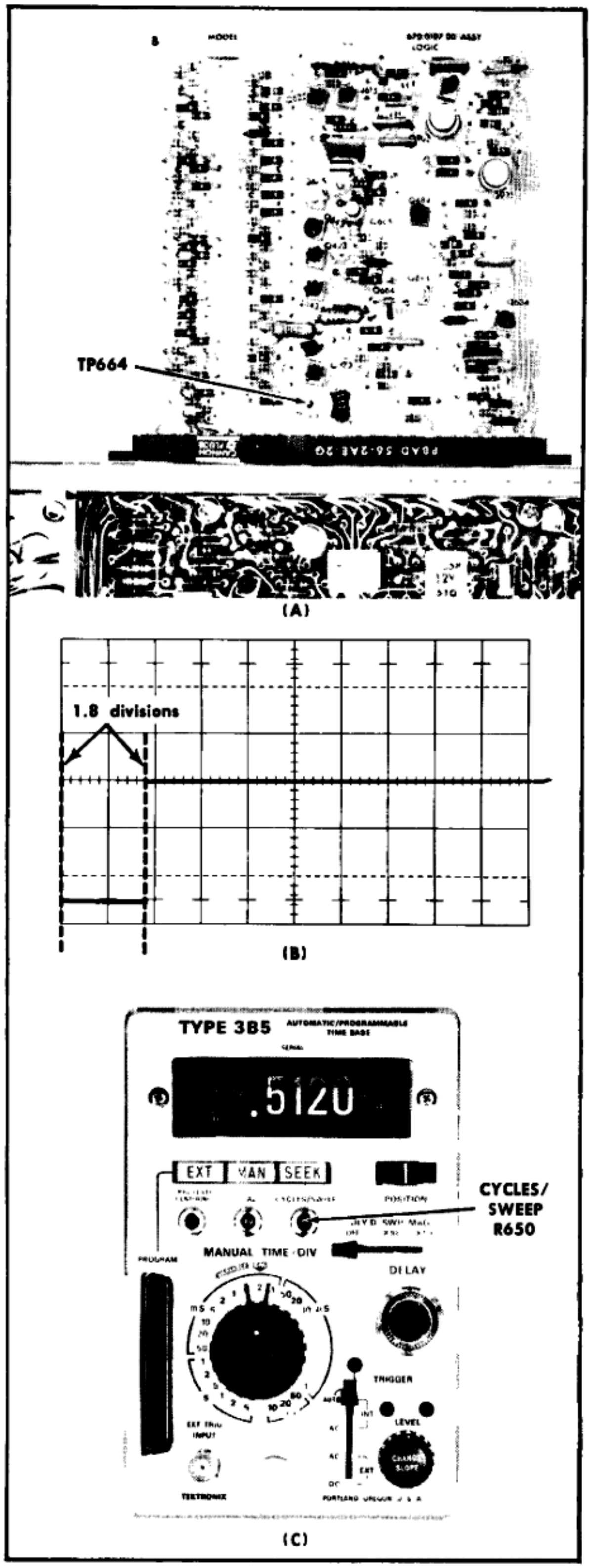

Fig. 6-25. (A) Location of TP664, Logic Card, (B) Typical test oscilloscope display showing nominal CYCLES/SWEEP adjustment, (C) Location of CYCLES/SWEEP adjustment (front-panel).

nine divisions in duration (one second to 1.8 seconds; see Fig. 6-24B) and about 1.6 divisions in amplitude (approximately eight volts).

d. Change the test oscilloscope sweep rate to 0.5 second/division.

e. Hold the SEEK button depressed.

f. CHECK—Test oscilloscope display for a waveform period of two to four divisions (one to two seconds; see Fig. 6-24C).

24. Adjust Cycles/Sweep

a. Remove the Logic Card and re-install it using the circuit-card extender (turn off indicator oscilloscope power while installing extender).

b. Connect the 10× probe tip to TP664 (Logic Card; see Fig. 6-25A).

c. Set the test oscilloscope for a vertical deflection of 0.1 volt/division (1 volt/division including probe), sweep rate of one millisecond/division and set the trigger slope to trigger on the negative slope.

d. Press the MAN button.

e. CHECK—Test oscilloscope display for a 1.8-division window-gate signal (see Fig. 6-25B).

f. ADJUST—CYCLES/SWEEP adjustment, R650 (see Fig. 6-25C), so the window-gate signal is 1.8 divisions in length.

NOTE

This procedure provides a nominal range of operation for a typical Seek Mode display of between two and six cycles; the exact number of cycles displayed for a particular signal will vary due to the sweep rate selected by the Seek circuit. This adjustment can be reset for the desired range during normal use.

g. Remove the circuit-card extender and the plug-in extender. Re-install the Logic Card and insert the Type 3B5 into the right plug-in compartment. Set the indicator osciloscope upright.

h. Disconnect the time-mark generator.

25. Check Seek Mode Operation

a. Connect the remote-seeking probe to the automatic/programmable amplifier unit input connector.

b. Connect the probe tip to the indicator oscilloscope calibrator output connector.

c. Press the seek button on the remote-seeking probe.

d. CHECK—Both the amplifier unit and the Type 3B5 seek a stable CRT display showing between two and six cycles horizontally and two to six divisions vertically (may vary due to calibration of front-panel adjustments).

e. Connect a jumper lead (#18 or #20 wire) between terminals 4 and 22 of the amplifier unit program connector

f. CHECK—Both the amplifier unit and the Type 3B5 seek a stable CRT display (units continuously recycle approximately every two to four seconds).

g. Disconnect the jumper lead.

h. Press the front-panel seek button on the amplifier unit.

i. CHECK—Only the amplifier unit seeks.

j. Press the front-panel SEEK button on the Type 3B5.

k. CHECK—Only the Type 3B5 seeks a stable display.

l. Connect a jumper lead between terminals 12 and 22 of the Type 3B5 PROGRAM connector (see Fig. 6-26).

m. CHECK—Only the Type 3B5 seeks a stable display (unit continuously recycles every one to two seconds).

26. Check Seek Mode Frequency Response

a. Connect the low-frequency sine-wave generator to the amplifier unit input connector through the BNC cable (use the BNC to alligator clips adapter to connect the generator output to the BNC cable).

b. Set the low-frequency sine-wave generator for about two volts output at 30 hertz.

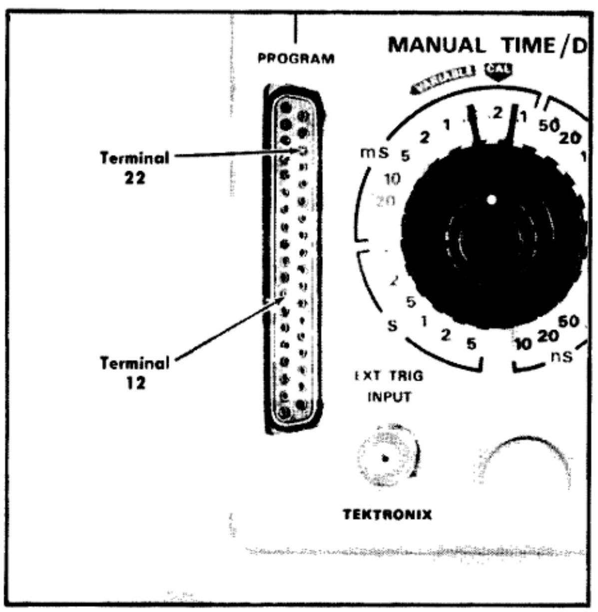

Fig. 6-26. Location of terminals 12 and 22 of PROGRAM connector (front panel).

c. Set the Trigger Function switch to EXT-DC.

d. CHECK—Slowly increase the output frequency of the low-frequency sine-wave generator and check that the unit progressively seeks the next faster sweep rate, presenting a stable display (leave on continuous seek) as the frequency is increased. Allow time for the seek circuits to recycle (about one to two seconds) before increasing the frequency. Check from 30 hertz to 2 megahertz.

e. Disconnect the low-frequency sine-wave generator and connect the time-mark generator to the amplifier unit through the 50-ohm BNC cable and the 50-ohm termination.

f. Set the time-mark generator for 50-nanosecond markers (20 MHz sine wave; this check can only be made with an amplifier unit which has a bandwidth of at least 15 MHz).

g. CHECK—A stable CRT display is presented (about 20 cycles displayed; readout-panel indication, .1 μs/DIV) before the seek circuits recycle.

h. Disconnect the jumper lead and set the Trigger Function switch to INT-AUTO.

27. Check Multitrace Sync Pulse

a. Connect the 10× probe tip to pin connector AV on the Time-Base Board (see Fig. 6-27A).

b. Set the test oscilloscope for a vertical deflection of 0.2 volts/division (2 volts/division including 10× probe) and the sweep rate to 50 microseconds/division.

c. Set the MANUAL TIME/DIV switch to 10 μs.

d. CHECK—Test oscilloscope display for positive and negative going pulses of about 2.5 divisions (about five volts; see Fig. 6-27B).

28. Check Delayed Sweep Magnifier Intensifier Levels

a. Connect the 10× probe tip to pin connector X on the Time-Base Board (see Fig. 6-28A).

b. Set the test oscilloscope for a vertical deflection of 0.2 volt/division (2 volts/division including 10× probe), the sweep rate to one millisecond/division, input coupling to DC and set the triggering controls for a free-running display.

c. Establish the zero-volt level on the test oscilloscope CRT. Position the trace so the zero-volt level is at the top of the display area.

d. Set the MANUAL TIME/DIV switch to 5 s (reduce the intensity level to protect the CRT).

e. CHECK—Test oscilloscope display for a trace about six divisions below the zero-volt level (—12 volts; see Fig. 6-28B).

f. Set the DLY'D SWP MAG switch to ×10.

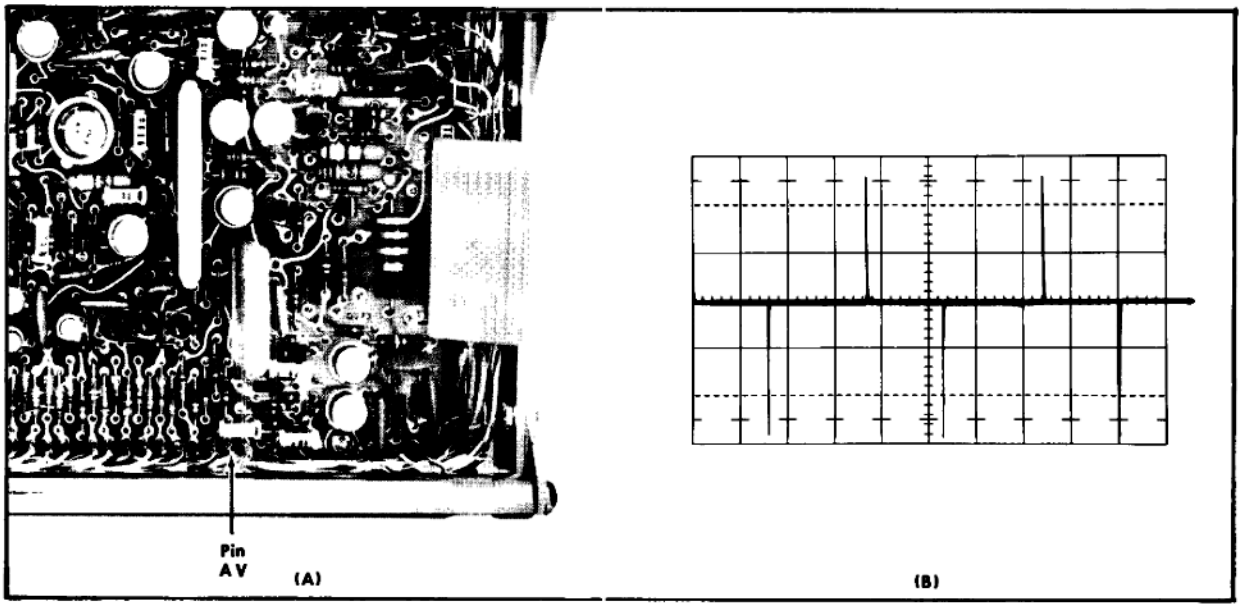

Fig. 6-27. (A) Location of pin connector AV on Time-Base Board, (B) Typical test oscilloscope display when checking multitrace sync pulse.

g. CHECK—Test oscilloscope display for a trace about three divisions below the zero-volt level during the magnified sweep time (—6 volts; see Fig. 6-28B).

NOTE

The DC level returns to about —12 volts at the start of each sweep.

h. Set the DLY'D SWP MAG switch to ×100.

i. CHECK—Test oscilloscope display for a trace near the zero-volt level during the magnified sweep time.

29. Check Sawtooth Output Through Program Connector

a. Set the time-mark generator for 0.1-millisecond markers.

b. Set the MANUAL TIME/DIV switch to 0.1 ms.

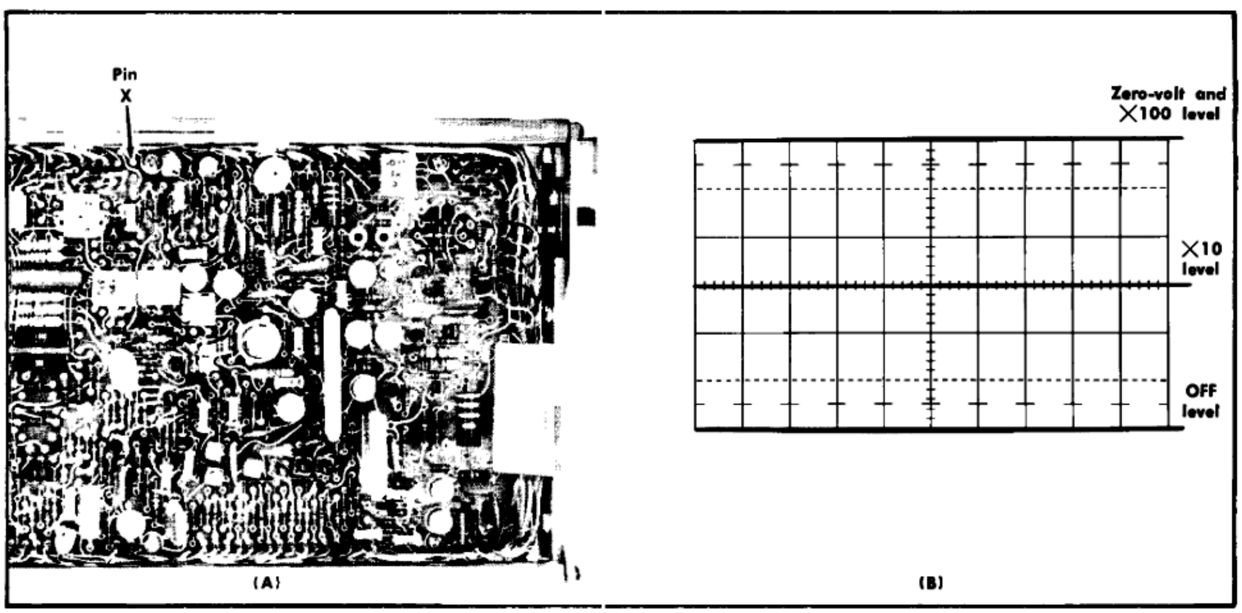

Fig. 6-28. (A) Location of pin connector X on Time-Base Board, (B) Typical test oscilloscope display when checking delayed sweep magnifier intensifier operation.

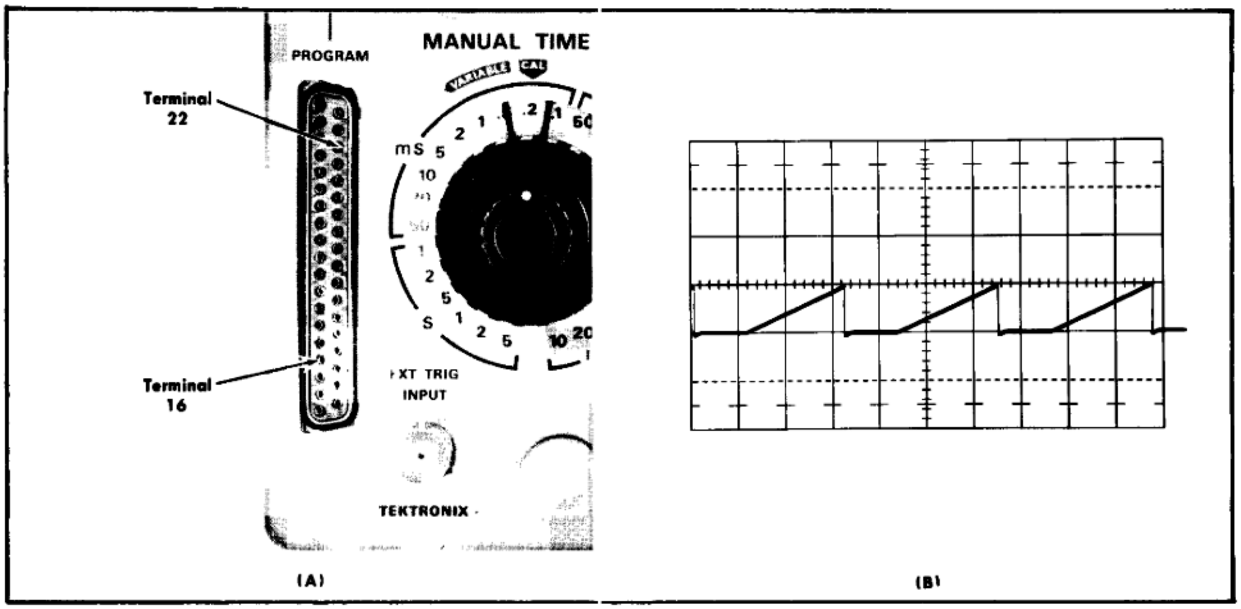

Fig. 6-29. (A) Location of terminals 16 and 22 of PROGRAM connector, (B) Typical test oscilloscope display when checking sawtooth output.

c. Set the DLY'D SWP MAG switch to OFF.

d. Set the test oscilloscope for a vertical deflection of 0.05 volt/division (0.5 volt/division including probe) and a sweep rate of 0.5 millisecond/division.

e. Connect a 1 kΩ, ½ watt, 1% resistor between terminals 16 and 22 of the PROGRAM connector (see Fig. 6-29A).

f. Connect the 10X probe tip to terminal 16 of the PROGRAM connector.

g. CHECK—Test oscilloscope display for about three cycles of the sawtooth signal and a vertical deflection of one division, ±0.1 division; see Fig. 6-29B (0.05 milliamp/division, ±10%, output from Type 3B5).

30. Check Sawtooth Output to Amplifier Unit

a. Set the test oscilloscope vertical deflection to one volt/division (10 volts/division including probe).

b. Connect the 10X probe tip to pin connector AH on the Time-Base Board (see Fig. 6-30).

c. CHECK—Test oscilloscope display for about three cycles of the sawtooth and vertical deflection of about five divisions.

d. Disconnect all test equipment.

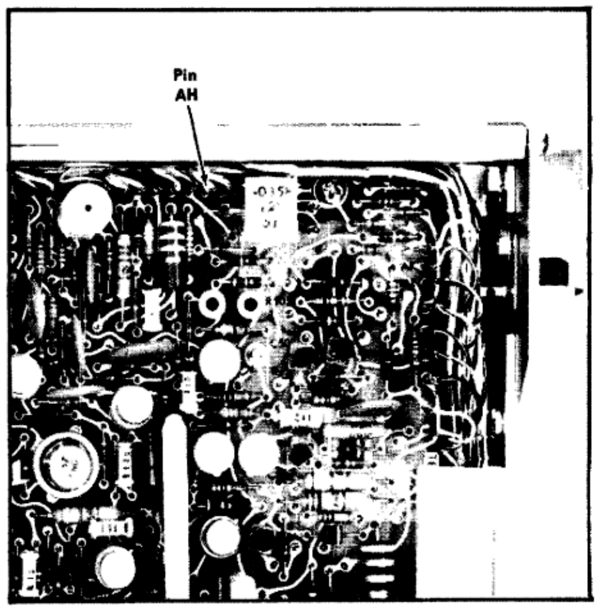

Fig. 6-30. Location of pin connector AH on Time-Base Board.

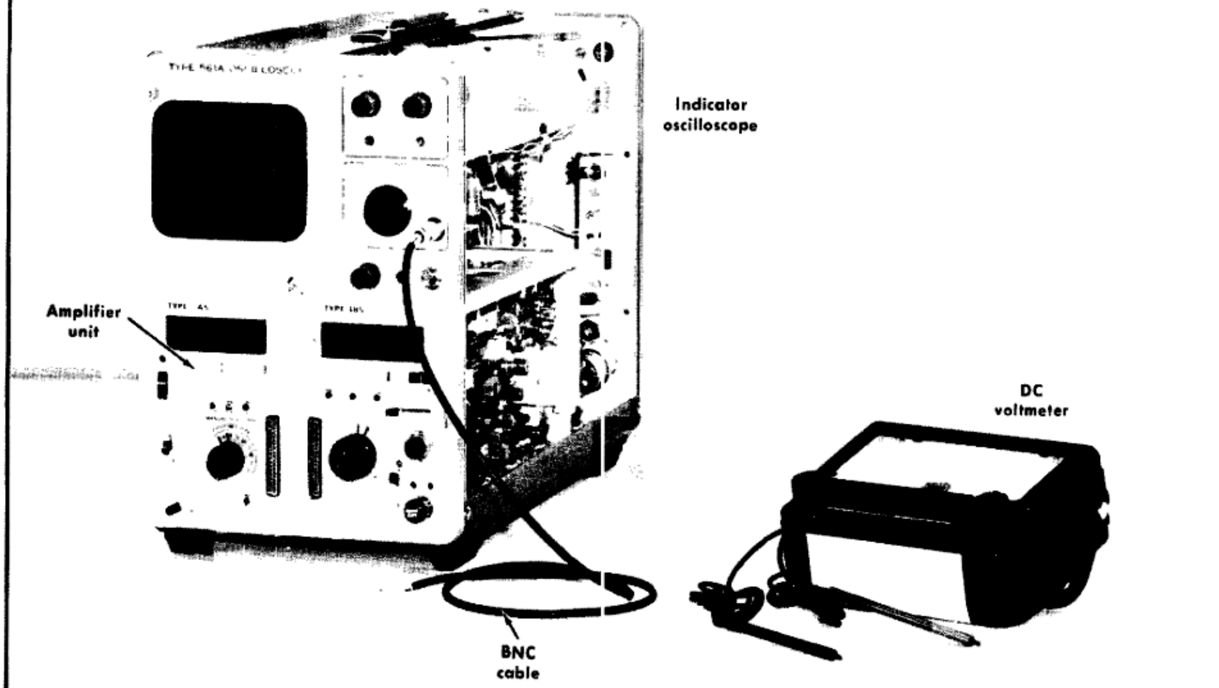

Fig. 6-31. Initial test equipment setup for steps 31—35.

Control Settings

Type 3B5

Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	0.00
MANUAL TIME/DIV	**0.1 ms**
VARIABLE	CAL
Trigger Function	INT-AUTO
LEVEL	Midrange
SLOPE	+

Amplifier Unit

Position	Midrange
Input Coupling	DC
Volts/Division	0.5 Volts
Mode	Manual

Indicator Oscilloscope

Focus	Adjust for correct display
Intensity	Visible display
Calibrator	10 Volts
Power	On

31. Check Front-Panel Output Voltages

a. Connect the DC voltmeter from terminal 1 of the PROGRAM connector (see Fig. 6-32) to chassis ground.

b. CHECK—Meter reading approximately —12.2 volts.

c. Connect the DC voltmeter from terminal 18 of the PROGRAM connector (see Fig. 6-32) to chassis ground.

d. CHECK—Meter reading approximately +125 volts

e. Connect the DC voltmeter from terminal 19 of the PROGRAM connector (see Fig. 6-32) to chassis ground.

f. CHECK—Meter reading approximately —100 volts.

NOTE

The special single sweep, external horizontal circuit shown in Fig. 2-6 provides the most convenient method of checking steps 32 to 34. It is recommended that this circuit be constructed if these features are to be checked frequently. However, the following procedure provides a method for checking these steps either with or without the special circuit.

32. Check Output DC Level

a. Set the Trigger Function switch to EXT-AC or DC (no trigger signal connected). Connect a jumper lead (#18 or #20 solid wire) between terminals 1 and 13 of the PROGRAM connector (see Fig. 6-32) and connect a 20 kΩ, ½ watt resistor between terminals 14 and 22. (If using the special circuit, set switch to external horizontal.)

b. Reduce the intensity level so the spot is just visible on the CRT.

c. Move the spot to the center of the CRT with the POSITION control.

d. Connect the DC voltmeter between the horizontal deflection-plate pins on the indicator oscilloscope CRT. Be careful not to bend the pins.

e. Adjust the POSITION control for a zero-volt reading on the voltmeter.

f. Disconnect the negative lead of the DC voltmeter and connect it to ground (set meter for range which will measure 180 volts).

g. CHECK—Meter reading for +180 volts, ±10 volts.

h. Disconnect the DC voltmeter.

NOTE

The remaining steps in this procedure verify various operating features of this instrument which do not directly affect instrument performance or measurement capability.

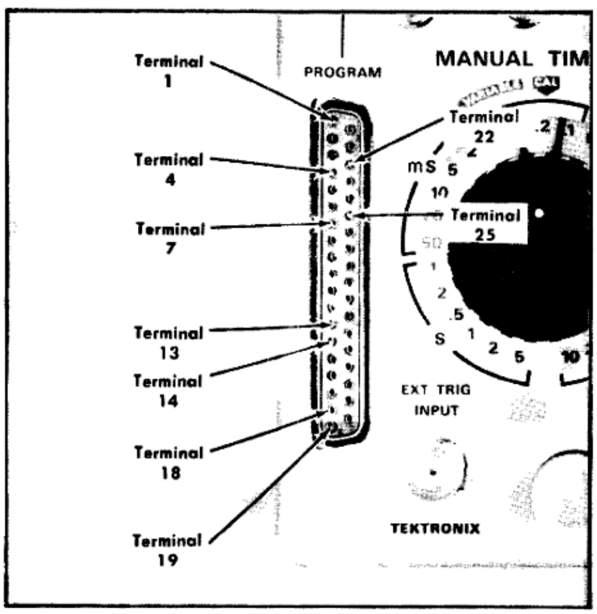

Fig. 6-32. Location of PROGRAM connector terminals used in steps 31—35.

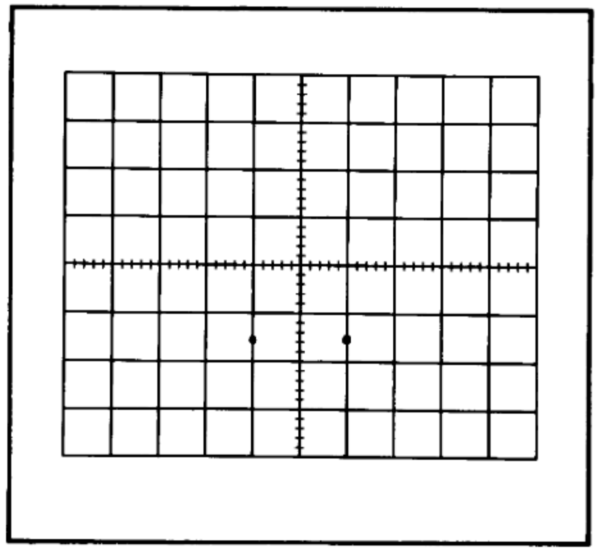

Fig. 6-33. Typical CRT display when checking external horizontal operation.

33. Check External Horizontal Input

a. Connect a jumper lead (wire) from the indicator oscilloscope calibrator output connector to terminal 4 of the PROGRAM connector (see Fig. 6-32). (If using the special circuit, connect a BNC cable from the calibrator output connector to the external horizontal input connector and switch to external horizontal.)

b. CHECK—Two dots displayed on screen about two divisions apart (deflection factor about five volts/division; see Fig. 6-33).

c. Disconnect all connections to the PROGRAM connector (special circuit may be left in place).

34. Check Single Sweep Operation

a. Set the MANUAL TIME/DIV switch to 20 ms and the Trigger Function switch to INT-AC.

b. Connect the indicator oscilloscope calibrator output to the amplifier unit input connector with a BNC cable.

c. Set the amplifier unit for about four divisions of vertical deflection.

d. Set the LEVEL control for a stable display.

e. Connect a jumper lead (wire) between terminals 7 and 18 (Caution; +125 volts) of the PROGRAM connector (see Fig. 6-32). (If using special circuit, set switch to single sweep.)

f. CHECK—No trace is displayed but the NOT TRIG'D readout remains off.

g. Connect a jumper lead to terminal 25 of the PROGRAM connector (see Fig. 6-32). Momentarily touch the other end of the jumper lead to terminal 1. (Disregard this step for special circuit.)

h. CHECK—A single display (one sweep only) is presented each time the circuit is reset by touching the jumper lead to terminal 1 (there will be more than one sweep if the jumper lead is connected to terminal 1 throughout the entire sweep). If using the special circuit, check that a single display is presented each time the reset button is pressed.

i. Disconnect all test equipment.

35. Check External Programmed Operation

No test procedure is given here for checking the external programmed operation of this unit. If a Tektronix external programmer is used, a complete checkout procedure for the programmable functions is given in the Instruction Manual for that unit. To check external programmed operation without a programmer, use the external program information given in Section 2.

This completes the calibration procedure for the Type 3B5. If the instrument has been completely checked and calibrated to the tolerances given in this procedure, it will meet the electrical characteristics listed in the Performance Requirement column in the Characteristics section of this manual.

NOTES

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.

SECTION 7

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description	S/N Range

Bulbs

B47	150-0055-00	Neon 5AB-B	
B72	150-0055-00	Neon 5AB-B	
B82	150-0055-00	Neon 5AB-B	
B905	150-0049-00	Incandescent #685	
B915	150-0049-00	Incandescent #685	
B925	150-0049-00	Incandescent #685	
B982	150-0049-00	Incandescent #685	
B983	150-0048-00	Incandescent #683	
B985	150-0054-00	Incandescent #683 w/red coating	
B987	150-0054-00	Incandescent #683 w/red coating	
B991	150-0048-00	Incandescent #683	
B992	150-0049-00	Incandescent #685	
B993	150-0049-00	Incandescent #685	
B994	150-0049-00	Incandescent #685	
B995	150-0049-00	Incandescent #685	
B997	150-0048-00	Incandescent #683	
B998	150-0048-00	Incandescent #683	
B999	150-0049-00	Incandescent #685	

Capacitors

Tolerance ±20% unless otherwise indicated.

C1	281-0629-00	33 pF	Cer	600 V	5%	
C2	281-0511-00	22 pF	Cer	500 V	10%	
C3	*285-0727-00	0.1 μF	MT	600 V	10%	
C14	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C21	283-0026-00	0.2 μF	Cer	25 V		
C23	290-0244-00	0.47 μF	EMT	35 V	5%	
C26	290-0244-00	0.47 μF	EMT	35 V	5%	
C31	290-0264-00	0.22 μF	EMT	35 V	10%	
C69	283-0067-00	0.001 μF	Cer	200 V	10%	
C77	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C92	290-0138-00	330 μF	EMT	6 V		
C99	283-0067-00	0.001 μF	Cer	200 V	10%	
C102	283-0081-00	0.01 μF	Cer	25 V	+80%—20%	
C123	281-0524-00	150 pF	Cer	500 V		
C133	281-0546-00	330 pF	Cer	500 V	10%	

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C137	283-0079-00	0.01 μF	Cer		250 V		
C138	283-0079-00	0.01 μF	Cer		250 V		
C139	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C146	283-0081-00	0.1 μF	Cer		25 V	+80%—20%	
C151	281-0549-00	68 pF	Cer		500 V	10%	X123-up
C163	283-0079-00	0.01 μF	Cer		250 V		
C167	281-0513-00	27 pF	Cer		500 V		
C168	281-0080-00	1.7-11 pF	Air	Var	800 V		
C173	283-0081-00	0.1 μF	Cer		25 V		
C174	283-0079-00	0.01 μF	Cer		250 V		
C176	283-0079-00	0.01 μF	Cer		250 V		
C183	281-0540-00	51 pF	Cer		500 V	5%	
C186	281-0592-00	4.7 pF	Cer		200 V	±0.5 pF	
C193	283-0079-00	0.01 μF	Cer		250 V		
C207	283-0051-00	0.0033 μF	Cer		100 V	5%	
C217	283-0010-00	0.05 μF	Cer		50 V		
C227	283-0134-00	0.47 μF	Cer		50 V	+80%—20%	
C233	281-0518-00	47 pF	Cer		500 V		
C234	281-0513-00	27 pF	Cer		500 V		
C235	281-0518-00	47 pF	Cer		500 V		
C252	281-0518-00	47 pF	Cer		500 V		100-172X
C253	283-0079-00	0.01 μF	Cer		250 V		
C255	281-0525-00	470 pF	Cer		500 V		
C257	281-0543-00	270 pF	Cer		500 V	10%	100-172
C257	281-0605-00	200 pF	Cer		500 V		173-up
C262	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C266	281-0605-00	200 pF	Cer		500 V		
C269	283-0001-00	0.005 μF	Cer		500 V		
C275	283-0079-00	0.01 μF	Cer		250 V		
C284	290-0158-00	50 μF	EMT		25 V	+75%—15%	
C291	281-0543-00	270 pF	Cer		500 V	10%	
C293	283-0059-00	1 μF	Cer		25 V	+80%—20%	
C295	283-0081-00	0.1 μF	Cer		25 V	+80%—20%	
C309	281-0511-00	22 pF	Cer		500 V	10%	
C311	*295-0097-00	1 μF	Timing Capacitor				
C312		0.1 μF					
C313		0.01 μF					
C314		990 pF					
C315	281-0093-00	5.5-18 pF	Cer	Var			
C316	283-0616-00	75 pF	Cer		500 V	5%	
C317	281-0626-00	3.3 pF	Cer		500 V	5%	
C353	283-0079-00	0.01 μF	Cer		250 V		
C372	281-0592-00	4.7 pF	Cer		200 V	±0.5 pF	
C502	281-0064-00	0.2-1.5 pF	Tub.	Var			
C507	281-0093-00	5.5-18 pF	Cer	Var			
C515	281-0518-00	47 pF	Cer		500 V		100-122X
C517	281-0504-00	10 pF	Cer		500 V	10%	100-172
C517	281-0505-00	12 pF	Cer		500 V	10%	173-up
C529	283-0079-00	0.01 μF	Cer		250 V		
C546	281-0538-00	1 pF	Cer		500 V		

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C547	281-0092-00	9-35 pF	Cer	Var		100-122
C547	281-0093-00	5.5-18 pF	Cer	Var		123-up
C551	281-0092-00	9-35 pF	Cer	Var		100-172
C551	281-0093-00	5.5-18 pF	Cer	Var		173-up
C567	281-0538-00	1 pF	Cer	500 V		
C572	283-0079-00	0.01 μF	Cer	250 V		
C931	283-0057-00	0.1 μF	Cer	200 V	+80%—20%	
C934	283-0079-00	0.01 μF	Cer	250 V		100-172
C934	283-0002-00	0.01 μF	Cer	500 V		173-up
C935	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C936	283-0057-00	0.1 μF	Cer	200 V	+80%—20%	
C945	283-0079-00	0.01 μF	Cer	250 V		
C946	283-0079-00	0.01 μF	Cer	250 V		

Diodes

Ckt. No.	Tektronix Part No.	Description		S/N Range
D9	*152-0075-00	Germanium	Tek Spec	
D10	*152-0185-00	Silicon	Replaceable by 1N4152	
D23	*152-0075-00	Germanium	Tek Spec	
D24	*152-0075-00	Germanium	Tek Spec	
D26	*152-0075-00	Germanium	Tek Spec	
D37	*152-0107-00	Silicon	Replaceable by 1N647	
D39	*152-0185-00	Silicon	Replaceable by 1N4152	
D41	*152-0075-00	Germanium	Tek Spec	
D42	*152-0185-00	Silicon	Replaceable by 1N4152	
D43	*152-0075-00	Germanium	Tek Spec	
D44	*152-0075-00	Germanium	Tek Spec	
D45	*152-0075-00	Germanium	Tek Spec	
D46	*152-0075-00	Germanium	Tek Spec	
D52	*152-0075-00	Germanium	Tek Spec	
D54	*152-0075-00	Germanium	Tek Spec	
D56	*152-0075-00	Germanium	Tek Spec	
D62	*152-0185-00	Silicon	Replaceable by 1N4152	
D65	152-0071-00	Germanium	ED-2007	
D66	152-0071-00	Germanium	ED-2007	
D72	*152-0107-00	Silicon	Replaceable by 1N647	
D82	*152-0107-00	Silicon	Replaceable by 1N647	
D86	152-0139-00	Zener	1N751 0.4 W, 5.1 V, 10%	100-279
D86	152-0279-00	Zener	1N751A 0.4 W, 5.1 V, 5%	280-up
D91	*152-0075-00	Germanium	Tek Spec	
D92	*152-0075-00	Germanium	Tek Spec	
D95	152-0071-00	Germanium	ED-2007	
D96	152-0071-00	Germanium	ED-2007	
D105	152-0093-00	Tunnel	1N3716 4.7 mA	100-119
D105	*152-0125-00	Tunnel	TD3A 4.7 mA, Selected	120-up
D115	152-0093-00	Tunnel	1N3716 4.7 mA	100-119
D115	*152-0125-00	Tunnel	TD3A 4.7 mA, Selected	120-up
D142	152-0071-00	Germanium	ED-2007	
D143	152-0071-00	Germanium	ED-2007	
D145	152-0093-00	Tunnel	1N3716 4.7 mA	
D147	*152-0075-00	Germanium	Tek Spec	
D148	152-0071-00	Germanium	ED-2007	
D149	152-0076-00	Zener	1N4372 0.4 W, 3 V, 10%	100-279
D149	152-0278-00	Zener	1N4372A 0.4 W, 3 V, 5%	280-up
D155	*152-0263-00	Silicon	Tek Spec	100-429
D155	*152-0445-00	Silicon	Schottky Barrier, Tek made	430-up

Diodes (Cont)

Ckt. No.	Tektronix Part No.		Description	S/N Range
D156	*152-0061-00	Silicon	Tek Spec	
D162	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D165	*152-0075-00	Germanium	Tek Spec	
D172	*152-0075-00	Germanium	Tek Spec	
D173	152-0166-00	Zener	1N753A 0.4 W, 6.2 V, 5%	
D183	*152-0061-00	Silicon	Tek Spec	
D202	*152-0185-00	Silicon	Replaceable by 1N3605	
D203	*152-0075-00	Germanium	Tek Spec	
D207	*152-0075-00	Germanium	Tek Spec	
D208	*152-0075-00	Germanium	Tek Spec	
D216	*152-0075-00	Germanium	Tek Spec	
D217	*152-0075-00	Germanium	Tek Spec	
D225	*152-0075-00	Germanium	Tek Spec	
D226	*152-0075-00	Germanium	Tek Spec	
D227	*152-0075-00	Germanium	Tek Spec	
D228	*152-0061-00	Silicon	Tek Spec	
D229	*152-0061-00	Silicon	Tek Spec	
D241	152-0071-00	Germanium	ED-2007	
D254	152-0071-00	Germanium	ED-2007	
D256	*152-0075-00	Germanium	Tek Spec	
D261	*152-0075-00	Germanium	Tek Spec	
D264	*152-0061-00	Silicon	Tek Spec	
D265	152-0119-00	Zener	1N969A 0.4 W, 22 V, 10%	100-279
D265	152-0281-00	Zener	1N969B 0.4 W, 22 V, 5%	280-up
D269	*152-0061-00	Silicon	Tek Spec	
D272	152-0071-00	Germanium	ED-2007	
D281	152-0071-00	Germanium	ED-2007	
D282	*152-0075-00	Germanium	Tek Spec	
D284	*152-0075-00	Germanium	Tek Spec	
D294	*152-0075-00	Germanium	Tek Spec	
D295	152-0076-00	Zener	1N4372 0.4 W, 3 V, 10%	100-279
D295	152-0278-00	Zener	1N4372A 0.4 W, 3 V, 5%	280-up
D296	*152-0107-00	Silicon	Replaceable by 1N647	
D297	*152-0185-00	Silicon	Replaceable by 1N3605	
D298	152-0166-00	Zener	1N753A 0.4 W, 6.2 V, 5%	
D299	*152-0075-00	Germanium	Tek Spec	
D302	*152-0075-00	Germanium	Tek Spec	
D303	*152-0075-00	Germanium	Tek Spec	
D304	*152-0075-00	Germanium	Tek Spec	
D305	*152-0075-00	Germanium	Tek Spec	
D306	*152-0075-00	Germanium	Tek Spec	
D307	*152-0075-00	Germanium	Tek Spec	
D312	*152-0075-00	Germanium	Tek Spec	
D313	*152-0075-00	Germanium	Tek Spec	
D314	*152-0075-00	Germanium	Tek Spec	
D315	*152-0075-00	Germanium	Tek Spec	
D317	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	

Diodes *(Cont)*

Ckt. No.	Tektronix Part No.	Description		S/N Range
D318	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D319	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D322	*152-0075-00	Germanium	Tek Spec	
D323	*152-0075-00	Germanium	Tek Spec	
D324	*152-0075-00	Germanium	Tek Spec	
D327	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D328	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D329	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D337	*152-0185-00	Silicon	Replaceable by 1N4152	
D338	*152-0185-00	Silicon	Replaceable by 1N4152	
D342	*152-0107-00	Silicon	Replaceable by 1N647	
D343	*152-0185-00	Silicon	Replaceable by 1N4152	
D344	*152-0075-00	Germanium	Tek Spec	
D345	*152-0075-00	Germanium	Tek Spec	
D348	*152-0185-00	Silicon	Replaceable by 1N4152	
D349	*152-0185-00	Silicon	Replaceable by 1N4152	
D354	*152-0075-00	Germanium	Tek Spec	
D355	*152-0075-00	Germanium	Tek Spec	
D362	*152-0185-00	Silicon	Replaceable by 1N4152	
D365	152-0169-00	Tunnel	1N3712 1 mA	
D366	152-0076-00	Zener	1N4372 0.4 W, 3 V, 10%	
D367	*152-0239-00	Silicon	Tek Spec	
D368	*152-0239-00	Silicon	Tek Spec	
D369	*152-0239-00	Silicon	Tek Spec	
D371	*152-0075-00	Germanium	Tek Spec	
D374	*152-0075-00	Germanium	Tek Spec	
D375	152-0166-00	Zener	1N753A 0.4 W, 6.2 V, 5%	
D376	*152-0075-00	Germanium	Tek Spec	
D380	*152-0185-00	Silicon	Replaceable by 1N4152	
D381	*152-0185-00	Silicon	Replaceable by 1N4152	
D382	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D383	*152-0239-00	Silicon	Tek Spec	
D385	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D386	*152-0239-00	Silicon	Tek Spec	
D388	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D389	*152-0239-00	Silicon	Tek Spec	
D390	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D391	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D392	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D393	152-0246-00	Silicon	Low Leakage 0.25 W, 40 V	
D395	*152-0075-00	Germanium	Tek Spec	
D398	*152-0107-00	Silicon	Replaceable by 1N647	
D403	*152-0075-00	Germanium	Tek Spec	
D404	*152-0075-00	Germanium	Tek Spec	
D407	*152-0107-00	Silicon	Replaceable by 1N647	
D409	*152-0107-00	Silicon	Replaceable by 1N647	

Diodes *(Cont)*

Ckt. No.	Tektronix Part No.	Description		S/N Range
D485	*152-0107-00	Silicon	Replaceable by 1N647	
D486	*152-0107-00	Silicon	Replaceable by 1N647	
D487	*152-0107-00	Silicon	Replaceable by 1N647	
D489	*152-0107-00	Silicon	Replaceable by 1N647	
D491	*152-0107-00	Silicon	Replaceable by 1N647	
D492	*152-0107-00	Silicon	Replaceable by 1N647	
D493	*152-0107-00	Silicon	Replaceable by 1N647	
D494	*152-0107-00	Silicon	Replaceable by 1N647	
D496	*152-0107-00	Silicon	Replaceable by 1N647	
D497	*152-0107-00	Silicon	Replaceable by 1N647	
D498	*152-0107-00	Silicon	Replaceable by 1N647	
D499	*152-0107-00	Silicon	Replaceable by 1N647	
D503	*152-0075-00	Germanium	Tek Spec	
D504	*152-0075-00	Germanium	Tek Spec	
D512	*152-0075-00	Germanium	Tek Spec	
D525	*152-0075-00	Germanium	Tek Spec	
D526	*152-0075-00	Germanium	Tek Spec	
D528	*152-0185-00	Silicon	Replaceable by 1N4152	
D531	152-0243-00	Zener	1N965B 0.4 W, 15 V, 5%	
D532	152-0071-00	Germanium	ED-2007	
D572	152-0166-00	Zener	1N753A 0.4 W, 6.2 V, 5%	
D909	*152-0107-00	Silicon	Replaceable by 1N647	
D911	*152-0075-00	Germanium	Tek Spec	
D912	*152-0075-00	Germanium	Tek Spec	
D915	*152-0107-00	Silicon	Replaceable by 1N647	
D916	*152-0075-00	Germanium	Tek Spec	
D919	*152-0107-00	Silicon	Replaceable by 1N647	
D944	*152-0075-00	Germanium	Tek Spec	
D945	*152-0075-00	Germanium	Tek Spec	
D946	*152-0075-00	Germanium	Tek Spec	
D947	*152-0075-00	Germanium	Tek Spec	
D948	*152-0075-00	Germanium	Tek Spec	
D949	*152-0075-00	Germanium	Tek Spec	

Connectors

Ckt. No.	Tektronix Part No.	Description	S/N Range
J2	131-0227-00	Terminal Stand Off	
P21	131-0149-00	Chassis mtd., 24 contact, male	
J30	131-0408-00	37 pin contact	
J400	131-0292-00	56 pin contact	100-259
J400	131-0292-01	56 pin contact	260-up
J700	131-0292-00	56 pin contact	100-259
J700	131-0292-01	56 pin contact	260-up

Relays

Ckt. No.	Tektronix Part No.	Description	S/N Range
K3	*108-0358-00	Coil, Reed (typical resistance 900 Ω)	
K3-1	260-0721-00	Reed	
K4	*108-0358-00	Coil, Reed (typical resistance 900 Ω)	
K4-1	260-0552-00	Reed	
K310	*108-0358-00	Coil, Reed (typical resistance 900 Ω)	

Relays *(Cont)*

Ckt. No.	Tektronix Part No.	Description		S/N Range
K310-1	260-0552-00	Reed		
K311	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K311-1	260-0552-00	Reed		
K312	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K312-1	260-0552-00	Reed		
K313	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K313-1	260-0552-00	Reed		
K314	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K314-1	260-0552-00	Reed		
K315	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K315-1	260-0552-00	Reed		
K395	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K395-1	260-0817-00	Reed		
K512	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K512-1	260-0721-00	Reed		
K915	*108-0358-00	Coil, Reed (typical resistance 900 Ω)		
K915-1	260-0721-00	Reed		

Inductors

L106	*108-0215-00	1.1 μH		
L139	108-0226-00	100 μH		
L563	*108-0165-00	4.7 mH		
L935	*108-0359-00	100 μH		

Transistors

Q14	*151-0155-00	Silicon	Replaceable by 2N2925	
Q23	151-0175-00	Silicon	2N3662	
Q33	*151-0126-00	Silicon	Replaceable by 2N2484	
Q34	151-0188-00	Silicon	2N3906	
Q44	151-0179-00	Silicon	2N3877A	
Q54	151-0188-00	Silicon	2N3906	
Q74	151-0162-00	Germanium	2N3324	
Q75	151-0179-00	Silicon	2N3877A	
Q84	151-0162-00	Silicon	2N3324	
Q85	151-0179-00	Silicon	2N3877A	
Q104	151-0162-00	Silicon	2N3324	
Q124	151-0175-00	Silicon	2N3662	
Q134	151-0175-00	Silicon	2N3662	
Q144	*151-0155-00	Silicon	Replaceable by 2N2925	
Q153	*151-0155-00	Silicon	Replaceable by 2N2925	
Q161	*151-0124-00	Silicon	Selected from 2N3119	
Q174	*151-0124-00	Silicon	Selected from 2N3119	
Q183	*151-0059-00	Silicon	Selected from 2N1893	
Q193	*151-0136-00	Silicon	Replaceable by 2N3053	
Q204	151-0179-00	Silicon	2N3877A	

Transistors (Cont)

Ckt. No.	Tektronix Part No.		Description	S/N Range
Q214	151-0179-00	Silicon	2N3877A	
Q224	151-0179-00	Silicon	2N3877A	
Q235	151-0162-00	Silicon	2N3324	
Q245	151-0162-00	Silicon	2N3324	
Q253	151-0162-00	Silicon	2N3324	
Q264	*151-0124-00	Silicon	Selected from 2N3119	
Q273	*151-0121-00	Silicon	Selected from 2N3118	
Q285	151-0162-00	Silicon	2N3324	
Q293	*151-0183-00	Silicon	Selected from 2N2192	
Q295	*151-0155-00	Silicon	Replaceable by 2N2925	
Q324	151-0188-00	Silicon	2N3906	
Q333	151-0179-00	Silicon	2N3877A	
Q343	*151-0200-00	Silicon	2N3499	
Q344	*151-0155-00	Silicon	Replaceable by 2N2925	
Q346	*151-0155-00	Silicon	Replaceable by 2N2925	
Q356	*151-0155-00	Silicon	Replaceable by 2N2925	
Q364	151-0162-00	Silicon	2N3324	
Q374	151-0162-00	Silicon	2N3324	
Q404	*151-0183-00	Silicon	Selected from 2N2192	
Q514	151-0190-00	Silicon	2N3904	
Q534	151-0188-00	Silicon	2N3906	
Q543	151-0190-00	Silicon	2N3904	100-172
Q543	*151-0155-00	Silicon	Replaceable by 2N2925	173-up
Q553	151-0190-00	Silicon	2N3904	
Q554	*151-0103-00	Silicon	Replaceable by 2N2219	
Q915	*151-0183-00	Silicon	Selected from 2N2192	
Q944	151-0188-00	Silicon	2N3906	

Resistors

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

Ckt. No.	Tektronix Part No.					S/N Range
R1	315-0333-00	33 kΩ	¼ W		5%	
R2	315-0104-00	100 kΩ	¼ W		5%	
R3	315-0122-00	1.2 kΩ	¼ W		5%	
R6	316-0475-00	4.7 MΩ	¼ W			
R7	316-0684-00	680 kΩ	¼ W			
R8	316-0684-00	680 kΩ	¼ W			
R9	321-0427-00	274 kΩ	⅛ W	Prec	1%	
R11	315-0102-00	1 kΩ	¼ W		5%	
R12	301-0683-00	68 kΩ	½ W		5%	
R13	315-0103-00	10 kΩ	¼ W		5%	
R14	315-0103-00	10 kΩ	¼ W		5%	
R15	311-0390-00	25 kΩ		Var		
R17	315-0471-00	470 Ω	¼ W		5%	
R18	321-0409-00	178 kΩ	⅛ W	Prec	1%	
R21	315-0101-00	100 Ω	¼ W		5%	

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Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R22	315-0470-00	47 Ω	¼ W			5%	
R25A[1] R25B	311-0623-00	1 MΩ 1 MΩ		Var			
R26	315-0302-00	3 kΩ	¼ W			5%	
R29	315-0104-00	100 kΩ	¼ W			5%	
R33	315-0105-00	1 MΩ	¼ W			5%	
R34	315-0152-00	1.5 kΩ	¼ W			5%	
R35	311-0605-00	200 Ω		Var			
R36	315-0474-00	470 kΩ	¼ W			5%	
R37	321-0328-00	25.5 kΩ	⅛ W		Prec	1%	
R39	321-0425-00	261 kΩ	⅛ W		Prec	1%	
R41	321-0445-00	422 kΩ	⅛ W		Prec	1%	
R43	315-0124-00	120 kΩ	¼ W			5%	
R44	315-0562-00	5.6 kΩ	¼ W			5%	
R45	315-0222-00	2.2 kΩ	¼ W			5%	
R47	315-0224-00	220 kΩ	¼ W			5%	
R53	315-0222-00	2.2 kΩ	¼ W			5%	
R54	315-0222-00	2.2 kΩ	¼ W			5%	
R56	315-0124-00	120 kΩ	¼ W			5%	
R62	315-0124-00	120 kΩ	¼ W			5%	
R63	323-0366-00	63.4 kΩ	½ W		Prec	1%	
R69	315-0332-00	3.3 kΩ	¼ W			5%	
R71	315-0332-00	3.3 kΩ	¼ W			5%	100-369
R71	315-0182-00	1.8 kΩ	¼ W			5%	370-up
R72	316-0564-00	560 kΩ	¼ W				
R74	315-0163-00	16 kΩ	¼ W			5%	
R75	315-0752-00	7.5 kΩ	¼ W			5%	
R76	315-0562-00	5.6 kΩ	¼ W			5%	
R82	316-0564-00	560 kΩ	¼ W				
R84	315-0163-00	16 kΩ	¼ W			5%	
R85	315-0432-00	4.3 kΩ	¼ W			5%	
R87	315-0102-00	1 kΩ	¼ W			5%	
R92	315-0470-00	47 Ω	¼ W			5%	
R93	323-0366-00	63.4 kΩ	½ W		Prec	1%	
R94	315-0101-00	100 Ω	¼ W			5%	
R99	315-0332-00	3.3 kΩ	¼ W			5%	
R101	315-0392-00	3.9 kΩ	¼ W			5%	
R102	315-0822-00	8.2 kΩ	¼ W			5%	
R104	323-0352-00	45.3 kΩ	½ W		Prec	1%	
R106	315-0121-00	120 Ω	¼ W			5%	
R107	315-0121-00	120 Ω	¼ W			5%	
R108	321-0039-00	24.9 Ω	⅛ W		Prec	1%	
R109	323-0164-00	499 Ω	½ W		Prec	1%	
R119	315-0101-00	100 Ω	¼ W			5%	
R123	301-0363-00	36 kΩ	½ W			5%	
R124	315-0222-00	2.2 kΩ	¼ W			5%	

[1]Furnished as a unit with SW87.

Resistors (Cont)

Ckt. No.	Tektronix Part No.		Description			S/N Range
R131	315-0101-00	100 Ω	¼ W		5%	
R133	303-0243-00	24 kΩ	1 W		5%	
R137	315-0470-00	47 Ω	¼ W		5%	
R138	315-0470-00	47 Ω	¼ W		5%	
R143	315-0621-00	620 Ω	¼ W		5%	
R145	315-0910-00	91 Ω	¼ W		5%	
R146	315-0101-00	100 Ω	¼ W		5%	
R147	315-0271-00	270 Ω	¼ W		5%	
R149	301-0683-00	68 kΩ	½ W		5%	
R151	315-0332-00	3.3 kΩ	¼ W		5%	
R152	315-0222-00	2.2 kΩ	¼ W		5%	
R153	315-0223-00	22 kΩ	¼ W		5%	
R154	315-0101-00	100 Ω	¼ W		5%	
R162	315-0101-00	100 Ω	¼ W		5%	
R163	315-0101-00	100 Ω	¼ W		5%	
R165	315-0332-00	3.3 kΩ	¼ W		5%	
R167	315-0221-00	220 Ω	¼ W		5%	
R168	*310-0634-00	47 kΩ	8 W	Prec	1%	
R173	315-0101-00	100 Ω	¼ W		5%	
R174	315-0101-00	100 Ω	¼ W		5%	
R175	303-0333-00	33 kΩ	1 W		5%	
R176	315-0101-00	100 Ω	¼ W		5%	
R179	315-0101-00	100 Ω	¼ W		5%	
R181	315-0103-00	10 kΩ	¼ W		5%	
R182	315-0103-00	10 kΩ	¼ W		5%	
R183	315-0184-00	180 kΩ	¼ W		5%	
R184	315-0154-00	150 kΩ	¼ W		5%	
R185	315-0105-00	1 MΩ	¼ W		5%	
R186	315-0513-00	51 kΩ	¼ W		5%	
R187	321-0372-00	73.2 kΩ	⅛ W	Prec	1%	
R189	315-0104-00	100 kΩ	¼ W		5%	
R192	323-0302-00	13.7 kΩ	½ W	Prec	1%	
R193	323-0331-00	27.4 kΩ	½ W	Prec	1%	
R194	304-0122-00	1.2 kΩ	1 W			
R201	323-0332-00	28 kΩ	½ W	Prec	1%	
R202	315-0163-00	16 kΩ	¼ W		5%	
R203	315-0222-00	2.2 kΩ	¼ W		5%	
R204	315-0273-00	27 kΩ	¼ W		5%	
R206	323-0369-00	68.1 kΩ	½ W	Prec	1%	
R207	315-0152-00	1.5 kΩ	¼ W		5%	
R217	315-0152-00	1.5 kΩ	¼ W		5%	100-279
R217	315-0102-00	1 kΩ	¼ W		5%	280-up
R222	315-0102-00	1 kΩ	¼ W		5%	
R223	315-0222-00	2.2 kΩ	¼ W		5%	
R227	315-0152-00	1.5 kΩ	¼ W		5%	
R231	315-0102-00	1 kΩ	¼ W		5%	

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R232	315-0273-00	27 kΩ	¼ W			5%	
R233	315-0122-00	1.2 kΩ	¼ W			5%	
R235	315-0223-00	22 kΩ	¼ W			5%	
R236	315-0112-00	1.1 kΩ	¼ W			5%	
R237	301-0303-00	30 kΩ	½ W			5%	
R239	315-0223-00	22 kΩ	¼ W			5%	
R241	315-0102-00	1 kΩ	¼ W			5%	
R242	315-0102-00	1 kΩ	¼ W			5%	
R244	315-0242-00	2.4 kΩ	¼ W			5%	
R251	315-0104-00	100 kΩ	¼ W			5%	
R252	315-0222-00	2.2 kΩ	¼ W			5%	100-172
R252	315-0471-00	470 Ω	¼ W			5%	173-up
R253	315-0101-00	100 Ω	¼ W			5%	
R254	315-0102-00	1 kΩ	¼ W			5%	
R255	315-0821-00	820 Ω	¼ W			5%	
R256	315-0822-00	8.2 kΩ	¼ W			5%	
R257	315-0222-00	2.2 kΩ	¼ W			5%	100-172
R257	315-0392-00	3.9 kΩ	¼ W			5%	173-up
R258	315-0102-00	1 kΩ	¼ W			5%	
R259	315-0222-00	2.2 kΩ	¼ W			5%	
R262	315-0821-00	820 Ω	¼ W			5%	
R263	315-0562-00	5.6 kΩ	¼ W			5%	
R265	301-0362-00	3.6 kΩ	½ W			5%	
R268	*310-0632-00	30 kΩ	4 W		Prec	1%	
R272	315-0101-00	100 Ω	¼ W			5%	
R274	301-0104-00	100 kΩ	½ W			5%	
R275	315-0222-00	2.2 kΩ	¼ W			5%	
R281	315-0221-00	220 Ω	¼ W			5%	
R282	315-0102-00	1 kΩ	¼ W			5%	
R284	315-0102-00	1 kΩ	¼ W			5%	
R291	315-0222-00	2.2 kΩ	¼ W			5%	
R292	315-0102-00	1 kΩ	¼ W			5%	
R294	315-0222-00	2.2 kΩ	¼ W			5%	
R295	315-0105-00	1 MΩ	¼ W			5%	
R297	301-0820-00	82 Ω	½ W			5%	
R298	301-0473-00	47 kΩ	½ W			5%	
R309	321-0356-00	49.9 kΩ	⅛ W		Prec	1%	
R311	315-0470-00	47 Ω	¼ W			5%	
R312	315-0470-00	47 Ω	¼ W			5%	
R313	315-0470-00	47 Ω	¼ W			5%	
R323	315-0103-00	10 kΩ	¼ W			5%	
R324	315-0273-00	27 kΩ	¼ W			5%	
R325	315-0223-00	22 kΩ	¼ W			5%	
R326	315-0103-00	10 kΩ	¼ W			5%	
R330	311-0172-00	2.5 kΩ		Var			
R331	311-0318-00	30 kΩ		Var			
R332	321-0329-00	26.1 kΩ	⅛ W		Prec	1%	

Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description					S/N Range
R333	311-0405-00	10 kΩ		Var			
R335	301-0433-00	43 kΩ	½ W			5%	
R336	321-0356-00	49.9 kΩ	⅛ W		Prec	1%	
R337	323-0367-00	64.9 kΩ	½ W		Prec	1%	
R340	321-0431-00	301 kΩ	⅛ W		Prec	1%	
R341	321-0452-00	499 kΩ	⅛ W		Prec	1%	
R342	315-0513-00	51 kΩ	¼ W			5%	100-164
R342	322-0357-00	51.1 kΩ	¼ W		Prec	1%	165-up
R343	315-0104-00	100 kΩ	¼ W			5%	
R345	315-0472-00	4.7 kΩ	¼ W			5%	
R346	315-0472-00	4.7 kΩ	¼ W			5%	
R347	315-0102-00	1 kΩ	¼ W			5%	
R348	315-0222-00	2.2 kΩ	¼ W			5%	
R349	323-0354-00	47.5 kΩ	½ W		Prec	1%	
R351	315-0332-00	3.3 kΩ	¼ W			5%	
R352	321-0276-00	7.32 kΩ	⅛ W		Prec	1%	
R353	321-0407-00	169 kΩ	⅛ W		Prec	1%	
R354	315-0222-00	2.2 kΩ	¼ W			5%	
R355	315-0334-00	330 kΩ	¼ W			5%	
R356	315-0124-00	120 kΩ	¼ W			5%	
R364	315-0222-00	2.2 kΩ	¼ W			5%	
R371	315-0332-00	3.3 kΩ	¼ W			5%	
R372	315-0332-00	3.3 kΩ	¼ W			5%	
R373	315-0563-00	56 kΩ	¼ W			5%	
R374	308-0407-00	12 kΩ	3 W		WW	5%	
R381	309-0023-00	2 MΩ	½ W		Prec	1%	
R382	323-0418-00	221 kΩ	½ W		Prec	1%	
R383	324-0322-00	22.1 kΩ	1 W		Prec	1%	
R384	309-0093-00	4 MΩ	½ W		Prec	1%	
R385	323-1446-00	437 kΩ	½ W		Prec	1%	
R386	323-0351-00	44.2 kΩ	½ W		Prec	1%	
R387	309-0095-00	10 MΩ	½ W		Prec	1%	
R388	323-0485-00	1.1 MΩ	½ W		Prec	1%	
R389	323-0610-00	111 kΩ	½ W		Prec	1%	
R390	315-0823-00	82 kΩ	¼ W	(Selected, nominal value)			
R394	308-0320-00	15.6 kΩ	3 W		WW	1%	
R395	311-0633-00	5 kΩ		Var			
R397[a]	311-0108-00	20 kΩ		Var			
R398	323-0248-00	3.74 kΩ	½ W		Prec	1%	
R402	315-0472-00	4.7 kΩ	¼ W			5%	
R403	315-0222-00	2.2 kΩ	¼ W			5%	
R485	301-0101-00	100 Ω	½ W			5%	
R486	301-0101-00	100 Ω	½ W			5%	
R487	301-0820-00	82 Ω	½ W			5%	
R488	301-0101-00	100 Ω	½ W			5%	
R501	315-0101-00	100 Ω	¼ W			5%	
R502	321-0385-00	100 kΩ	⅛ W		Prec	1%	
R503	315-0363-00	36 kΩ	¼ W			5%	100-122
R503	315-0203-00	20 kΩ	¼ W			5%	123-199
R503	315-0243-00	24 kΩ	¼ W			5%	200-up
R504	315-0823-00	82 kΩ	¼ W			5%	100-122
R504	315-0683-00	68 kΩ	¼ W			5%	123-up

[a]Furnished as a unit with SW397.

®

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R505	311-0606-00	500 kΩ		Var			
R506	315-0224-00	220 kΩ	¼ W			5%	
R507	315-0122-00	1.2 kΩ	¼ W			5%	
R508	311-0607-00	10 kΩ		Var			
R509	321-0274-00	6.98 kΩ	⅛ W		Prec	1%	
R514	301-0473-00	47 kΩ	½ W			5%	
R515	311-0629-00	3 kΩ		Var			
R516	321-0283-00	8.66 kΩ	⅛ W		Prec	1%	
R517	315-0102-00	1 kΩ	¼ W			5%	100-172
R517	315-0222-00	2.2 kΩ	¼ W			5%	173-up
R520	311-0604-00	250 kΩ		Var			
R521	321-0387-00	105 kΩ	⅛ W		Prec	1%	
R522	315-0474-00	470 kΩ	¼ W			5%	
R523	315-0103-00	10 kΩ	¼ W			5%	
R525	315-0224-00	220 kΩ	¼ W			5%	
R528	315-0334-00	330 kΩ	¼ W			5%	
R529	321-0395-00	127 kΩ	⅛ W		Prec	1%	
R531	321-0277-00	7.5 kΩ	⅛ W		Prec	1%	
R534	321-0431-00	301 kΩ	⅛ W		Prec	1%	
R542	315-0102-00	1 kΩ	¼ W			5%	
R543	315-0104-00	100 kΩ	¼ W			5%	
R544	*310-0619-00	13.5 kΩ	4 W		Prec	1%	
R546	323-0400-00	143 kΩ	½ W		Prec	1%	
R549	315-0181-00	180 Ω	¼ W			5%	
R551	321-0277-00	7.5 kΩ	⅛ W		Prec	1%	
R552	323-0360-00	54.9 kΩ	½ W		Prec	1%	
R553	315-0103-00	10 kΩ	¼ W			5%	
R561	315-0101-00	100 Ω	¼ W			5%	100-172
R561	315-0102-00	1 kΩ	¼ W			5%	173-up
R563	*310-0633-00	10 kΩ	8 W		Prec	1%	
R564	315-0101-00	100 Ω	¼ W			5%	
R566	305-0433-00	43 kΩ	2 W			5%	
R567	323-0402-00	150 kΩ	½ W		Prec	1%	
R569	315-0181-00	180 Ω	¼ W			5%	
R579	315-0104-00	100 kΩ	¼ W			5%	
R650	311-0326-00	10 kΩ		Var			
R651	315-0512-00	5.1 kΩ	¼ W			5%	
R911	315-0222-00	2.2 kΩ	¼ W			5%	
R912	315-0102-00	1 kΩ	¼ W			5%	
R913	315-0102-00	1 kΩ	¼ W			5%	
R914	315-0222-00	2.2 kΩ	¼ W			5%	
R926	315-0430-00	43 Ω	¼ W			5%	
R927	301-0221-00	220 Ω	½ W			5%	
R931	315-0100-00	10 Ω	¼ W			5%	
R932	308-0303-00	750 Ω	3 W		WW	1%	
R933	308-0077-00	1 kΩ	3 W		WW		
R934	315-0100-00	10 Ω	¼ W			5%	
R936	315-0470-00	47 Ω	¼ W			5%	

Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description			S/N Range
R942	315-0222-00	2.2 kΩ	¼ W	5%	
R943	315-0472-00	4.7 kΩ	¼ W	5%	
R949	315-0222-00	2.2 kΩ	¼ W	5%	
R992	301-0101-00	100 Ω	½ W	5%	
R993	301-0101-00	100 Ω	½ W	5%	
R994	301-0101-00	100 Ω	½ W	5%	

Switches

Ckt. No.	Unwired	Wired		
SW50	260-0495-00		Lever	Trigger Function
SW87[3]	311-0623-00			CHANGE SLOPE
SW397[4]	311-0108-00			
SW450	260-0775-00	*262-0776-00	Rotary	MANUAL TIME/DIV
SW604[5]				SEEK
SW914[5]				MAN
SW924[5]				EXT
SW940	260-0776-00		Lever	DLY'D SWP MAG

Transformers

Ckt. No.	Tektronix Part No.	Description
T140	*120-0180-00	Toroid, 4 turns, trifilar
T275	276-0557-00	Core, Toroid Ferrite

Electron Tubes

Ckt. No.	Tektronix Part No.	Description
V163	*157-0080-00	7586, aged
V544	154-0047-00	12BY7
V564	154-0340-00	7119

LOGIC CARD

Ckt. No.	Tektronix Part No.	Description	Model No.
	*670-0107-00	Complete Card	

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Description			
C602	283-0079-00	0.01 μF	Cer	250 V	
C603	283-0059-00	1 μF	Cer	25 V	+80%—20%
C604	281-0523-00	100 pF	Cer	350 V	
C616	290-0302-00	100 μF	EMT	20 V	
C627	290-0301-00	10 μF	EMT	20 V	

[3]Furnished as a unit with R25A,B.
[4]Furnished as a unit with R397.
[5]Furnished as a unit with Push-Button Board (*388-0712-00).

LOGIC CARD *(Cont)*

Capacitors *(Cont)*

Ckt. No.	Tektronix Part No.	Description				Model No.
C629	283-0026-00	0.2 μF	Cer	25 V		
C632	283-0026-00	0.2 μF	Cer	25 V		
C636	281-0523-00	100 pF	Cer	350 V		
C638	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C655	283-0026-00	0.2 μF	Cer	25 V		
C657	281-0504-00	10 pF	Cer	500 V	10%	
C662	290-0136-00	2.2 μF	EMT	20 V		
C664	281-0543-00	270 pF	Cer	500 V	10%	
C671	283-0059-00	1 μF	Cer	25 V	+80%—20%	
C681	283-0026-00	0.2 μF	Cer	25 V		

Diodes

Ckt. No.	Tektronix Part No.	Description	
D411	*152-0075-00	Germanium	Tek Spec
D412	*152-0075-00	Germanium	Tek Spec
D413	*152-0075-00	Germanium	Tek Spec
D414	*152-0075-00	Germanium	Tek Spec
D415	*152-0075-00	Germanium	Tek Spec
D416	*152-0075-00	Germanium	Tek Spec
D421	*152-0075-00	Germanium	Tek Spec
D422	*152-0075-00	Germanium	Tek Spec
D424	*152-0075-00	Germanium	Tek Spec
D425	*152-0075-00	Germanium	Tek Spec
D427	*152-0075-00	Germanium	Tek Spec
D428	*152-0075-00	Germanium	Tek Spec
D431	*152-0075-00	Germanium	Tek Spec
D432	*152-0075-00	Germanium	Tek Spec
D434	*152-0075-00	Germanium	Tek Spec
D435	*152-0075-00	Germanium	Tek Spec
D437	*152-0075-00	Germanium	Tek Spec
D438	*152-0075-00	Germanium	Tek Spec
D441	*152-0075-00	Germanium	Tek Spec
D442	*152-0075-00	Germanium	Tek Spec
D444	*152-0075-00	Germanium	Tek Spec
D445	*152-0075-00	Germanium	Tek Spec
D447	*152-0075-00	Germanium	Tek Spec
D448	*152-0075-00	Germanium	Tek Spec
D451	*152-0075-00	Germanium	Tek Spec
D452	*152-0075-00	Germanium	Tek Spec
D454	*152-0075-00	Germanium	Tek Spec
D455	*152-0075-00	Germanium	Tek Spec
D457	*152-0075-00	Germanium	Tek Spec
D458	*152-0075-00	Germanium	Tek Spec
D462	*152-0075-00	Germanium	Tek Spec
D463	*152-0075-00	Germanium	Tek Spec
D464	*152-0075-00	Germanium	Tek Spec
D466	*152-0075-00	Germanium	Tek Spec
D467	*152-0075-00	Germanium	Tek Spec

LOGIC CARD *(Cont)*
Diodes *(Cont)*

Ckt. No.	Tektronix Part No.		Description	Model No.
D468	*152-0075-00	Germanium	Tek Spec	
D469	*152-0075-00	Germanium	Tek Spec	
D470	*152-0075-00	Germanium	Tek Spec	
D471	*152-0075-00	Germanium	Tek Spec	
D472	*152-0075-00	Germanium	Tek Spec	
D473	*152-0107-00	Silicon	Replaceable by 1N647	
D475	*152-0075-00	Germanium	Tek Spec	
D476	*152-0075-00	Germanium	Tek Spec	
D478	*152-0075-00	Germanium	Tek Spec	
D479	*152-0075-00	Germanium	Tek Spec	
D481	*152-0075-00	Germanium	Tek Spec	
D482	*152-0075-00	Germanium	Tek Spec	
D483	*152-0075-00	Germanium	Tek Spec	
D601	*152-0185-00	Silicon	Replaceable by 1N3605	
D602	*152-0075-00	Germanium	Tek Spec	
D605	*152-0075-00	Germanium	Tek Spec	
D612	*152-0075-00	Germanium	Tek Spec	
D614	*152-0075-00	Germanium	Tek Spec	
D619	*152-0075-00	Germanium	Tek Spec	
D629	*152-0075-00	Germanium	Tek Spec	
D632	*152-0075-00	Germanium	Tek Spec	
D635	*152-0075-00	Germanium	Tek Spec	
D640	*152-0075-00	Germanium	Tek Spec	
D641	*152-0075-00	Germanium	Tek Spec	
D642	*152-0075-00	Germanium	Tek Spec	
D643	*152-0075-00	Germanium	Tek Spec	
D644	*152-0075-00	Germanium	Tek Spec	
D655	152-0169-00	Tunnel	1N3712 1 mA	
D657	*152-0075-00	Germanium	Tek Spec	
D660	*152-0075-00	Germanium	Tek Spec	
D661	*152-0071-00	Germanium	ED-2007	
D665	*152-0075-00	Germanium	Tek Spec	
D666	152-0076-00	Zener	1N4372 0.4W, 3 V, 10%	1
D666	152-0278-00	Zener	1N4372A 0.4 W, 3 V, 5%	2-up
D668	*152-0075-00	Germanium	Tek Spec	
D669	152-0076-00	Zener	1N4372 0.4W, 3 V, 10%	1
D669	152-0278-00	Zener	1N4372A 0.4 W, 3 V, 5%	2-up
D681	*152-0075-00	Germanium	Tek Spec	
D682	*152-0075-00	Germanium	Tek Spec	
D901	*152-0075-00	Germanium	Tek Spec	
D902	*152-0075-00	Germanium	Tek Spec	
D905	*152-0107-00	Silicon	Replaceable by 1N647	
D924	*152-0075-00	Germanium	Tek Spec	
D925	*152-0107-00	Silicon	Replaceable by 1N647	

LOGIC CARD *(Cont)*

Transistors

Ckt. No.	Tektronix Part No.	Description		Model No.
Q423	151-0188-00	Silicon	2N3906	
Q443	151-0188-00	Silicon	2N3906	
Q453	151-0188-00	Silicon	2N3906	
Q473	151-0188-00	Silicon	2N3906	
Q604	151-0188-00	Silicon	2N3906	
Q615	151-0188-00	Silicon	2N3906	
Q625	151-0188-00	Silicon	2N3906	
Q634	*151-0155-00	Silicon	Replaceable by 2N2925	
Q643	*151-0155-00	Silicon	Replaceable by 2N2925	
Q653	151-0080-00	Silicon	2N706	
Q664	151-0162-00	Germanium	2N3324	
Q665	151-0162-00	Germanium	2N3324	
Q675	151-0080-00	Silicon	2N706	
Q684	*151-0155-00	Silicon	Replaceable by 2N2925	
Q905	*151-0183-00	Silicon	Selected from 2N2192	
Q925	*151-0183-00	Silicon	Selected from 2N2192	

Resistors

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

Ckt. No.	Tektronix Part No.	Value	Power	Type	Tolerance
R411	315-0222-00	2.2 kΩ	¼ W		5%
R412	315-0222-00	2.2 kΩ	¼ W		5%
R413	315-0222-00	2.2 kΩ	¼ W		5%
R431	315-0222-00	2.2 kΩ	¼ W		5%
R434	315-0222-00	2.2 kΩ	¼ W		5%
R437	315-0222-00	2.2 kΩ	¼ W		5%
R443	308-0075-00	100 Ω	3 W	WW	5%
R441	315-0472-00	4.7 kΩ	¼ W		5%
R444	315-0472-00	4.7 kΩ	¼ W		5%
R447	315-0472-00	4.7 kΩ	¼ W		5%
R451	315-0472-00	4.7 kΩ	¼ W		5%
R454	315-0472-00	4.7 kΩ	¼ W		5%
R457	315-0472-00	4.7 kΩ	¼ W		5%
R461	315-0472-00	4.7 kΩ	¼ W		5%
R463	315-0472-00	4.7 kΩ	¼ W		5%
R466	315-0472-00	4.7 kΩ	¼ W		5%
R468	315-0472-00	4.7 kΩ	¼ W		5%
R471	315-0472-00	4.7 kΩ	¼ W		5%
R473	308-0075-00	100 Ω	3 W	WW	5%
R475	315-0472-00	4.7 kΩ	¼ W		5%
R478	315-0472-00	4.7 kΩ	¼ W		5%
R481	315-0222-00	2.2 kΩ	¼ W		5%
R601	315-0103-00	10 kΩ	¼ W		5%
R602	315-0105-00	1 MΩ	¼ W		5%
R603	315-0103-00	10 kΩ	¼ W		5%

LOGIC CARD (Cont)
Resistors (Cont)

Ckt. No.	Tektronix Part No.	Description			Model No.
R604	315-0222-00	2.2 kΩ	¼ W	5%	
R611	315-0273-00	27 kΩ	¼ W	5%	
R612	315-0224-00	220 kΩ	¼ W	5%	
R614	315-0104-00	100 kΩ	¼ W	5%	
R616	315-0105-00	1 MΩ	¼ W	5%	
R625	315-0242-00	2.4 kΩ	¼ W	5%	
R626	315-0102-00	1 kΩ	¼ W	5%	
R627	315-0273-00	27 kΩ	¼ W	5%	
R629	315-0103-00	10 kΩ	¼ W	5%	
R632	315-0104-00	100 kΩ	¼ W	5%	
R633	315-0562-00	5.6 kΩ	¼ W	5%	
R634	315-0681-00	680 Ω	¼ W	5%	
R635	315-0562-00	5.6 kΩ	¼ W	5%	
R636	315-0562-00	5.6 kΩ	¼ W	5%	
R637	315-0103-00	10 kΩ	¼ W	5%	
R638	315-0222-00	2.2 kΩ	¼ W	5%	
R641	315-0104-00	100 kΩ	¼ W	5%	
R643	315-0224-00	220 kΩ	¼ W	5%	
R645	315-0222-00	2.2 kΩ	¼ W	5%	
R646	315-0333-00	33 kΩ	¼ W	5%	
R653	315-0102-00	1 kΩ	¼ W	5%	
R654	315-0122-00	1.2 kΩ	¼ W	5%	
R655	315-0561-00	560 Ω	¼ W	5%	
R657	315-0561-00	560 Ω	¼ W	5%	
R658	315-0271-00	270 Ω	¼ W	5%	
R659	315-0222-00	2.2 kΩ	¼ W	5%	
R661	316-0564-00	560 kΩ	¼ W		
R662	315-0104-00	100 kΩ	¼ W	5%	
R663	315-0333-00	33 kΩ	¼ W	5%	
R664	315-0562-00	5.6 kΩ	¼ W	5%	
R665	315-0472-00	4.7 kΩ	¼ W	5%	
R671	315-0562-00	5.6 kΩ	¼ W	5%	
R675	315-0222-00	2.2 kΩ	¼ W	5%	
R681	315-0103-00	10 kΩ	¼ W	5%	
R682	315-0562-00	5.6 kΩ	¼ W	5%	
R683	315-0102-00	1 kΩ	¼ W	5%	
R684	315-0222-00	2.2 kΩ	¼ W	5%	
R901	315-0222-00	2.2 kΩ	¼ W	5%	
R902	315-0222-00	2.2 kΩ	¼ W	5%	
R903	315-0102-00	1 kΩ	¼ W	5%	
R904	315-0222-00	2.2 kΩ	¼ W	5%	
R923	315-0102-00	1 kΩ	¼ W	5%	
R924	315-0222-00	2.2 kΩ	¼ W	5%	

LOGIC CARD *(Cont)*
Transformer

Ckt. No.	Tektronix Part No.	Description	Model No.
T660	*120-0454-00	Toroid, 7 turns, bifi ar	

COUNTER CARD

	*670-0108-00	Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C704	283-0026-00	0.2 μF	Cer	25 V	
C709	283-0026-00	0.2 μF	Cer	25 V	
C714	283-0026-00	0.2 μF	Cer	25 V	
C719	283-0026-00	0.2 μF	Cer	25 V	
C724	283-0026-00	0.2 μF	Cer	25 V	
C729	283-0026-00	0.2 μF	Cer	25 V	
C731	290-0246-00	3.3 μF	EMT	15 V	10%
C756	283-0079-00	0.01 μF	Cer	250 V	
C766	283-0079-00	0.01 μF	Cer	250 V	
C776	283-0079-00	0.01 μF	Cer	250 V	
C786	283-0079-00	0.01 μF	Cer	250 V	
C812	283-0026-00	0.2 μF	Cer	25 V	
C817	283-0079-00	0.01 μF	Cer	250 V	
C822	283-0026-00	0.2 μF	Cer	25 V	
C827	283-0079-00	0.01 μF	Cer	250 V	
C856	283-0079-00	0.01 μF	Cer	250 V	
C866	283-0079-00	0.01 μF	Cer	250 V	
C876	283-0079-00	0.01 μF	Cer	250 V	
C886	283-0079-00	0.01 μF	Cer	250 V	

Diodes

D89	*152-0075-00	Germanium	Tek Spec
D702	*152-0075-00	Germanium	Tek Spec
D703	*152-0075-00	Germanium	Tek Spec
D704	*152-0075-00	Germanium	Tek Spec
D705	*152-0107-00	Silicon	Replaceable by 1N647
D712	*152-0075-00	Germanium	Tek Spec
D713	*152-0075-00	Germanium	Tek Spec
D714	*152-0075-00	Germanium	Tek Spec
D715	*152-0107-00	Silicon	Replaceable by 1N647
D722	*152-0075-00	Germanium	Tek Spec
D723	*152-0075-00	Germanium	Tek Spec
D724	*152-0075-00	Germanium	Tek Spec
D725	*152-0107-00	Silicon	Replaceable by 1N647
D731	*152-0075-00	Germanium	Tek Spec
D733	*152-0075-00	Germanium	Tek Spec

COUNTER CARD *(Cont)*
Diodes *(Cont)*

Ckt. No.	Tektronix Part No.	Description		Model No.
D735	*152-0075-00	Germanium	Tek Spec	
D751	*152-0075-00	Germanium	Tek Spec	
D752	*152-0075-00	Germanium	Tek Spec	
D753	*152-0075-00	Germanium	Tek Spec	
D754	*152-0075-00	Germanium	Tek Spec	
D755	*152-0075-00	Germanium	Tek Spec	
D756	*152-0075-00	Germanium	Tek Spec	
D761	*152-0075-00	Germanium	Tek Spec	
D762	*152-0075-00	Germanium	Tek Spec	
D763	*152-0075-00	Germanium	Tek Spec	
D764	*152-0075-00	Germanium	Tek Spec	
D765	*152-0075-00	Germanium	Tek Spec	
D766	*152-0075-00	Germanium	Tek Spec	
D771	*152-0075-00	Germanium	Tek Spec	
D772	*152-0075-00	Germanium	Tek Spec	
D773	*152-0075-00	Germanium	Tek Spec	
D774	*152-0075-00	Germanium	Tek Spec	
D775	*152-0075-00	Germanium	Tek Spec	
D776	*152-0075-00	Germanium	Tek Spec	
D781	*152-0075-00	Germanium	Tek Spec	
D782	*152-0075-00	Germanium	Tek Spec	
D783	*152-0075-00	Germanium	Tek Spec	
D784	*152-0075-00	Germanium	Tek Spec	
D785	*152-0075-00	Germanium	Tek Spec	
D786	*152-0075-00	Germanium	Tek Spec	
D811	*152-0075-00	Germanium	Tek Spec	
D814	*152-0075-00	Germanium	Tek Spec	
D818	*152-0075-00	Germanium	Tek Spec	
D824	*152-0075-00	Germanium	Tek Spec	
D851	*152-0075-00	Germanium	Tek Spec	
D852	*152-0075-00	Germanium	Tek Spec	
D853	*152-0075-00	Germanium	Tek Spec	
D854	*152-0075-00	Germanium	Tek Spec	
D855	*152-0075-00	Germanium	Tek Spec	
D856	*152-0075-00	Germanium	Tek Spec	
D861	*152-0075-00	Germanium	Tek Spec	
D862	*152-0075-00	Germanium	Tek Spec	
D863	*152-0075-00	Germanium	Tek Spec	
D864	*152-0075-00	Germanium	Tek Spec	
D865	*152-0075-00	Germanium	Tek Spec	
D866	*152-0075-00	Germanium	Tek Spec	
D871	*152-0075-00	Germanium	Tek Spec	
D872	*152-0075-00	Germanium	Tek Spec	
D873	*152-0075-00	Germanium	Tek Spec	
D874	*152-0075-00	Germanium	Tek Spec	

COUNTER CARD *(Cont)*

Diodes *(Cont)*

Ckt. No.	Tektronix Part No.	Description		Model No.
D875	*152-0075-00	Germanium	Tek Spec	
D876	*152-0075-00	Germanium	Tek Spec	
D881	*152-0075-00	Germanium	Tek Spec	
D882	*152-0075-00	Germanium	Tek Spec	
D883	*152-0075-00	Germanium	Tek Spec	
D884	*152-0075-00	Germanium	Tek Spec	
D885	*152-0075-00	Germanium	Tek Spec	
D886	*152-0075-00	Germanium	Tek Spec	

Transistors

Q705	*151-0183-00	Silicon	Selected from 2N2192
Q715	*151-0183-00	Silicon	Selected from 2N2192
Q725	*151-0183-00	Silicon	Selected from 2N2192
Q755	*151-0183-00	Silicon	Selected from 2N2192
Q765	*151-0183-00	Silicon	Selected from 2N2192
Q775	*151-0183-00	Silicon	Selected from 2N2192
Q785	*151-0183-00	Silicon	Selected from 2N2192
Q815	*151-0183-00	Silicon	Selected from 2N2192
Q825	*151-0183-00	Silicon	Selected from 2N2192
Q855	*151-0183-00	Silicon	Selected from 2N2192
Q865	*151-0183-00	Silicon	Selected from 2N2192
Q875	*151-0183-00	Silicon	Selected from 2N2192
Q885	*151-0183-00	Silicon	Selected from 2N2192

Resistors

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

R89	315-0472-00	4.7 kΩ	¼ W	5%
R701	315-0222-00	2.2 kΩ	¼ W	5%
R702	315-0222-00	2.2 kΩ	¼ W	5%
R703	315-0222-00	2.2 kΩ	¼ W	5%
R704	315-0104-00	100 kΩ	¼ W	5%
R705	315-0222-00	2.2 kΩ	¼ W	5%
R707	315-0103-00	10 kΩ	¼ W	5%
R711	315-0222-00	2.2 kΩ	¼ W	5%
R712	315-0222-00	2.2 kΩ	¼ W	5%
R713	315-0222-00	2.2 kΩ	¼ W	5%
R714	315-0104-00	100 kΩ	¼ W	5%
R715	315-0222-00	2.2 kΩ	¼ W	5%
R717	315-0103-00	10 kΩ	¼ W	5%
R721	315-0222-00	2.2 kΩ	¼ W	5%
R722	315-0222-00	2.2 kΩ	¼ W	5%

COUNTER CARD *(Cont)*
Resistors *(Cont)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R723	315-0222-00	2.2 kΩ	¼ W	5%	
R724	315-0104-00	100 kΩ	¼ W	5%	
R725	315-0222-00	2.2 kΩ	¼ W	5%	
R727	315-0103-00	10 kΩ	¼ W	5%	
R731	315-0222-00	2.2 kΩ	¼ W	5%	
R732	315-0103-00	10 kΩ	¼ W	5%	
R735	315-0222-00	2.2 kΩ	¼ W	5%	
R751	315-0222-00	2.2 kΩ	¼ W	5%	
R752	315-0222-00	2.2 kΩ	¼ W	5%	
R753	315-0222-00	2.2 kΩ	¼ W	5%	
R754	315-0104-00	100 kΩ	¼ W	5%	
R755	315-0222-00	2.2 kΩ	¼ W	5%	
R761	315-0222-00	2.2 kΩ	¼ W	5%	
R762	315-0222-00	2.2 kΩ	¼ W	5%	
R763	315-0222-00	2.2 kΩ	¼ W	5%	
R764	315-0104-00	100 kΩ	¼ W	5%	
R765	315-0222-00	2.2 kΩ	¼ W	5%	
R771	315-0222-00	2.2 kΩ	¼ W	5%	
R772	315-0222-00	2.2 kΩ	¼ W	5%	
R773	315-0222-00	2.2 kΩ	¼ W	5%	
R774	315-0104-00	100 kΩ	¼ W	5%	
R775	315-0222-00	2.2 kΩ	¼ W	5%	
R781	315-0222-00	2.2 kΩ	¼ W	5%	
R782	315-0222-00	2.2 kΩ	¼ W	5%	
R783	315-0222-00	2.2 kΩ	¼ W	5%	
R784	315-0104-00	100 kΩ	¼ W	5%	
R785	315-0222-00	2.2 kΩ	¼ W	5%	
R811	315-0222-00	2.2 kΩ	¼ W	5%	
R812	315-0222-00	2.2 kΩ	¼ W	5%	
R813	315-0222-00	2.2 kΩ	¼ W	5%	
R814	315-0473-00	47 kΩ	¼ W	5%	
R815	315-0621-00	620 Ω	¼ W	5%	
R817	315-0123-00	12 kΩ	¼ W	5%	
R818	315-0222-00	2.2 kΩ	¼ W	5%	
R819	316-0564-00	560 kΩ	¼ W		
R823	315-0222-00	2.2 kΩ	¼ W	5%	
R824	315-0473-00	47 kΩ	¼ W	5%	
R825	315-0621-00	620 Ω	¼ W	5%	
R827	315-0123-00	12 kΩ	¼ W	5%	
R829	316-0564-00	560 kΩ	¼ W		
R851	315-0222-00	2.2 kΩ	¼ W	5%	
R852	315-0222-00	2.2 kΩ	¼ W	5%	
R853	315-0222-00	2.2 kΩ	¼ W	5%	
R854	315-0104-00	100 kΩ	¼ W	5%	
R855	315-0222-00	2.2 kΩ	¼ W	5%	

COUNTER CARD *(Cont)*
Resistors *(Cont)*

Ckt. No.	Tektronix Part No.		Description		Model No.
R861	315-0222-00	2.2 kΩ	¼ W	5%	
R862	315-0222-00	2.2 kΩ	¼ W	5%	
R863	315-0222-00	2.2 kΩ	¼ W	5%	
R864	315-0104-00	100 kΩ	¼ W	5%	
R865	315-0222-00	2.2 kΩ	¼ W	5%	
R871	315-0222-00	2.2 kΩ	¼ W	5%	
R872	315-0222-00	2.2 kΩ	¼ W	5%	
R873	315-0222-00	2.2 kΩ	¼ W	5%	
R874	315-0104-00	100 kΩ	¼ W	5%	
R875	315-0222-00	2.2 kΩ	¼ W	5%	
R881	315-0222-00	2.2 kΩ	¼ W	5%	
R882	315-0222-00	2.2 kΩ	¼ W	5%	
R883	315-0222-00	2.2 kΩ	¼ W	5%	
R884	315-0104-00	100 kΩ	¼ W	5%	
R885	315-0222-00	2.2 kΩ	¼ W	5%	

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 LIST ILLUSTRATIONS

(Located behind diagrams)

SECTION 8
MECHANICAL PARTS LIST

FIG. 1 FRONT & SWITCHES

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-1	333-0923-01	100	12299	1	PANEL, front
	333-0737-02	13000		1	PANEL, front
-2	366-0208-00			1	KNOB, charcoal—MANUAL TIME/DIV
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-3	366-0081-00			1	KNOB, red—VARIABLE CAL
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-4	262-0776-00			1	SWITCH, wired—MANUAL TIME/DIV
	- - - - - -			-	switch includes:
	260-0775-00			1	SWITCH, unwired—MANUAL TIME/DIV
	- - - - - -			-	mounting hardware: (not included w/switch)
-5	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-6	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-7	384-0397-00			1	ROD, extension
-8	376-0052-00			1	ASSEMBLY, coupling, flexible
	- - - - - -			-	assembly includes:
-9	354-0251-00			1	RING, 3/8 diameter x 0.172 inch long
-10	354-0261-00			1	RING, 3/8 diameter x 0.437 inch long
-11	376-0049-00			1	COUPLING, plastic
	213-0022-00	100	249	2	SCREW, set, 4-40 x 3/16 inch, HSS
	213-0048-00	250		2	SCREW, set, 4-40 x 1/8 inch, HSS
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS
	213-0115-00			1	SCREW, set, 4-40 x 5/16 inch, HSS
-12	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-13	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-14	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-15	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-16	406-0023-00			1	BRACKET, variable resistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
-17	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-18	331-0096-00	100	369	1	DIAL, w/charcoal knob
	331-0139-00	370		1	DIAL, w/aluminum knob
-19	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-20	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-21	366-0109-00			1	KNOB, aluminum, fastener
	- - - - - -			-	knob includes:
	213-0005-00			1	SCREW, set, 8-32 x 1/8 inch, HSS
-22	214-0052-00			1	FASTENER, pawl right w/stop
	- - - - - -			-	mounting hardware: (not included w/fastener)
-23	210-0004-00			2	LOCKWASHER, internal, #4
-24	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-25	366-0347-00			1	KNOB, charcoal—LEVEL
	- - - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-26	366-0349-00			1	KNOB, red—SLOPE
	- - - - - -			-	knob includes:
	213-0076-00			1	SCREW, set, 2-56 x 1/8 inch, HSS
-27	- - - - - -			1	RESISTOR, variable (with switch)
	- - - - - -			-	mounting hardware: (not included w/resistor)
-28	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-29	210-0583-00			1	NUT, hex, 1/4-32 x 5/16 inch
-30	366-0215-01			1	KNOB, charcoal—TRIGGER INT-EXT
-31	260-0495-00			1	SWITCH, unwired—TRIGGER INT EXT
	- - - - - -			-	mounting hardware: (not included w/switch)
-32	220-0413-00			2	NUT, hex., 4-40 x 3/16 x 0.562 inch long
-33	366-0215-01			1	KNOB, charcoal—DLY'D SWP MAG
-34	260-0776-00			1	SWITCH, unwired—DLY'D SWP MAG
	- - - - - -			-	mounting hardware: (not included w/switch)
-35	220-0413-00			2	NUT, hex., 4-40 x 3/16 x 0.562 inch long
-36	131-0106-00			1	CONNECTOR, coaxial, 1 contact, BNC
	- - - - - -			-	mounting hardware: (not included w/connector)
-37	210-0255-00			1	LUG, solder, 3/8 ID x 0.500 inch OD, SE
-38	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-39	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-40	210-0471-00			1	NUT, hex., 1/4-32 x 5/16 x 19/32 inch long
-41	358-0054-00			1	BUSHING, 1/4-32 x 0.406 inch long
-42	358-0054-00			1	BUSHING, 1/4-32 x 0.406 inch long
	- - - - - -			-	mounting hardware: (not included w/bushing)
-43	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
-44	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-45	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
-46	210-0471-00			1	NUT, hex., 1/4-32 x 5/16 x 19/32 inch long
-47	358-0054-00			1	BUSHING, 1/4-32 x 0.406 inch long
-48	352-0084-00			1	HOLDER, neon, single
-49	378-0541-00			1	FILTER, lens, neon, clear
-50	200-0643-00			1	CAP, lamp, holder

FIG. 1 FRONT & SWITCHES *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-51	352-0064-00			1	HOLDER, neon, double
	- - - - - -			-	mounting hardware: (not included w/holder)
	211-0109-00			1	SCREW, 4-40 x 7/8 inch, FHS
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-52	378-0541-00			2	FILTER, lens, neon, clear
-53	366-0341-00			1	KNOB, charcoal—POSITION
	- - - - - -			-	knob includes:
	213-0076-00			2	SCREW, set, 2-56 x 1/8 inch, HSS
-54	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-55	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-56	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-57	407-0232-00			1	BRACKET, variable resistor
	- - - - - -			-	mounting hardware: (not included w/bracket)
-58	220-0413-00			2	NUT, hex., 4-40 x 3/16 x 0.562 inch long
-59	210-0994-00			2	WASHER, flat, 0.125 ID x 0.250 inch OD
-60	131-0408-00			1	CONNECTOR, 37 pin
	- - - - - -			-	mounting hardware: (not included w/connector)
-61	210-0004-00			1	LOCKWASHER, internal, #4
	210-0201-00			1	LUG, solder, SE #4
-62	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
	211-0099-00	X230	279	2	SCREW, 4-40 x 5/16 inch
	211-0038-00	280		2	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
-63	366-0342-01			1	KNOB, pushbutton—EXT
-64	366-0342-02			1	KNOB, pushbutton—MAN
-65	366-0342-03			1	KNOB, pushbutton—SEEK
-66	380-0084-00			1	HOUSING, pushbutton
-67	670-0103-00			1	ASSEMBLY, circuit board—PUSHBUTTON
	- - - - - -			-	assembly includes:
	388-0712-00			1	BOARD, circuit
	- - - - - -			-	mounting hardware: (not included w/assembly)
-68	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-69	380-0086-00			1	HOUSING, readout
-70	386-0239-00			1	PLATE, horizontal readout
-71	361-0098-00			1	SPACER, light divider
-72	670-0105-00			1	ASSEMBLY, circuit board—READOUT
	- - - - - -			-	assembly includes:
	388-0714-00			1	BOARD, circuit
	- - - - - -			-	board includes:
-73	214-0506-00			14	CONNECTOR, square pin
	- - - - - -			-	mounting hardware: (not included w/assembly)
-74	211-0094-00			2	SCREW, 4-40 x 1/2 inch, THS
-75	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-76	348-0031-00			1	GROMMET, plastic, 5/32 inch diameter
-77	386-1041-00			1	PLATE, sub-panel

FIG. 2 CHASSIS & REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-1	407-0231-00			1	BRACKET, angle
	- - - - - -			-	mounting hardware: (not included w/bracket)
-2	211-0097-00	100	145	2	SCREW, 4-40 x 5/16 inch, PHS
	211-0101-00	146		2	SCREW, 4-40 x 5/16 inch, 100° csk, FHS
-3	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-4	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-5	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-6	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-7	386-1042-00			1	PLATE, bulkhead
	- - - - - -			-	plate includes:
-8	211-0094-00			4	SCREW, 4-40 x 1/2 inch, THS
-9	348-0063-00			3	GROMMET, plastic, 1/2 inch diameter
-10	131-0227-00			1	CONNECTOR, standoff
	- - - - - -			-	mounting hardware: (not included w/connector)
	358-0176-00			1	BUSHING, connector
-11	358-0215-00			1	BUSHING, plastic
-12	384-0615-00			4	ROD, spacer, 12 1/4 inches long
-13	131-0292-00	100	259	2	CONNECTOR, 56 pin
	131-0292-01	260		2	CONNECTOR, 56 pin
	- - - - - -			-	mounting hardware for each: (not included w/connector)
-14	211-0014-00			2	SCREW. 4-40 x 1/2 inch. PHS
-15	214-0572-00	100	259	2	KEY, plastic
	214-0702-00	260		2	KEY, plastic
	386-1136-00			1	PLATE, connector support (not shown)
-16	351-0059-00			4	GUIDE, circuit card
-17	386-1040-00			1	PLATE, guide mounting
	- - - - - -			-	mounting hardware: (not included w/plate)
-18	211-0510-00			2	SCREW, 6-32 x 3/8 inch, PHS
-19	361-0106-00			1	SPACER, hex., 1/4 diameter x 5 1/8 inches long
	- - - - - -			-	mounting hardware: (not included w/spacer)
-20	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-21	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-22	407-0233-00			1	BRACKET, guide mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
-23	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-24	344-0101-00			2	CLIP, circuit card retainer
	- - - - - -			-	mounting hardware for each: (not included w/clip)
-25	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-26	441-0672-00			1	CHASSIS
	- - - - - -			-	mounting hardware: (not included w/chassis)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-27	211-0507-00			3	SCREW, 6-32 x 5/16 inch, PHS

FIG. 2 CHASSIS & REAR *(cont)*

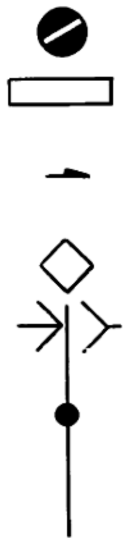
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-28	------			1	RESISTOR, variable
	------			-	mounting hardware: (not included w/resistor)
-29	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-30	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-31	376-0050-00			1	ASSEMBLY, coupling, flexible
	------			-	assembly includes:
-32	354-0251-00			2	RING, 3/8 diameter x 0.172 inch long
-33	376-0046-00			1	COUPLING, plastic
	213-0022-00			4	SCREW, set, 4-40 x 3/16 inch, HSS
-34	384-0396-00			1	ROD, extension
-35	670-0104-00			1	ASSEMBLY, circuit board—CONTROL
	------			-	assembly includes:
-36	136-0183-00			3	SOCKET, transistor, 3 pin
-37	136-0220-00			3	SOCKET, transistor, 3 pin
	388-0713-00			1	BOARD, circuit
	------			-	board includes:
-38	214-0506-00			27	CONNECTOR, square pin
-39	200-0385-00			2	COVER, insulator, plastic
	------			-	mounting hardware: (not included w/assembly)
-40	211-0601-00			4	SCREW, sems, 6-32 x 5/16 inch, PHB
-41	210-0201-00			1	LUG, solder, SE #4
	------			-	mounting hardware: (not included w/lug)
-42	213-0044-00			1	SCREW, thread forming, 5-32 x 3/16 inch, PHS
-43	131-0149-00			1	CONNECTOR, 24 pin
	------			-	mounting hardware: (not included w/connector)
-44	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-45	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-46	210-0202-00			1	LUG, solder, SE #6
	------			-	mounting hardware: (not included w/lug)
-47	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-48	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
-49	387-0647-00			1	PLATE, panel, rear
	------			-	mounting hardware: (not included w/plate)
-50	212-0044-00			4	SCREW, 8-32 x 1/2 inch, RHS
-51	214-0276-00			2	SPRING, ground
	------			-	mounting hardware for each: (not included w/spring)
-52	211-0504-00			1	SCREW, 6-32 x 1/4 inch, PHS
-53	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch

FIG. 2 CHASSIS & REAR *(cont)*

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
2-54	351-0037-00			1	GUIDE, shoe, plug-in
	- - - - - -			-	mounting hardware: (not included w/guide)
-55	211-0013-00			1	SCREW, 4-40 x 3/8 inch, RHS
-56	210-0586-00			1	NUT, keps, 4-40 x 1/4 inch
-57	670-0106-00			1	ASSEMBLY, circuit board—TIME BASE
	- - - - - -			-	assembly includes:
-58	136-0220-00			30	SOCKET, transistor, 3 pin
-59	136-0183-00			8	SOCKET, transistor, 3 pin
-60	136-0061-00			1	SOCKET, tube, 9 pin
-61	136-0239-00			1	SOCKET, tube, ceramic, 9 pin
-62	136-0125-00			1	SOCKET, nuvistor, 5 pin
-63	136-0235-00			1	SOCKET, transistor, 6 pin
-64	214-0506-00			15	CONNECTOR, square pin
-65	344-0108-00			2	CLIP, diode
-66	352-0086-00			1	HOLDER, plastic, 1/2 inch diameter
-67	426-0121-00			1	MOUNT, plastic
	- - - - - -			-	mounting hardware: (not included w/mount)
-68	361-0007-00			1	SPACER, plastic, 0.188 inch long
	388-0715-00			1	BOARD, circuit
	- - - - - -			-	board includes:
-69	214-0506-00			95	CONNECTOR, square pin
	214-0506-01			2	CONNECTOR, square pin, resistor mtg. (not shown)
-70	200-0687-00	100	279	1	COVER, plastic, transistor
	200-0687-01	280		1	COVER, plastic, transistor
	- - - - - -			-	mounting hardware: (not included w/assembly)
-71	211-0601-00			6	SCREW, sems, 6-32 x 5/16 inch, PHB
-72	337-0863-00			1	SHIELD, tube, heat sink
-73	670-0107-00			1	ASSEMBLY, circuit card—LOGIC
	- - - - - -			-	assembly includes:
-74	136-0220-00			14	SOCKET, transistor, 3 pin
-75	136-0183-00			2	SOCKET, transistor, 3 pin
	388-0716-00			1	CARD, circuit
	- - - - - -			-	card includes:
-76	214-0579-00			1	PIN, test point
-77	670-0108-00			1	ASSEMBLY, circuit card—COUNTER
	- - - - - -			-	assembly includes:
-78	136-0183-00			13	SOCKET, transistor, 3 pin
	388-0717-00			1	CARD, circuit
-79	348-0055-00			1	GROMMET, plastic, 1/4 inch diameter
-80	179-1078-00			1	CABLE HARNESS, programmer
	- - - - - -			-	cable harness includes:
	131-0371-00			37	CONNECTOR, square pin
-81	179-1077-00			1	CABLE HARNESS, chassis
	- - - - - -			-	cable harness includes:
	131-0371-00			95	CONNECTOR, square pin
-82	124-0149-00			1	STRIP, ceramic, 7/16 inch h, w/7 notches
	- - - - - -			-	strip includes:
	355-0046-00			2	STUD, plastic
	- - - - - -			-	mounting hardware: (not included w/strip)
	361-0008-00			2	SPACER, plastic, 0.281 inch long
-83	343-0089-00	X108		2	CLAMP, cable, plastic

SECTION 9
DIAGRAMS

The following symbols are used on the diagrams:



Screwdriver adjustment

Front-, side- or rear-panel control or connector

Clockwise control rotation in direction of arrow

Refer to indicated diagram

Connection to circuit board made with pin connector at indicated pin

Connection soldered to circuit board

Blue line encloses components located on circuit board

VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements and waveform photographs were obtained using the equipment listed and the following operating conditions, unless noted otherwise on the individual diagrams:

Test Oscilloscope (with 10× Probe)

Frequency response	DC to 20 MHz
Deflection factor (with probe)	0.5 volt to 50 volts/division
Input impedance (with probe)	10 Megohms, 7.5 picofarads
Probe ground	Type 3B5 chassis ground
Trigger Source	External from pin BH of the Time-Base board to indicate true time relationship between signals
Recommended type (as used for waveforms on diagrams)	Type 543B with Type 1A2 plug-in unit

Voltmeter

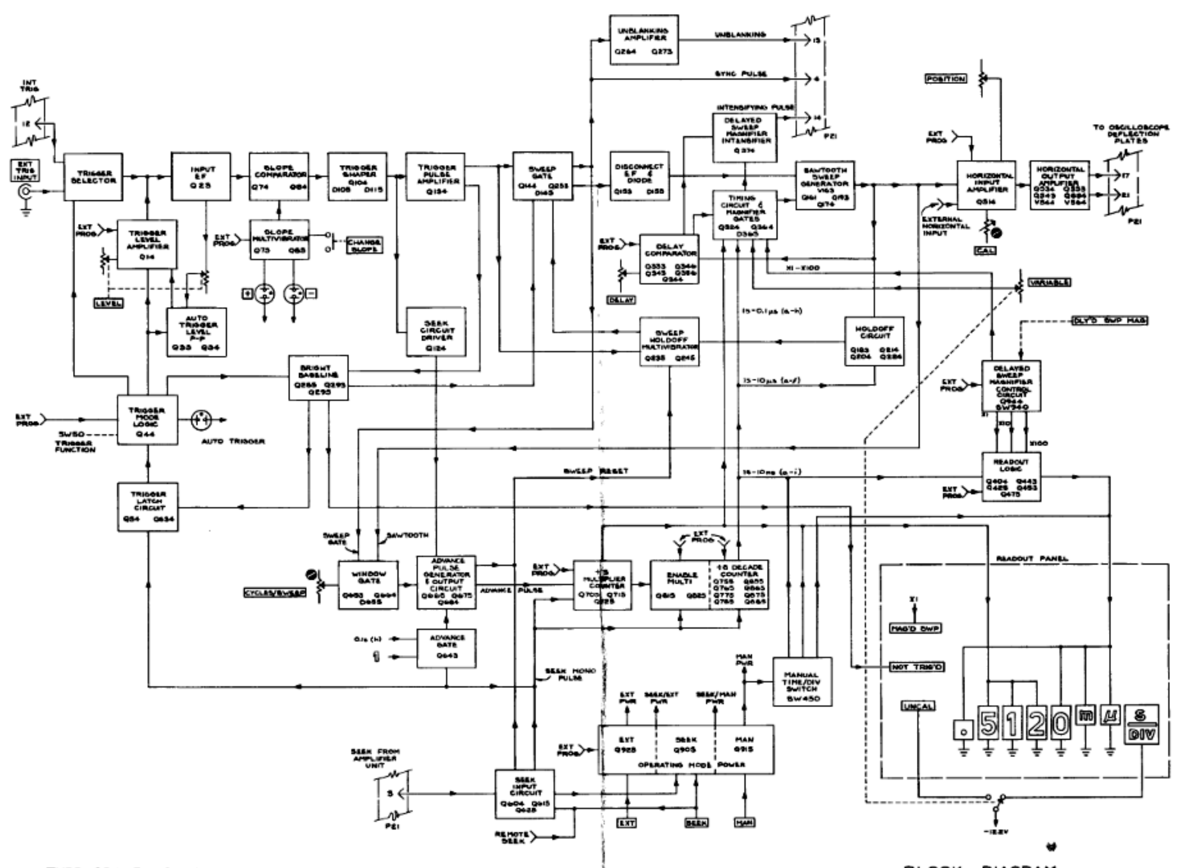
Type	AC (RMS)—DC volt-ohm-meter
Sensitivity	20,000 ohms/volt
Range	0 to 500 volts
Reference voltage	Type 3B5 chassis ground
Recommended type (as used for voltages on diagrams)	Simpson Type 262

Type 3B5 Conditions

Line Voltage	115 volts
Signal applied	None
Connectors	No connections
Trace position	Centered
Control settings	As follows except as noted otherwise on individual diagrams:
Mode	MAN
POSITION	Midrange
DLY'D SWP MAG	OFF
DELAY	1.00
MANUAL TIME/DIV	1 ms
VARIABLE	CAL
Trigger Function	INT-AUTO
LEVEL	Midrange
SLOPE	+

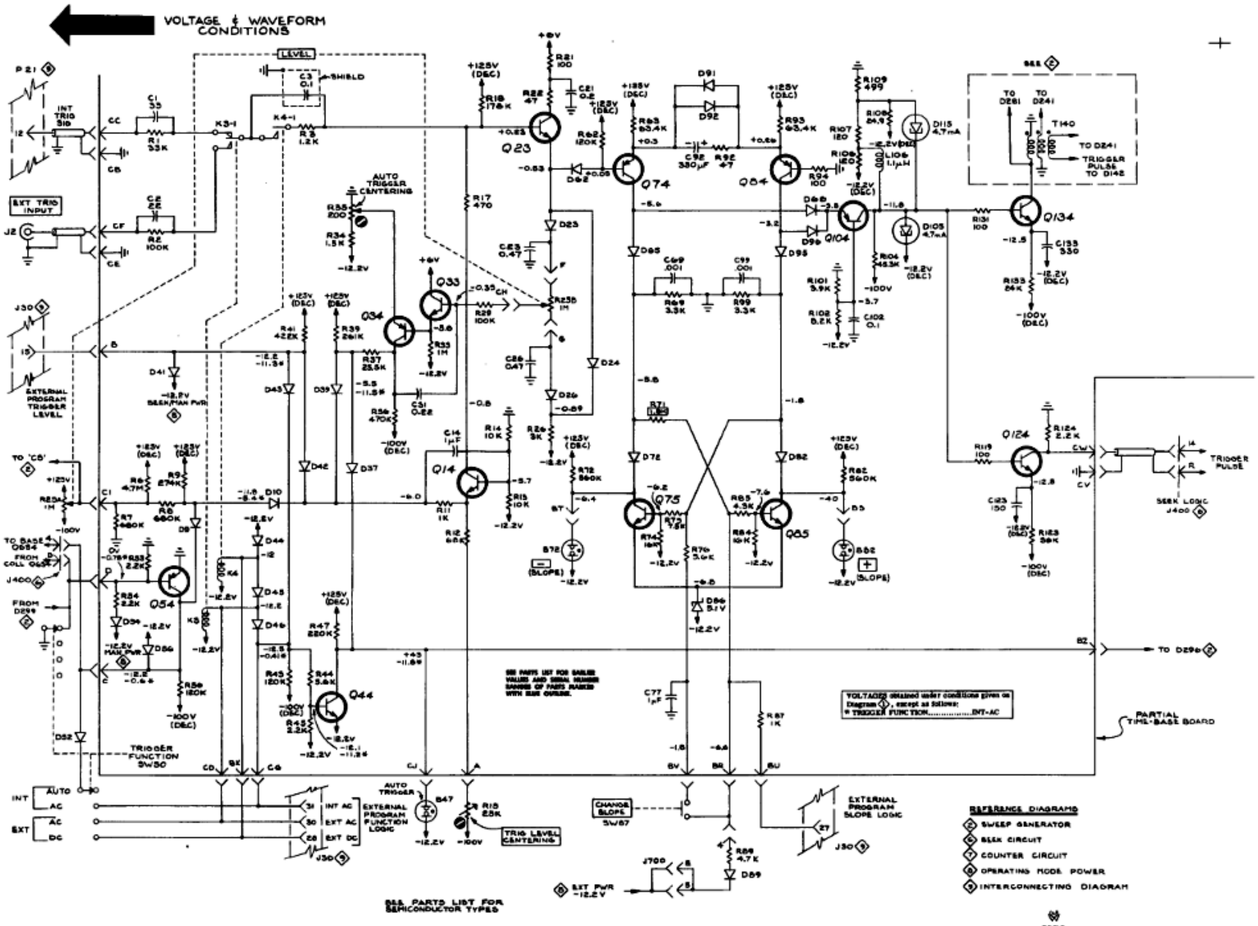
All voltages given on the diagrams are in volts. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

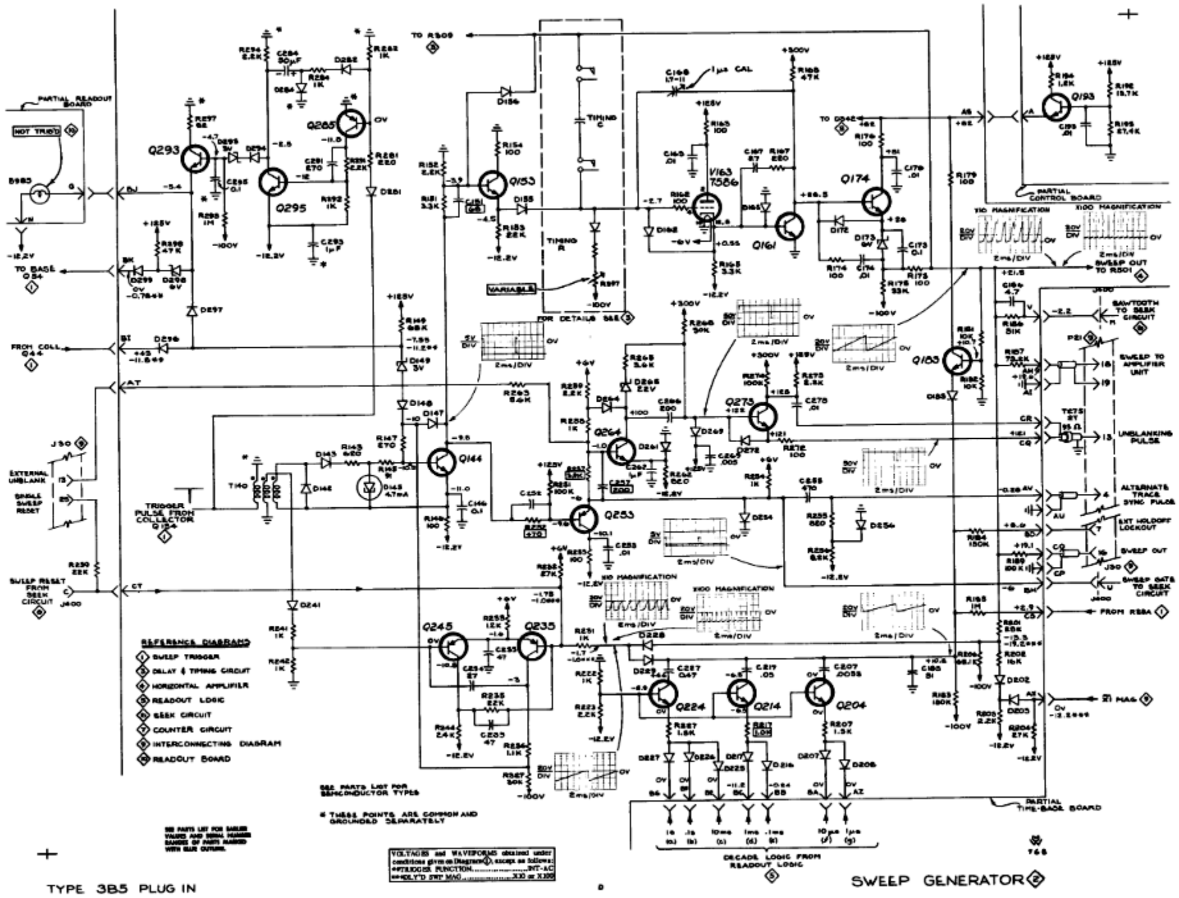
Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration or front-panel control settings. Any apparent differences between voltage levels measured with the voltmeter and those shown on the waveforms are due to circuit loading of the voltmeter.



TYPE 3B5 PLUG-IN

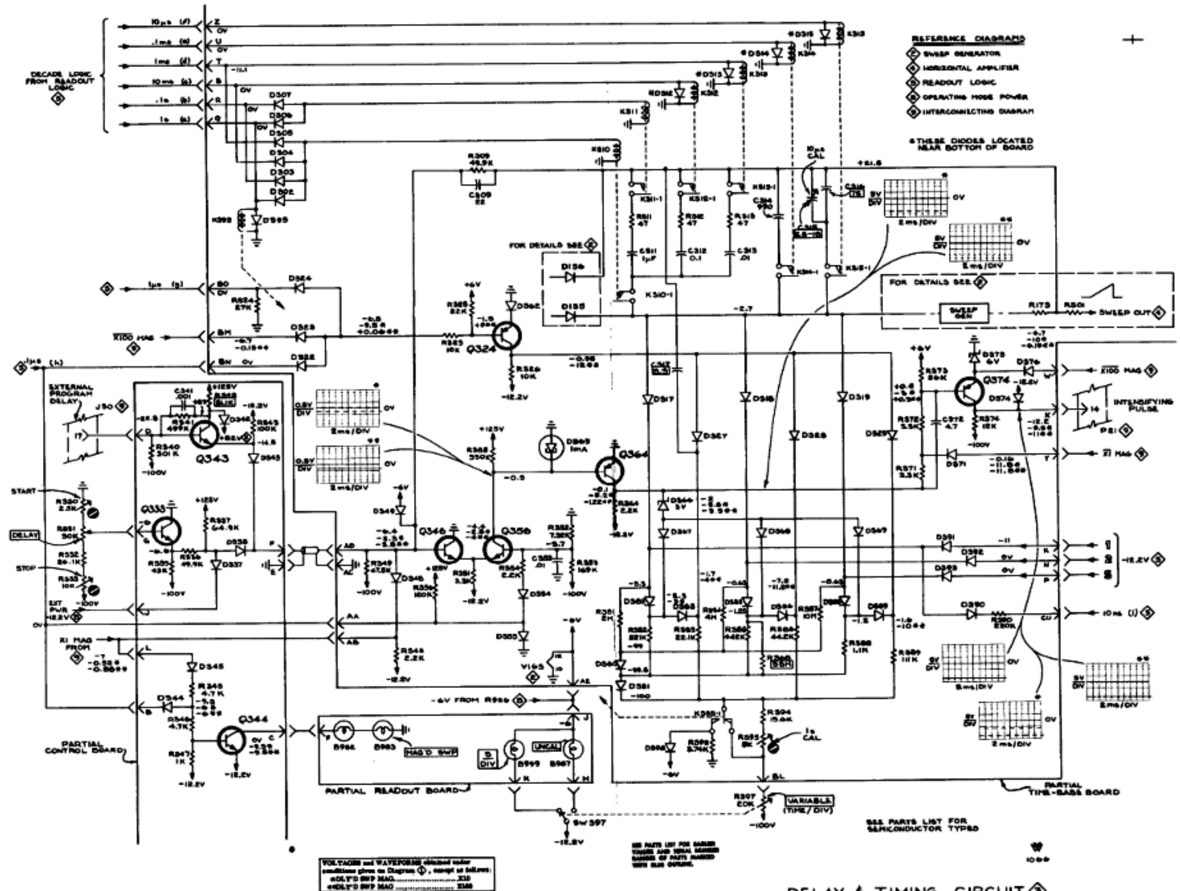
BLOCK DIAGRAM


VOLTAGE & WAVEFORM CONDITIONS
EXT TRIG INPUT
EXTERNAL PROGRAM TRIGGER LEVEL
AUTO TRIGGER CENTERING
TRIGGER FUNCTION SW50
EXTERNAL PROGRAM FUNCTION LOGIC
TRIG LEVEL CENTERING
CHANGE SLOPE SW87
EXTERNAL PROGRAM SLOPE LOGIC
TRIGGER PULSE
PARTIAL TIME-BASE BOARD
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DIAGRAMS
SWEEP GENERATOR
SEEK CIRCUIT
COUNTER CIRCUIT
OPERATING MODE POWER
INTERCONNECTING DIAGRAM



TYPE 3B5 PLUG IN

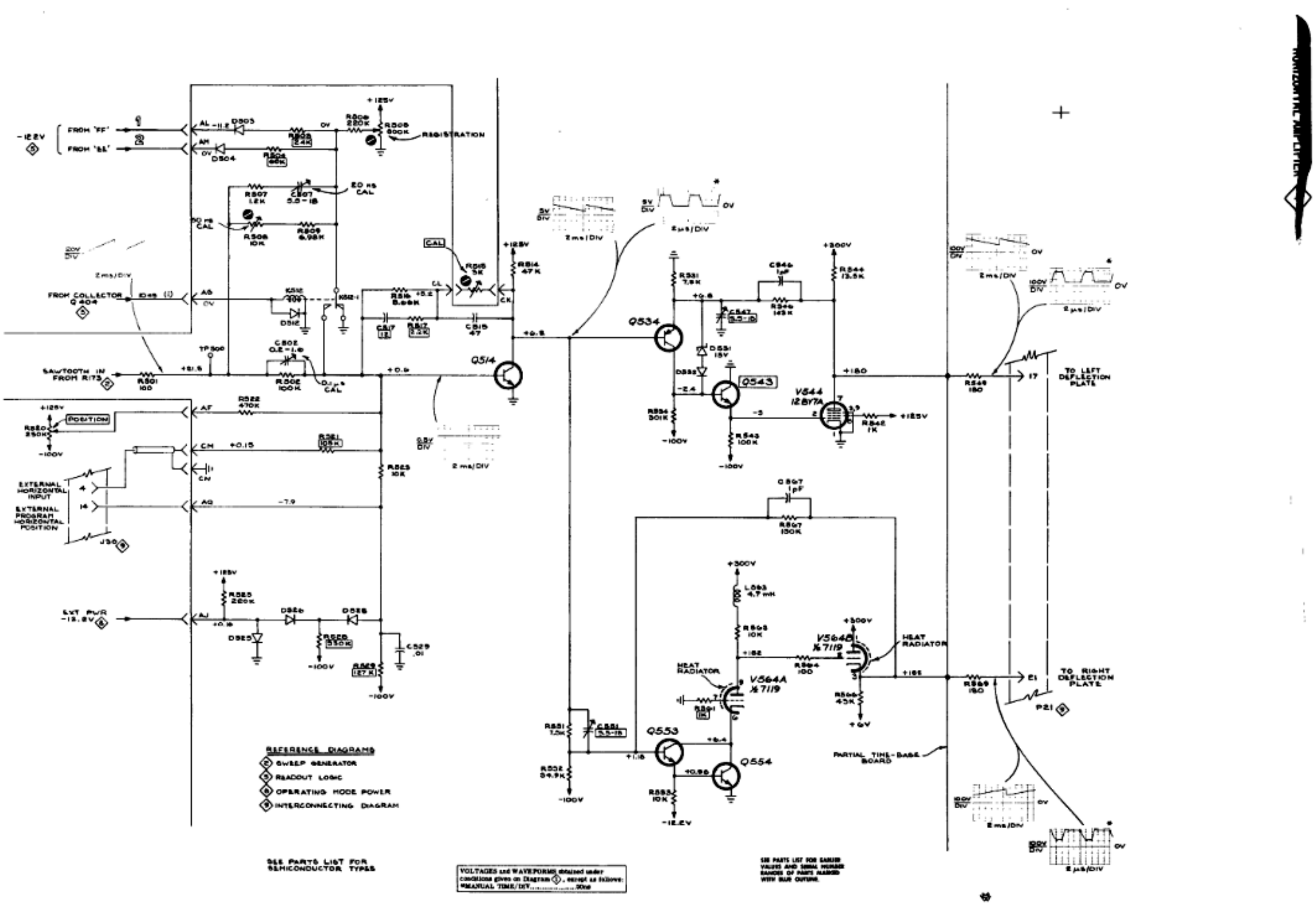
SWEEP GENERATOR ②

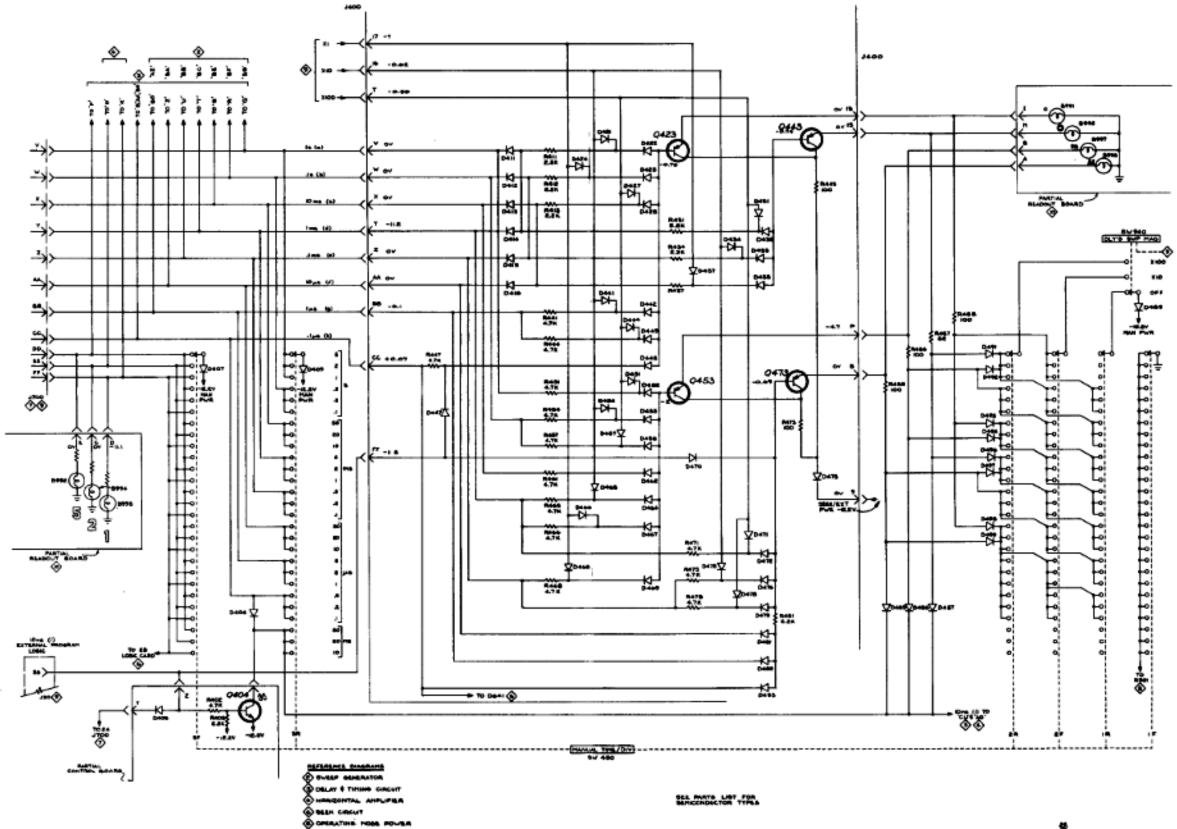


TYPE 3B5 PLUG IN

DELAY & TIMING CIRCUIT 3

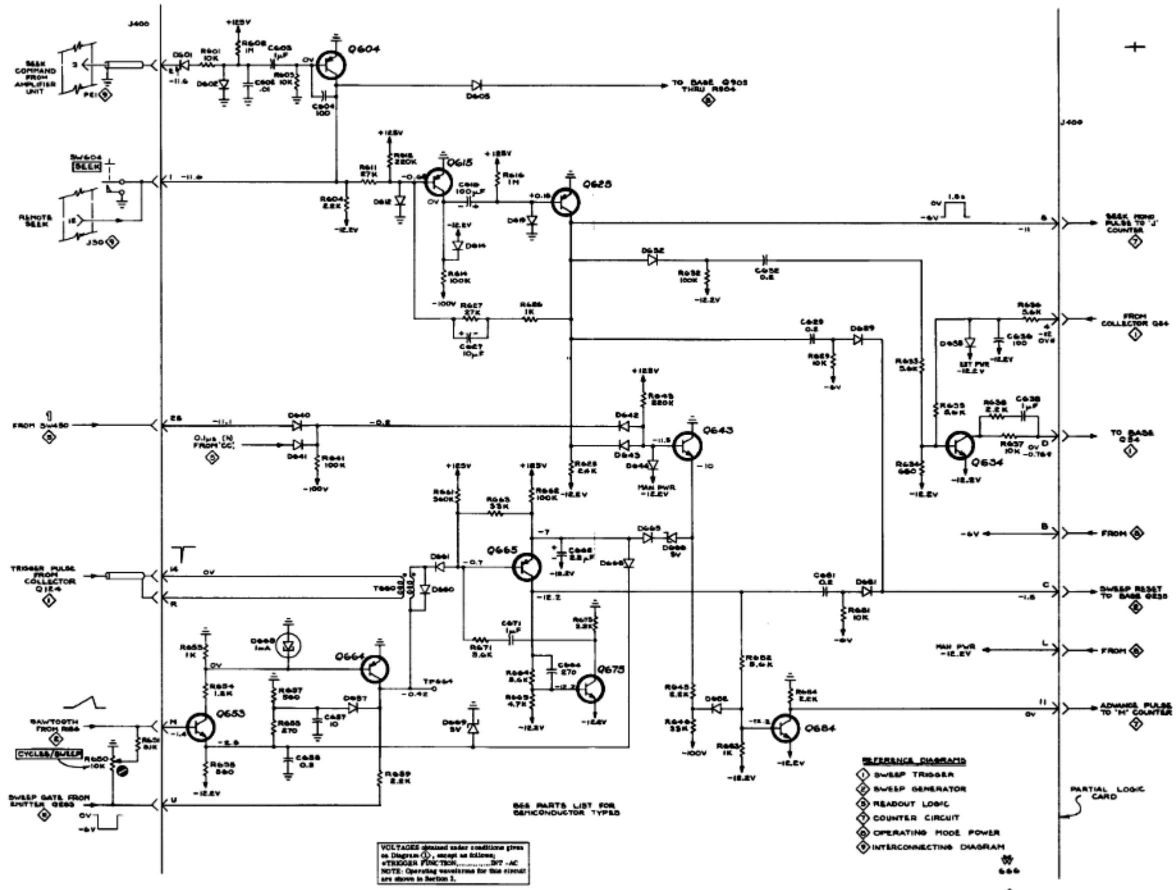
DELAY & TIMING 3





TYPE 3B5 PLUG-IN

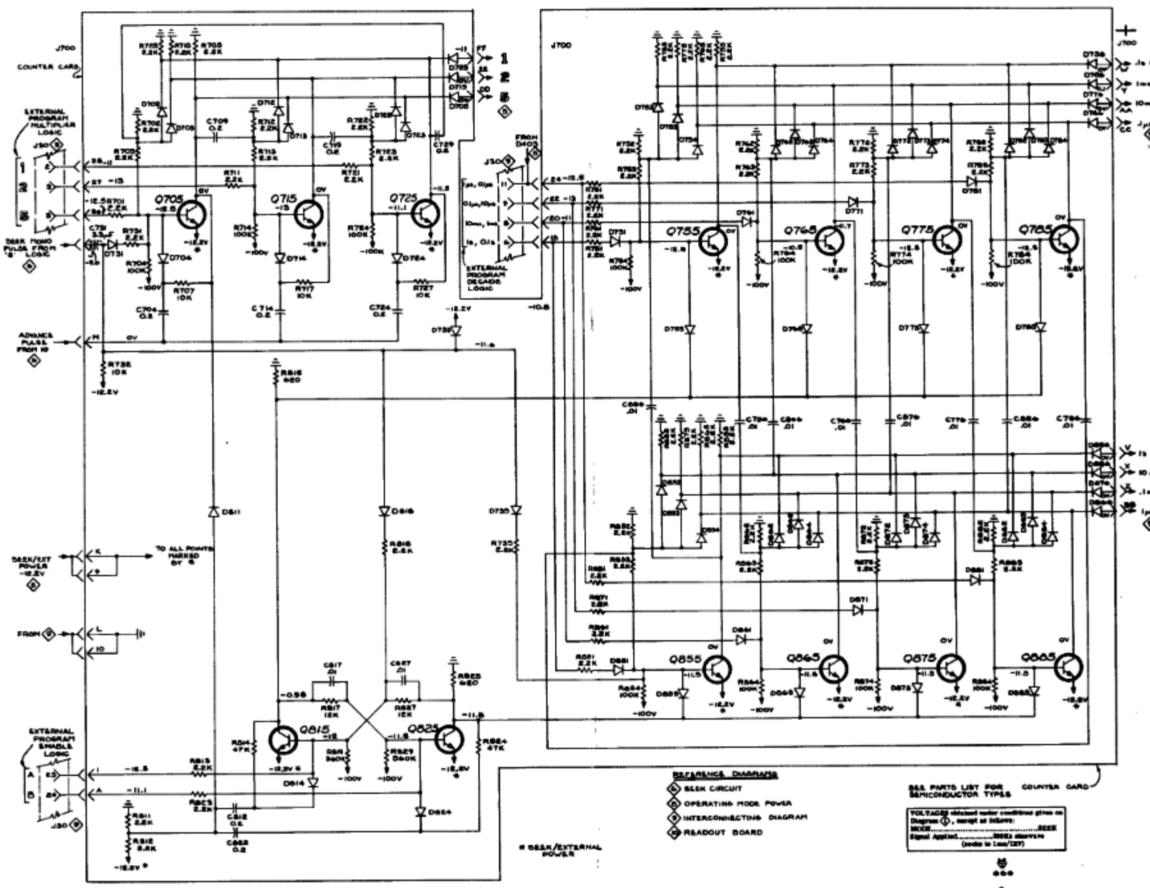
READOUT LOGIC



TYPE 3B5 PLUG-IN

SEEK CIRCUIT ⑥

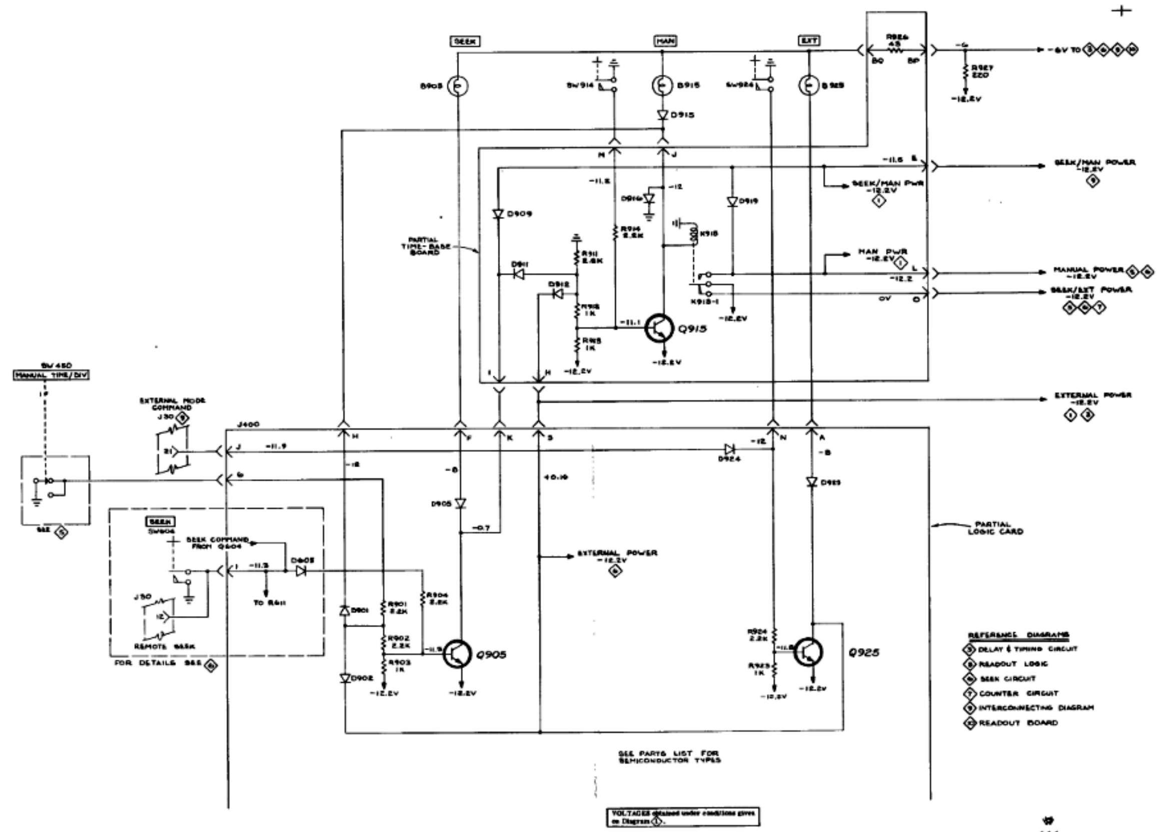
SEEK CIRCUIT 6



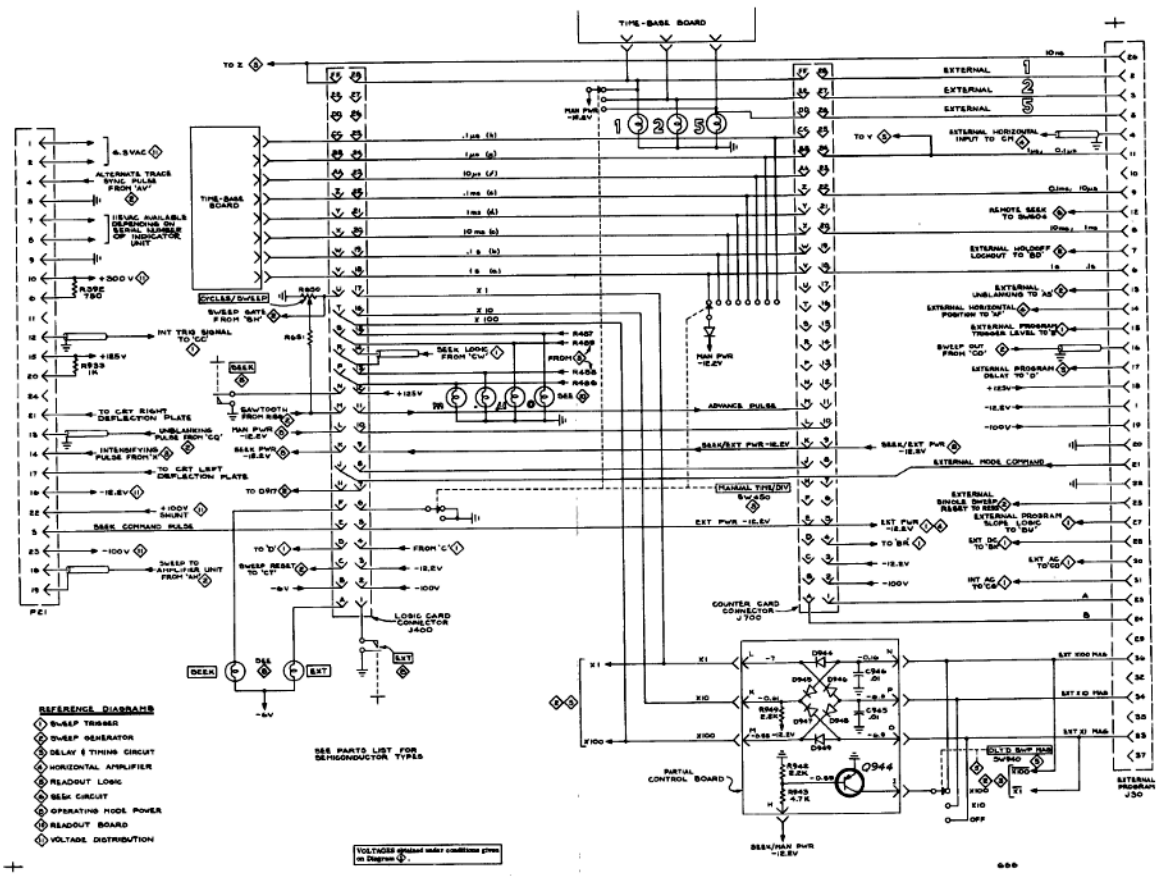
TYPE 3B5 PLUG-IN

COUNTER CIRCUIT ⑦

COUNTER CIRCUIT ⑦



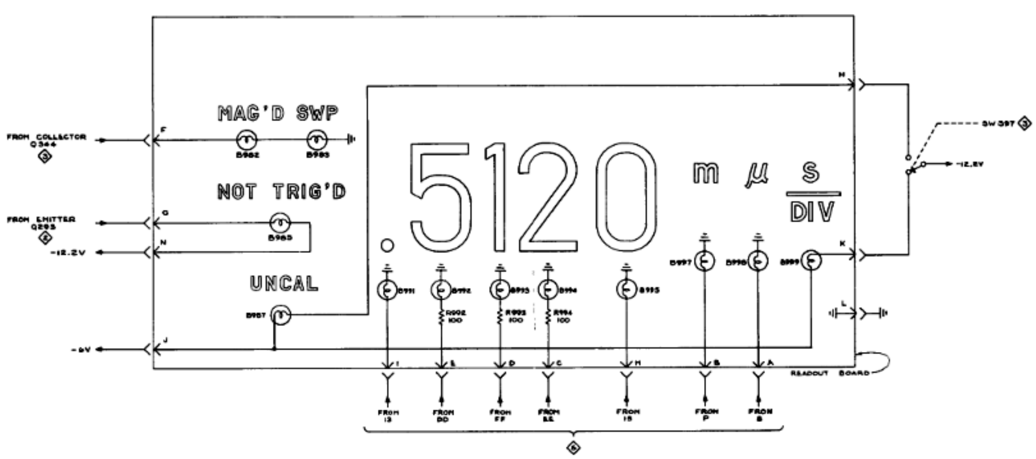
OPERATING MODE POWER 8



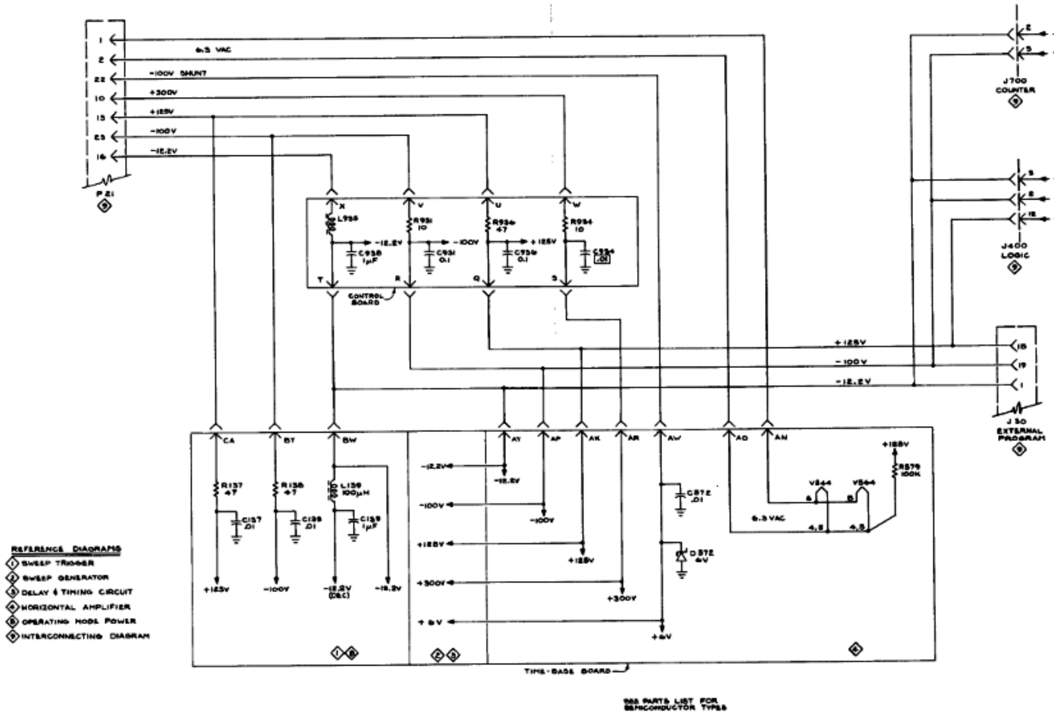
TYPE 3B5 PLUG-IN

INTERCONNECTING DIAGRAM 9

REFERENCE DIAGRAMS
② SWEEP GENERATOR
③ DELAY & TIMING CIRCUIT
⑤ READOUT LOGIC

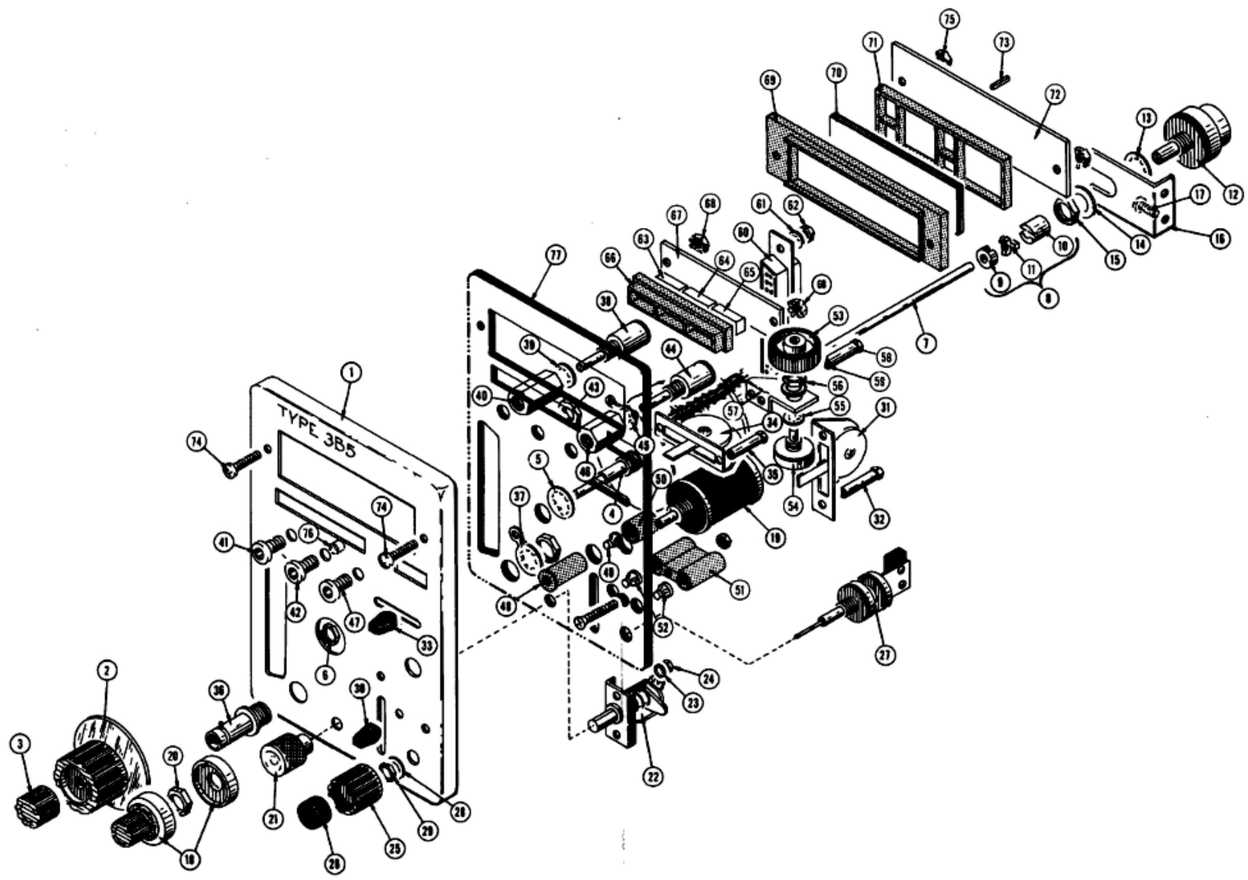


READOUT BOARD ⑩

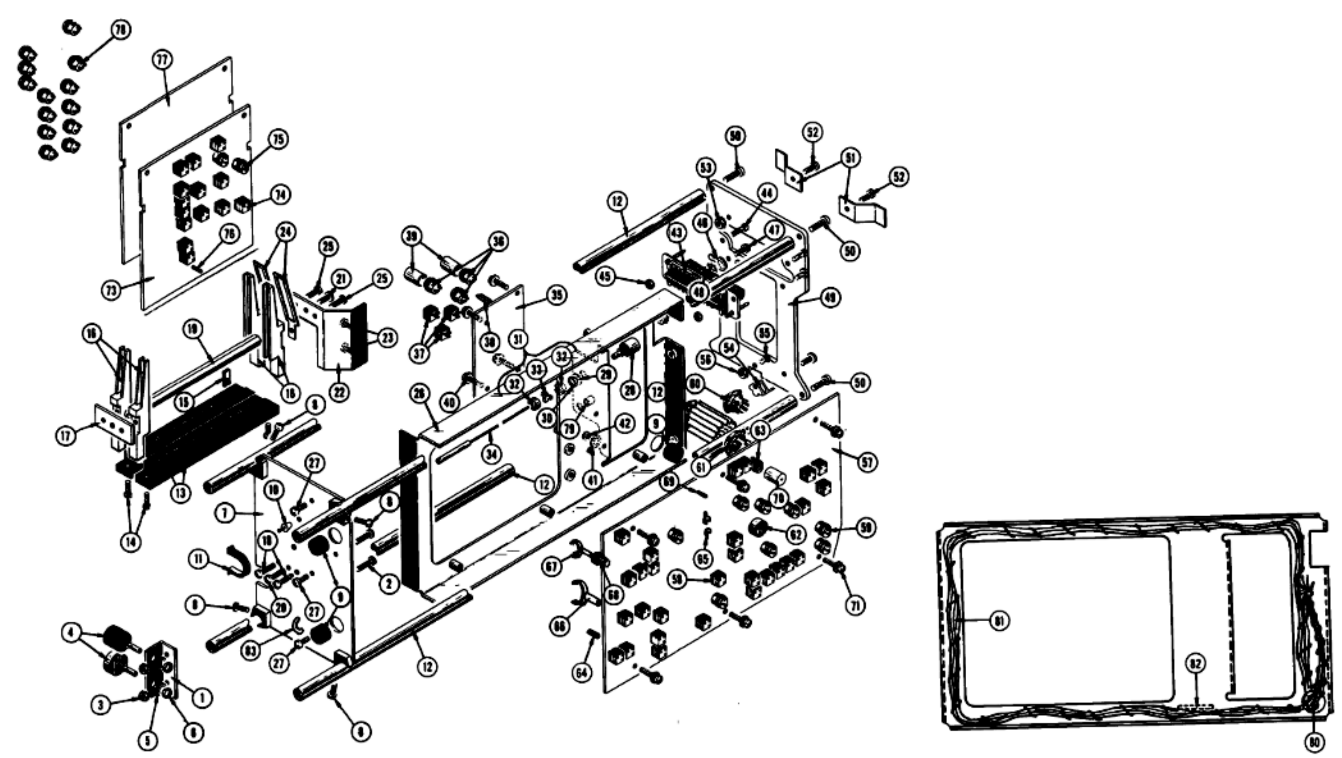


VOLTAGE DISTRIBUTION ⑪

FIG. 1 FRONT & SWITCHES



TYPE 3B5 AUTOMATIC PROGRAMMABLE TIME BASE



OPTIONAL ACCESSORIES

FIG. 3 STANDARD ACCESSORIES

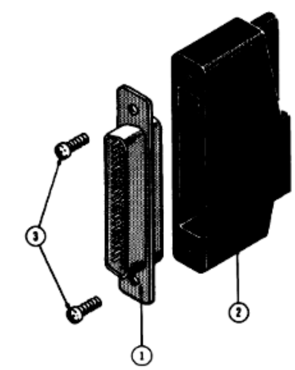


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	1 2 3 4 5 Description
3-1	131-0422-00			1	CONNECTOR, 37 pin
-2	200-0660-01			1	COVER, plastic, connector
-3	213-0045-00			2	SCREW, thread cutting, 4-40 x $^3/_{16}$ inch, PHS
	070-0538-00			2	MANUAL, instruction, (not shown)