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OPERATOR'S HANDBOOK

TEKTRONIX INC. P.O. BOX 831 PORTLAND 7, OREGON

INTRODUCTION

The following pages provide a rapid means of setting the controls of your Tektronix Type 535A or Type 545A Oscilloscope. This information is designed to give you not only control settings for specific applications but also various functions of these controls during different operational procedures.

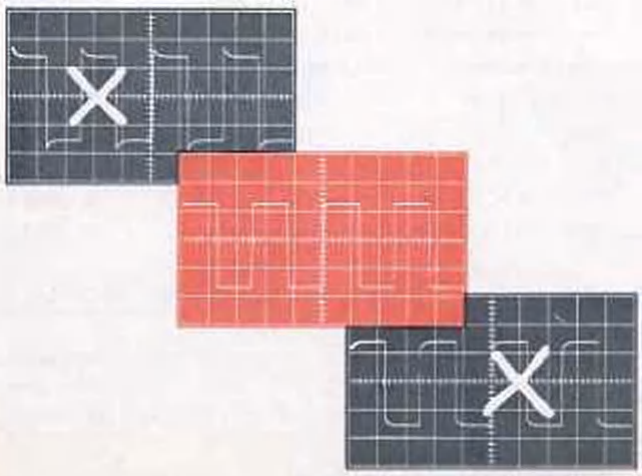
An important part of this book covers "triggered" operation of the oscilloscope. Here, some "triggering" signal starts the horizontal trace across the screen, beginning at the left hand side of the graticule. For present purposes, then, "triggering" can be taken as synonymous with starting the horizontal sweep of the trace.

CONTENTS

BEFORE USING PROBE
ALWAYS CHECK ITS ADJUSTMENT

PROBE ADJUSTMENT

An adjustable capacitor in the probe body compensates for variations in input capacitance from one instrument to another, so that your pulse and transient measurements will be accurate. Touch the probe tip to the oscilloscope calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform. Adjust the probe capacitor for a flat top on the calibrator square wave.



CHARACTERISTICS OF PLUG-IN

AND TYPE 535A/TYPE 545A COMBINATIONS

For the complete list of specifications, including risetime and input capacitance, see the instruction manual for the instrument involved.

PLUG-IN	DEFLECTION FACTOR (Calibrated)	BANDPASS 535A/545A
TYPE A	.05 v/cm to 20 v/cm	dc to 14 mc/20 mc
TYPE B	.05 v/cm to 20 v/cm	dc to 14 mc/12 mc
TYPE B	5 mv/cm to .05 v/cm	2 c to 10 mc/dc to 20 mc
TYPE CA*	.05 v/cm to 20 v/cm	dc to 15 mc/24 mc
TYPE D†	1 mv/cm to 50 v/cm	dc to 2 mc
TYPE E†	50 μv/cm to 10mv/cm	.06 c to 60 kc
TYPE G †	.05 v/cm to 20 v/cm	dc to 14 mc/20 mc
TYPE H	5 mv/cm to 20 v/cm	dc to 11 mc/15 mc
TYPE K	.05 v/cm to 20 v/cm	dc to 15 mc/30 mc
TYPE L	5 mv/cm to 2 v/cm	3 c to 15 mc/24 mc
TYPE L	.05 v/cm to 20 v/cm	dc to 15 mc/30 mc

*Dual-Trace or Single-Trace Differential.

† Differential Input Available.

SELECTING THE TRIGGERING SIGNAL

1. To trigger the sweep from the waveform being observed, set the black TRIGGER SLOPE switch to +INT. or —INT.

2. To trigger the sweep from the power-line wave (to observe a waveform having a time relationship to the power-line wave), set the black TRIGGER SLOPE SWITCH to + LINE or —LINE.

3. To trigger the sweep from an external waveform which has a time relationship to the observed waveform, connect the triggering wave to the appropriate TRIGGER INPUT connector, and set the black TRIGGER SLOPE switch to +EXT. or —EXT.

4. If you want the start of the display to occur at a time when the triggering signal is rising (has a positive slope), use the + positions of the black TRIGGER SLOPE switch. To start the display at a time when the triggering signal is falling (has a negative slope), use the — positions of the black TRIGGER SLOPE switch.

TRIGGERED OPERATION

AUTOMATIC MODE

For periodic signals
60 cycles to 2 megacycles

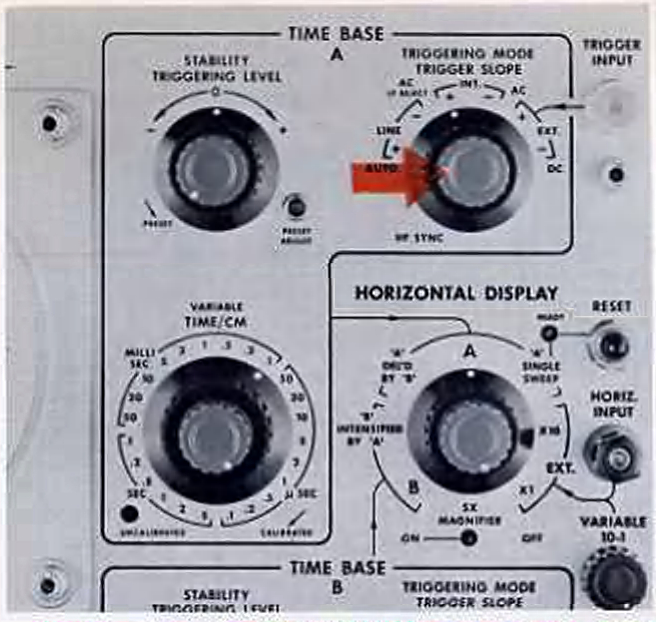
This mode is particularly useful when changing the input connection from one point in the circuit to another. It provides a trace with or without a triggering signal.

CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	AUTO.	31
TRIGGER SLOPE	† +INT or —INT	31
STABILITY	NOT USED	31
TRIGGERING LEVEL	NOT USED	32

*Refers to description of the control function in this book.

† See page 3.

Set the appropriate TIME/CM switch for the desired time base and the red VARIABLE knob to CALIBRATED. If the waveform does not appear, refer to page 29.



In this mode, the red STABILITY knob and the black TRIGGERING LEVEL control need no adjustment. Each sweep is triggered at the average-voltage point on the waveform.

TRIGGERED OPERATION

AC MODE

For transient or periodic signals
15 cycles to 5 megacycles

This mode is particularly useful for low-frequency signals. It provides a trace only when a triggering signal occurs.

CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	AC	31
TRIGGER SLOPE	† + INT or —INT	31
STABILITY	‡ PRESET	31
TRIGGERING LEVEL	Full left or right	32

*Refers to description of the control function in this book.

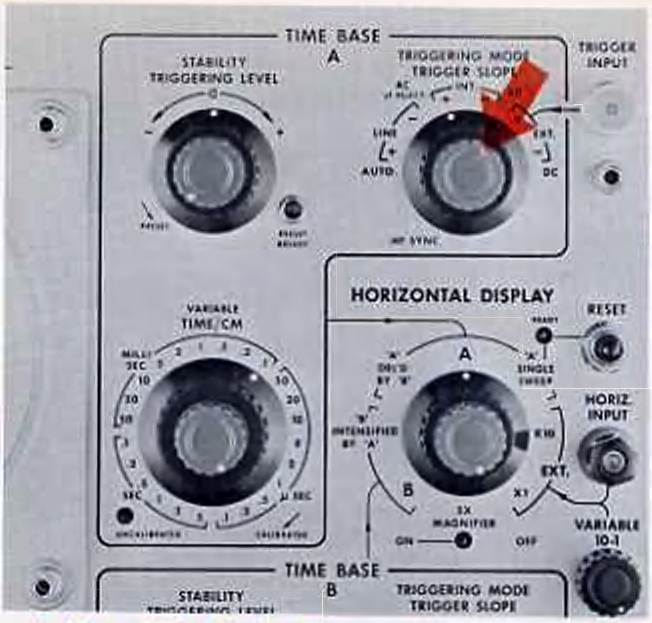
† See page 3.

‡ Click the red STABILITY knob full left to PRESET.

1. Set the black TIME/CM switch for the desired TIME BASE and the red VARIABLE knob to CALIBRATED.

2. Turn the black TRIGGERING LEVEL CONTROL slowly toward the center of its range for a stable display.

If the waveform does not appear, refer to Page 29.



In this mode, the black TRIGGERING LEVEL control determines the height on the waveform at which the trace will start. Triggering is unaffected by the dc components of the triggering signal or by the VERTICAL POSITION control.

TRIGGERED OPERATION

DC MODE

For transient or periodic signals
DC to 5 megacycles

This mode is particularly useful for signals that change slowly, signals below the lower frequency limit of the AC MODE.

CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	DC	31
TRIGGER SLOPE	† +INT or —INT	31
STABILITY	‡ PRESET	31
TRIGGERING LEVEL	Full left or right	32

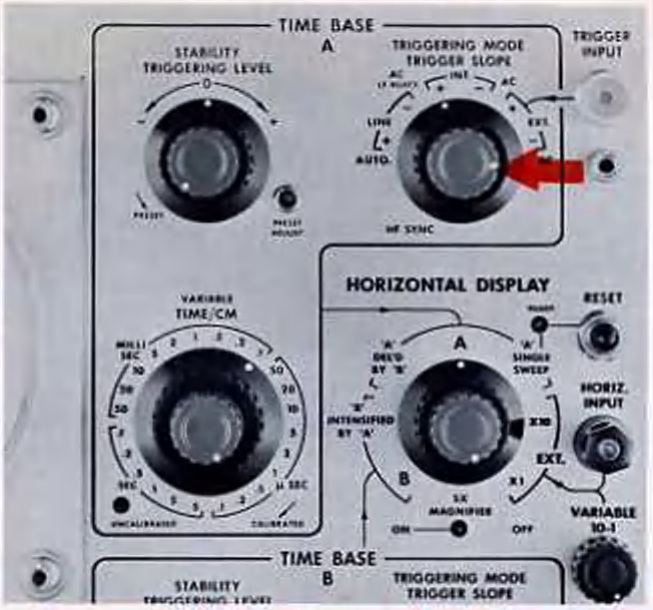
*Refers to description of the control function in this book.

† See page 3.

‡ Click the red STABILITY knob full left to PRESET.

1. Set the appropriate TIME/CM switch for the desired time base, and the red VARIABLE knob to CALIBRATED.

2. Turn the black TRIGGERING LEVEL control slowly toward the center of its range for a stable display. Final setting of this control will depend upon the VERTICAL POSITION control. If the display is positioned to the top or bottom of the graticule, the TRIGGERING LEVEL control will be set to either side of the mid-range position. If the waveform does not appear, refer to page 29.



In this mode, the black TRIGGERING LEVEL control determines the point on the triggering waveform where triggering of the sweep occurs. The trace always starts at a given point on the graticule for a given TRIGGERING LEVEL control setting.

AC, LF, REJECT MODE

For transient or periodic signals, 10 kilocycles to 5 megacycles

This mode is particularly useful for eliminating undesirable low-frequency components in the triggering signal.

CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	AC, LF REJECT	31
TRIGGER SLOPE	† + INT or — INT	31
STABILITY	‡ PRESET	31
TRIGGERING LEVEL	Full left or right	32

*Refers to description of the control function in this book.

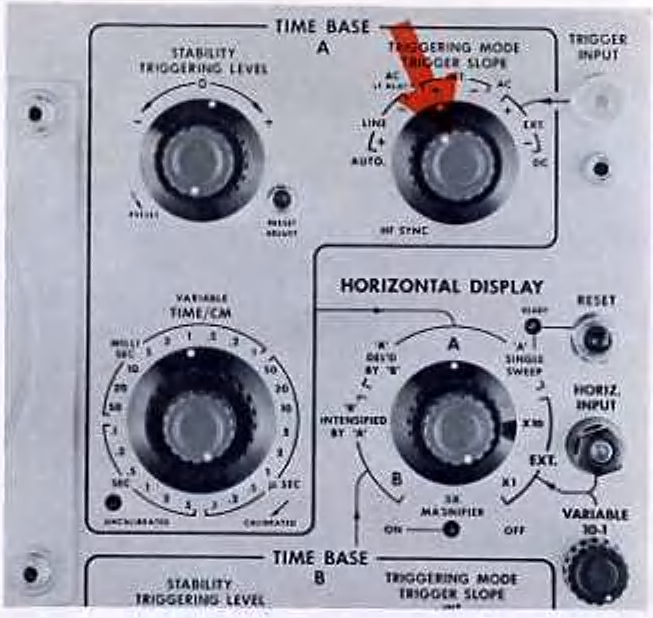
† See page 3.

‡ Click the red STABILITY knob full left to PRESET.

1. Set the black TIME/CM switch for the desired time base and the red VARIABLE knob to CALIBRATED.

2. Turn the black TRIGGERING LEVEL control slowly toward the center of its range for a stable display.

If the waveform does not appear, refer to Page 29.



This mode is principally for use with a dual-trace plug-in unit. However, it may be useful for reducing jitter due to hum in the "triggering" signal.

TRIGGERED OPERATION

USING THE TYPE CA PLUG-IN UNIT

For transient or periodic signals, 10 kilocycles to 5 megacycles

Dual-trace operation is possible with the Type CA PLUG-IN UNIT. In the ALTERNATE position, two traces may be displayed alternately. In the CHOPPED position, two traces may be displayed simultaneously.

CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	AC, LF REJECT	31
TRIGGER SLOPE	† + INT or —INT	31
STABILITY	‡ PRESET	31
TRIGGERING LEVEL	Full left or right	32

*Refers to description of the control function in this book.

† See page 3.

‡ Click the red STABILITY knob full left to PRESET.

1. Connect the source of the waveforms to the CHANNEL A and the CHANNEL B connectors on the plug-in, and place the MODE switch in the desired position.

2. Set the black TIME/CM switch for the desired time base and the red VARIABLE knob to CALIBRATED.

3. Turn the black TRIGGERING LEVEL control slowly toward the center of its range for a stable display.

If the waveform does not appear, refer to page 29.

Two waveforms displayed with the Type CA Plug-In Unit. The MODE switch is set at the ALTERNATE position.

HF SYNC MODE

For repetitive signals
Above 5 megacycles

In contrast to triggered operation, this mode gives a recurrent horizontal sweep which may be synchronized by the red STABILITY knob.

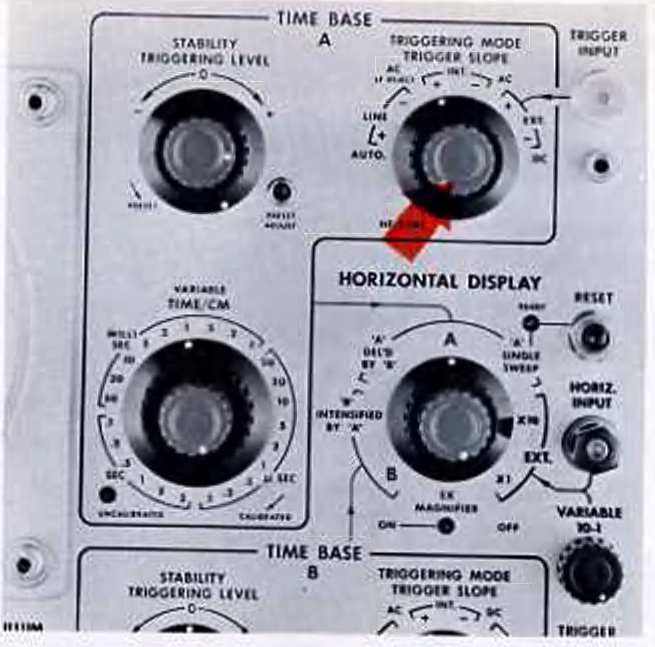
CONTROL	POSITION	PAGE*
HORIZONTAL DISPLAY	A or B	30
TRIGGERING MODE	HF SYNC	31
TRIGGER SLOPE	† +INT or —INT	31
STABILITY	full right	31
TRIGGERING LEVEL	not used	32

*Refers to description of the control function in this book.

† See page 3.

1. Set the appropriate TIME/CM switch for the desired time base and the red VARIABLE knob to CALIBRATED.
2. Turn the red STABILITY knob slowly to the left for a stable display.

If the waveform does not appear, refer to Page 29.



In this mode, the black TRIGGERING LEVEL control is not used. Final setting of the red STABILITY knob depends upon the nature of the synchronizing signal.

FREE-RUNNING SWEEP OPERATION

In usual oscilloscope applications, the sweep is triggered or synchronized by the input waveform. However, it is possible to use the output from either of the + GATE connectors or the SAWTOOTH A connector to trigger or synchronize the input waveform. Not only does this free running sweep provide a means for controlling an applied waveform, but it also supplies a convenient reference trace without requiring an input signal.

1. Use no input to the TRIGGER INPUT connector.

2. To free-run the sweep, set the STABILITY knob full right.

3. In all positions of the TRIGGERING MODE switch except AUTO., the sweep runs at a rate determined by the setting of the appropriate TIME/CM control. In the AUTO. position, the sweep repetition rate remains at approximately 50 sweeps per second, regardless of the setting of the TIME/CM control.

If the waveform does not appear, refer to page 29.

DELAYED TRIGGER OPERATION

A delayed triggering pulse can be obtained from the DEL'D TRIG. binding-post connector of the oscilloscope any time from 0.1 microseconds to 50 seconds after the start of a sweep.

1. Set the controls of the appropriate time-base unit for triggered operation or for free-running operation, depending upon the application.

2. Set the appropriate TIME/CM control and the DELAY-TIME MULTIPLIER control for the delay time.

3. Set the HORIZONTAL DISPLAY switch to any position. In the A position and the 'A' SINGLE SWEEP position, the delayed trigger is controlled by TIME BASE A. In the other positions, the delayed trigger is controlled by TIME BASE B. In all positions, an indicator light, located above the DELAY-TIME MULTIPLIER control, will designate the time base used.

If the waveform does not appear, refer to page 29.

DELAYED-SWEEP OPERATION

The delayed-sweep mode of operation makes possible accurate time and phase measurements as well as high magnification of a selected portion of a low duty-cycle waveform.

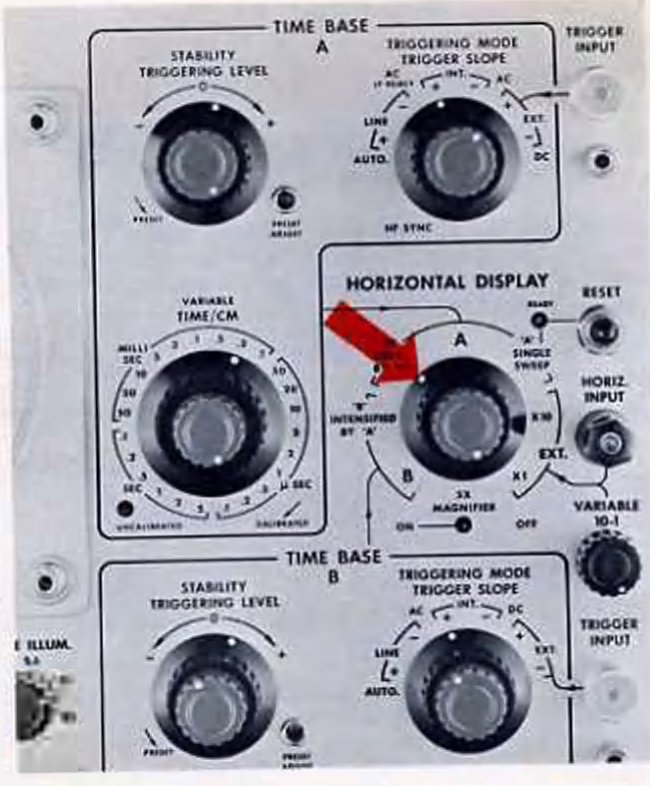
1. Set the controls of both time bases for TRIGGERED OPERATION.

2. Select the delaying sweep by placing the HORIZONTAL DISPLAY switch in the 'A' DEL'D BY 'B' position.

3. Determine the amount of delay occuring from the application of the triggering waveform until the sweep runs by multiplying the settings of the TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER control.

NOTE: When the TIME BASE A STABILITY control is turned full right, the horizontal sweep starts immediately after completion of the delay period, at a rate determined by the settings of the TIME BASE A TIME/CM controls. When the TIME BASE A STABILITY control is not turned full right, but set with the TRIGGERING LEVEL control for normal triggering, the horizontal sweep starts after completion of the delay period, but not until a triggering waveform is applied to TIME BASE A.

If the waveform does not appear, refer to page 29.



DELAYED SWEEP EXPANDED

1. Set the controls of both time bases for delayed sweep operation, with the TIME BASE A TIME/CM switch set for a faster sweep rate than TIME BASE B.

2. Place the HORIZONTAL DISPLAY switch in the 'B' INTENSIFIED BY 'A' position. The brightened portion (the delayed sweep) is more noticeable when the INTENSITY control is not turned too high.

3. Use the DELAY-TIME MULTIPLIER control to position the start of the brightened portion (the delayed sweep) to left or right.

4. Use the TIME BASE A TIME/CM control to adjust the length of the brightened portion (the delayed sweep) to part of a cycle or to many cycles.

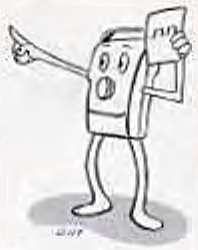
5. To expand the brightened portion (the delayed sweep) set the HORIZONTAL DISPLAY switch to the 'A' DEL'D BY 'B' position. The amount of magnification is the ratio of the TIME BASE B TIME/CM OR DELAY TIME control to the TIME BASE A TIME/CM control.

6. Further magnification may be effected by the 5X MAGNIFIER switch.

If the waveform does not appear, refer to page 29.

SINGLE SWEEPS

MANUAL OPERATION



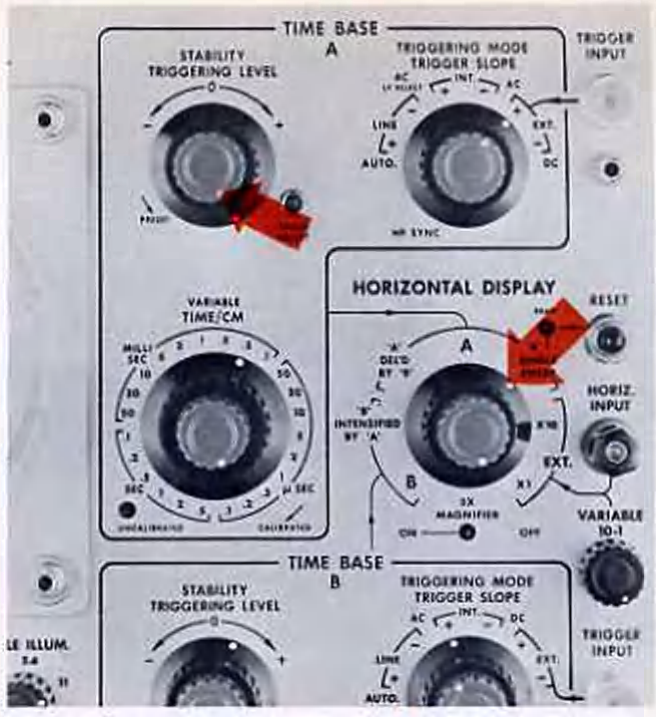
This mode of operation permits photographing recurrent phenomena when succeeding waves are similar but not necessarily identical.

1. Set the controls of the appropriate time base for free-running operation.

2. Place the HORIZONTAL DISPLAY switch in the 'A' SINGLE SWEEP position.

3. After preparing the camera to receive the picture, open the camera shutter, press the RESET button once, and then close the camera shutter.

NOTE: Each time the RESET button is pressed, the procedure is repeated.



In this mode of operation, the +GATE waveform can be used to initiate the action to be photographed.

SINGLE SWEEPS

TRIGGERED OPERATION

This mode of operation permits photographing a single transient, without interference from succeeding signals.

1. Set the HORIZONTAL DISPLAY switch to Time-Base A. Click the STABILITY knob full left to PRESET. Get a stable display of the signal from the AMPLITUDE CALIBRATOR connector, whose amplitude is about that expected of the desired signal.
2. Select the desired triggering signal. See page 3.
3. Place the HORIZONTAL DISPLAY switch in the 'A' SINGLE SWEEP position.
4. Remove the lead from the AMPLITUDE CALIBRATOR connector. Connect the source of expected signal to the plug-in INPUT connector. Actuate RESET button. The READY lamp should light.
5. The next trigger signal received will cause a single trace to be displayed. The READY lamp will go out.

NOTE: Each time the RESET button is pressed, the procedure is repeated.

In this mode of operation, an action occuring at an undetermined time can be photographed.

EXTERNAL SWEEP

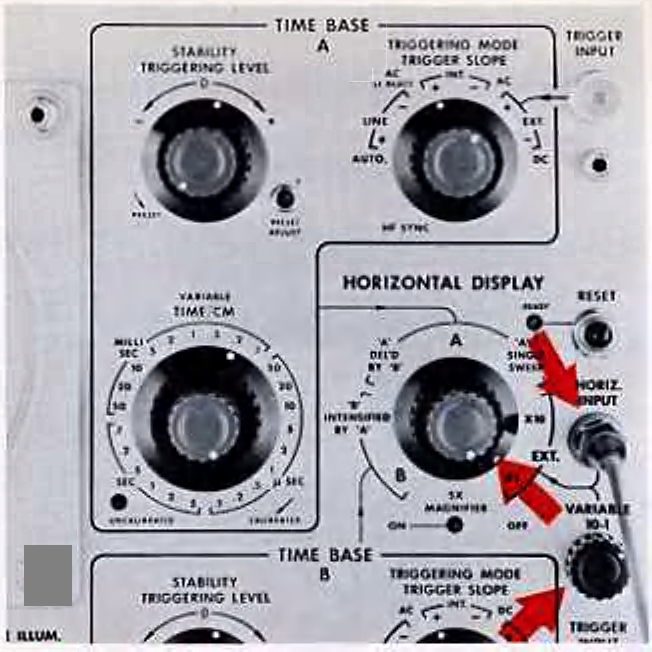
This mode of operation uses externally derived waveforms to deflect the trace both horizontally and vertically.

1. Connect one externally derived waveform to the input connector on the plug-in unit for vertical deflection and connect the other to the HORIZ. INPUT binding post connector on the oscilloscope for horizontal deflection. The sweep voltage should not have a large dc component, or horizontal positioning problems may result.

2. Place the HORIZONTAL DISPLAY switch to either EXT. position.

3. To vary the horizontal deflection factor from approximately .2 volts per centimeter to 15 volts per centimeter, use the VARIABLE 10-1 control.

If the waveform does not appear, refer to page 29.



In this mode of operation, set the TRIGGERING MODE switch to some position other than AUTO. Also, set the red STABILITY knob as far to the left as possible, without actuating the PRESET switch.

USING THE

VARIABLE STABILITY CONTROL

For a few extremely difficult triggering applications, a setting of the red STABILITY knob, other than PRE-SET position, is desirable. This may occur in the DC, AC, or AC, LF REJECT Modes.

1. After setting the oscilloscope controls for the desired triggering mode, turn the black TRIGGERING LEVEL control full right.

2. Turn the red STABILITY knob full right.

3. Slowly turn the red STABILITY knob left until the trace disappears.

4. Slowly turn the black TRIGGERING LEVEL control toward zero for a stable display.

POSSIBLE CAUSES FOR LACK OF TRACE

1. The INTENSITY control is not turned sufficiently to the right. CAUTION: The oscilloscope screen can be damaged in a few seconds if the spot remains overly long in one position, or excessively bright.

2. The TIME/CM switch or the TIME/CM or DELAY TIME switch may be set incorrectly.

3. The plug-in vertical-deflection control may be set incorrectly.

4. The waveform may be off the screen. The beam-position-indicator lamps will light. Adjust the HORIZONTAL POSITION control on the oscilloscope, or the VERTICAL POSITION control on the plug-in, accordingly.

OPERATING DESCRIPTIONS OF CONTROLS AND CONNECTORS

HORIZONTAL DISPLAY

The seven position switch determines the time base used and the type of display presented. In the three TIME BASE A positions, the A sweep is connected to the horizontal amplifier input. In the two TIME BASE B positions, the B sweep is connected to the horizontal amplifier input. In the two EXT. positions, an externally derived sweep (coupled through the HORIZ. INPUT connector) is connected to the horizontal amplifier input.

In the 'B' position, TIME BASE B is the only sweep. In the 'B' INTENSIFIED BY 'A' position, TIME BASE A is used to brighten a portion of TIME BASE B. In the 'A' DEL'D BY 'B' position, the brightened portion, as seen in the 'B' INTENSIFIED BY 'A' position, will be expanded the full width of the screen. In the 'A' position, TIME BASE A is the only sweep. In the 'A' SINGLE SWEEP position, the RESET button controls start of the single sweep (SEE RESET).

In all positions of the HORIZONTAL DISPLAY switch, except 'A' and 'A' SINGLE SWEEP, the delayed trigger is controlled by TIME BASE B. In all positions of the HORIZONTAL DISPLAY switch, the time base used is indicated by a light above the DELAY-TIME MULTIPLIER control.

TRIGGERING MODE (2 switches)

For TIME BASE A, the five position red TRIGGERING MODE switch selects one of four modes of triggering (AUTO., AC, DC, OR AC, LF REJECT), plus synchronized operation (HF SYNC). For TIME BASE B, the three position switch selects one of three modes of triggering (AUTO., AC, or DC).

TRIGGER SLOPE (2 switches)

The TRIGGER SLOPE switch selects the sweep triggering signal—the signal being displayed (+INT. or —INT.), an externally derived triggering signal (+EXT. or —EXT.), or the power-line wave (+LINE or—LINE). In the +INT., +EXT., or +LINE positions, triggering occurs during the voltage rise of the triggering waveform. In the —INT., —EXT., or —LINE positions, triggering occurs during the voltage fall of the triggering waveform.

STABILITY (2 controls)

The red STABILITY control adjusts the sweep for triggered or for free-running operation. When the TRIGGERING MODE switch is in the DC or AC positions (also AC, LF REJECT, in TIME BASE A), the STABILITY control can generally be used in the PRESET position. When the TRIGGERING MODE switch is in the AUTO. position, the STABILITY control is disabled. When the TRIGGERING MODE switch is in the HF SYNC position (Time Base A), the STABILITY control serves as the synchronizing control. For manual operation of the variable STABILITY control, see page 30.

TRIGGERING LEVEL (2 controls)

The TRIGGERING LEVEL control determines the voltage on the triggering signal at which the horizontal trace will start. This control is disabled when the TRIGGERING MODE switch is in the AUTO. or HF SYNC positions.

5X MAGNIFIER

The sweep magnifier expands any two centimeter portion of the displayed waveform the full ten centimeter width of the graticule. The expanded two centimeter portion is determined by the setting of the HORIZONTAL POSITION switch. When the 5X MAGNIFIER is turned to ON, the indicator lamp will light.

TIME/CM (TIME BASE A)

The twenty-four position TIME/CM switch determines the sweep speed and the horizontal size of the TIME BASE A waveform. The CALIBRATED sweep rate is obtained only when the red VARIABLE control is turned fully clockwise.

VARIABLE (TIME/CM)

The red VARIABLE (TIME/CM) control provides continuous uncalibrated sweep rates between the ranges of the TIME/CM switch. The associated UNCALIBRATED indicator lamp will light when the VARIABLE control is turned away from the CALIBRATED position.

TIME/CM OR DELAY TIME (TIME BASE B)

The eighteen position TIME/CM OR DELAY TIME switch has two functions, depending upon the setting of the HORIZONTAL DISPLAY switch. When the HORIZONTAL DISPLAY switch is in the B or the 'B' INTENSIFIED BY 'A' positions, the TIME/CM OR DELAY TIME switch determines the sweep speed and the horizontal size of the TIME BASE B waveform. When the HORIZONTAL DISPLAY switch is in the 'A' DEL'D BY 'B' position, the TIME/CM OR DELAY TIME switch determines the delay time after the triggering signal that TIME BASE A sweep will run. (See DELAY-TIME MULTIPLIER).

LENGTH (TIME/CM OR DELAY TIME)

The red LENGTH control adjusts the sweep length of the TIME BASE B waveform between approximately 4 and 10 centimeters. Turning the LENGTH control counterclockwise reduces the length of the sweep, increases the duty cycle, and brightens the display. Normally the LENGTH control is set fully clockwise.

DELAY-TIME MULTIPLIER 1-10

The ten turn control multiplies the setting of either the TIME/CM switch of TIME BASE A, or the TIME/CM OR DELAY TIME switch of TIME BASE B. An indicator lamp, located above the DELAY-TIME MULTIPLIER, will light designating the time base used, according to the setting of the HORIZONTAL DISPLAY switch.

HORIZONTAL POSITION AND VERNIER

The two controls position the trace horizontally.

AMPLITUDE CALIBRATOR

The AMPLITUDE CALIBRATOR switch selects any one of eighteen square-wave output amplitudes, adjustable from .2 MILLIVOLTS, PEAK-TO-PEAK, to 100 VOLTS, PEAK-TO-PEAK.

Beam-position Indicators

The four indicator lamps, marked with arrows, are located above the crt screen. If the beam is positioned horizontally or vertically away from the center of the graticule, either on or off the screen, the appropriate Beam-position Indicator lamp will light.

FOCUS

The FOCUS knob controls the sharpness of the crt spot or trace.

INTENSITY

The INTENSITY knob controls the brightness of the crt display.

ASTIGMATISM

The ASTIGMATISM knob controls the crt spot shape.

SCALE ILLUM.

The SCALE ILLUM. knob controls the graticule-light intensity. For convenience in photographic work, the SCALE ILLUM. knob is marked in approximate f-stops.

TRIGGER INPUT (2 connectors)

The coaxial TRIGGER INPUT connector accepts an external "triggering" signal. The TRIGGER SLOPE switch of either time base must be placed at +EXT. or —EXT. position.

RESET

A push button which prepares the sweep circuits for the reception of a triggering pulse when the HORIZONTAL DISPLAY switch is in the 'A' SINGLE SWEEP position. Otherwise pressing the RESET button has no effect.

HORIZ. INPUT

The HORIZ. INPUT binding post connector accepts an external signal for deflecting the trace horizontally. The HORIZONTAL DISPLAY switch must be placed at either EXT. position.

VARIABLE 10-1

The VARIABLE 10-1 knob works in conjunction with the EXT. position of the HORIZONTAL DISPLAY switch. The horizontal deflection factor of the external signal may be varied continuously from approximately .2 volts per centimeter to approximately 15 volts per centimeter.

DEL'D TRIG

The DEL'D TRIG binding post connector supplies a positive-going delayed trigger output.

+GATE A and +GATE B

The two +GATE binding post connectors supply positive-going waveforms with peak values of approximately +30 volts. The start and duration of the +GATE A waveform corresponds to the start and duration of the positive-going sawtooth waveform available from the SAWTOOTH A binding post connector.

SAWTOOTH A

The SAWTOOTH A binding post connector supplies a positive-going waveform with a peak value of approximately +150 volts. The start of the waveform coincides with the start of the TIME BASE A sweep. The rate at which the sawtooth rises is determined by the setting of the TIME BASE A TIME/CM switch.

POWER ON

A toggle switch through which power is applied to the instrument.

CAL. OUT

The coaxial CAL. OUT connector supplies a square-wave output from the AMPLITUDE CALIBRATOR at about 1 KC.

VERT. SIG. OUT

The VERT. SIG. OUT binding post connector supplies a sample of the waveform being displayed on the oscilloscope.

CRT CATHODE SELECTOR

A toggle switch located on the rear of the cabinet. For normal applications, the switch is placed in the EXTERNAL CRT CATHODE position and jumper to ground. For accepting beam-intensity modulation voltage, the switch is placed in the EXTERNAL CRT CATHODE position and not jumpered to ground. For eliminating undesirable switching transients in the CHOPPED MODE of the CA PLUG-IN UNIT, the switch is placed in the DUAL-TRACE CHOPPED BLANKING position.

EXTERNAL CRT CATHODE

The EXTERNAL CRT CATHODE binding post connector should remain jumpered to the nearby GND binding post connector unless used for beam-intensity modulation.