OPERATING INFORMATION

This section of the manual provides information on instrument installation and power requirements, and the functions of controls, connectors, and indicators are described. Operating considerations, intended to familiarize the operator with basic measurement techniques, and operator's checks and adjustments for the 2465 are included. For additional operating information, refer to the 2465 Operators Manual.

PREPARATION FOR USE

SAFETY CONSIDERATIONS

Refer to the Safety Summaries at the front of this manual for power source, grounding, and other safety considerations pertaining to the use of the instrument. Before connecting the oscilloscope to a power source, read entirely both this section and the Safety Summaries.

CAUTION

This instrument may be damaged if operated with the LINE VOLTAGE SELECTOR switch set for the wrong applied ac input-source voltage or if the wrong line fuse is installed.

LINE VOLTAGE SELECTION

The 2465 operates from either a 115-V or a 230-V nominal ac power-input source having line frequency ranging from 48 Hz to 440 Hz. Before connecting the power cord to a power-input source, verify that the LINE VOLTAGE SELECTOR switch, located on the rear panel (see Figure 2-1), is set for the correct nominal ac input-source voltage. To convert the instrument for operation from one line-voltage range to the other, move the LINE VOLTAGE SELECTOR switch to the correct nominal ac source-voltage setting (see Table 2-1). The detachable power cord may have to be changed to match the particular power-source output.

LINE FUSE

To verify that the instrument power-input fuse is of proper value for the nominal ac source voltage selected, perform the following procedure:

1. Press in the fuse-holder cap and release it with a slight counterclockwise rotation.
2. Pull the cap (with the attached fuse inside) out of the fuse holder.
3. Verify proper fuse value (see Table 2-1).
4. Install the proper fuse and reinstall the fuse-holder cap.

NOTE

The two types of fuses listed are not directly interchangeable; they require different types of fuse caps.

POWER CORD

This instrument has a detachable, three-wire power cord with a three-contact plug for connection to both the power source and protective ground. The power cord is secured to the rear panel by a cord-set-securing clamp. The protective-ground contact on the plug connects (through the power-cord protective grounding conductor) to the accessible metal parts of the instrument. For electrical-shock protection, insert this plug into a power-source outlet that has a properly grounded protective-ground contact.

Instruments are shipped with the required power cord as ordered by the customer. Available power-cord information is presented in Table 2-1. Part numbers are listed both in the "Accessories" information at the rear of this manual and in the "Options and Accessories" section of the Operators Manual (Section 7). Contact your Tektronix representative or local Tektronix Field Office for additional power-cord information.

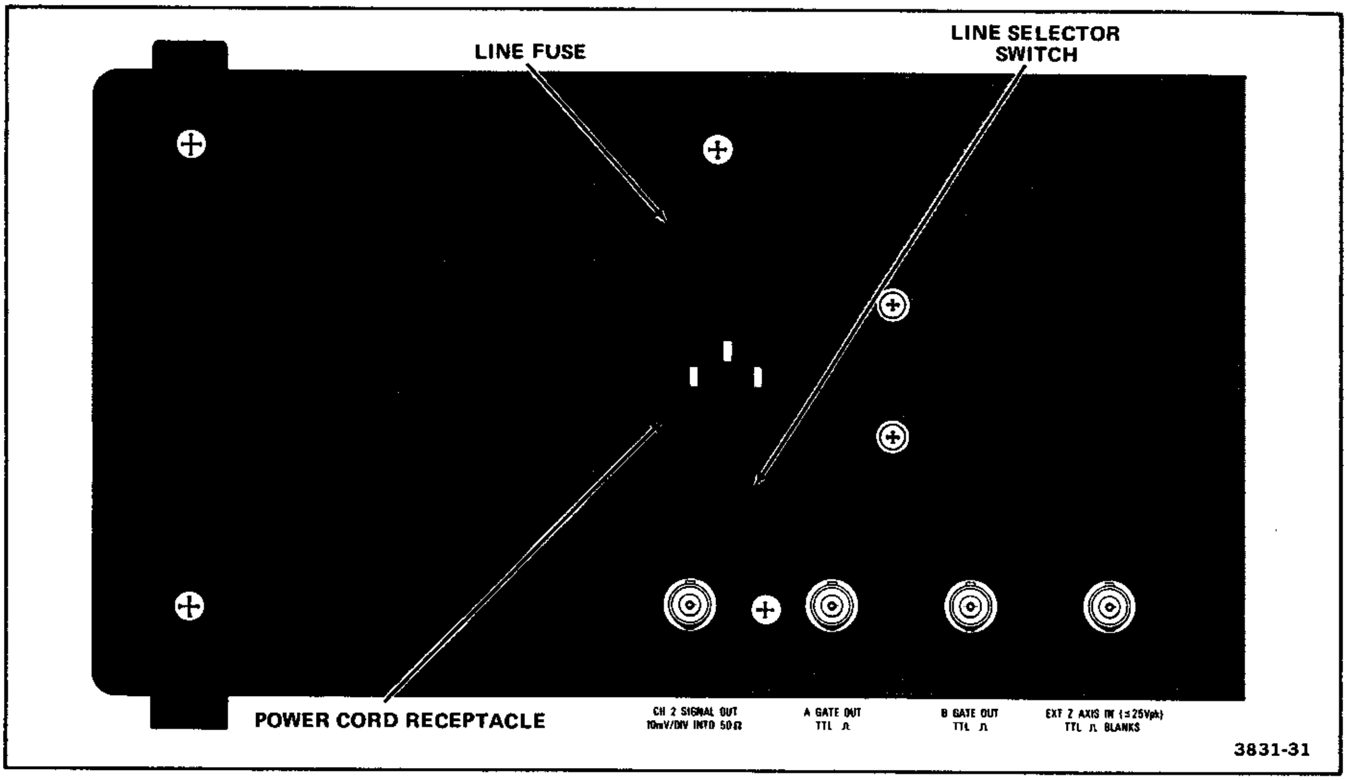


Figure 2-1. Line selector switch, line fuse, and detachable power cord.

INSTRUMENT COOLING

To prevent instrument damage from overheated components, adequate internal airflow must be maintained at all times. Before turning on the power, first verify that both the air-intake holes on the bottom of the cabinet and the fan-exhaust holes in the rear panel are free of any obstruction to airflow.

START-UP

The 2465 automatically performs power-up tests each time the instrument is turned on. The purpose of these tests is to provide the user with the highest possible confidence level that the instrument is fully functional. If no faults are encountered, the power-up tests normally will be completed in under five seconds, after which the instrument will enter the normal operating mode. A failure of any of the power-up tests will be indicated by either a flashing TRIG'D indicator on the instrument front panel or a bottom-line readout on the crt in the form: **TEST XX FAIL YY** (where XX is the test number and YY is the failure code of the failed test).

If a failure of any power-up test occurs, the instrument may still be usable for some applications. To put the instrument into the operating mode after a power-up test failure, press the A/B TRIG button. If the instrument then functions for your particular measurement requirement, it may be used, but refer it to a qualified service technician for repair of the problem at the earliest convenience. Additional information on the power-up tests may be found in the "Maintenance" section of this manual and in Appendix A of the Operators Manual. Consult your service department, your local Tektronix Service Center, or nearest Tektronix representative if additional assistance is needed.

REPACKAGING FOR SHIPMENT

If this instrument is to be shipped by commercial transportation, it is recommended that it be packaged in the original manner. The carton and packaging material in which your instrument was shipped to you should be saved and used for this purpose.

If the original packaging is unfit for use or is not available, repackage the instrument as follows:

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions and having a carton test strength of at least 275 pounds.

2. If the instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following: owner of the instrument (with address), the name of a person at your firm who can be contacted, complete instrument type and serial number, and a description of the service required.

3. Wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and prevent entry of packing materials into the instrument.

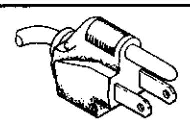
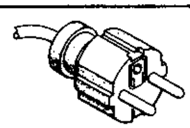
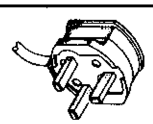
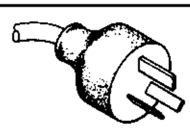
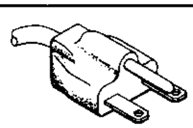
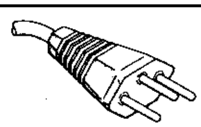
4. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing three inches on each side.

5. Seal the carton with shipping tape or with an industrial stapler.

6. Mark the address of the Tekronix Service Center and your return address on the carton in one or more prominent locations.

Table 2-1

Voltage, Fuse, and Power-Cord Data

Plug Configuration	Category	Power Cord And Plug Type	Line Voltage Selector Setting	Voltage Range (AC)	Factory Installed Instrument Fuse	Fuse Holder Cap	Reference Standards[b]
	U.S. Domestic Standard	U.S. 120V 15A	115V	90V to 132V	2A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	ANSI C73.11 NEMA 5-15-P IEC 83 UL 198.6
	Option A1	EURO 240V 10-16A	230V	180V to 250V	1.6A, 250V 5x20 mm Quick-Acting (F) (IEC 127)	5×20 mm	CEE(7), II, IV, VII IEC 83 IEC 127
	Option A2	UK[a] 240V 6A	230V	180V to 250V	1.6A, 250V 5x20 mm Quick-Acting (F) (IEC 127)	5×20 mm	BS 1363 IEC 83 IEC 127
	Option A3	Australian 240V 10A	230V	180V to 250V	1.6A, 250V 5x20 mm Quick-Acting (F) (IEC 127)	5×20 mm	AS C112 IEC 127
	Option A4	North American 240V 15A	230V	180V to 250V	2A, 250V AGC/3AG Fast-blow (UL 198.6)	AGC/3AG	ANSI C73.20 NEMA 6-15-P IEC 83 UL 198.6
	Option A5	Switzerland 220V 6A	230V	180V to 250V	1.6A, 250V 5x20 mm Quick-Acting (F) (IEC 127)	5×20 mm	SEV IEC 127

[a] A 6A, Type C fuse is also installed inside the plug of the Option A2 power cord.

[b] Reference Standards Abbreviations:

- ANSI—American National Standards Institute
- AS—Standards Association of Australia
- BS—British Standards Institution
- CEE—International Commission on Rules for the Approval of Electrical Equipment
- IEC—International Electrotechnical Commission
- NEMA—National Electrical Manufacturer's Association
- SEV—Schweizevischer Elektrotechischer Verein
- UL—Underwriters Laboratories Inc.

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CONTROLS, CONNECTORS, AND INDICATORS

The following descriptions are intended to familiarize the operator with the location and function of the instrument's controls, connectors, and indicators.

POWER AND DISPLAY

Refer to Figure 2-2 for location of items 1 through 9.

(1) **INTENSITY Control**—Adjusts brightness of the crt trace display. This control does not affect intensity of the crt readout display.

(2) **BEAM FIND Switch**—When held in, compresses the display to within the graticule area. Aids the operator in locating off-screen displays.

(3) **FOCUS Control**—Adjusts the display for optimum definition.

(4) **TRACE ROTATION Control**—Operator-adjusted screwdriver control used to align the crt trace with the horizontal graticule lines. Once adjusted, it does not require readjustment during normal operation of the instrument.

(5) **READOUT INTENSITY Control**—Adjusts the intensity of the crt readout display. This control is also used to either enable or disable the scale-factor display. Setting the control to MIN reduces the readout intensity to minimum. Clockwise rotation from midrange increases the readout intensity and enables the scale-factor display; counterclockwise rotation from midrange also increases the intensity but disables the scale-factor display. Delta Volts and Delta Time readouts and control messages will continue to be enabled even when the scale-factor display is disabled.

(6) **ASTIG Control**—Operator-adjusted screwdriver control used in conjunction with the FOCUS control to obtain a well-defined display over the entire graticule area. Once adjusted, it does not require readjustment during normal operation of the instrument.

(7) **SCALE ILLUM Control**—Adjusts the light level of the graticule illumination.

(8) **POWER Switch**—Turns instrument power on and off. Press in for ON; press again for OFF. An internal indicator in the switch shows green when the switch is on and black when it is off. Front-panel settings that were unchanged for at least 10 seconds prior to power-off will be returned when power is reapplied to the instrument.

(9) **CRT**—Has an 80-mm vertical and 100-mm horizontal display area. Internal graticule lines eliminate parallax-viewing error between the trace and the graticule lines. Rise-time measurement points are indicated at the left edge of the graticule.

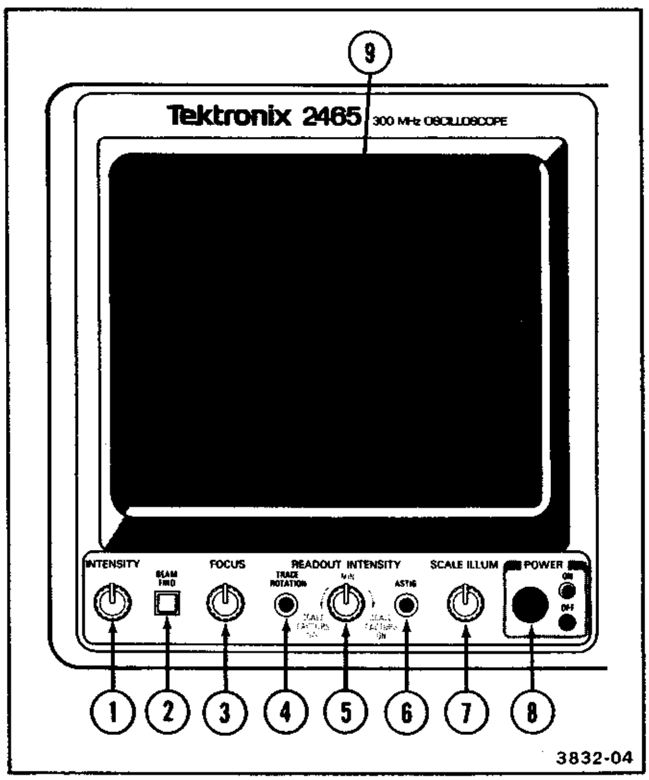

Figure 2-2. Power and display controls.

VERTICAL

Refer to Figure 2-3 for location of items 10 through 17.

(10) **CH 1 OR X and CH 2 Input Connectors**—Provide for application of external signals to the inputs of Channel 1 and Channel 2 vertical attenuators. A signal applied to the CH 1 OR X connector provides the horizontal deflection for an X-Y display. Any one or all of the channels (including Channel 1) may supply the signal for the X-Y display vertical deflection. These connectors each include a coding-ring contact that activates the scale-factor-switching circuitry whenever a scale-factor-switching probe is connected. The internal circuitry recognizes Tektronix attenuation-coded probes.

(11) **Input Coupling Switches and Indicators**—Select the method of coupling input signals to the Channel 1 and Channel 2 vertical attenuators and indicate the selection made. If the Channel 1 and Channel 2 input signals are both AC coupled and if both input coupling switches are pushed up together, the instrument automatically performs a dc balance of Channel 1 and Channel 2 vertical circuitry.

1 MΩ AC—Input signal is capacitively coupled to the vertical attenuator. The dc component of the input signal is blocked. The low-frequency limit (−3 dB point) is 10 Hz or less when using either a 1X probe or a coaxial cable and is 1 Hz or less when using a properly compensated 10X probe.

1 MΩ GND—The input of the vertical amplifier is grounded to provide a zero (ground) reference-voltage display. Input resistance is 1 MΩ to ground. This position of the switch allows precharging of the input-coupling capacitor to prevent a sudden shift of the trace if AC input coupling is selected later.

1 MΩ DC—All frequency components of the input signal are coupled to the vertical attenuator. Input resistance is 1 MΩ to ground.

1 MΩ GND—In this position, the switch operates exactly the same as previously described.

50 Ω DC—All frequency components of the input signal are coupled to the vertical attenuator, with the input terminated by 50 Ω to ground. If excessive signal is applied to either the CH 1 or the CH 2 input connector while 50 Ω DC input coupling is selected, input coupling will revert to 1 MΩ GND and a crt readout will indicate the overloaded condition. Moving the input coupling switch of the affected channel removes the overload message. While power is off, coupling is at 1 MΩ GND.

(12) **Channel 1 and Channel 2 VOLTS/DIV Switches**—Select vertical deflection factor settings in a 1-2-5 sequence with 11 positions. The VAR control must be in the detent (fully clockwise) position to obtain a calibrated deflection factor. Basic deflection factors are from 2 mV per division to 5 V per division. Deflection factors shown in the crt readout reflect actual deflection factors in use when Tektronix attenuation-coded probes are connected to the inputs.

(13) **VAR Controls**—Provide continuously variable, uncalibrated deflection factors between the calibrated settings of the VOLTS/DIV switches. These controls vary the deflection factors from calibrated (fully clockwise detent position) to at least 2.5 times the calibrated deflection factor (fully counterclockwise position). When out of the calibrated detent, a greater than (>) sign appears in front of the associated VOLTS/DIV readout display.

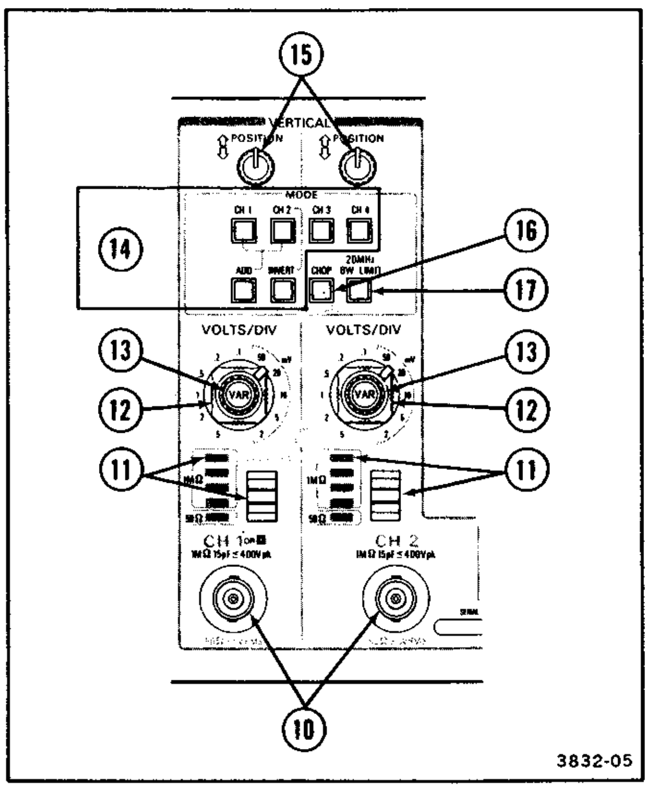

Figure 2-3. Vertical controls and CH 1 OR X and CH 2 connectors.

(14) **MODE Switches**—Select the indicated channel(s) for display when latched in. Any combination of the five possible signal selections can be displayed by pressing in the appropriate push buttons. The Channel 1 signal will be displayed if none of the MODE switches are latched in.

The algebraic sum of Channel 1 and Channel 2 is displayed when the ADD push button is latched in. When both ADD and INVERT buttons are latched in, the waveform displayed is the difference between the Channel 1 and Channel 2 signals. The INVERT button also inverts the polarity of the signal output at the CH 2 SIG OUT connector on the rear panel. At the same time, the Channel 2 trigger-signal polarity is inverted so that if CH 2 is selected as the TRIGGER SOURCE, the displayed slope will agree with the TRIGGER SLOPE switch setting.

When multiple channels are selected, they are displayed sequentially in order of priority. The established priority order is: CH 1, CH 2, ADD, CH 3, then CH 4.

(15) **POSITION Controls**—Set vertical position of the Channel 1 and Channel 2 signal displays. Clockwise rotation of a control moves the associated trace upward. When the X-Y display feature is in use, Channel 1 POSITION control moves the display horizontally; clockwise moves it to the right. The Channel 2, Channel 3, and Channel 4 vertical POSITION controls move the associated X-Y display vertically.

(16) **CHOP-OUT: ALT Switch**—Selects the vertical display mode for multiple-channel displays.

CHOP (latched in)—When more than one channel is selected, the vertical display switches sequentially through the selected channels at the chop-switching rate.

The chop frequency changes between 1 MHz and 2.5 MHz, depending on the SEC/DIV switch setting. At all sweep speeds, the chop-switching rate is desynchronized with the sweep frequency to minimize waveform breaks when viewing repetitive signals.

OUT: ALT (released out)—When more than one channel is selected, the vertical display switches sequentially through the selected channels. Alternate switching occurs during sweep-retrace times. If both A and B Sweeps are displayed, alternate switching occurs at the completion of the B Sweep.

The position of this switch has no effect on the switching rate of multiple X-Y displays. When more than one X-Y display is selected, switching occurs at 2.5 MHz.

(17) **20 MHz BW LIMIT Switch**—Reduces upper 3 dB bandpass of the vertical deflection system to a limit of 13 to 24 MHz when latched in. Full instrument bandwidth is available when push button is out.

Refer to Figure 2-4 for location of items 18 through 22.

(18) **CH 3 and CH 4 Input Connectors**—Provide for application of external signals to Channel 3 and Channel 4. Input coupling from these connectors is DC only. Coding-ring contacts, identical in operation to the CH 1 OR X and CH 2 input connectors, are also provided. Channel 3 and Channel 4 are most useful as digital signal and trigger signal input channels, given their limited choice of deflection factors.

(19) **POSITION Controls**—Set vertical position of the Channel 3 and Channel 4 signal displays. The controls operate identically to the Channel 2 POSITION control, but with less range on their associated traces.

(20) **Channel 3 and Channel 4 VOLTS/DIV Switches**—Select either of two basic deflection factors for Channel 3 and Channel 4. With the push button OUT, the basic deflection factor (using a 1X probe or a coaxial cable input connection) is 0.1 V per division; when it is latched IN, deflection factor is 0.5 V per division.

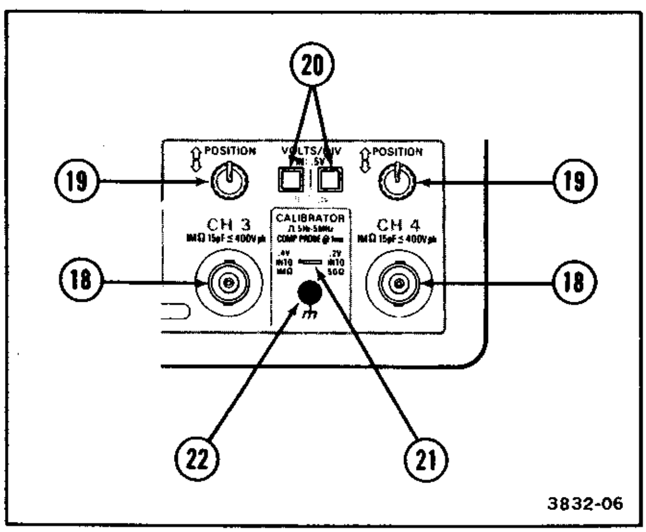

Figure 2-4. Channel 3 and Channel 4 controls and connectors and CALIBRATOR output.

(21) **CALIBRATOR Connector**—Provides a 0.4-V p-p square-wave signal into a 1-MΩ load, a 0.2-V p-p square-wave signal into a 50-Ω dc-coupled load, or an 8-mA p-p square-wave current signal into a short circuit at a sweep speed of 1 ms per division. The CALIBRATOR output signal is useful for checking the sweep, the delays, and the vertical deflection accuracies, as well as compensating voltage probes and checking the accuracy of current probes. The repetition rate of the square wave changes with the setting of the A SEC/DIV switch. For all sweep-speed settings from 100 ms per division to 100 ns per division, the A Sweep display, as seen on the instrument supplying the CALIBRATOR signal, will be five cycles per 10 divisions. At 100 ms per division and slower, the CALIBRATOR frequency will be 5 Hz; at 100 ns per division and faster, the frequency will be 5 MHz. The signal amplitude at 5 MHz will be at least 50% of the signal amplitude obtained when the sweep speed is set to 1 ms per division.

NOTE

Due to internal circuitry constraints, the calibrator signal is not synchronized during trace holdoff. This does not affect the accuracy of the calibrator signal that is present during a trace display. However, if the 2465 CALIBRATOR signal is used to calibrate other instruments, the sweep of the 2465 must be shut off. If it is not, the signal will appear to jitter and will give false (low) frequency counts. The sweep of the 2465 is easily shut off by setting the TRIGGER MODE switch to SGL SEQ.

(22) **Auxiliary Ground Jack**—Provides an auxiliary signal ground when interconnecting equipment under test and the oscilloscope. Hookup is made via a banana-tip connector.

HORIZONTAL AND DELTA MEASUREMENT

Refer to Figure 2-5 for location of items 23 through 33.

(23) **A SEC/DIV Switch**—Selects 25 calibrated A Sweep speeds from 0.5 s per division to 5 ns per division, or delay ranges from 5 s to 100 ns, in a 1-2-5 sequence. Extreme counterclockwise switch rotation selects the X-Y display mode. In X-Y, the signal applied to the CH 1 OR X input connector drives the horizontal deflection system.

(24) **B SEC/DIV Switch**—Selects 22 calibrated B Sweep speeds from 50 ms per division to 5 ns per division in a 1-2-5 sequence. This switch also controls Horizontal Display Mode switching, as explained in the following descriptions.

Knobs Locked—When both the A SEC/DIV and B SEC/DIV switches are set to the same sweep speed and the B SEC/DIV knob is pushed in, the two knobs are locked together; in this position, only the A Sweep is displayed on the crt.

PULL-INTEN—Pulling the B SEC/DIV knob to the out position intensifies the A Sweep display for the duration of the B Sweep time. When both the A SEC/DIV and B SEC/DIV switches are set to the same sweep speed, the B Sweep is not displayed, but it runs at one of two speeds: either 100 times faster than the A Sweep speed or at 5 ns per division, whichever is slower. The A and B SEC/DIV knobs are interlocked to prevent the B SEC/DIV switch from ever being set to a slower sweep speed than the A SEC/DIV switch setting.

The position of the intensified zone on the A Sweep indicates the delay time between the start of the A Sweep and start of the B Sweep interval. Its position is controlled by the Δ REF OR DLY POS control.

For single-trace displays, when either the Delta Time (Δt) or the reciprocal Delta Time (1/Δt) function is activated, two intensified zones will appear on the A Sweep if the B TRIGGER MODE

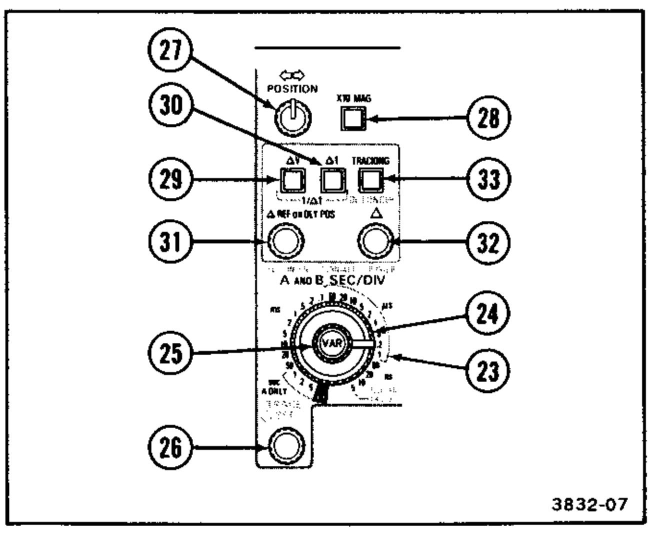

Figure 2-5. Horizontal and delta measurement controls.

is set to RUN AFT DLY. When the B TRIGGER MODE is set to TRIG AFT DLY, intensified zones appear on the A Sweep only if proper B Sweep triggering occurs before the end of the A Sweep. When set to RUN AFT DLY, the position of the Reference zone is controlled by the Δ REF OR DLY POS control as before, and the position of the Delta zone is controlled by the Δ control. In TRIG AFT DLY mode, if the B Sweep is triggered, the positions of both intensified zones are determined by the first triggering events that occur after delay times set by the Δ REF OR DLY POS and the Δ controls have elapsed.

When more than one trace is displayed using ALT VERT MODE, and if the A Sweep is being triggered from a single source, with the Δt or 1/Δt function selected, the Reference zone will appear on the first selected trace from the following sequence: CH 1, CH 2, ADD, CH 3, then CH 4. The Delta zone appears on the second selected trace, and both zones appear on any additional traces. With CHOP VERT MODE or multiple-channel triggering, both zones appear on all traces.

Pulling the B SEC/DIV knob to the out position will cancel the Delta Volts (ΔV) function, if it is activated. Pushing in the B SEC/DIV knob to the locked position will cancel the **NO ΔV WITH DELAY** message on the crt readout, if it is being displayed.

PULL-ADJ CH 2 DLY—When the A SEC/DIV switch is set to 5 ns per division, pulling the B SEC/DIV knob to the out position activates the Channel 2 delay-offset (CH 2 DLY) adjustment feature. See "Matching Channel 2 Delay" in Section 5, "Operator's Checks and Adjustments," to use this feature.

TURN-ALT—Pulling the B SEC/DIV knob to the out position, then turning it to a faster sweep-speed setting than the A SEC/DIV sweep-speed setting, produces the Alternate (ALT) Horizontal Display Mode. The A Sweep with an intensified zone will be alternately displayed with the B Sweep, provided the B TRIGGER MODE is set either to RUN AFT DLY or to TRIG AFT DLY with a proper B triggering signal occurring before the end of the A Sweep. The position of the intensified zone on the A Sweep indicates the approximate delay of the B Sweep, and the length of the intensified zone indicates the approximate B Sweep duration set by the B SEC/DIV switch.

If either Δt or 1/Δt is also activated, intensified zones and associated B Sweeps will be established in the same manner as described in "PULL-INTEN."

PUSH-B—Pushing in the B SEC/DIV knob when the B SEC/DIV switch is set to a faster sweep speed than the A SEC/DIV switch presents only the B Sweep trace(s) on the crt display.

(25) **SEC/DIV VAR Control**—Continuously varies the sweep speed between settings of either the A or the B SEC/DIV switch. This control affects the A Sweep speed when the A and B SEC/DIV switches are locked together. When any of the delayed-sweep horizontal modes are displayed, the control affects only the B Sweep speed.

Fully counterclockwise rotation extends the sweep speed of the slowest A SEC/DIV switch setting (0.5 s per division) to 1.5 s per division. Fully clockwise rotation (detent position) produces the sweep speed indicated by the position of the SEC/DIV switches. The crt readout displays the actual time-per-division scale factor for all settings of the VAR control.

This control produces fine resolution over a portion of its range, after which it changes to coarse resolution. It reenters the fine-resolution range upon reversing the direction of rotation.

(26) **TRACE SEP Control**—Provides for vertical positioning of the B trace downward from the A trace when TURN-ALT Horizontal Display Mode is selected. Counterclockwise rotation moves the B trace downward. At the fully clockwise stop position of the control, there is no separation between the A and B traces. When the PUSH-B Horizontal Display Mode is selected and when either Δt or 1/Δt measurement mode is active, the TRACE SEP control provides for vertical positioning of the trace or traces associated with the Δ control.

(27) **Horizontal POSITION Control**—Sets the horizontal position of the sweep displays on the crt. Clockwise rotation of the control positions the display to the right. This control produces fine resolution over a portion of its range, after which it changes to coarse resolution. It reenters the fine-resolution range upon reversing the direction of rotation. The Horizontal POSITION control does not affect the X-Y display position on the crt.

(28) **X10 MAG Switch**—Horizontally magnifies the portion of the sweep display positioned at the center vertical graticule line by a factor of 10 when pressed in. When the A trace and the B trace are displayed alternately (TURN-ALT Horizontal Display Mode selected), only the B trace is magnified. Using X10 magnification extends the fastest sweep speed to 500 ps per division. The push button must be pressed in a second time to release it and regain the X1 sweep-speed magnification.

(29) **ΔV Switch**—Activates the Delta Volts (ΔV) measurement function, when momentarily pressed in alone, and cancels any other Delta measurement function in effect. In the A Sweep mode (A and B SEC/DIV switches locked together), two horizontal cursors are superimposed on the crt display. The crt readout displays the equivalent voltage represented by the separation between the two cursors. The position of one cursor on the display is set by the Δ REF OR DLY POS control and the position of the other is set by the Δ control. With multiple-channel displays, the deflection factor of the first channel selected in the display sequence determines the scale factor of the Delta Volts readout on the crt. The Delta Volts readout is displayed as a percentage ratio if either one of the following conditions exists: (1) the channel determining the scale factor is uncalibrated (VAR control out of detent), or (2) ADD is displayed alone when the Channel 1 and Channel 2 deflection factors are not the same (VOLTS/DIV switches are at different settings or are uncalibrated). Either pressing in the ΔV switch or pulling the B SEC/DIV knob to the out position when the Delta Volts function is active, cancels it. Attempting to activate the Delta Volts function while the A and B SEC/DIV knobs are unlocked causes the message **NO ΔV WITH DELAY** to appear in the top row of the crt readout. If displayed, the error message will be canceled (removed from the display) by any of the following actions: pressing either the ΔV or Δt switch; pushing in the B SEC/DIV if it is out or pulling it out if it is in; or locking the A and B SEC/DIV knobs together (set to the same sweep speed with the B SEC/DIV knob in).

(30) **Δt Switch**—Activates the Delta Time measurement function and cancels any other Delta measurements in effect, when momentarily pressed in alone. When the Delta Time function is active, momentarily pressing in the Δt push button cancels the function.

When the A and B SEC/DIV knobs are locked together (A trace only), two vertical cursors are superimposed on the crt display while the Delta Time function is active. In any of the delay-time Horizontal Display modes (PULL-INTEN, TURN-ALT, or PUSH-B), two separate delay times are established by the Delta Time function. One cursor position (or delay time) is set by the Δ REF OR DLY POS control, and the other is set by the Δ control. The crt readout displays either the time difference between the two delays or the equivalent time difference between the two vertical cursors.

If the SEC/DIV VAR control is not in the detent position, Δt cursor difference on the A trace only displays is expressed as a ratio, with five divisions corresponding to a 100% ratio. For the delay-time Horizontal Display modes, the SEC/DIV VAR control varies the B-sweep scale factor as it is rotated, but it has no effect on the delay time.

Pressing in the ΔV and Δt push buttons together activates the 1/Δt measurement function and cancels any other Delta measurement functions in effect. The crt waveform display and operation of both the Δ REF OR DLY POS and Δ controls remain the same as explained for Δt operation. However, with 1/Δt selected, the crt readout shows the reciprocal of the time-difference measurement, with units being frequency (Hz, kHz, MHz, or GHz).

For A trace only displays, with the SEC/DIV VAR control out of the detent (fully clockwise) position, the time difference between 1/Δt cursors is displayed in degrees of phase, with five divisions equal to 360 degrees. As with Δt measurements, the position of the SEC/DIV VAR control has no effect on delay-time displays except to change the B Sweep scale factor, and the readout remains in units of frequency.

When the 1/Δt function is active, pressing both the ΔV and the Δt push buttons together cancels the function and exits the Delta measurement mode. Pressing either ΔV or Δt alone cancels the 1/Δt function and activates the function associated with the button pressed.

(31) **Δ REF OR DLY POS Control**—Sets the reference B Sweep delay time or positions the Reference cursor when ΔV, Δt, or 1/Δt Measurement Mode is active. When any delay-time Horizontal Display Mode (PULL-INTEN, TURN-ALT, or PUSH-B) is selected, the reference B Sweep delay time is determined by the rotation of the Δ REF OR DLY POS control in conjunction with the A SEC/DIV switch setting.

This control produces fine resolution over a portion of its range, after which it changes to coarse resolution. It reenters the fine-resolution range upon reversing the direction of rotation.

(32) Δ **Control**—Sets the alternate B Sweep delay time or positions the Delta-time cursor (vertical line) when either the Δt or 1/Δt Measurement Mode is active. When the ΔV Measurement Mode is active (A Sweep Horizontal Display Mode only), the control positions one of the two horizontal voltage cursors that appear on the crt display.

This control produces fine resolution over a portion of its range, after which it changes to coarse resolution. It reenters the fine-resolution range upon reversing the direction of rotation.

(33) **TRACKING-OUT:INDEP Switch**—Selects either the TRACKING or INDEP (independent) mode for the Δ REF OR DLY POS control. When in the TRACKING mode (push button latched in), the difference between alternate delay times or cursors (in either time or volts Measurement Mode) does not change with rotation of the Δ REF OR DLY POS control. When the Δ REF OR DLY POS control is rotated, the positions of both delays or of both cursors move equally until the limit of either is reached.

If OUT:INDEP is selected (push button released), the cursors (or delay positions) are independently movable using the Δ REF OR DLY POS and Δ controls. In either mode (TRACKING or INDEP) the Delta cursor remains independently movable using the Δ control.

TRIGGER

Refer to Figure 2-6 for location of items 34 through 42.

(34) **MODE Switch and Indicators**—Selects the trigger mode of either the A Sweep or the B Sweep. A single push of the switch steps the MODE selection once; holding the switch up or down causes the MODE selection to step repeatedly. Indicators show the selected trigger mode of either the A Sweep or the B Sweep according to the selected Horizontal Display Mode and as directed by the A/B TRIG switch.

A Trigger Modes:

AUTO LVL—Automatically establishes the trigger level on a triggering signal and free runs the sweep in the absence of a triggering signal. The LEVEL control covers a range between the positive and negative peaks of repetitive triggering signals. If the triggering signal amplitude changes, the trigger level does not change unless a trigger is no longer produced at the established level. The signal peak-reference levels and the trigger level are redefined whenever triggering ceases, whenever the LEVEL control is turned to either extreme, or when the MODE switch is pushed up. If the LEVEL control is set near either end position, the trigger level set by AUTO LVL will be near the corresponding signal peak. If the LEVEL control is set in the midrange between either end, the trigger level set by AUTO LVL will be near the midpoint of the trigger signal amplitude. The established trigger level remains in effect when switching to AUTO or NORM Trigger MODE unless the LEVEL control is moved.

If VERT TRIGGER SOURCE is selected, the lowest-numbered displayed channel (or the algebraic sum of Channel 1 and Channel 2 if ADD vertical display is selected) becomes the trigger-signal source. If Trigger MODE is changed from AUTO LVL to AUTO while more than one channel is displayed, the single-channel trigger source is retained, and the VERT SOURCE indicator is turned off. To regain the VERT TRIGGER SOURCE, press up momentarily on the SOURCE switch.

AUTO—Sweep free runs in the absence of a triggering signal. The triggering level changes only when the LEVEL control is adjusted to a new position.

NORM—Sweep is triggered and runs when a triggering signal compatible with the LEVEL setting is applied. Sweep free runs either when the input coupling of the selected trigger SOURCE is set to GND or when the input coupling of both Channel 1 and Channel 2 is set to GND, with ADD VERTICAL MODE and VERT TRIGGER SOURCE selected.

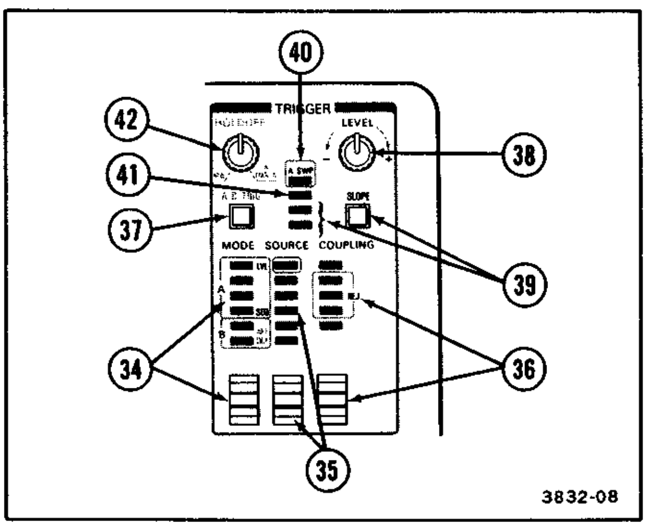

Figure 2-6. Trigger controls and indicators.

SGL SEQ—When armed by pushing the MODE switch down momentarily, the sweep runs one or more times to produce a single sweep of each of the traces defined by the following controls: VERTICAL MODE, A and B SEC/DIV, and Δt. Each sweep requires a distinct A Sweep triggering event. The READY indicator remains illuminated until the final trace in the sequence is completed. At the end of the sequence the crt readout is written once to present scale factors and other readout data, and scale illumination flashes on momentarily for oscilloscope photography purposes.

B Trigger Modes:

RUN AFT DLY—The B Sweep runs immediately after the established delay time has elapsed. Delay time is set by the A SEC/DIV switch and the Δ POS OR DLY REF control when no Delta Time measurements are selected (neither Δt nor 1/Δt).

When either Δt or 1/Δt measurements are made, two delay times are established: one by the Δ REF OR DLY POS control and the other by the Δ control.

TRIG AFT DLY—The B Sweep runs when triggered by a triggering signal after the established delay time has elapsed, provided the A Sweep has not terminated. Since the B Sweep runs at the time the triggering signal occurs, the display is stable, even with jittering signals; but the actual delay time is greater than the delay-time setting. Therefore, the crt readout shows a question mark in this mode.

(35) **SOURCE Switch and Indicators**—Selects the trigger signal source for either the A or the B Sweep. Indicators show the selection made. A single push of the switch steps the SOURCE selection once; holding the switch up or down causes the SOURCE selection to step repeatedly. Indicators do not illuminate for B triggering signals when RUN AFT DLY is selected.

VERT—The sweep triggers on the displayed channel when only one channel is selected. If multiple vertical displays are selected, both the Trigger MODE in use and position of the CHOP/ALT button affect the trigger-source selection. When ALT VERTICAL MODE is selected, each displayed channel in turn provides the triggering signal, and the respective LED indicator for each displayed channel is illuminated, except in the case of AUTO LVL MODE triggering. For AUTO LVL triggering or CHOP VERTICAL MODE, the lowest numbered channel, or ADD if it is displayed, is the triggering-signal source. The LED indicator for the lowest numbered channel displayed is illuminated, except if ADD is selected. Then, the CH 1, CH 2, and VERT indicators are illuminated.

CH 1, CH 2, CH 3, or CH 4—A triggering signal is obtained from the corresponding vertical channel.

LINE (A Trigger Only)—A triggering signal is obtained from a sample of the ac power-source waveform. This trigger source is useful when vertical input signals are time related (multiple or submultiple) to the frequency of the ac power-source voltage.

(36) **COUPLING Switch and Indicators**—Selects the method of coupling the triggering signal to the A and the B trigger generator circuitry. A single push of the switch steps the COUPLING selection once; holding the switch up or down causes the COUPLING selection to step repeatedly. Indicators show the coupling method selected for either the A triggering signals (when an A TRIGGER MODE is in effect) or the B triggering signals when TRIG AFT DLY is selected for the B TRIGGER MODE. Indicators do not illuminate for B triggering signals when RUN AFT DLY is selected.

DC—All frequency components of the signal are coupled to the trigger-generator circuitry. This coupling method is useful for triggering on most signals.

NOISE REJ—All frequency components of the input signal are coupled to the trigger-generator circuitry, but the peak-to-peak signal amplitude required to produce a trigger event is increased. This coupling method is useful for improving trigger stability on signals accompanied by low-level noise.

HF REJ—Attenuates high-frequency triggering-signal components above 50 kHz. This coupling method is useful for eliminating radio-frequency interference and high-frequency noise components from the signal applied to the trigger-generator circuitry; it allows stable triggering on the low-frequency components of a complex waveform.

LF REJ—Signals are capacitively coupled, and the dc component of the triggering signal is blocked. Attenuates the low-frequency signal components below 50 kHz. This coupling method is useful for producing stable triggering on the high-frequency components of a complex waveform. Low-frequency components such as power-supply hum are removed from the signal applied to the trigger-generator circuitry.

AC—Signals are capacitively coupled. Frequency components below 60 Hz are attenuated, and the dc component of the input signal is blocked. This coupling method is useful for signals that are superimposed on slowly changing dc voltages. This method will work for most signals when trigger-level readout is not desired.

(37) **A/B TRIG Switch**—Directs the MODE, SOURCE, COUPLING, SLOPE, and LEVEL controls to either the A Trigger or the B Trigger, under the allowed switching conditions. Controls are normally directed to the A Trigger when the A and B SEC/DIV knobs are locked together (A Sweep display only). Controls are normally directed to the B Trigger when the B TRIGGER MODE is set to TRIG AFT DLY and the A and B SEC/DIV knobs are unlocked (PULL-INTEN, TURN-ALT, or PUSH-B Horizontal Display Mode). Pressing and holding in the A/B TRIG switch will direct the trigger controls away from their normal trigger direction, but releasing the A/B TRIG switch will redirect the trigger controls back to the original triggers.

If the A and B SEC/DIV knobs are unlocked and either the B TRIGGER MODE is set to RUN AFT DLY or the A TRIGGER MODE is set to SGL SEQ, the A/B TRIG switch will direct the trigger controls to the opposite trigger each time it is momentarily pressed and released.

Locking the A and B SEC/DIV knobs together will switch the trigger controls to the A Trigger if they are currently directed to the B Trigger. Pulling the B SEC/DIV knob to the out position will cause the trigger controls to revert to the B Trigger if the B TRIGGER MODE is set to TRIG AFT DLY. However, if the B TRIGGER MODE is set to RUN AFT DLY when the B SEC/DIV knob is unlocked from the A SEC/DIV knob, the trigger controls remain directed to the A Trigger until the B Trigger is reselected by the A/B TRIG switch.

(38) **LEVEL Control**—Sets the amplitude point on the triggering signal at which either A or B Sweep triggering occurs. This control produces fine resolution for a portion of its range, after which it changes to coarse resolution. It reenters the fine-resolution range upon reversing the direction of rotation.

When the A TRIGGER MODE is set to AUTO LVL, the effect of the LEVEL control is spread over the A Sweep triggering-signal amplitude from peak to peak. In this case, rotating the control to either extreme causes the triggering level to be redefined by the AUTO LVL circuitry.

(39) **SLOPE Switch and Indicators**—Select the slope of the signal that triggers either the A Sweep or the B Sweep. Indicators illuminate to show slope selection made for the A Sweep and for TRIG AFT DLY B Sweeps. The + and − indicators do not illuminate for B triggering when RUN AFT DLY is selected.

(40) **A SWP TRIG'D Indicator**—Illuminates to indicate that the A Sweep is triggered. It extinguishes after a nominal length of time when a triggering signal is not received following completion of the sweep.

(41) **READY Indicator**—Illuminates when SGL SEQ MODE is selected and the A Sweep is armed and waiting for a triggering event to occur. It extinguishes following the completion of all the traces selected for the SGL SEQ display.

(42) **HOLDOFF Control**—Varies the amount of holdoff time between the end of the sweep and the time a triggering signal can initiate the next sweep. The ability to obtain stable triggering on some aperiodic signals is improved using this control. In the B ENDS A position (fully clockwise) trigger holdoff time is reduced to minimum, and the A Sweep terminates immediately at the end of the B Sweep. This enables the fastest possible sweep-repetition rate at slow A Sweep speeds.

REAR PANEL

Refer to Figure 2-7 for location of items 43 through 50.

(43) **A GATE OUT and B GATE OUT Connectors**—Provide TTL-compatible, positive-going gate signals that are HI during their respective sweeps and LO while the sweep is not running. When the A SEC/DIV switch is set to 5 ns per division, an output gate is present at both the A GATE OUT and the B GATE OUT connectors.

(44) **CH 2 SIGNAL OUT Connector**—Provides an output signal that is a normalized representation of the Channel 2 input signal. The output amplitude into a 1-MΩ load is approximately 20 mV per division of input signal. Into a 50-Ω load, the output amplitude is approximately 10 mV per division of input signal.

(45) **EXT Z-AXIS IN Connector**—Provides an input connection point to apply external Z-axis modulation signals to the Z-Axis Amplifier. Either the sweep or the X-Y display may be intensity modulated. Positive-going signals decrease the intensity. From dc to 2 MHz, an input-signal amplitude of +2 V will blank a maximum-intensity trace; from 2 MHz to 20 MHz, an input-signal amplitude of +2 V will produce noticeable modulation on a normal-intensity trace.

Modulating signals with fast rise and fall times produce the most abrupt intensity changes. External Z-axis signals must be time related to the displayed signal frequency to obtain a stable intensity-modulation pattern on the crt.

(46) **Optional PROBE POWER Connectors**—Provide output power for using Tektronix active probes.

(47) **Fuse Holder**—Contains the ac power-source fuse.

(48) **Detachable Power Cord Receptacle**—Provides the connection point for the ac power source to the instrument.

(49) **LINE VOLTAGE SELECTOR Switch**—Selects the nominal instrument operating voltage range. When set to 115V, the instrument operates from a power-source voltage having a range of 90 V to 132 V ac. Set to 230V, the instrument operates on an input-voltage range of 180 V to 250 V ac.

(50) **Mod Slots**—Contain the identification numbers of any installed instrument modifications.

READOUT DISPLAY

The Readout System provides an alphanumeric display of information on the crt along with the analog waveform display. The readout is displayed in two rows of 32 characters each. One row is within the top graticule division, and the other row is within the bottom graticule division.

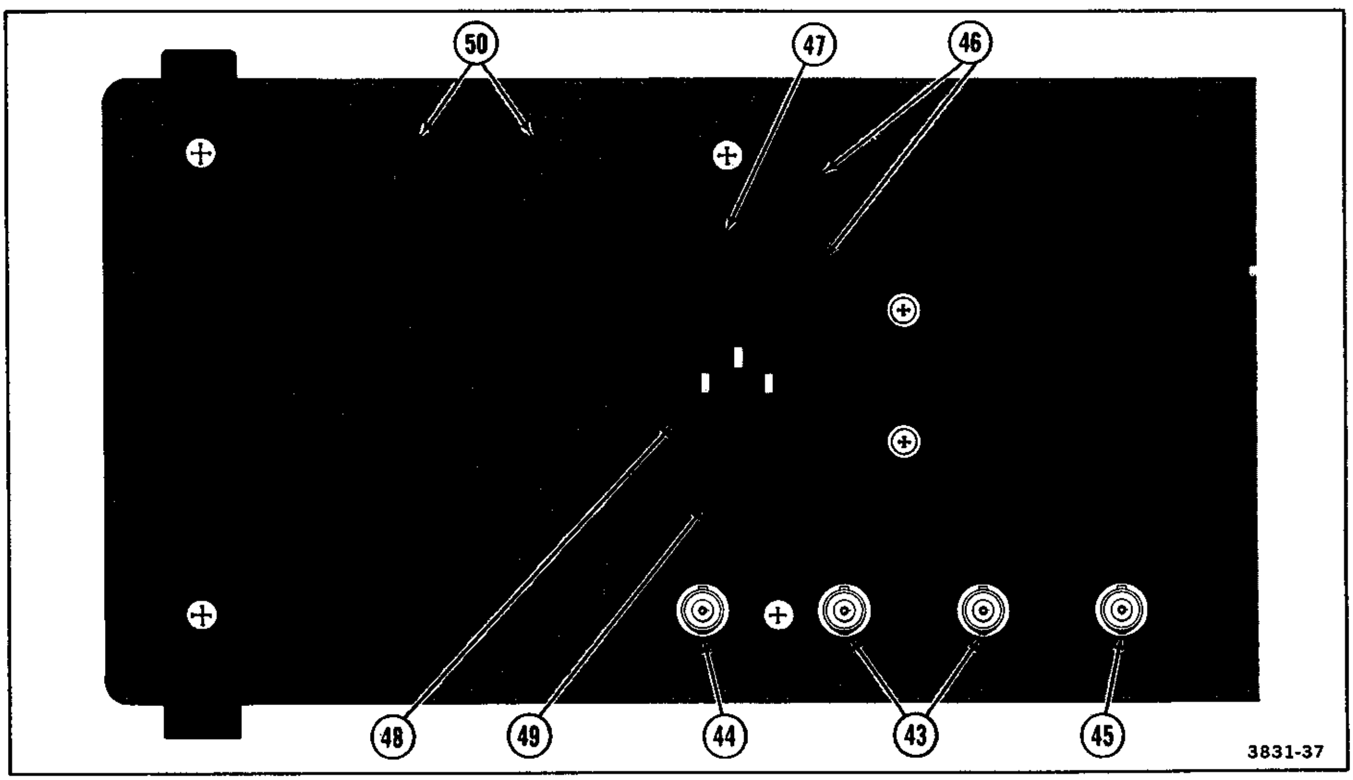

Figure 2-7. Rear-panel controls and connectors.

The locations and types of information displayed under normal operating modes are illustrated in Figure 2-8.

NOTE

Other information is displayed when the instrument is in a diagnostic mode or has experienced a fault. The diagnostic displays are explained in the "Maintenance" section of this manual.

If the bottom row of the readout contains dots in the normally blank spaces, a wrong calibration constant has been encountered. The instrument must be readjusted to remove the incorrect calibration constant from the EAROM.

Each of the scale-factor displays appears when the respective vertical channel or sweep is displayed. When X-Y mode is selected, the Channel 1 scale factor is displayed, and **CH 1 X** appears in place of the A Sweep scale factor.

Special characters or abbreviations are displayed to indicate GND or AC coupling of Channel 1 or Channel 2 signals, ADD, CH 2 INVERT, Vertical bandwidth limited, or HOLDOFF not set to minimum.

The Trigger-Level readout shows the signal voltage (at the probe tip of encoded probes) that will initiate the sweep. The readout appears only if the following conditions exist: a single vertical channel is selected as the trigger source, the vertical input coupling is not AC, the VOLTS/DIV VAR control of the source channel is in the calibrated detent, and trigger coupling is either DC or NOISE REJ.

A question mark may appear in a DLY (delay time), a Δt (delta time), or a 1/Δt readout when the SEC/DIV knobs are unlocked (not with cursors). This indicates that either the delay time (or one of the two delay times) is set at less than 0.5% of the maximum delay or the B TRIGGER MODE is set to TRIG AFT DLY. A question mark will also appear in a 1/Δt display readout when the difference between the two delays (or the distance between the two cursors displayed when the A and B SEC/DIV knobs are locked together) is less than 1% of full scale.

The **50 Ω OVERLOAD** display appears if excessive signal is applied to either the CH 1 or the CH 2 input connector while 50 Ω DC input coupling is selected. The readout will return to the normal display when the input coupling of the overloaded channel is switched.

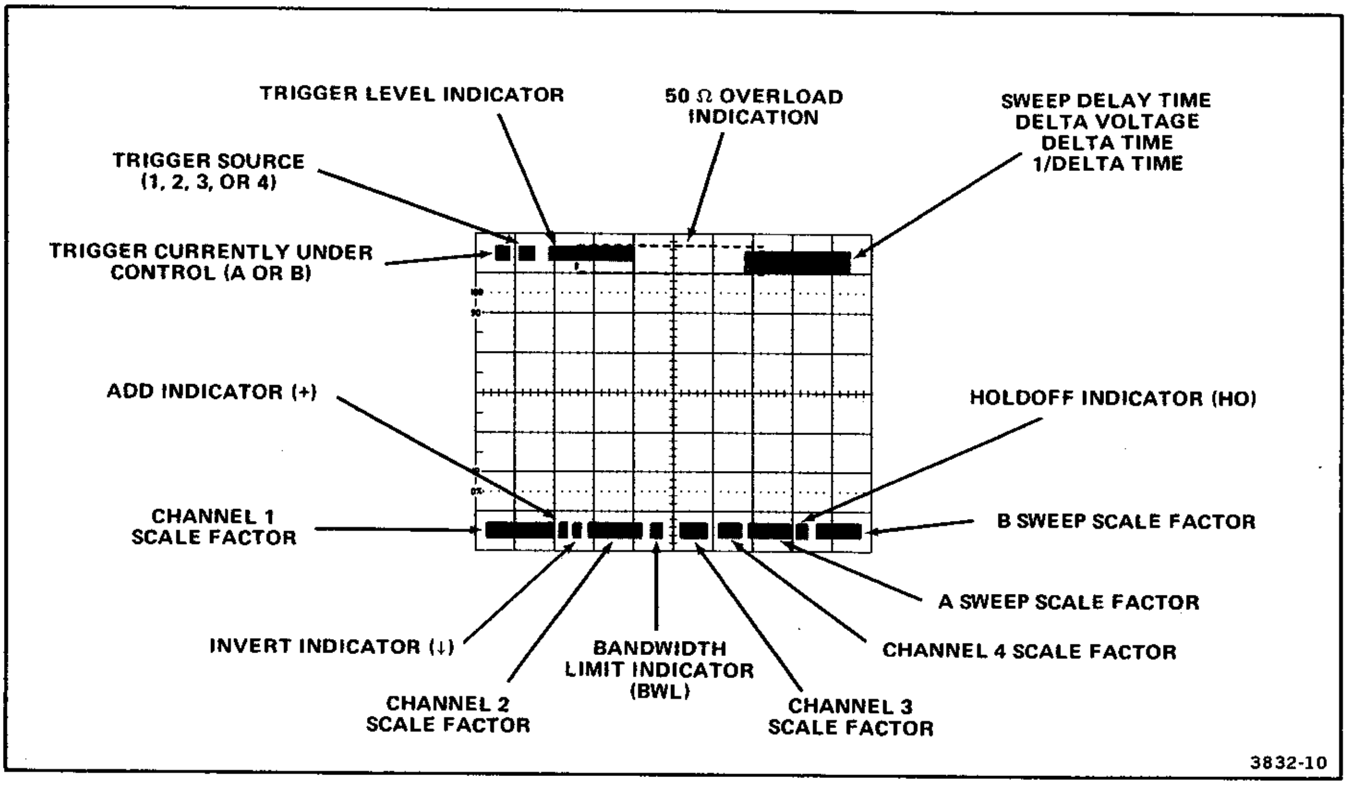

Figure 2-8. Readout display locations.

OPERATING CONSIDERATIONS

This part contains basic operating information and techniques that should be considered before attempting to make any measurements with your instrument.

GRATICULE

The graticule is internally marked on the faceplate of the crt to eliminate parallax-viewing error and to enable accurate measurements (see Figure 2-9). It is marked with eight vertical and ten horizontal major divisions. In addition, each major division is divided into five subdivisions. The vertical deflection factors and horizontal timing are calibrated to the graticule so that accurate measurements can be made directly from the crt. Also, percentage marks for the measurement of rise and fall times are located on the left side of the graticule.

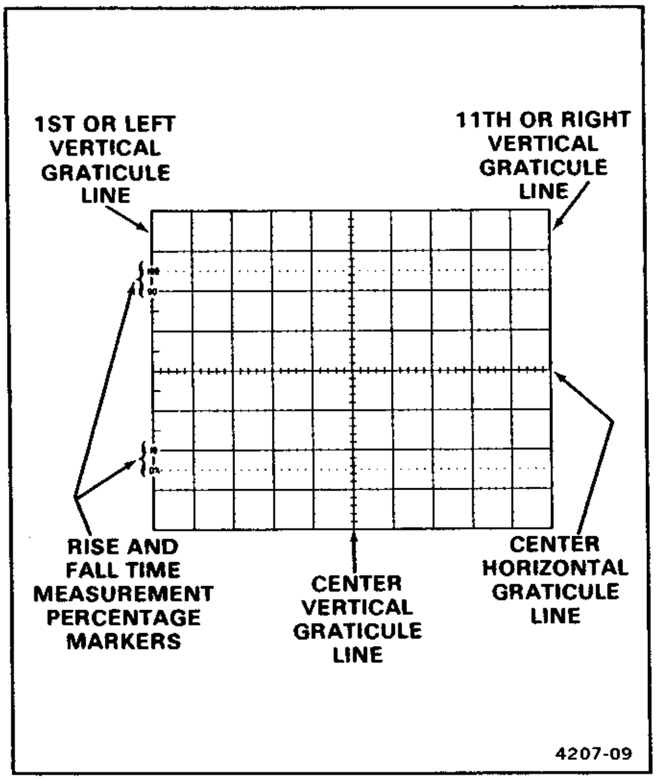

Figure 2-9. Graticule measurement markings.

TIME AND VOLTAGE MEASUREMENTS

The 2465 provides three basic ways to make time measurements and two basic ways to make voltage measurements. These methods require varying degrees of time and care and can result in varying degrees of accuracy.

Using graticule markings for determining voltage or time values produces the least accurate measurement values. This method should be used only for measuring very-low-repetition-rate signals or for single-shot measurements which require a photograph for viewing.

The Δt and ΔV cursors provide for better accuracy and easier operation than using the graticule, and they should be used in most measurement situations. Use of the cursors avoids vertical- and horizontal-gain errors and crt-linearity errors. Cursors also eliminate the inconvenience of counting and interpolating graticule markings.

The Delayed Sweep mode provides the highest accuracy for making time measurements. This method avoids errors introduced either by visual-resolution limits or by slight mismatches between the sweep and the cursors.

More details relating to various measurement techniques are contained in "Basic Applications," Section 6 of the Operators Manual.

GROUNDING

The most reliable signal measurements are made when the 2465 and the unit under test are connected by a common reference (ground lead) in addition to the signal lead or probe. The probe's ground lead provides the best grounding method for signal interconnection and ensures the maximum amount of signal-lead shielding in the probe cable. A separate ground lead can also be connected from the unit under test to the oscilloscope ground receptacle on the front panel.

SIGNAL CONNECTIONS

Probes

Generally, probes offer the most convenient means of connecting an input signal to the instrument. Shielded to prevent pickup of electromagnetic interference, the standard 10X probes supplied with this instrument offer a high input impedance that minimizes circuit loading. This allows the circuit under test to operate with a minimum of change from the normal, unloaded condition. Also, the subminiature body of these probes has been designed for ease of use either when probing circuitry containing close lead spacing or when probing in a confined space.

Both the probe itself and the probe accessories should be handled carefully at all times to prevent damage. Avoid dropping the probe body. Striking a hard surface can cause damage to both the probe body and the probe tip. Exercise care to prevent the cable from being crushed or kinked. Do not place excessive strain on the cable by pulling.

The standard-accessory probe is a compensated 10X voltage divider. It is a resistive voltage divider for low frequencies and a capacitive voltage divider for high-frequency signal components. Inductance introduced by either a long signal or ground lead forms a series-resonant circuit. This circuit will affect system bandwidth and will ring if driven by a signal containing significant frequency components at or near the circuit's resonant frequency. Oscillations (ringing) can then appear on the oscilloscope display and distort the true signal waveform. Always keep both the ground lead and the probe signal-input connections as short as possible to maintain the best waveform fidelity.

Misadjustment of probe compensation is a common source of measurement error. Due to variations in oscilloscope input characteristics, probe compensation should be checked and adjusted, if necessary, whenever the probe is moved from one oscilloscope to another or between channels of a multichannel oscilloscope. See the procedure in the "Operator's Checks and Adjustments" part of this section or consult the probe instruction manual.

Coaxial Cables

Cables may also be used to connect signals to the input connectors, but they may have considerable effect on the accuracy of a displayed waveform. To maintain the original frequency characteristics of an applied signal, only high-quality, low-loss coaxial cables should be used. Coaxial cables should be terminated at both ends in their characteristic impedance. If this is not possible, use suitable impedance-matching devices.

INPUT-COUPLING CAPACITOR PRECHARGING

When the input coupling switch is set to GND, the input signal is connected to ground through the input-coupling capacitor in series with a 1-MΩ resistor to form a precharging network. This network allows the input-coupling capacitor to charge to the average dc voltage level of the signal applied to the probe. Thus, any large voltage transients that may accidentally be generated will not be applied to the amplifier input when input coupling is switched from GND to AC. The precharging network also provides a measure of protection to the external circuitry by reducing the current levels that can be drawn from the external circuitry during capacitor charging.

EXTERNAL TRIGGERING

Both the A and the B trigger signals may be independently obtained from any of the four vertical input channels. When viewing signals that require a trigger source different from one of the displayed vertical signals (traditionally referred to as "external triggering"), any free vertical channel may be used to input a trigger signal. The signal can be viewed on the crt to aid in setting the trigger circuit controls by selecting that respective channel for the vertical display (replaces the usual "trigger view" feature). After establishing the correct triggering, the trigger signal display can then be removed from the vertical signal display or allowed to remain, at the operator's descretion.

Channel 1 and Channel 2 can condition a wide range of signals to produce triggers—over the full vertical deflection range of the channel from millivolts to hundreds of volts in amplitude. Channel 3 and Channel 4 inputs have a much more limited choice of vertical deflection ranges available (0.1 volt and 0.5 volt per division without external attenuation) and are more useful for digital signal amplitudes. However, signals much larger can be processed, provided they do not exceed the maximum-rated signal amplitude for the input.

OPERATOR'S CHECKS AND ADJUSTMENTS

INTRODUCTION

This part contains procedures that may be used to verify the operation and basic accuracy of your instrument before making measurements. Adjustment procedures provided enable the user to optimize the display for viewing as well as compensate several of the oscilloscope control functions for variations in ambient operating temperature. Adjustments beyond the scope of "Operator's Checks and Adjustments" are in the "Adjustment Procedures," Section 5 of this manual.

Before proceeding with these instructions, refer to "Preparation for Use" in this section for first-time start-up considerations.

Verify that the POWER switch is OFF (push button is out), then plug the power cord into the power outlet.

INITIAL SETUP

1. Press in the POWER switch button (ON) and allow the instrument to warm up (20 minutes is recommended for maximum accuracy).

2. Set instrument controls to obtain a baseline trace:

Display

READOUT INTENSITY	Midrange between MIN and fully clockwise
FOCUS	Midrange

Vertical

POSITION	Midrange
MODE	CH 1
BW LIMIT	Off (button out)
CH 1 VOLTS/DIV	10 mV
CH 1 Input Coupling	1 MΩ GND

Horizontal

A AND B SEC/DIV	Locked together at 1 ms
SEC/DIV VAR	Calibrated detent
POSITION	Midrange
10X MAG	Off (button out)

Trigger

HOLDOFF	Fully counterclockwise
LEVEL	Midrange
MODE	AUTO LVL
SOURCE	VERT
COUPLING	DC
SLOPE	+

3. Adjust the INTENSITY and READOUT INTENSITY controls for desired display and readout brightness and best trace definition.

4. Adjust the Vertical and Horizontal POSITION controls to position the trace within the graticule area.

TRACE ROTATION ADJUSTMENT

1. Preset instrument controls and obtain a baseline trace as described in "Initial Setup."

2. Use the Channel 1 POSITION control to move the baseline trace to the center horizontal graticule line.

NOTE

Normally, the resulting trace will be parallel to the center horizontal graticule line, and the Trace Rotation adjustment should not be required.

3. If the trace is not parallel to the center horizontal graticule line, use a small-bladed screwdriver to adjust the TRACE ROTATION control (see Figure 2-2) and align the trace with the center horizontal graticule line.

ASTIGMATISM ADJUSTMENT

1. Preset instrument controls and obtain a baseline trace as described in "Initial Setup." Set 20 MHz BW LIMIT On (in)

2. Connect a 10X probe to the CH 1 OR X input connector and connect the probe tip to the CALIBRATOR output.

3. Adjust the Channel 1 POSITION control to center the display on the screen.

4. Set A and B SEC/DIV controls at 1 μs.

5. Slowly adjust the FOCUS control to its optimum setting (best-defined display).

NOTE

If the ASTIG adjustment is correctly set already, all portions of the trace will come into sharpest focus at the same position of the FOCUS control.

6. If focusing is not uniform over the entire graticule area, use a small-bladed screwdriver to adjust the ASTIG control (see Figure 2-2).

7. Since the ASTIG and FOCUS adjustments interact, repeat steps 5 and 6 until the best-defined display over the entire graticule area is obtained.

NOTE

Once it is set, the ASTIG adjustment should be correct for any display. However, it may be necessary to reset the FOCUS control slightly when the INTENSITY control setting is changed.

AUTO DC BALANCE ADJUSTMENT

The 2465 can automatically perform a dc-balance adjustment of Channel 1 and Channel 2. This adjustment assures that the trace shifts associated with attenuator stepping, changing the variable volts per division setting, and switching Channel 2 between noninverted and inverted operation are within nominal limits. The dc balance attained by the Auto DC Balance adjustment remains valid as long as the instrument is operating within 5°C of the ambient temperature at which the adjustment was performed provided a 20-minute warm-up period is allowed before performing the adjustment. To initiate the adjustment, set both the Channel 1 and Channel 2 input coupling switches to AC. Then simultaneously push up on both switches. An alternate method of entering the auto-adjustment mode is possible with only one of the input coupling switches set to AC. Press up and hold the input coupling switch that is not set to AC, then press up the other input coupling switch. With either method, the instrument will enter an auto-adjustment mode for about ten seconds. When the Auto DC Balance adjustment cycle is complete, the instrument will return to the normal operating mode.

NOTE

If a circuit defect prevents accurate dc balance, the routine halts and **LIMIT** *is displayed. Push the Trigger COUPLING switch up to continue balancing the remainder of the circuitry.*

If power to the instrument is interrupted before the balancing cycle is completed, an error will be detected by the next power-on self test. Press A/B TRIG to exit the diagnostic monitor and restart the Auto DC Balance adjustment to allow the cycle to be completed.

PROBE LOW-FREQUENCY COMPENSATION

Misadjustment of probe compensation is one of the sources of measurement error. The attenuator probes are equipped with compensation adjustments. To ensure optimum measurement accuracy, always check probe compensation before making measurements. Probe low-frequency compensation is accomplished as follows:

1. Preset instrument controls and obtain a baseline trace as described in "Initial Setup." Set 20 MHz BW LIMIT On (in).

2. Connect the two 10X probes (supplied with the instrument) to the CH 1 OR X and the CH 2 input connectors. Observe that the CHANNEL 1 SCALE FACTOR on the readout display changes from **10 mV** to **100 mV** when the 10X probe is attached.

3. Connect the Channel 1 probe (using the probe hook tip) to the oscilloscope CALIBRATOR output.

4. Set triggering controls for a stable display. The display should be five cycles of the CALIBRATOR square-wave signal, with an amplitude of four divisions. Center the display on the screen.

5. Check the waveform for overshoot and rolloff (see Figure 2-10). If necessary, use a small-bladed screwdriver to adjust the probe low-frequency compensation for a square front corner on the waveform.

6. Release the CH 1 VERTICAL MODE switch, select CH 2 VERTICAL MODE, and connect the Channel 2 probe input to the CALIBRATOR output. Observe that the CH 2 SCALE FACTOR on the readout display indicates **100 mV** with the 10X probe attached.

7. Use the Channel 2 POSITION control to vertically center the display and repeat step 5 for the Channel 2 probe.

NOTE

Refer to the instruction manual supplied with the probe for more complete information about low-frequency and high-frequency compensation of the probes.

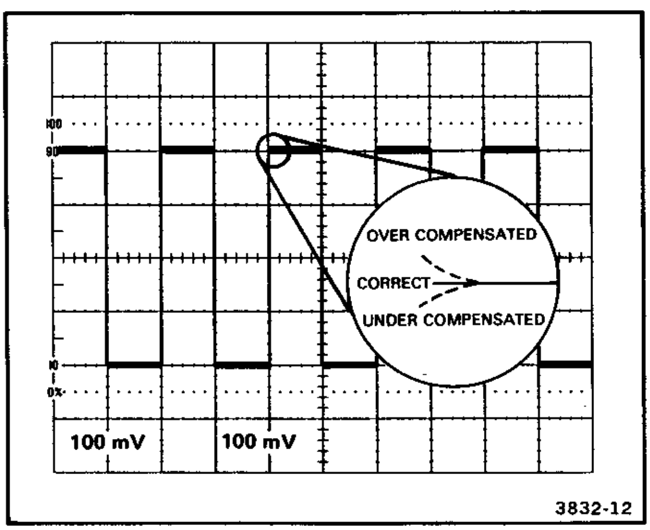

Figure 2-10. Probe low-frequency compensation.

MATCHING CHANNEL 2 DELAY

The apparent signal delay in Channel 2 may be adjusted up to ±500 ps to match the apparent delay present in any of the other three channels. This adjustment is most commonly used to eliminate delay differences between Channel 1 and Channel 2 that may be introduced by the probes and has no effect on common-mode rejection when ADD VERTICAL MODE is selected. Matching Channel 1 and Channel 2 delay is accomplished as follows:

1. Preset the instrument controls and obtain a baseline trace as described in "Initial Setup."

2. Connect the two 10X probes (supplied with the instrument) to the CH 1 OR X and CH 2 input connectors.

3. Check and adjust, if necessary, the probes' low-frequency compensation. Refer to "Probe Low-Frequency Compensation" in this section.

4. Connect both probes via hook tips to a pulse generator fast-rise output.

5. Press in both the CH 1 and CH 2 VERTICAL MODE switches.

6. Set oscilloscope triggering controls for a stable display.

7. Set the A AND B SEC/DIV switches to 5 ns.

8. Adjust the Channel 1 and Channel 2 POSITION controls to vertically overlay the two displayed signals.

9. Pull out the B SEC/DIV switch and observe the message **CH 2 DELAY – TURN Δ** in the upper right-hand corner of the screen.

NOTE

The 2465 can be set to preclude operator adjustment of Channel 2 delay. If the delay-offset feature is disabled, the message **CH 2 DLY DISABLED** *appears in the top row of the readout when attempting to activate the feature. Refer the instrument to a qualified service technician if adjustment of the delay matching is required.*

10. Set X10 MAG ON (button in) and adjust the Δ control until the two signals are overlaid horizontally.

NOTE

The Δ REF OR DLY POS control may also be used to make the Channel 2 delay-offset adjustment when the feature is enabled.

11. Push in the B SEC/DIV switch.

AMPLITUDE CHECK

1. Preset instrument controls and obtain a baseline trace as described in "Initial Setup."

2. Connect a 10X probe to the CH 1 OR X input connector and connect the probe tip to the CALIBRATOR output.

3. Adjust the Channel 1 POSITION control to center the display on the screen.

4. Adjust triggering controls to obtain a stable display.

5. CHECK—Amplitude of the CALIBRATOR signal is between 3.88 and 4.12 divisions as measured on the center vertical graticule line.

6. Repeat this procedure using the Channel 2 connector and controls.

TIMING CHECK

The CALIBRATOR signal on the 2465 automatically changes repetition rate with the setting of the A SEC/DIV switch within the range of 100 ms to 100 ns. This feature allows the operator to make a quick and easy check of the basic operation and adjustment of the oscilloscope timing. Use the following procedure:

1. Preset instrument controls and obtain a baseline trace as described in "Initial Setup."

2. Connect a 10X probe to the CH 1 OR X input connector and connect the probe tip to the CALIBRATOR output.

3. Adjust the Channel 1 POSITION control to center the display on the screen.

4. Adjust triggering controls to obtain a stable display.

5. CHECK—Timing accuracy by confirming that five complete cycles of the square-wave signal are displayed over 10 major divisions (±0.1 division) along the center horizontal graticule line for all A SEC/DIV settings from 100 ms to 100 ns. Confirm that the number of cycles displayed in 10 divisions goes to 2 1/2 and 1 for respective A SEC/DIV settings of 50 ns and 20 ns and that the displayed transition time of the signal remains approximately the same when the A SEC/DIV switch is changed to 10 ns and 5 ns. (The horizontal divisions in which the transition time of the signal at 10 ns per division is displayed should be two times the horizontal divisions occupied by the transition at 20 ns per division. At 5 ns per division, the transition time should occupy four times the horizontal divisions seen at 20 ns per division.) Return the A SEC/DIV switch to 1 ms and confirm that the display changes to 1/2 cycle over 10 divisions when the X10 MAG switch is pressed in.