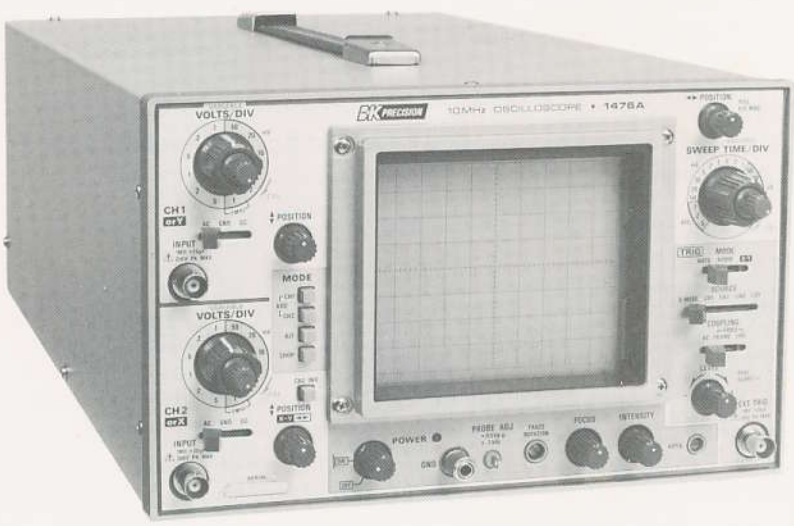
INSTRUCTION MANUAL

B+K PRECISION

1466A
1476A

Model 1466A-Single Trace
Model 1476A-Dual Trace

10 MHz Oscilloscope



B+K PRECISION DYNASCAN CORPORATION

TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly in the equipment under test. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.
2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.
4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
5. When using a probe, touch only the insulated portion. Never touch the exposed tip portion.
6. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.
7. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments (including this oscilloscope) to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

Instruction Manual
for
B+K PRECISION

Model 1466A-Single Trace
Model 1476A-Dual Trace
10 MHz Oscilloscope

⚠ This symbol on oscilloscope means "refer to instruction manual for further precautionary information". This symbol appears in the manual where the corresponding information is given.

B+K PRECISION DYNASCAN CORPORATION

6460 West Cortland Street
Chicago, Illinois 60635

TABLE OF CONTENTS

FEATURES

FEATURES OF SINGLE-TRACE AND DUAL-TRACE MODELS

CRT FEATURES

Rectangular CRT with large 8 x 10 centimeter viewing area. High brightness, 2 kV acceleration voltage. Internal 8 x 10 division graticule eliminates parallax error. Trace rotation electrically adjustable from front panel.

10 MHz BANDWIDTH/35 ns RISE TIME

Conservatively rated -3 dB bandwidth is dc to 10 MHz. Triggering beyond 10 MHz.

HIGH SENSITIVITY

2 mV/div sensitivity for full 10 MHz bandwidth. Selectable 1 mV/div sensitivity to 7 MHz. Permits the low capacitance, high impedance 10:1 probe to be used for nearly all measurements, thus assuring minimum circuit loading.

CALIBRATED TIME MEASUREMENTS

Accurate time (period) measurements (±3%) on 19 calibrated ranges from 0.5 s/div to 0.5 μs/div, provides every sweep rate needed for viewing waveforms from dc to 10 MHz. Sweep time fully adjustable between calibrated ranges.

X10 SWEEP MAGNIFICATION

Allows closer examination of waveforms, increases maximum sweep rate to 50 ns/div.

CALIBRATED VOLTAGE MEASUREMENTS

Accurate voltage measurements (±3%) on 12 calibrated ranges from 1 mV/div to 5 V/div. Vertical gain fully adjustable between calibrated ranges.

AUTO SWEEP

Selectable AUTO sweep provides sweep without trigger input, automatically reverts to triggered sweep operation when adequate trigger is applied.

VERSATILE TRIGGERING

Selectable INTernal, LINE (50/60 Hz), or EXTernal triggering. Fully variable trigger LEVEL control.

VIDEO SYNC

Selectable FRAME or LINE triggering for observing composite video waveforms.

X-Y OPERATION

External trigger input (channel 2 on dual-trace model) can be applied as horizontal (X-axis) deflection while the vertical input (channel 1 on dual-trace model) provides vertical deflection (Y-axis).

Z AXIS INPUT

Intensity modulation capability. Trace brightens with positive signal; TTL compatible.

BUILT-IN PROBE ADJUST SQUARE WAVE

A 0.5 V p-p, 1 kHz square wave generator permits probe compensation adjustment.

ADDITIONAL FEATURES OF DUAL-TRACE MODEL

DUAL TRACE

Two identical vertical input channels permit simultaneous viewing of two waveforms. Alternate or chop sweep selectable at all sweep rates.

SUM AND DIFFERENCE CAPABILITY

Permits algebraic addition or subtraction of channel 1 and channel 2 waveforms, displayed as a single trace. Useful for differential voltage and distortion measurements.

EXPANDED INTERNAL TRIGGERING

Selectable CH 1, CH 2, or V. MODE source. In V. MODE, each waveform displayed becomes its own trigger (alternate triggering in ALT dual-sweep mode).

SPECIFICATIONS

MODEL 1476A DUAL-TRACE

CRT

Type
150GTM31. Rectangular with internal graticule.

Acceleration Voltage
2 kV.

Display Area
8 x 10 divisions; 1 div = 10 mm.

VERTICAL AXIS (CH 1 and CH 2)

Sensitivity
1 mV/div to 5 V/div, ±3%.

Attenuator
12 steps, 1 mV/div to 5 V/div in 1-2-5 sequence. Vernier control for fully adjustable sensitivity between steps.

Input Impedance
1 MΩ ±2% shunted by approx. 35 pF.

Frequency Response

2 mV/div to 5 V/div
DC: DC to 10 MHz, -3 dB.
AC: 5 Hz to 10 MHz, -3 dB.

1 mV/div
DC: DC to 7 MHz, -3 dB.
AC: 5 Hz to 7 MHz, -3 dB.

Rise Time

2 mV/div to 5 V/div
35 ns or less.

1 mV/div
50 ns or less.

Overshoot
5% or less, 100 kHz square wave.

Maximum Input Voltage
500 V p-p or 250 V (dc + ac peak).

MODEL 1466A SINGLE-TRACE

CRT

Type
150GTM31. Rectangular with internal graticule.

Acceleration Voltage
2 kV.

Display Area
8 x 10 divisions; 1 div = 10 mm.

VERTICAL AXIS

Sensitivity
1 mV/div to 5 V/div, ±3%.

Attenuator
12 steps, 1 mV/div to 5 V/div in 1-2-5 sequence. Vernier control for fully adjustable sensitivity between steps.

Input Impedance
1 MΩ ±2% shunted by approx. 35 pF.

Frequency Response

2 mV/div to 5 V/div
DC: DC to 10 MHz, -3 dB.
AC: 5 Hz to 10 MHz, -3 dB.

1 mV/div
DC: DC to 7 MHz, -3 dB.
AC: 5 Hz to 7 MHz, -3 dB.

Rise Time

2 mV/div to 5 V/div
35 ns or less.

1 mV/div
50 ns or less.

Overshoot
5% or less, 100 kHz square wave.

Maximum Input Voltage
500 V p-p or 250 V (dc + ac peak).

MODEL 1476A DUAL-TRACE	MODEL 1466A SINGLE-TRACE
Maximum Non-Distorted Amplitude More than 6 divisions, dc to 10 MHz.	**Maximum Non-Distorted Amplitude** More than 6 divisions, dc to 10 MHz.
Operating Modes CH 1: Single trace. CH 2: Single trace. ADD: CH 1 + CH 2 single trace. ALT: Dual trace, alternate sweep. CHOP: Dual trace, chopped sweep.	- - -
Chop Frequency Approx. 250 kHz.	- - -
CH 2 Polarity Normal or inverted.	- - -
Crosstalk -40 dB minimum.	- - -
HORIZONTAL AXIS (Input thru CH 2, X10 MAG not included)	**HORIZONTAL AXIS (X10 MAG not included)**
Operating Mode X-Y mode selectable with TRIG MODE switch. CH 1 = Y axis, CH 2 = X axis.	**Operating Mode** X-Y mode selectable with TRIG MODE switch. VERT INPUT = Y axis, EXT TRIG INPUT = X axis.
Sensitivity Same as vertical axis.	**Sensitivity** 100 mV/div.
Input Impedance Same as vertical axis.	**Input Impedance** 1 MΩ ±2%, approx. 35 pF.
Frequency Response DC: DC to 500 kHz, -3 dB. AC: 5 Hz to 500 kHz, -3 dB.	**Frequency Response** DC: DC to 500 kHz, -3 dB.
X-Y Phase Difference 3° or less at 50 kHz.	**X-Y Phase Difference** 3° or less at 50 kHz.
Maximum Input Voltage Same as vertical axis.	**Maximum Input Voltage** 50 V dc + ac peak.
SWEEP	**SWEEP**
Type NORM: Triggered sweep. AUTO: Sweep free runs in absence of trigger.	**Type** NORM: Triggered sweep. AUTO: Sweep free runs in absence of trigger.

MODEL 1476A DUAL-TRACE

Sweep Time
0.5 µs/div to 0.5 s/div, ±3% in 19 ranges, in 1-2-5 sequence. Vernier control provides fully adjustable sweep time between steps.

Sweep Magnification
X10 (ten times), ±5%.

Linearity
±3% all ranges.

TRIGGERING

Internal Sync

V. MODE:	Trigger selected by vertical MODE switch.
CH 1:	Triggered by CH 1 signal.
CH 2:	Triggered by CH 2 signal.
LINE:	Triggered by line voltage.

External Sync

EXT:	Triggered by signal applied to EXT TRIG jack.

External Sync Input Impedance
1 MΩ ±2%, approx. 35 pF.

Maximum External Trigger Voltage
50 V (dc + ac peak).

Coupling
AC, VIDEO FRAME, VIDEO LINE.

Trigger Sensitivity

AUTO:	20 Hz to 10 MHz: 1 div internal or 0.1 V p-p external.
NORM:	5 Hz to 10 MHz: 1 div internal or 0.1 V p-p external.
VIDEO:	FRAME or LINE: 1 div internal or 0.1 V p-p external.

PROBE ADJUST VOLTAGE
0.5 V p-p ±6% square wave, positive polarity. Approx. 1 kHz.

TRACE ROTATION
Electrical, adjustable from front panel.

MODEL 1466A SINGLE-TRACE

Sweep Time
0.5 µs/div to 0.5 s/div, ±3% in 19 ranges, in 1-2-5 sequence. Vernier control provides fully adjustable sweep time between steps.

Sweep Magnification
X10 (ten times), ±5%.

Linearity
±3% all ranges.

TRIGGERING

Internal Sync

INT:	Triggered by vertical input signal.
LINE:	Triggered by line voltage.

External Sync

EXT:	Triggered by signal applied to EXT TRIG jack.

External Sync Input Impedance
1 MΩ ±2%, approx. 35 pF.

Maximum External Trigger Voltage
50 V (dc + ac peak).

Coupling
AC, VIDEO FRAME, VIDEO LINE.

Trigger Sensitivity

AUTO:	20 Hz to 10 MHz: 1 div internal or 0.1 V p-p external.
NORM:	5 Hz to 10 MHz: 1 div internal or 0.1 V p-p external.
VIDEO:	FRAME or LINE: 1 div internal or 0.1 V p-p external.

PROBE ADJUST VOLTAGE
0.5 V p-p ±6% square wave, positive polarity. Approx. 1 kHz.

TRACE ROTATION
Electrical, adjustable from front panel.

MODEL 1476A DUAL-TRACE

INTENSITY MODULATION

Sensitivity
TTL compatible. Positive voltage increases brightness, negative voltage decreases brightness.

Input Impedance
Approx. 10 kΩ.

Usable Frequency Range
DC to 1 MHz.

Maximum Input Voltage
50 V (dc + ac peak).

POWER REQUIREMENTS
100/120/220/240 VAC ±10%, 50/60 Hz, approx. 41 W.

DIMENSIONS (WxHxD)
10-1/4 x 6-3/8 x 15-3/4" (260 x 160 x 400 mm).
10-1/4 x 7-1/8 x 18-1/8" (260 x 180 x 460 mm) including all projections.

WEIGHT
Approx. 18-1/2 lb (8.4 kg).

ENVIRONMENTAL

Within Specifications
0^{o} to $+40^{o}$ C, 85% max. relative humidity.

Full Operation
0^{o} to $+50^{o}$ C, 90% max. relative humidity.

ACCESSORIES SUPPLIED
Two 10:1/direct probes.
Spare fuses: one 0.8 A, one 0.5 A.
Instruction manual.
Schematic diagram & parts list.

MODEL 1466A SINGLE-TRACE

INTENSITY MODULATION

Sensitivity
TTL compatible. Positive voltage increases brightness, negative voltage decreases brightness.

Input Impedance
Approx. 10 kΩ.

Usable Frequency Range
DC to 1 MHz.

Maximum Input Voltage
50 V (dc + ac peak).

POWER REQUIREMENTS
100/120/220/240 VAC ±10%, 50/60 Hz, approx. 36 W.

DIMENSIONS (WxHxD)
10-1/4 x 6-3/8 x 15-3/4" (260 x 160 x 400 mm).
10-1/4 x 7-1/8 x 18-1/8" (260 x 180 x 460 mm) including all projections.

WEIGHT
Approx. 18 lb (8.1 kg).

ENVIRONMENTAL

Within Specifications
0^{o} to $+40^{o}$ C, 85% max. relative humidity.

Full Operation
0^{o} to $+50^{o}$ C, 90% max. relative humidity.

ACCESSORIES SUPPLIED
One 10:1/direct probe.
Spare fuses: one 0.8 A, one 0.5 A.
Instruction manual.
Schematic diagram & parts list.

CONTROLS AND INDICATORS

MODEL 1476A
DUAL-TRACE

MODEL 1466A
SINGLE-TRACE

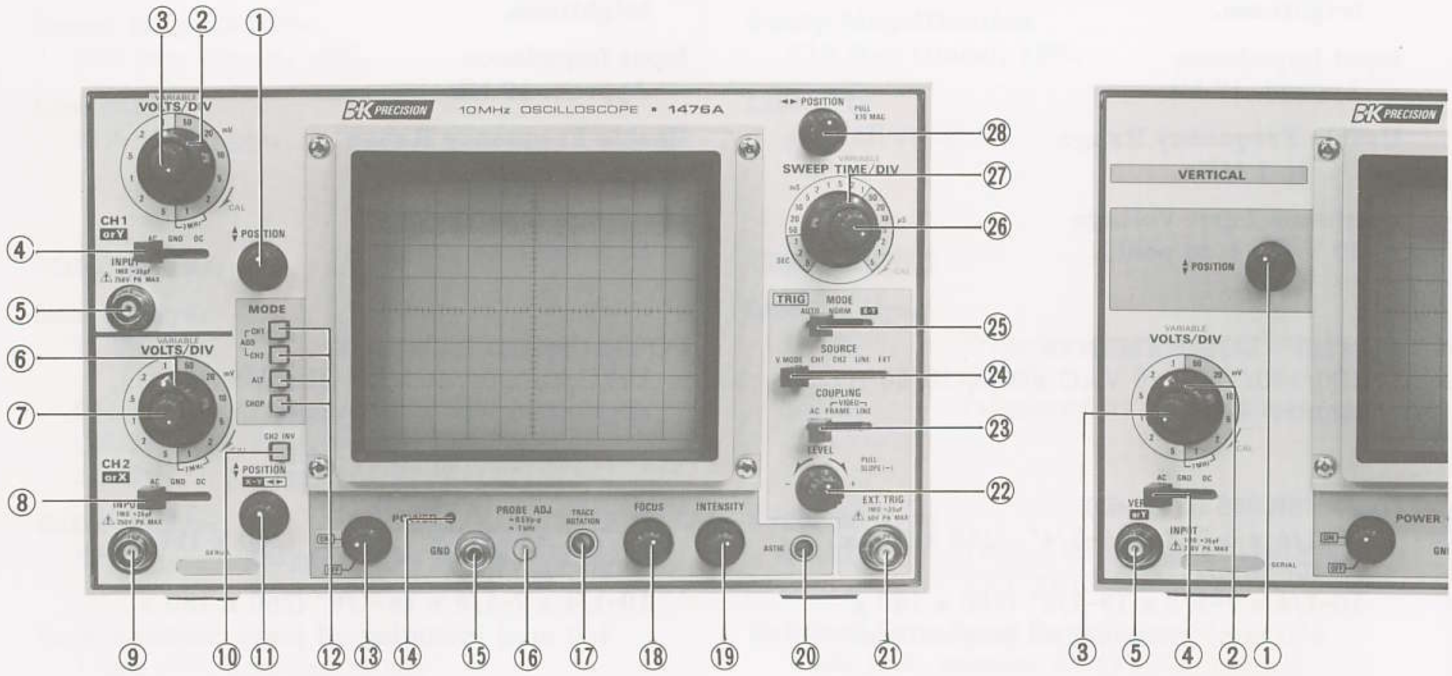


Fig. 1. Front Panel Controls and Indicators.

MODEL 1476A
DUAL-TRACE

1. **Channel 1 ♦ POSITION Control.** Rotation adjusts vertical position of channel 1 trace. In X-Y operation, rotation adjusts vertical position of display.

2. **Channel 1 VOLTS/DIV Control.** Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity. When channel 1 VARIABLE control is set to CAL, vertical sensitivity is calibrated in 12 steps from 1 mV/div to 5 V/div. For X-Y operation, provides step adjustment of vertical (Y axis) sensitivity.

MODEL 1466A
SINGLE-TRACE

1. **Vertical ♦ POSITION Control.** Rotation adjusts vertical position of trace. In X-Y operation, rotation adjusts vertical position of display.

2. **VOLTS/DIV Control.** Vertical attenuator. Provides step adjustment of vertical sensitivity. When VARIABLE control is set to CAL, vertical sensitivity is calibrated in 12 steps from 1 mV/div to 5 V/div. For X-Y operation, provides step adjustment of vertical (Y axis) sensitivity.

MODEL 1476A
DUAL-TRACE

3. **Channel 1 VARIABLE Control.** Rotation provides fine control of channel 1 vertical sensitivity. In fully clockwise (CAL) position, vertical attenuator is calibrated. For X-Y operation, this control serves as fine vertical (Y axis) gain adjustment.

4. **Channel 1 AC-GND-DC Switch.** Three-position lever switch selects channel 1 input coupling:

   AC: Channel 1 input capacitively coupled; dc component blocked.

   GND: Opens channel 1 signal path and grounds input to vertical amplifier. This provides a zero-signal, zero-volt dc base line for reference.

   DC: Channel 1 input direct coupled; both ac and dc component of waveform displayed.

5. **Channel 1 INPUT Jack.** Channel 1 vertical input connector; Y axis input connector for X-Y operation. Maximum input voltage is 500 volts peak-to-peak; 250 volts dc + ac peak.

6. **Channel 2 VOLTS/DIV Control.** Vertical attenuator for channel 2. Provides step adjustment of vertical sensitivity. When channel 2 VARIABLE control is set to CAL, vertical sensitivity is calibrated in 12 steps from 1 mV/div to 5 V/div. For X-Y operation, this control provides step adjustment of horizontal (X axis) sensitivity.

7. **Channel 2 VARIABLE Control.** Rotation provides fine control of channel 2 vertical sensitivity. In fully clockwise (CAL) position, channel 2 attenuator is calibrated. For X-Y operation, this control serves as fine horizontal (X axis) gain adjustment.

MODEL 1466A
SINGLE-TRACE

3. **VARIABLE Control.** Rotation provides fine control of vertical sensitivity. In fully clockwise (CAL) position, vertical attenuator is calibrated. For X-Y operation, this control serves as fine vertical (Y axis) gain adjustment.

4. **AC-GND-DC Switch.** Three-position lever switch selects vertical input coupling:

   AC: Input capacitively coupled; dc component blocked.

   GND: Opens signal path and grounds input to vertical amplifier. This provides a zero-signal, zero-volt dc base line for reference.

   DC: Input direct coupled; both ac and dc component of waveform displayed.

5. **VERT INPUT Jack.** Vertical input connector; Y axis input connector for X-Y operation. Maximum input voltage is 500 volts peak-to-peak; 250 volts dc + ac peak.

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MODEL 1476A DUAL-TRACE	MODEL 1466A SINGLE-TRACE
8. Channel 2 AC-GND-DC Switch. Three-position lever switch selects channel 2 input coupling: AC: Channel 2 input capacitively coupled; dc component blocked. GND: Opens channel 2 signal path and grounds input to vertical amplifier. This provides a zero-signal, zero-volt dc base line for reference. DC: Channel 2 input direct coupled; both ac and dc component of waveform displayed.	- - -
9. Channel 2 INPUT Jack. Channel 2 vertical input connector; X axis input connector for X-Y operation. Maximum input voltage is 500 volts peak-to-peak; 250 volts dc + ac peak.	- - -
10. CH 2 INV Pushbutton Switch. Channel 2 signal inverted with button engaged; non-inverted with button released. Provides subtraction of CH 1 - CH 2 when used with ADD mode.	- - -
11. Channel 2 ⬍ POSITION/ ◂▸ X-Y Control. Rotation adjusts vertical position of channel 2 trace. In X-Y operation, rotation adjusts horizontal position of display.	- - -
12. MODE Switch Assembly. Interlocking pushbutton switch assembly selects basic operating mode of oscilloscope; pressing a button releases the previous selection: CH 1: Only the input to channel 1 is displayed as a single trace. CH 2: Only the input to channel 2 is displayed as a single trace. ADD: Enabled by simultaneously pressing CH 1 and CH 2 buttons; the inputs from channel 1 and channel 2 are algebraically added and the sum is displayed as a single trace.	- - -

MODEL 1476A DUAL-TRACE

ALT: Dual trace display of channel 1 and channel 2 inputs. Alternate sweep is selected regardless of sweep time (channel 1 is displayed during one sweep, channel 2 during the next sweep).

CHOP: Dual trace display of channel 1 and channel 2 inputs. Chop sweep is selected regardless of sweep time (sweep is chopped into segments and switched between channel 1 and channel 2 to display both traces).

13. **POWER Switch.** Counterclockwise rotation (OFF position) turns off oscilloscope. Clockwise rotation turns on oscilloscope.

14. **Pilot Light.** Lights when oscilloscope is turned on.

15. **GND Terminal/Binding Post.** Earth and chassis ground.

16. **PROBE ADJ Terminal.** Provides 0.5 volt p-p square wave signal, approximately 1 kHz; useful for probe compensation adjustment.

17. **TRACE ROTATION Control.**

18. **FOCUS Control.**

19. **INTENSITY Control.** Clockwise rotation increases brightness of trace.

20. **ASTIG (Astigmatism) Control.**

21. **EXT TRIG Jack.** Input terminal for external trigger signal. ⚠ Maximum input voltage is 50 volts dc + ac peak.

MODEL 1466A SINGLE-TRACE

- - -

13. **POWER Switch.** Counterclockwise rotation (OFF position) turns off oscilloscope. Clockwise rotation turns on oscilloscope.

14. **Pilot Light.** Lights when oscilloscope is turned on.

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17. **TRACE ROTATION Control.**

18. **FOCUS Control.**

19. **INTENSITY Control.** Clockwise rotation increases brightness of trace.

20. **ASTIG (Astigmatism) Control.**

21. **EXT TRIG Jack.** Input terminal for external trigger signal. ⚠ Input terminal for external horizontal input in X-Y operation. Maximum input voltage is 50 volts dc + ac peak.

MODEL 1476A DUAL-TRACE

22. **LEVEL/PULL SLOPE (-) Control.** Rotation performs trigger LEVEL adjustment function; push-pull action performs SLOPE switch function:

    LEVEL: Rotation adjusts point on waveform where triggering occurs. The (-) direction equals a more negative triggering point and the (+) direction equals a more positive triggering point. The LEVEL control has no effect when VIDEO FRAME or VIDEO LINE trigger coupling is used.

    SLOPE: Sweep is triggered on positive-going slope of sync waveform when pushed in; on negative-going slope when pulled out (PULL SLOPE -).

23. **COUPLING Switch.** Three-position lever switch selects coupling for sync trigger:

    AC: Trigger is capacitively coupled; this is the most commonly used position for all signals except composite video.

    FRAME: Vertical sync pulses of a composite video signal are selected for triggering. LEVEL control has no effect.

    LINE: Horizontal sync pulses of a composite video signal are selected for triggering. May also be used for non-video signals. LEVEL control has no effect.

24. **SOURCE Switch.** Five-position lever switch selects sweep triggering source:

    V. MODE: The trigger source is determined by vertical MODE selection. Synchronization is not possible in CHOP mode, since the chopping signal becomes the trigger.

MODEL 1466A SINGLE-TRACE

22. **LEVEL/PULL SLOPE (-) Control.** Rotation performs trigger LEVEL adjustment function; push-pull action performs SLOPE switch function:

    LEVEL: Rotation adjusts point on waveform where triggering occurs. The (-) direction equals a more negative triggering point and the (+) direction equals a more positive triggering point. The LEVEL control has no effect when VIDEO FRAME or VIDEO LINE trigger coupling is used.

    SLOPE: Sweep is triggered on positive-going slope of sync waveform when pushed in; on negative-going slope when pulled out (PULL SLOPE -).

23. **COUPLING Switch.** Three-position lever switch selects coupling for sync trigger:

    AC: Trigger is capacitively coupled; this is the most commonly used position for all signals except composite video.

    FRAME: Vertical sync pulses of a composite video signal are selected for triggering. LEVEL control has no effect.

    LINE: Horizontal sync pulses of a composite video signal are selected for triggering. May also be used for non-video signals. LEVEL control has no effect.

24. **SOURCE Switch.** Three-position lever switch selects sweep triggering source:

    INT: The waveform being observed is used as sync trigger.

    LINE: Sweep is triggered by line voltage (50/60 Hz).

MODEL 1476A DUAL-TRACE

CH 1: Sweep is triggered by channel 1 signal regardless of vertical MODE.

CH 2: Sweep is triggered by channel 2 signal regardless of vertical MODE.

LINE: Sweep is triggered by line voltage (50/60 Hz).

EXT: Sweep is triggered by signal applied to EXT TRIG jack.

25. **TRIG MODE Switch.** Three-position lever switch selects triggering mode:

AUTO: Triggered sweep operation when trigger signal is present, automatically generates sweep (free runs) in absence of trigger signal.

NORM: Normal triggered sweep operation. No trace unless proper trigger signal is applied.

X-Y: X-Y operation. Channel 1 input signal produces vertical (Y axis) deflection, channel 2 input signal produces horizontal (X axis) deflection. During X-Y operation, the vertical MODE selection switch has no effect.

26. **Sweep Time VARIABLE Control.** Fine sweep time adjustment. In extreme clockwise (CAL) position, sweep time is calibrated.

27. **SWEEP TIME/DIV Control.** Coarse horizontal sweep time selector. Selects calibrated sweep times of 0.5 μs/div to 0.5 s/div in 19 steps when sweep time VARIABLE control is set to CAL.

28. **Horizontal ◂▸ POSITION/PULL X10 MAG Control.** Rotation adjusts horizontal position of trace. Rotation has no effect in X-Y operation. Push-pull switch selects X10 sweep magnification (PULL X10 MAG) when pulled out. Do not use X10 MAG during X-Y operation.

MODEL 1466A SINGLE-TRACE

EXT: Sweep is triggered by signal applied to EXT TRIG jack.

25. **TRIG MODE Switch.** Three-position lever switch selects triggering mode:

AUTO: Triggered sweep operation when trigger signal is present, automatically generates sweep (free runs) in absence of trigger signal.

NORM: Normal triggered sweep operation. No trace unless proper trigger signal is applied.

X-Y: X-Y operation. Vertical input signal produces vertical (Y axis) deflection, EXT TRIG input signal produces horizontal (X axis) deflection.

26. **Sweep Time VARIABLE Control.** Fine sweep time adjustment. In extreme clockwise (CAL) position, sweep time is calibrated.

27. **SWEEP TIME/DIV Control.** Coarse horizontal sweep time selector. Selects calibrated sweep times of 0.5 μs/div to 0.5 s/div in 19 steps when sweep time VARIABLE control is set to CAL.

28. **Horizontal ◂▸ POSITION/PULL X10 MAG Control.** Rotation adjusts horizontal position of trace in both sweep and X-Y operation. Push-pull switch selects X10 sweep magnification (PULL X10 MAG) when pulled out. Do not use X10 MAG during X-Y operation.

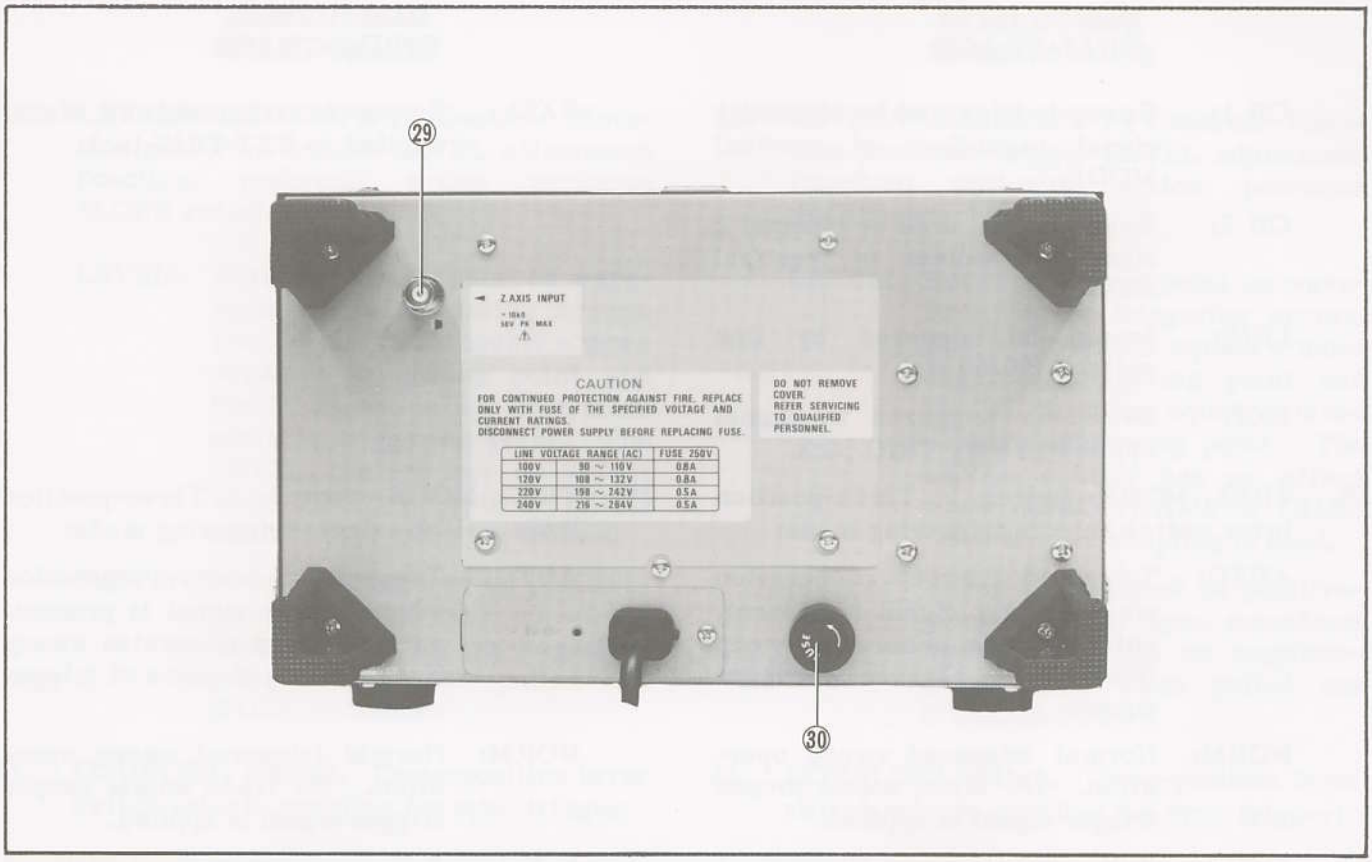

Fig. 2. Rear Panel Controls and Indicators.

MODEL 1476A
DUAL-TRACE

29. Z AXIS INPUT Jack. External intensity modulation input; TTL compatible. ⚠ Positive voltage increases brightness, negative voltage decreases brightness. Maximum input voltage is 50 volts dc + ac peak.

30. Fuse Holder. Use 0.8 A fuse for 100 or 120 VAC operation, 0.5 A fuse for 220 or 240 VAC operation.

MODEL 1466A
SINGLE-TRACE

29. Z AXIS INPUT Jack. External intensity modulation input; TTL compatible. ⚠ Positive voltage increases brightness, negative voltage decreases brightness. Maximum input voltage is 50 volts dc + ac peak.

30. Fuse Holder. Use 0.8 A fuse for 100 or 120 VAC operation, 0.5 A fuse for 220 or 240 VAC operation.

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to prevent electric shock.

1. When the oscilloscope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.

2. Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 2,000 volts is present when the unit is operating with the case removed.

3. The ground wire of the 3-wire ac power plug places the chassis and housing of the oscilloscope at earth ground. Use only a 3-wire outlet, and do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.

4. Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:

   a. Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.

   b. Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. The power transformer of this instrument may be wired to operate from nominal line voltage of 100, 120, 220, or 240 VAC, 50/60 Hz. Be sure the line voltage selection is correct before applying power. Also, make sure the correct fuse value is used, corresponding to line voltage as follows:

   100 VAC operation - 0.8 A.

   120 VAC operation - 0.8 A.

   220 VAC operation - 0.5 A.

   240 VAC operation - 0.5 A.

2. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur only when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, apply signal, or switch back to normal sweep operation.

3. Do not rest objects on top of the oscilloscope or otherwise obstruct the ventilating holes in the case, as this will increase the internal temperature.

4. Excessive voltage applied to the input jacks may damage the oscilloscope. The maximum ratings of the inputs are as follows:

⚠ VERT INPUT (single-trace model):

500 V p-p; 250 V dc + ac peak.

CH 1 and CH 2 (dual-trace model):

500 V p-p; 250 V dc + ac peak.

EXT TRIG INPUT (both models):

50 V dc + ac peak.

Z AXIS INPUT (both models):

50 V dc + ac peak.

Never apply external voltage to oscilloscope output jacks.

5. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment under test. Without this precaution, the entire current for the equipment under test may be drawn through the probe clip lead under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

6. The probe ground clips are at oscilloscope ground and should be connected only to the common of the equipment under test.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips as undesired signals may be induced.

2. Avoid the following operating conditions:

   a. Direct sunlight.

   b. High temperature and humidity.

   c. Mechanical vibration.

   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, astigmatism, and calibration accuracy of the oscilloscope using the procedures found in the MAINTENANCE section of this manual.

4. The circuit loading effect of the PR-40 Probe (which is typical of most 10:1/direct probes) is 10 MΩ and 18 pF in the X10 mode, compared to 1 MΩ and 100 pF in the DIRECT mode. Use X10 attenuation whenever possible for minimum circuit loading and improved high frequency response. The DIRECT position is required only when the waveforms to be observed are below 20 mV p-p.

5. Terminate the output of a signal generator in its characteristic impedance to minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating resistor and connected to the oscilloscope with 50 Ω coaxial cable.

6. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, then readjusted when a probe from a different oscilloscope is used. On dual-trace oscilloscopes, the same probe should always used with channel 1 and channel 2 respectively.

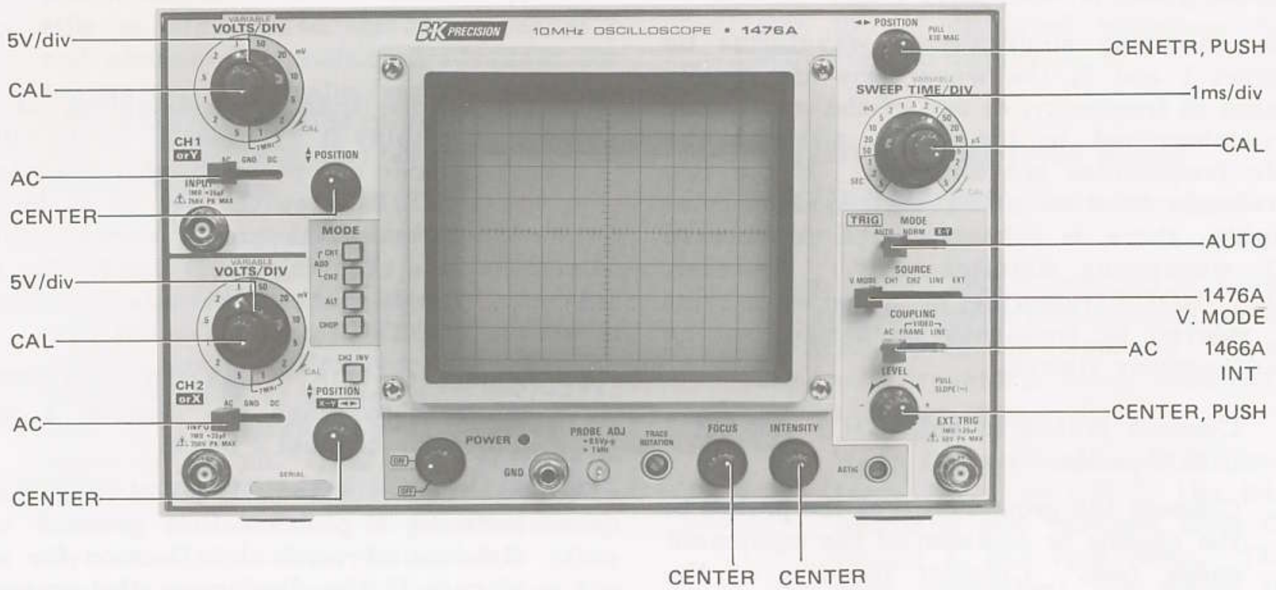

Fig. 3. Initial Control Settings.

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the settings shown in Fig. 3 may be used as a reference point to obtain a trace on the CRT in preparation for waveform observation.

1. Turn the POWER control clockwise; the unit will be turned on and the pilot light will be illuminated.
2. Set the TRIGGER MODE switch to AUTO, and on the dual-trace model, set the vertical MODE switch to CH 1.
3. A trace should appear on the CRT. Adjust the trace brightness with the INTENSITY control, and the trace sharpness with the FOCUS control.

SINGLE TRACE DISPLAY

The following procedure may be used for the single-trace model, or for single-trace operation of the dual-trace model. Either channel 1 or channel 2 may be used for single-trace operation on the dual-trace model; the advantage of using channel 2 is that the waveform on the display can be inverted if desired with the CH 2 INV switch. (Procedures within parentheses are for the dual-trace model.)

1. Perform the steps of the "Initial Starting Procedure". (Set the MODE switch to CH 2).
2. Connect the probe to the VERT INPUT jack (CH 2 INPUT jack).
3. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.
4. If no waveforms appear, increase the sensitivity by turning the VOLTS/ DIV control (CH 2 VOLTS/DIV control) clockwise to a position that gives 2 to 6 divisions vertical deflection.
5. The display on the CRT may be unsynchronized. Refer to the "Triggering" paragraphs in this section for procedures on setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

DUAL TRACE DISPLAY
(Dual-Trace Model Only)

In observing simultaneous waveforms on channel 1 and 2, the waveforms are usually related in frequency, or one of the waveforms is synchronized to the other, although the basic frequencies are different. If the two waveforms have no phase or frequency relationship, there is seldom reason to observe both waveforms simultaneously. However, with V. MODE triggering, even two waveforms not related in frequency or period can be simultaneously viewed.

1. Connect probes to both CH 1 and CH 2 INPUT jacks.
2. Connect the ground clips of the probes to the chassis or common of the equipment under test. Connect the tips of the probes to the two points in the circuit where waveforms are to be measured.
3. In the ADD mode (both CH 1 and CH 2 buttons engaged), the algebraic sum of CH 1 + CH 2 is displayed as a single trace. When the CH 2 INV button is engaged, the algebraic difference of CH 1 - CH 2 is displayed.
4. In the ALT mode, one sweep displays the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence. Alternate sweep is normally used for viewing high-frequency or high-speed waveforms at sweep times of 1 ms/div and faster, but may be selected at any sweep time.
5. In the CHOP mode, the sweep is chopped at an approximate 250 kHz rate and switched between channel 1 and channel 2. Chop sweep is normally used for low-frequency or low-speed waveforms at sweep times of 1 ms/div and slower.
   a. If chop sweep is used at sweep times of 0.2 ms/div and faster, the chop rate becomes a significant portion of the sweep and may become visible in the displayed waveform. However, you may select chop sweep at any sweep time for special applications. For example, the only way to observe simultaneous events on a dual-trace scope at any sweep rate is with chop sweep.
   b. Note that synchronization of the display is not possible in the CHOP mode of operation with the trigger SOURCE switch set to V. MODE, because the trigger source becomes the chopping signal itself. Use ALT mode instead, or select a trigger SOURCE of CH 1 or CH 2.
6. Adjust the CH 1 and CH 2 POSITION controls to place the channel 1 trace above the channel 2 trace.
7. Set the CH 1 and CH 2 VOLTS/DIV controls to a position that gives 2 to 3 divisions of vertical deflection for each trace. If the display on the screen is unsynchronized, refer to the "Triggering" paragraphs in this section of the manual for procedures for setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

TRIGGERING

Versatility in sync triggering provides the ability to obtain a stable, jitter-free display for most waveforms. The proper settings depend upon the type of waveforms being observed and the type of measurement desired. An explanation of the various controls which affect synchronization is given to help you select the proper setting over a wide range of conditions.

TRIG MODE Switch

1. The NORM position provides normal triggered sweep operation. The sweep remains at rest until the selected trigger source signal crosses the threshold level set by the LEVEL control. The trigger causes one sweep to be generated, after which the sweep again remains at rest until triggered. In the NORM position, there will be no trace unless an adequate trigger signal is present. (In the ALT

mode of dual-trace operation with the SOURCE switch set to V. MODE, there will be no trace unless both channel 1 and channel 2 signals are adequate for triggering.) Typically, signals that produce even 1/2 division of vertical deflection are adequate for normal triggered sweep operation.

2. In the AUTO position, automatic sweep operation is selected. In automatic sweep operation, the sweep generator free runs to generate a sweep without a trigger signal. However, it automatically switches to triggered sweep operation if an acceptable trigger source signal is present. The AUTO position is handy when first setting up the scope to observe a waveform; it provides sweep for waveform observation until other controls can be properly set. Once the controls are set, operation is often switched back to the NORM triggering mode, since it is more sensitive. Automatic sweep must be used for dc measurements and signals of such low amplitude that they will not trigger the sweep.

3. In the X-Y position, the sweep generator and triggering circuits are disconnected and have no effect. The VERT INPUT (CH 1 INPUT) provides Y axis deflection and the EXT TRIG input (CH 2 INPUT) provides X axis deflection.

SOURCE Switch (Single-Trace Model)

The SOURCE switch selects the signal to be used as the sync trigger.

1. When the INT position is selected (internal sync), the vertical input signal is also used to trigger the sweep. In this manner, the waveform being observed becomes its own trigger signal.

2. If the SOURCE switch is set to the LINE position, triggering is derived from the input line voltage (50/60 Hz). This is useful for measurements that are related to line frequency.

3. If the SOURCE switch is set to the EXT position, the signal applied to the EXT TRIG jack becomes the trigger source. This signal must have a timing relationship to the displayed waveform for a synchronized display.

SOURCE Switch (Dual-Trace Model)

The SOURCE switch selects the signal to be used as the sync trigger.

1. When the V. MODE position is selected, the trigger source is dependent upon the vertical MODE selection. In this manner, each waveform being observed becomes its own trigger signal.

    a. When the vertical mode is changed from CH 1 to CH 2, the trigger source is also changed from CH 1 to CH 2, and vice versa. This is very convenient for single trace operation.

    b. When the ALT dual-trace vertical mode is selected, the trigger source alternates between CH 1 and CH 2 with each sweep. This is convenient for checking amplitudes, waveshape, or waveform period measurements, and even permits simultaneous observation of two waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, both traces must be triggered by the same sync signal.

    c. When the CHOP dual-trace vertical mode is selected, synchronization of the display is not possible because the chopping signal becomes the trigger. Use the ALT mode instead, or change the SOURCE switch setting to CH 1 or CH 2.

2. If the SOURCE switch is set to CH 1 (or CH 2), the channel 1 (or channel 2) signal becomes the trigger source regardless of the vertical MODE selection. CH 1 or CH 2 is often used as the trigger source for phase or timing comparison measurements.

3. The LINE position is the same as for the single-trace model; triggering is derived from the input line voltage (50/60 Hz).
4. The EXT position is also the same as for the single-trace model; the signal applied to the EXT TRIG jack becomes the trigger source.

COUPLING Switch

1. Use the AC position for viewing all types of waveforms except composite video waveforms. The trigger signal is capacitively coupled and may be used for all signals from 5 Hz to over 10 MHz.
2. The VIDEO positions (FRAME and LINE) are primarily for viewing composite video waveforms. A sync separator circuit separates sync pulses from video, permits selection of horizontal (LINE) or vertical (FRAME) sync pulses for triggering, and automatically sets the triggering level so a sweep is generated from high or low amplitude signals. The LEVEL control has no effect. The LINE position may also be used with non-video waveforms to utilize the automatic triggering level feature. Additional procedures for observing video waveforms is given later in this section of the manual.

LEVEL Control
(Refer to Fig. 4)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the LEVEL control varies the threshold level. In the + direction, the triggering threshold shifts to a more positive value, and in the - direction, the triggering threshold shifts to a more negative value. When the control is centered, the threshold level is set at the approximate average of the signal used as the triggering source. Proper adjustment of this control usually synchronizes the display.

The LEVEL control adjusts the start of the sweep to almost any desired point on a waveform. On sine wave signals, the phase at which sweep begins is variable. Note that if the LEVEL control is rotated toward its extreme + or - setting, no sweep may be developed in the NORM trigger mode because the triggering threshold may exceed the peak amplitude of the sync signal.

Slope Selection
(Refer to Fig. 4)

Normally, a sweep trigger is developed from the trigger source waveform as it crosses a threshold level in a positive-going direction. When the LEVEL control is pulled out (PULL SLOPE -), a sweep trigger is developed from the trigger source waveform as it crosses the threshold level in a negative-going direction.

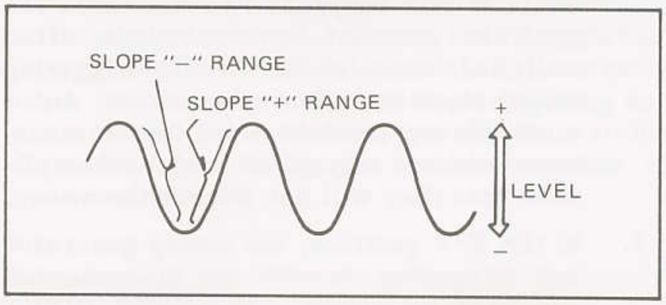

Fig. 4. Function of Slope and Level Controls.

SWEEP TIME Control

Set the SWEEP TIME/DIV control to display the desired number of cycles of the waveform. If there are too many cycles displayed for good resolution, switch to a faster sweep time. If only a line is displayed, try a slower sweep time. When the sweep time is faster than the waveform being observed, only part of it will be displayed, which may appear as a straight line for a square wave or pulse waveform.

MAGNIFIED SWEEP OPERATION

Since merely shortening the sweep time to magnify a portion of an observed waveform can result in the desired portion disappearing off the screen, such magnified display should be performed using MAGNIFIED SWEEP.

Using the horizontal ◂▸ POSITION control, adjust the desired portion of waveform to the center of the CRT. Pull out the PULL X10 MAG knob to magnify the display ten times. For this type of display the sweep time is the SWEEP TIME/DIV setting divided by 10.

X-Y OPERATION

X-Y opertion permits the oscilloscope to perform many measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of the two voltages such as vectorscope display of video color bar patterns. However, the X-Y mode can be used to graph almost any dynamic characteristic if a transducer is used to change the characteristic (frequency, temperature, velocity, etc.) into a voltage. One common application is frequency response measurements, where the Y axis corresponds to signal amplitude and the X axis corresponds to frequency.

For the dual-trace model, selection of the X-Y mode connects channel 1 to provide Y-axis (vertical) deflection and channel 2 to provide X-axis (horizontal) deflection. Sensitivity (gain) is adjusted by the channel 1 and 2 VOLTS/DIV and VARIABLE controls. The X and Y positions are adjusted with the CH 2 (◂▸ X-Y) POSITION and CH 1 ▴▾ POSITION controls respectively.

For the single-trace model, selection of the X-Y mode connects the VERT INPUT signal to provide Y-axis (vertical) deflection and the EXT TRIG input signal to provide X-axis (horizontal) deflection. Y-axis sensitivity (gain) is fully adjustable with the vertical VOLTS/DIV and VARIABLE controls, but X-axis sensitivity is fixed at approximately 100 mV/div. A horizontal input signal of about 1 volt p-p is usually satisfactory.

VIDEO SIGNAL OBSERVATION

The COUPLING switch (VIDEO FRAME and LINE positions) permits selection of vertical or horizontal sync pulses for sweep triggering when viewing composite video waveforms.

In the LINE position, horizontal sync pulses are selected as triggers to permit viewing of horizontal lines of video. A sweep time of about 10 µs/div is appropriate for displaying lines of video. The sweep time VARIABLE control can be set to display the exact number of waveforms desired.

In the FRAME position, vertical sync pulses are selected as triggers to permit viewing of vertical fields and frames of video. A sweep time of 2 ms/div is appropriate for viewing fields of video, and 5 ms /div for complete frames (two interlaced fields) of video.

At most points of measurement, a composite video signal is of the (-) polarity, that is, the sync pulses are negative and the video is positive. In this case, use (-) SLOPE. If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use (+) SLOPE.

In the VIDEO FRAME and LINE positions, the sync pulses are separated from the video and applied through an automatic trigger level circuit. The LEVEL control has no effect. Stable triggering is automatically provided for high or low amplitude composite video signals.

The Vertical Interval Test Signal (VITS) can be a valuable aid in servicing television receivers. When this signal is transmitted, it appears on the 17th, 18th, and 19th lines of each field. To view the VITS waveform, select FRAME coupling to trigger the sweep from vertical sync pulses. A sweep time of 0.2 ms/div will display about 32 lines of video. Expand the sweep by using X10 MAG; now about 3.2 lines of video are displayed. Since we are interested in the VITS signal (17th, 18th, and 19th lines), rotate the horizontal POSITION control to display the desired three lines of video. The sweep can be somewhat further expanded by switching to 0.1 ms/div and adjusting VARIABLE for about 20 lines of video (without X10 MAG).

For the dual-trace model, it is preferred to use the ALT dual-trace MODE, with both CH 1 and CH 2 probes to the point of measurement, because the VITS signal is sometimes different for field 1 than for field 2.

APPLICATIONS

SINGLE-TRACE APPLICATIONS

The following single-trace applications are applicable to Single-Trace Model 1466A, or to Dual-Trace Model 1476A when operated in a single-trace mode.

DC VOLTAGE MEASUREMENTS

(Refer to Fig. 5)

The following technique may be used to measure the instantaneous dc level at any portion of a waveform, or to measure a dc voltage where no waveform is present.

1. Connect the signal to be measured to the VERT INPUT jack and set the VOLTS/DIV and SWEEP TIME/DIV controls to obtain a normal display of the waveform to be measured. The vertical VARIABLE control must be set to CAL.

2. Set the TRIG MODE switch to AUTO and the AC-GND-DC switch to GND, which establishes a trace at the zero volt reference. Using the vertical POSITION control, adjust the trace to the desired reference level position, making sure not to disturb this setting once made.

3. Set the AC-GND-DC switch to DC to observe the waveform, including its dc component. If an inappropriate reference level position was selected in step 2 or an inappropriate VOLTS/DIV setting was made, the waveform may not be visible at this point (deflected completely off the screen). This is especially true when the dc component is large with respect to the waveform amplitude. If so, reset the VOLTS/DIV control and repeat steps 2 and 3 until the waveform and the zero reference are both on the screen.

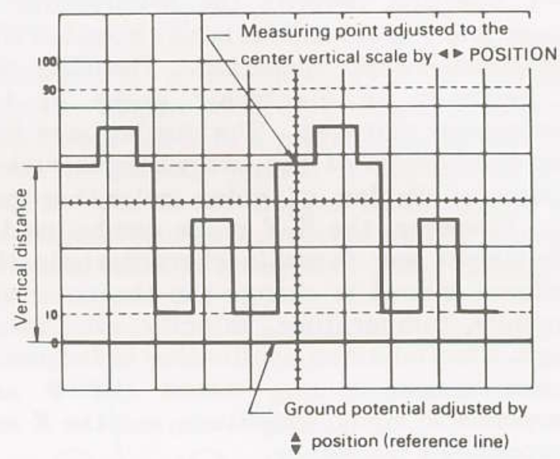

Fig. 5. DC Voltage Measurement.

4. Use the horizontal POSITION control to bring the portion of the waveform to be measured to the center vertical graduation line of the graticule scale.

5. Measure the vertical distance from the zero reference level to the point to be measured (at least 3 divisions desirable for best accuracy). The reference level can be rechecked by momentarily returning the AC-GND-DC switch to GND.

6. Multiply the distance measured above by the VOLTS/DIV setting and the probe attenuation ratio as well. Voltages above the reference level are positive and voltages below the reference level are negative.

The measurement is summarized by the following equation:

DC level = Vert div x VOLTS/DIV x Probe

For the example shown in Fig. 5, the point being measured is 3.8 divisions from the reference level (ground potential). If the VOLTS/DIV control is set to 0.2 V and a 10:1 probe is used, the dc voltage level is calculated as follows:

DC level = 3.8 (div) x 0.2 (V/div) x 10
= 7.6 V

PEAK-TO-PEAK VOLTAGE MEASUREMENTS
(Refer to Fig. 6)

This procedure may be used to measure peak-to-peak voltages, or for measuring the voltage difference between any two points on a waveform.

1. Connect the signal to be measured to the VERT INPUT jack. Set the AC-GND-DC switch to AC. Set the VOLTS/DIV and SWEEP TIME/DIV controls to obtain a normal display of the waveform to be measured. The vertical VARIABLE control must be set to CAL.

2. Using the vertical POSITION control, adjust the waveform position such that one of the two points falls on a major horizontal graduation line.

3. Using the horizontal POSITION control, adjust the second point to coincide with the center vertical graduation line.

4. Measure the vertical distance between the two points (at least 3 divisions desirable for best accuracy). Multiply the number of divisions by the setting of the VOLTS/DIV control. If a probe is used, further multiply this by the probe attenuation ratio.

The measurement is summarized by the following equation:

Voltage = Vert div x VOLTS/DIV x probe

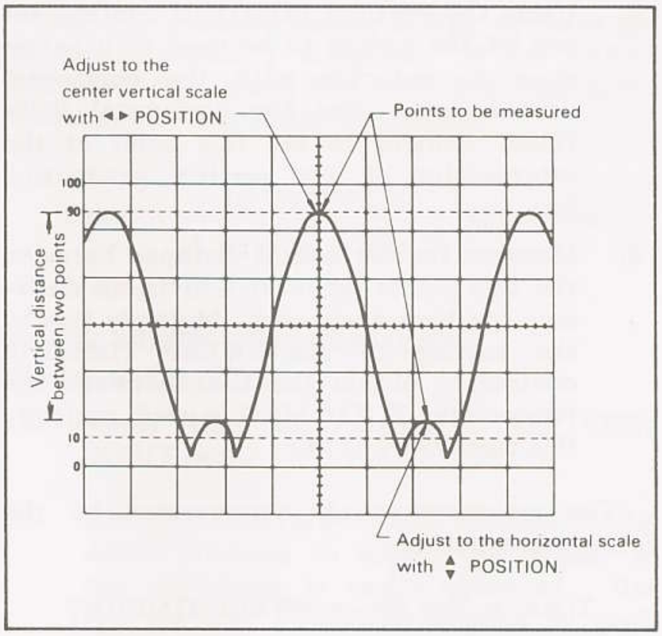

Fig. 6. Voltage Measurement.

For the example shown in Fig. 6, the two points are separated by 4.4 divisions vertically. If the VOLTS/DIV setting is 20 mV and a 10:1 probe is used, the voltage is calculated as follows:

Voltage = 4.4 (div) x 20 (mV/div) x 10
= 880 mV

TIME MEASUREMENTS
(Refer to Fig. 7)

This is the procedure for making time (period) measurements between two points on a waveform. The two points may be the beginning and ending of one complete cycle if desired.

1. Connect the signal to be measured to the VERT INPUT jack. Set the VOLTS/DIV and SWEEP TIME/DIV controls to obtain a normal display of the waveform to be measured. Be sure the sweep time VARIABLE control is set to CAL.

2. Using the vertical POSITION control, set one of the points to be used as a reference to coincide with the horizontal center line. Use the horizontal POSITION control to set this point at the intersection of any vertical graduation line.

3. Measure the horizontal distance between the two points (at least 4 divisions desirable for best accuracy). Multiply this by the setting of the SWEEP TIME/DIV control to obtain the time between the two points. If X10 MAG is used, multiply this further by 1/10.

The measurement is summarized by the following equation:

$$\text{Time} = \text{Hor div} \times \text{SWEEP TIME/DIV}$$
$$(\times\ 1/10 \text{ if X10 MAG is used})$$

For the example shown in Fig. 7, the horizontal distance between the two points is 5.4 divisions. If the SWEEP TIME/DIV is 0.2 ms and X10 MAG is not used, the time period is calculated as follows:

$$\text{Time} = 5.4\ (\text{div}) \times 0.2\ (\text{ms/div})$$
$$= 1.08\ \text{ms}$$

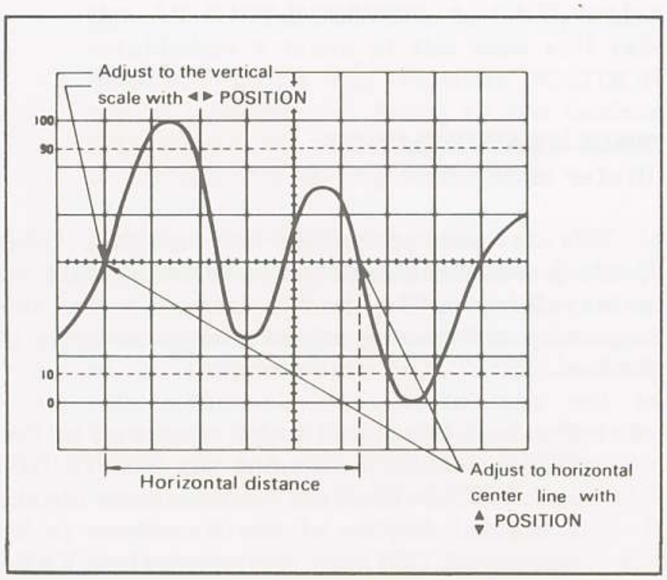

Fig. 7. Time Measurement.

FREQUENCY MEASUREMENTS

Method No. 1
(Refer to Fig. 8)

Frequency measurements are made by measuring the time period of one cycle of waveform and calculating the frequency, which equals the reciprocal of the time period.

1. Set up the oscilloscope to display one cycle of waveform (see Fig. 8).

2. Measure the time period of one cycle and calculate the frequency as follows:

$$\text{Freq} = \frac{1}{\text{Period}}$$

In the example shown in Fig. 8, a period of 40 µs is observed. Substituting this value into the above equation, the frequency is calculated as follows:

$$\text{Freq} = \frac{1}{40 \times 10^{-6}}$$
$$= 2.5 \times 10^{4}$$
$$= 25\ \text{kHz}$$

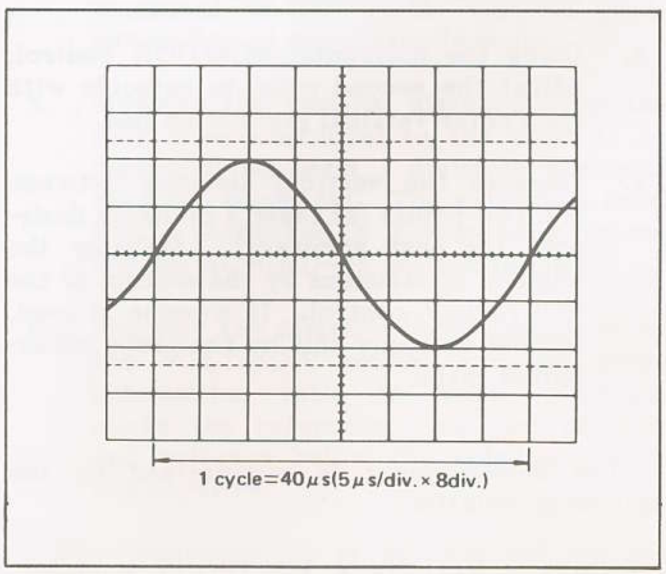

Fig. 8. Frequency Measurement.

Method No. 2
(Refer to Fig. 9)

While the previously described method relies upon direct period measurement of one cycle, the frequency may also be measured by counting the number of cycles present in a given time period.

1. Set up the oscilloscope to display several cycles of the waveform. The sweep time VARIABLE control must be set to CAL.
2. Count the number of cycles of waveform between a chosen set of vertical graduation lines (see Fig. 9).
3. Multiply the number of horizontal divisions times the SWEEP TIME/DIV setting to calculate the time span. Multiply the reciprocal of this value times the number of cycles present in the time span. If X10 MAG is used, multiply this further by 10. Note that errors will occur for displays having only a few cycles.

The measurement is summarized by the following equation:

$$\text{Freq} = \frac{\text{No of cycles (x 10 for X10 MAG)}}{\text{Hor div x SWEEP TIME/DIV}}$$

For the example shown in Fig. 9, there are 10 cycles within 7 divisions. If the SWEEP TIME/DIV is 5 µs and X10 MAG is not used, the frequency is calculated as follows:

$$\text{Freq} = \frac{10 \text{ (cycles)}}{7 \text{ (div)} \times 5 \text{ (µs)}} = 285.7 \text{ kHz}$$

PULSE WIDTH MEASUREMENTS
(Refer to Fig. 10)

1. Apply the pulse signal to the VERT INPUT jack.
2. Use the VOLTS/DIV and vertical VARIABLE controls to adjust the display so the waveform is easily observed. Use the vertical POSITION control to position the pulse over the center horizontal graduation line. Use the horizontal POSITION control to align the leading edge of the pulse with one of the vertical graduation lines.
3. Measure the distance between the leading edge and trailing edge of the pulse (along the center horizontal graduation line). Be sure that the sweep time VARIABLE control is set to CAL.

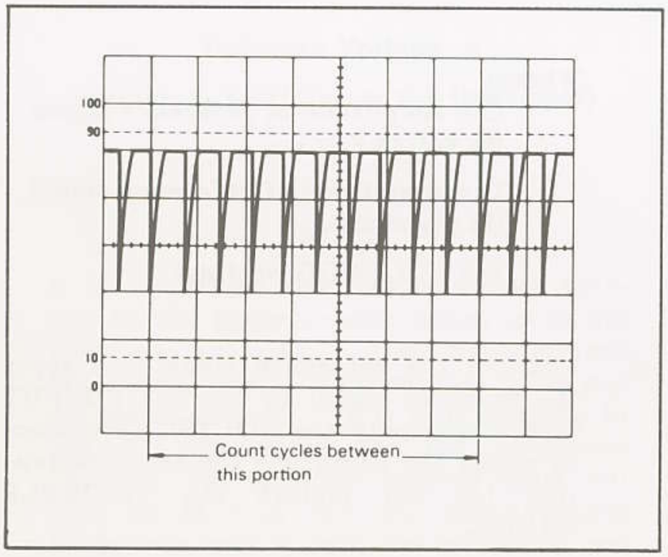

Fig. 9. Alternate Method of Frequency Measurement.

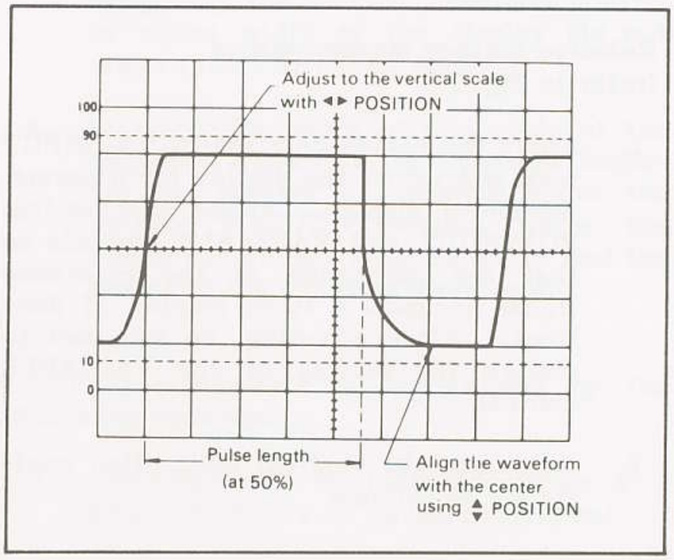

Fig. 10. Pulse Width Measurement.

4. Multiply the number of horizontal divisions by the SWEEP TIME/DIV, and if X10 MAG is used, further multiply this value by 1/10.

The measurement is summarized by the following equation:

Pulse Width = Hor div x SWEEP TIME/DIV

(x 1/10 if X10 MAG is used)

For the example shown in Fig. 10, the pulse width at the center of the pulse is 4.6 divisions. If the SWEEP TIME/DIV is 0.2 ms and X10 MAG is used, the pulse width is calculated as follows:

Pulse Width =

4.6 (div) x 0.2 (ms/div) x 1/10

= .092 ms or 92 µs

RELATIVE MEASUREMENTS

If the amplitude and period of some reference signal are known, an unknown signal may be measured for amplitude and period without the VARIABLE controls set to CAL. The measurement is made in units relative to the reference signal.

Relative Voltage Measurements
(refer to Fig. 11)

1. Apply the reference signal to the INPUT jack and adjust the display for a normal waveform display. Adjust the vertical VOLTS/DIV and VARIABLE controls so that the amplitude of the reference signal occupies a fixed number of divisions. After adjusting, be sure not to disturb the setting of the VARIABLE control.

2. Calculate the vertical calibration coefficient as follows:

$$\text{vertical coefficient} = \frac{C}{D \times E}$$

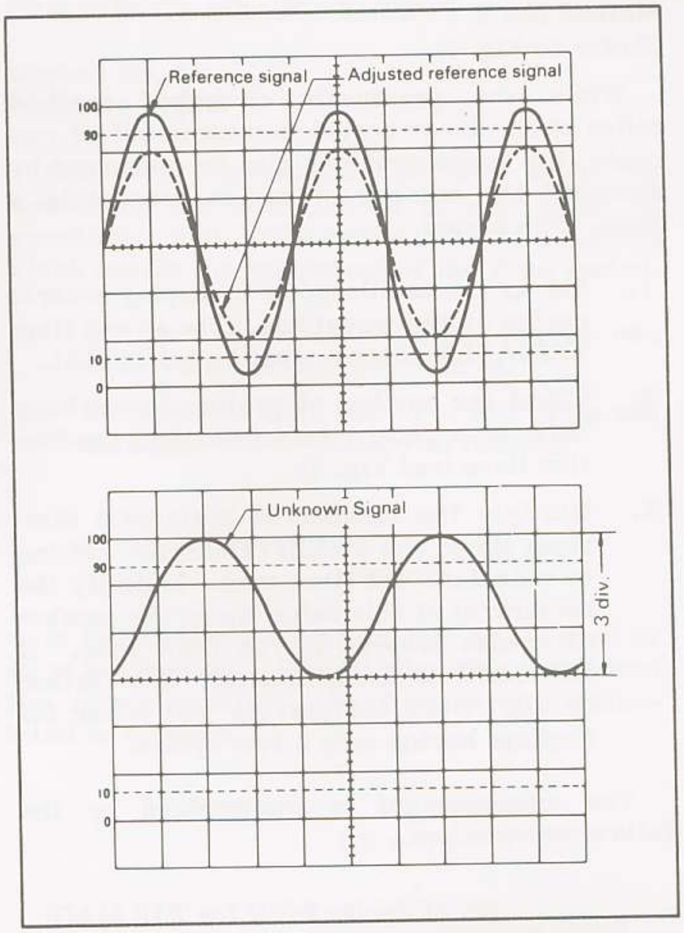

Fig. 11. Voltage Measurement, Relative Method.

Where:

C = Amplitude of reference signal (in volts).

D = Amplitude of reference signal (in divisions).

E = VOLTS/DIV setting.

3. Remove the reference signal and apply the unknown signal to the VERT INPUT jack, using only the VOLTS/DIV control to adjust the amplitude for easy observation (do not disturb the VARIABLE setting).

4. Measure the amplitude of the displayed waveform, in divisions. Multiply the

number of divisions times the VOLTS/DIV setting and the vertical coefficient from above to find the value of the unknown voltage.

The measurement is summarized by the following equation:

Unknown Voltage = Vert div x VOLTS/DIV x vert coefficient

For the example shown in Fig. 11, the VARIABLE control is adjusted so the amplitude of the reference signal is 4 divisions. If the reference signal is 2.0 volts p-p, and the VOLTS/DIV setting is 1 V, the vertical coefficient is 0.5; which was calculated as follows:

$$\text{vertical coefficient} = \frac{2\ (V)}{4\ (div) \times 1\ (V/div)} = 0.5$$

For the example shown in Fig. 11, the amplitude of the unknown signal is 3 divisions, and the previously calculated vertical coefficient is 0.5. If the VOLTS/ DIV setting is 5 V, the unknown signal is 7.5 V p-p; which was calculated as follows:

Unknown Voltage =

3 (div) x 5 (V/div) x 0.5 (vert coef)

= 7.5 V

NOTE

It is preferable that the reference voltage be the peak-to-peak value, as in the previous example. The measurement holds true for all waveforms if a p-p reference is used. It is also possible to use an rms value for the reference voltage. The unknown voltage value will also be in rms, but the measurement holds true only if both the reference and unknown are undistorted sine waves.

Relative Period Measurements
(refer to Fig. 12)

1. Apply the reference signal to the VERT INPUT jack and adjust for an easily observed waveform display. Using the SWEEP TIME/DIV and VARIABLE controls, adjust one cycle of the reference signal to occupy a fixed number of horizontal divisions. After this is done, be sure not to disturb the VARIABLE control setting.

2. Calculate the sweep (horizontal) calibration coefficient using the following equation:

$$\text{Sweep coefficient} = \frac{F}{G \times H}$$

Where:

F = Period of reference signal (seconds).

G = Horizontal width of reference signal (divisions).

H = SWEEP TIME/DIV setting.

3. Remove the reference signal and apply the unknown signal to the INPUT jack, using only the SWEEP TIME/DIV control to adjust width of the display (do not disturb the VARIABLE setting).

4. Measure the width of one cycle of the displayed waveform, in divisions. Multiply the number of divisions times the SWEEP TIME/DIV setting times the sweep coefficient from above to find the period of the unknown waveform.

The measurement is summarized by the following equation:

Unknown Period = Horizontal divisions x SWEEP TIME/DIV x sweep coefficient

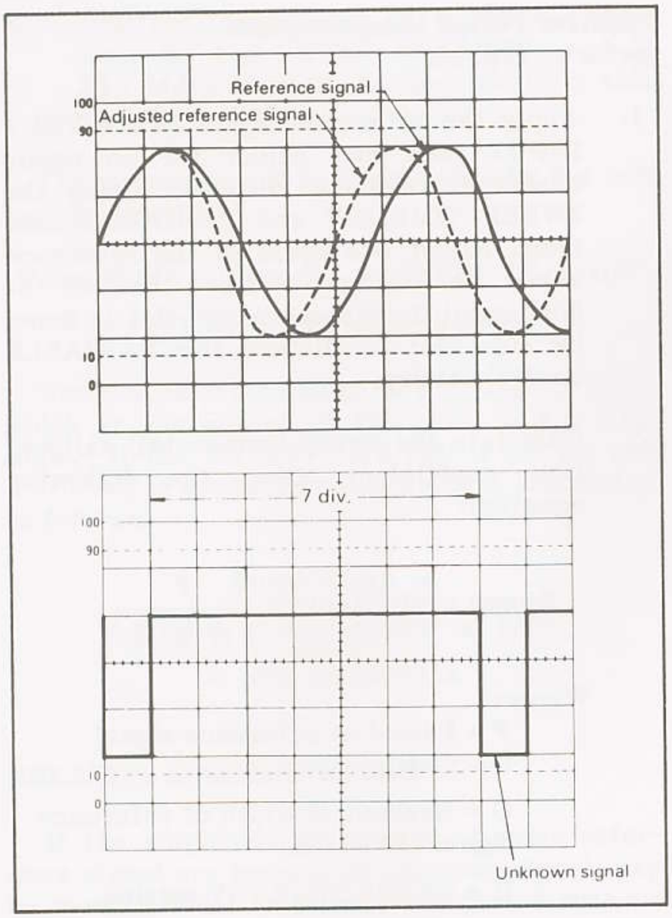

Fig. 12. Period Measurement, Relative Method.

For the example in Fig. 12, the VARIABLE control is adjusted so the reference signal occupies 5 horizontal divisions. If the reference signal is 1.75 kHz, and the SWEEP TIME/DIV control is 0.1 ms, the sweep coefficient is 1.143; which was caluculated as follows:

$$\text{sweep coefficient} = \frac{1.75\ \text{kHz}^{-1}}{5\ (\text{div}) \times 0.1\ (\text{ms/div})}$$

$$= 1.143$$

For the example in Fig. 12, the width of the unknown signal is 7 divisions, and the previously calculated sweep coefficient is 1.143. If the SWEEP TIME/DIV setting is 0.2 ms, the period of the unknown is 1.6 ms; which was calculated as follows:

$$\text{Unknown Period} =$$

$$7\ (\text{div}) \times 0.2\ (\text{ms/div}) \times 1.143\ (\text{sweep coef})$$

$$= 1.6\ \text{ms}$$

DUAL-TRACE APPLICATIONS

TIME DIFFERENCE MEASUREMENTS
(Refer to Fig. 13)

This procedure is useful in measurement of time difference between two signals that are synchronized to one another but skewed in time.

1. Apply the two signals to the CH 1 and CH 2 INPUT jacks and select either the CHOP or ALT mode for dual-trace display. CHOP is usually chosen for low frequency signals and ALT for high frequency signals.

2. Select the faster of the two signals as the SOURCE and use the VOLTS/DIV and SWEEP TIME/DIV controls to obtain an easily observed display.

3. Use the vertical POSTION controls to superimpose both waveforms to intersect the center horizontal graduation line as shown in Fig. 13. Use the horizontal POSITION control to set the reference signal coincident with one of the vertical graduation lines.

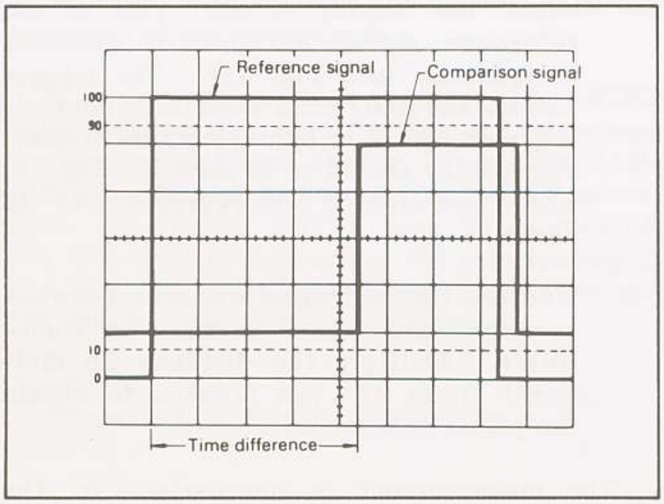

Fig. 13. Time Difference Measurement.

4. Measure the horizontal distance between the two signals and multiply this distance (in divisions) times the SWEEP TIME/DIV setting. If X10 MAG is used, multiply this again by 1/10.

The measurement is summarized by the following equation:

Time = Hor div x SWEEP TIME/DIV

(x 1/10 if X10 MAG is used)

For the example shown in Fig. 13, the horizontal distance measured is 4.4 divisions. If the SWEEP TIME/DIV is 0.2 ms and X10 MAG is not used, the time difference is calculated as follows:

Time = 4.4 (div) x 0.2 (ms/div)

= 0.88 ms or 880 µs

ELIMINATION OF AN UNDESIRED SIGNAL COMPONENT
(Refer to Fig. 14)

The ADD mode can be conveniently used to cancel out the effect of an undesired signal component which is superimposed on the signal you wish to observe (for example, undesired 60 Hz hum superimposed on an rf signal).

1. Apply the signal containing an undesired component to the CH 1 INPUT jack and the undesired signal itself alone to the CH 2 INPUT jack.

2. Set the MODE switch to CHOP and the SOURCE switch to CH 2. Adjust controls to display two signals, such as shown in Fig. 14. Verify that the channel 2 trace represents the unwanted signal in reverse polarity. The polarity may be reversed by pressing CH 2 INV.

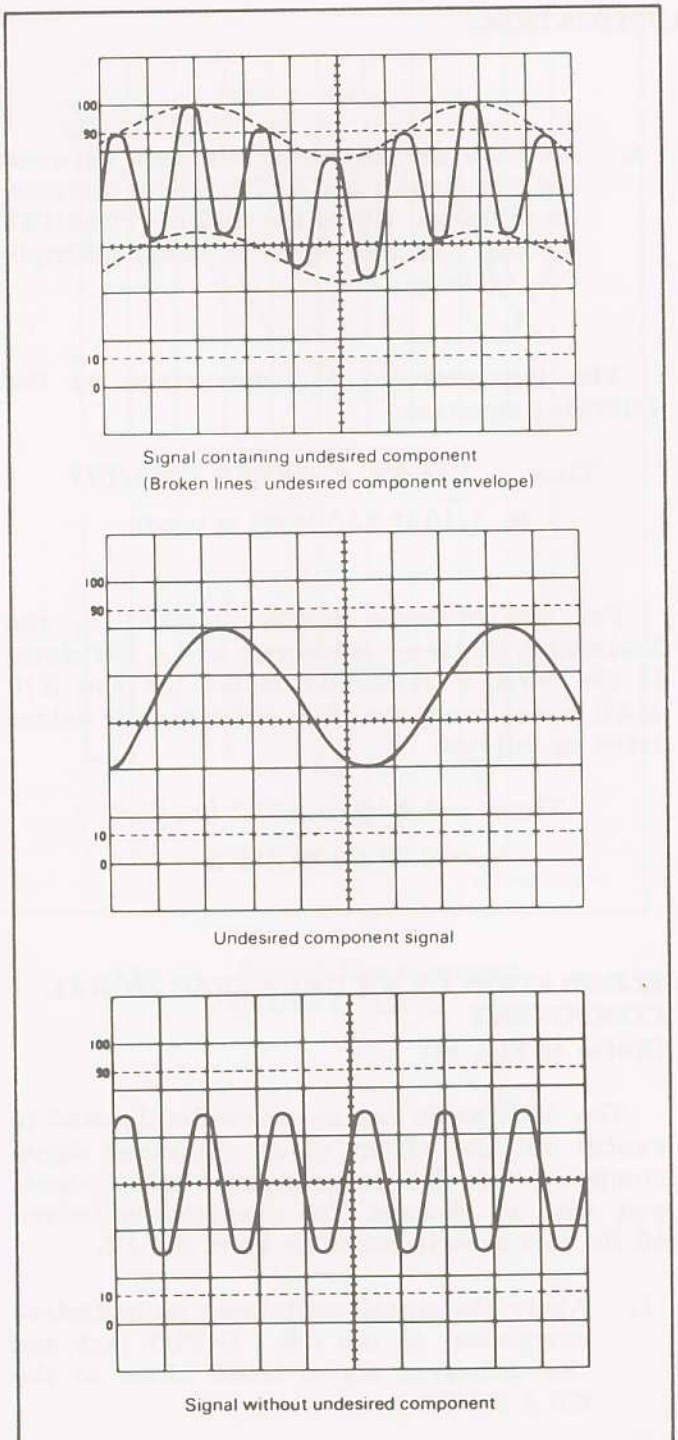

Fig. 14. Eliminating An Undesired Signal Component.

3. Now set the MODE switch to ADD and the SOURCE switch to V. MODE. Adjust the CH 2 VOLTS/DIV and VARIABLE controls so that the undesired signal component is cancelled as much as possible. The remaining signal should be the signal you wish to observe alone, and free of the unwanted signal.

PHASE DIFFERENCE MEASUREMENTS

Method No. 1
(Refer to Fig. 15)

This procedure is useful in measuring the phase difference of signals of the same frequency.

1. Apply the two signals to the CH 1 and CH 2 INPUT jacks, selecting either the ALT or CHOP mode for dual-trace display.

2. Set the SOURCE switch to the signal which is leading in phase and use the VOLTS/DIV controls to adjust the two waveforms so they are equal in amplitude.

3. Use the vertical POSITION controls to position the waveforms in the vertical center of the screen. Use the SWEEP TIME/DIV and VARIABLE controls to adjust the display so one cycle of the reference signal occupies 8 divisions horizontally (see Fig. 15). The trigger LEVEL and horizontal POSITION controls are also useful in achieving this display. The display should be as shown in Fig. 15, where one division now represents 45^{o} in phase.

4. Measure the horizontal distance between corresponding points on the two waveforms. Multiply the distance (in divisions) times 45^{o} per division to obtain the phase difference.

The measurement is summarized by the following equation:

$$\text{Phase difference} = \text{Hor div} \times 45^{o}/\text{div}$$

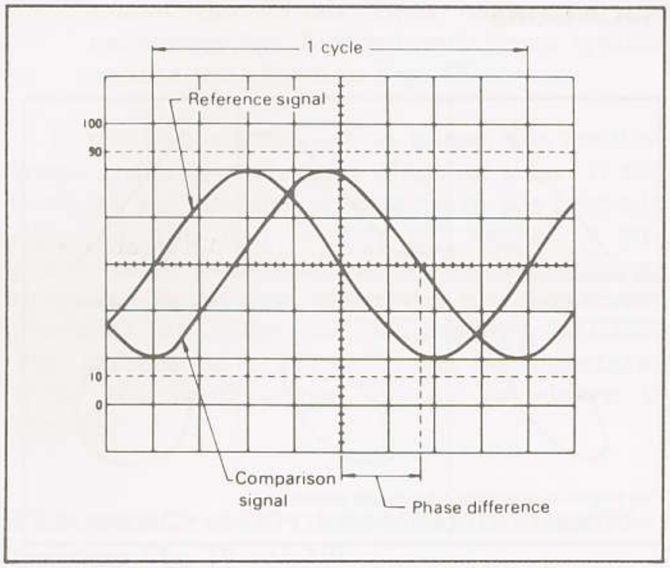

Fig. 15. Phase Difference Measurement.

For the example shown in Fig. 15, the horizontal distance is 1.7 divisions. Thus, the phase difference is calculated as follows:

$$\text{Phase difference} = 1.7 \times 45^{\circ}/\text{div} = 76.5^{\circ}$$

Method No. 2
(Refer to Fig. 16)

The above procedure allows 45° per division, which may not give the desired accuracy for small phase differences.

If greater accuracy is required, the SWEEP TIME/DIV setting may be changed to expand the display as shown in Fig. 16, but the VARIABLE setting must not be touched. If necessary, the trigger LEVEL may be readjusted. For this type of operation, the relationship of one division to 45° no longer holds. Instead the following equation must be used:

$$\text{Phase diff} = \text{Hor div} \times 45^{\circ}/\text{div} \times \frac{A}{B}$$

Where:
A = New SWEEP TIME/DIV setting.
B = Original SWEEP TIME/DIV setting.

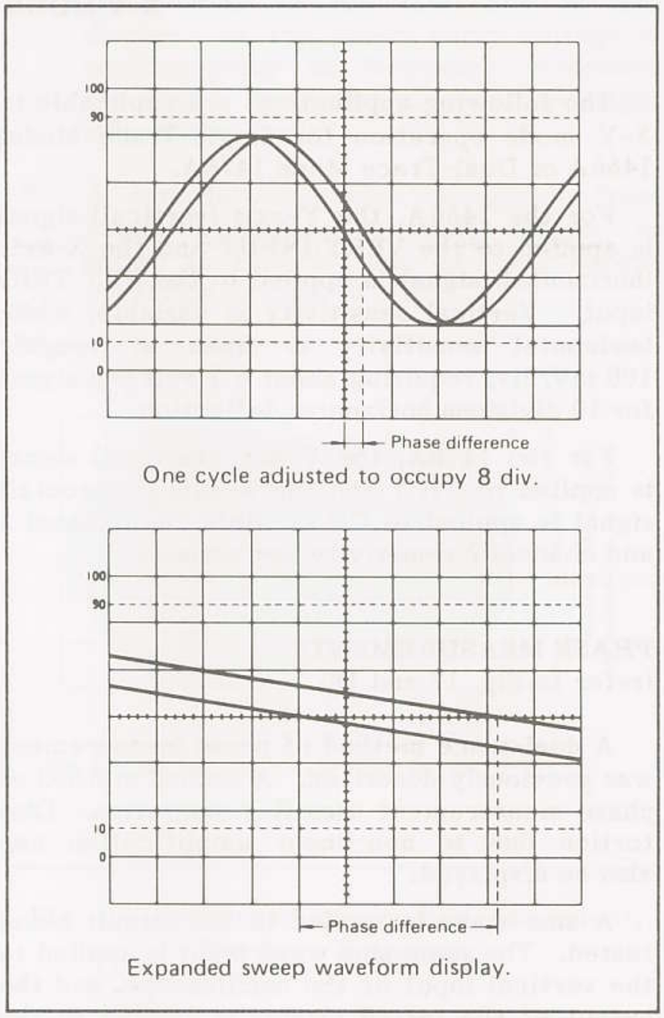

Fig. 16. Measuring Small Phase Difference.

A simpler method of obtaining more accuracy quickly is to simply use X10 MAG for a scale factor of 4.5°/division.

X-Y MODE APPLICATIONS

The following applications are applicable to X-Y mode operation for Single-Trace Model 1466A or Dual-Trace Mode 1476A.

For the 1466A, the Y-axis (vertical) signal is applied to the VERT INPUT and the X-axis (horizontal) signal is applied to the EXT TRIG input. Vertical sensitivity is variable, while horizontal sensitivity is fixed at roughly 100 mV/div, requiring about a 1 volt p-p signal for 10 divisions horizontal deflection.

For the 1476A, the Y-axis (vertical) signal is applied to CH 1 and the X-axis (horizontal) signal is applied to CH 2. Both the channel 1 and channel 2 sensitivity are variable.

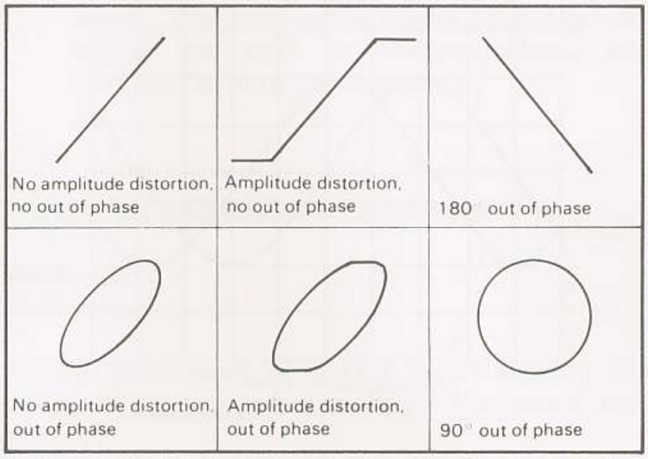

Fig. 17. Typical X-Y Phase Measurement Displays.

PHASE MEASUREMENTS
(refer to Fig. 17 and 18)

A dual-trace method of phase measurement was previously described. A second method of phase measurement uses X-Y operation. Distortion due to non-linear amplification can also be displayed.

A sine wave is applied to the circuit being tested. The same sine wave input is applied to the vertical input of the oscilloscope, and the output of the tested circuit is applied to the horizontal input of the oscilloscope. The amount of phase difference between the two signals can be caluclated from the resulting waveform.

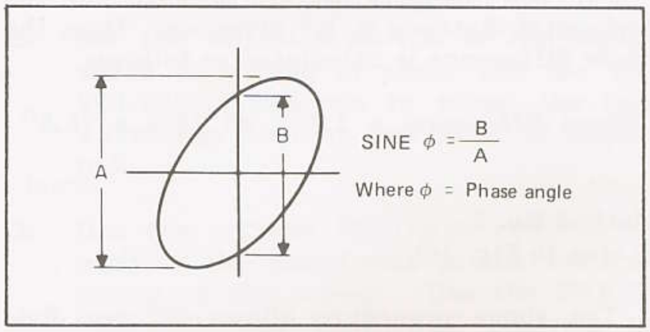

Fig. 18. Phase Measurement, X-Y Operation.

1. Using a signal generator with a pure sinusoidal signal, apply a sine wave test signal at the desired test frequency to the circuit being tested.

2. Set the signal generator output for the normal operating level of the circuit being tested. If desired, the circuit's output may first be observed on the oscilloscope with normal sweep operation. If the test circuit is overdriven, the sine wave display on the oscilloscope is clipped and the signal level must be reduced.

3. Select X-Y operation by placing the TRIG MODE in the X-Y position.

4. Connect the output of the test circuit to the oscilloscope X-axis input and set horizontal sensitivity (variable on dual-trace model only) for 5 to 10 divisions deflection; note number of divisions for reference. Temporarily disconnect the X-axis input. Connect the input of the test circuit to the oscilloscope Y-axis input and set vertical sensitivity for exactly the same number of vertical divisions as the horizontal reference.

5. Leave the Y-axis input connected and reconnect the X-axis input. Some typical results are shown in Fig. 17.

If the two signals are in phase, the oscilloscope trace is a straight diagonal line. If the vertical and horizontal sensitivity are properly adjusted, this line is at a 45° angle. A 90° phase shift produces a circular oscilloscope pattern. Phase shift of less (or more) than 90° produces an elliptical oscilloscope pattern. The amount of phase shift can be calculated from the oscilloscope display as shown in Fig. 18.

FREQUENCY RESPONSE MEASUREMENTS

(refer to Fig. 19 and 20)

The X-Y mode of this oscilloscope may be used to measure the frequency response of amplifiers, band pass filters, coupling networks, etc. The only additional test equipment needed is a sweep generator, such as the **B & K-Precision** Model 3020, 3025, or 3030 Sweep/Function Generator.

1. Connect the audio or rf output of the sweep generator to the input of the circuit under test. Connect the output of the test circuit to the Y-axis (vertical) input of the oscilloscope. Set the sweep generator to sweep the desired band of frequencies. For a typical audio frequency response measurement, the generator is set to sweep from 20 Hz to 20 kHz.

2. Connect the sweep ramp voltage of the sweep generator to the X-axis (horizontal) input of the oscilloscope.

3. Set the TRIGGER MODE switch to X-Y and adjust the vertical and horizontal sensitivity for a suitable viewing size.

4. A standard probe will result in an envelope display such as shown in Fig. 19. The example in Fig. 19 results from a negative-going sweep ramp voltage as frequency increases, with the higher frequencies at the left side of the display. If the sweep ramp voltage is positive-going as frequency increases, the higher frequencies are at the right side of the display.

5. A demodulator probe will give a "text book" frequency response display as shown in Fig. 20, and can also extend operation beyond 10 MHz.

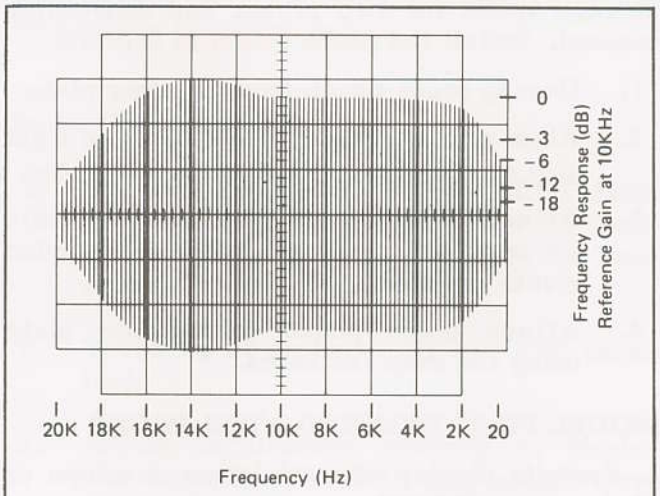

Fig. 19. Frequency Response Measurement, Envelope Response.

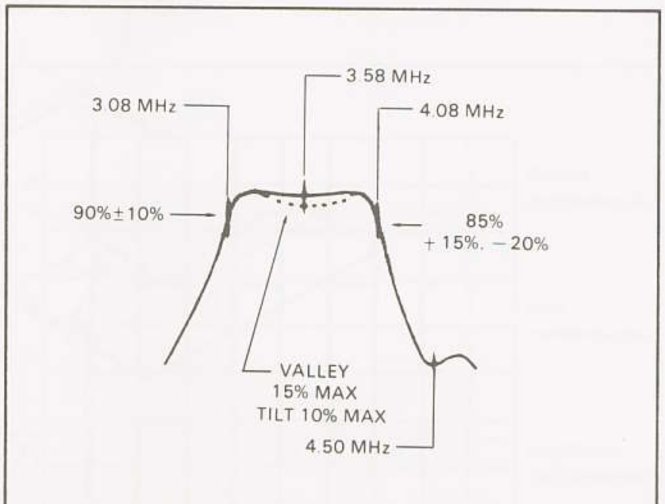

Fig. 20. Frequency Response Measurement, Demodulated Response.

OPTIONAL ACCESSORIES

MODEL LC-150 PROBE POUCH
(refer to Fig. 21)

This soft vinyl pouch attaches to the right side of the oscilloscope housing and provides storage space for two probes and instruction manual. Install the probe pouch as follows:

1. Unsnap probe pouch from retainer plate.
2. Align retainer plate with 4 holes on right side of the case, with 3 snaps at the top.
3. Attach the four corners of retainer plate to oscilloscope case with four nylon rivets supplied.
4. Attach probe pouch to retainer plate using the snap fasteners.

MODEL PR-32 DEMODULATOR PROBE

Permits display of modulation envelope of rf signals to 250 MHz.

MODEL PR-40 10:1/DIRECT PROBE

Standard replacement probe. At 10:1, -3dB bandwidth is 100 MHz with circuit loading of 10 MΩ and 18 pF. At direct, bandwidth is 15 MHz with circuit loading of 1 MΩ and 100 pF. Compensation range is 15 to 40 pF. Switch selects 10:1 or direct, or grounds the tip via 9 MΩ. Supplied with four tips; spring hook, IC tip, insulating tip, and BNC adapter.

MODEL PR-37 DELUXE 10:1/DIRECT PROBE

Deluxe replacement probe. At 10:1, -3 dB bandwidth is 100 MHz with circuit loading of 10 MΩ and 11.5 pF. At direct, bandwidth is 10 MHz with circuit loading of 1 MΩ and 40 pF. Compensation range is 10 to 60 pF. Switch selects 10:1 or direct, or grounds the tip via 9 MΩ. Supplied with four accessory tips as above and probe compensation trimmer tool.

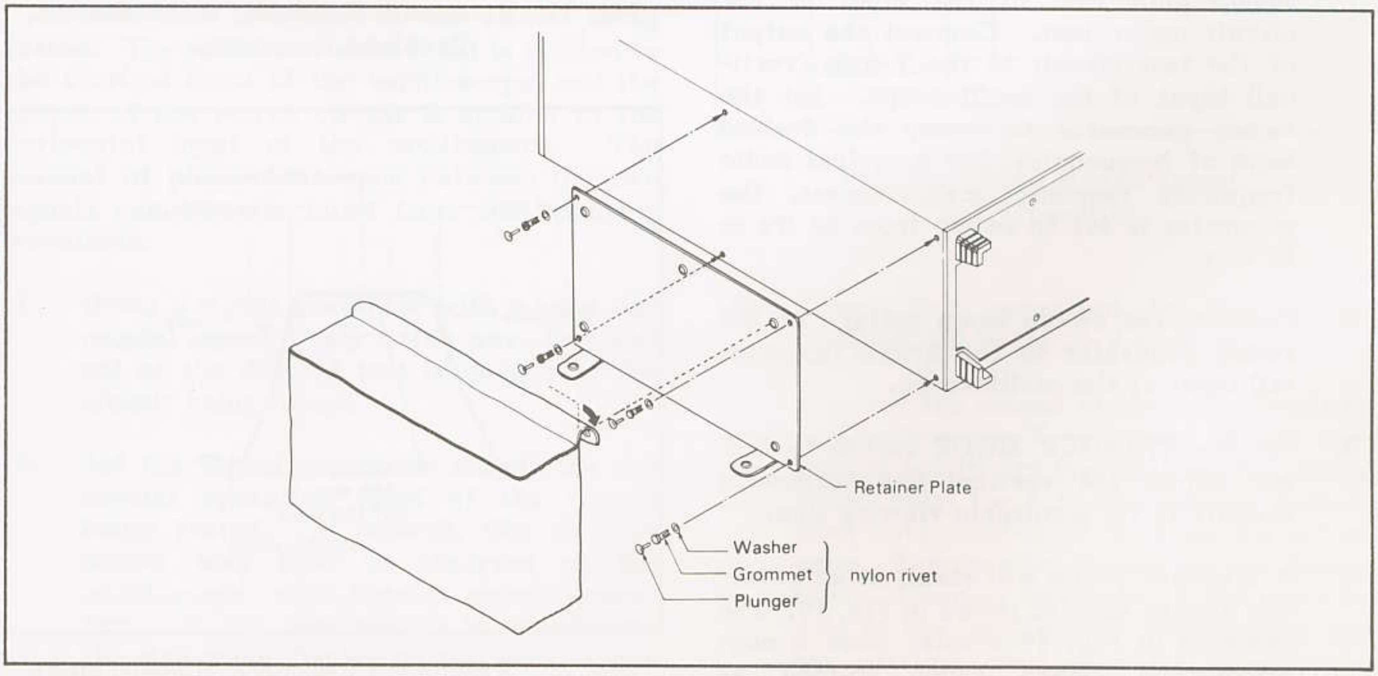

Fig. 21. Installation of LC-150 Probe Pouch.

MAINTENANCE

WARNING

The following instructions are for use by qualified service personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

High voltage up to 2,000 volts is present when covers are removed and the unit is operating. Remember that high voltage may be retained indefinitely on high voltage capacitors. Also remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the oscilloscope and discharge high voltage capacitors before performing service procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the oscilloscope will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with a fuse of the proper current rating; 0.8 amp for 100 or 120 volt operation or 0.5 amp for 220 or 240 volt operation. The fuse is located on the rear panel (see Fig. 2).

CASE REMOVAL

To remove the top cover, simply remove the nine screws (three from top and three from each side) and lift off the cover by the handle. The front of the top cover slides slightly under the lip formed by the front panel bezel. The bottom cover may be similarly removed by removing the three screws (two additional at sides if top cover is not removed) and lifting off the bottom cover.

PERIODIC ADJUSTMENTS

Screwdriver adjustments only need to be checked and adjusted periodically. Probe compensation, trace rotation, and astigmatism adjustments are included in this category. Procedures are given below.

Probe Compensation

1. Connect probes to VERT INPUT jack. (CH 1 and CH 2 INPUT jacks for dual-trace model. Repeat procedure for each probe).

2. Touch tip of probe to PROBE ADJ terminal.

3. Adjust oscilloscope controls to display 3 or 4 cycles of PROBE ADJ square wave at 5 or 6 divisions amplitude.

4. Adjust compensation trimmer on probe for optimum square wave (minimum overshoot, rounding off, and tilt). Refer to Fig. 22.

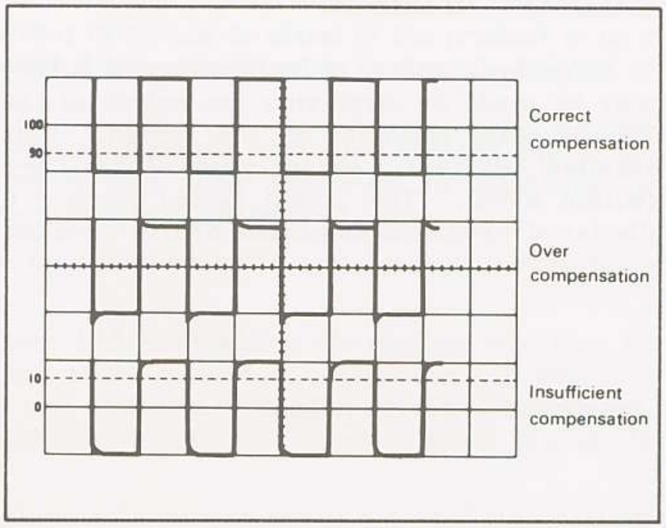

Fig. 22. Probe Compensation Adjustment.

Trace Rotation Adjustment

1. Set oscilloscope controls for a single-trace display, and with the AC-GND-DC switch set to GND.

2. Use the vertical POSITION control to position the trace over the center horizontal line on the graticule scale. The trace should be exactly parallel with the horizontal line.

3. Use the TRACE ROTATION adjustment on the front panel to eliminate any trace tilt.

Astigmatism Adjustment

1. Set the TRIG MODE switch to X-Y and AC-GND-DC switch(es) to GND. This will produce a spot on the screen.

2. With INTENSITY set about mid-range, adjust both the ASTIG and FOCUS controls for the sharpest, roundest spot. Do not readjust ASTIG after this step. (Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may be permanently burned.)

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the PROBE ADJ terminal on the screen. This terminal provides a square wave of 0.5 V p-p (within ± 6%). This signal should produce a displayed waveform amplitude of five divisions at 0.1 V/div sensitivity (with probe set for direct). With probe set for 10:1, there should be five divsions amplitude at 10 mV/div sensitivity. The VARIABLE control must be set to CAL during this check. Repeat check for channel 1 and channel 2 on dual-trace model.

The PROBE ADJ signal may be used only as a general check of calibration accuracy, not as a signal source for performing recalibration adjustments; a signal source of ± 0.5% or better accuracy is required for calibration adjustments.

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTION portion of this manual. There is a nominal charge for instruments out of warranty.

ADDITIONAL SERVICING INFORMATION

A complete service manual will soon be available for the Model 1466A and 1476A Oscilloscopes. Requests for the service manual should be sent to the **B & K-Precision** Service Department address listed in the WARRANTY SERVICE INSTRUCTIONS. Be sure to specify Model and serial number.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.
2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Dynascan Corporation
Factory Service Operations
4050 North Ravenswood Avenue
Chicago, Illinois 60613
Tel (312) 327-7270
Telex: 25-3475

Also use this address for technical inquiries and replacement parts orders.

LIMITED ONE-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, **B & K-Precision,** 6460 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 4050 North Ravenswood Avenue, Chicago, Illinois 60613, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

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