

## INTRODUCTION

The B & K Model 1460 Solid State, Triggered Sweep Oscilloscope is a laboratory quality, professional instrument for observing and measuring waveforms in electronic circuits. It performs all measurements made on conventional oscilloscopes,

usually with greater stability and better resolution. Additionally, it includes greater bandwidth, sweep speed, and sensitivity, plus extra features to provide the electronic sophistication required for servicing color television and other state-of-the-art devices.

## FEATURES

FULLY SOLID STATE	Only the cathode ray tube uses a filament. All other stages use transistors, diodes, and FET's (field effect transistors). Among the advantages of solid state construction are: No stabilization warm-up time required. Low power drain. Dependability—reliability. Ruggedness. Light Weight. Compactness.	VECTORSCOPE	Vectorscope inputs and controls on the front panel, plus a vector overlay supplied with the oscilloscope provide a color demodulator display exactly as specified by color television manufacturers.
TRIGGERED SWEEP	The stability of waveform presentation is beyond comparison with non-triggered sweep oscilloscopes. The sweep remains at rest until triggered by the signal being observed to assure that they are always synchronized, even when the waveform is of varying period recurrence. Fully adjustable trigger threshold allows the desired portion of the waveform to be used for triggering.	WIDE BANDWIDTH	DC to 10 MHz bandwidth and 35 nSEC rise time give distortion free, high resolution presentation at high frequencies.
LARGE SCREEN	The 130 mm (approx. 5.1 inches) diameter cathode ray tube gives easy-to-read presentation.	WIDE RANGE OF SWEEP SPEED	Sweep speeds of 0.5 $\mu$ SEC/cm to 0.5 SEC/cm provides every speed necessary for viewing waveforms from DC to 10 MHz.
CALIBRATED VOLTAGE SCALES	Accurate measurement of instantaneous voltages on 11 different ranges.	EXPANDED SCALE	A five time magnification (5X) of the horizontal sweep allows close-up examination of a portion of the waveform.
CALIBRATED SWEEP SPEED	Accurate time measurements on 19 different ranges.	HIGH SENSITIVITY	Allows the low capacitance, high impedance, 10:1 attenuation probe to be used for virtually all measurements, thus offering less circuit loading.
TV HORIZONTAL	Special sync and sweep speed positions specifically designed for observing television horizontal lines.	CALIBRATION SOURCE	A built-in calibrated 5 volt peak-to-peak square wave permits checking and recalibration of the vertical amplifiers without additional equipment.
TV VERTICAL	Special sync and sweep speed positions specifically designed for observing television vertical frames.	Z-AXIS INPUT	Intensity modulated capability included for time or frequency markers.
		ILLUMINATED SCALE	Fully variable illumination for the scale. Vertical and horizontal markers on the scale make voltage and time measurements easy to read.

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## SPECIFICATIONS

### VERTICAL AMPLIFIER

Deflection factor 0.01 V/cm to 20 V/cm,  $\pm$  5%, divided for all ranges each providing means for fine adjustment.

Frequency response DC — DC to 10 MHz (–3dB)  
AC — 2 Hz to 10 MHz (–3dB)

Risetime 35 nanoseconds

Overshoot 3% or less

Input resistance 1 Megohm (approximate)

Input capacity 35pF (approximate)

Tilt 5% or less

Max. input voltage 300 V (DC + AC peak) or 600 Vp-p

### SWEEP CIRCUIT

Sweep system TRIGGERED and AUTO-MATIC

Sweep time 0.5  $\mu$ SEC/cm to 0.5 SEC/cm ( $\pm$  5%), divided for 19 ranges each providing means for fine adjustment.  
TVH (13  $\mu$ SEC/cm) and TVV (3.6 mSEC/cm)

Sweep magnification As obtained by enlarging the above sweep 5 times from center

### TRIGGERING

Type Internal, line frequency and external (2Vp-p or higher) triggering

Trace Slope Positive and negative

Triggering range 20 Hz to 10 MHz (minimum 10mm of deflection, as measured on cathode ray tube scope)

TV synchronization HORIZONTAL 100 Hz to 1 MHz minimum 10mm of deflection

VERTICAL 100 Hz to 3 KHz minimum 10mm of deflection  
Any portion of complex TV waveforms can be synchronized and expanded for viewing

### HORIZONTAL AMPLIFIER

Deflection factor 300 mV/cm

Frequency response DC to 800 KHz (–3 dB)

Input resistance 100K ohm (Approximately)

Input capacity 40pF or less

### CALIBRATION VOLTAGE

1 KHz square wave of 5Vp-p ( $\pm$  5%)

### INTENSITY MODULATION

Voltage 30Vp-p minimum

### POWER REQUIREMENTS

117 VAC, 50/60 Hz, 20W (3-wire line cord)

### SEMICONDUCTOR

Complement 5 FET's  
40 Transistors  
14 Diodes

### ACCESSORIES (Not Included)

Probe: B&K-Precision Models PR-16 and PR-20  
Attenuation Combination 10:1 and Direct

Input Impedance 10:1 (Low capacity) 10 MEG $\Omega$ , 18pf

Direct 1 MEG $\Omega$ , 120pf

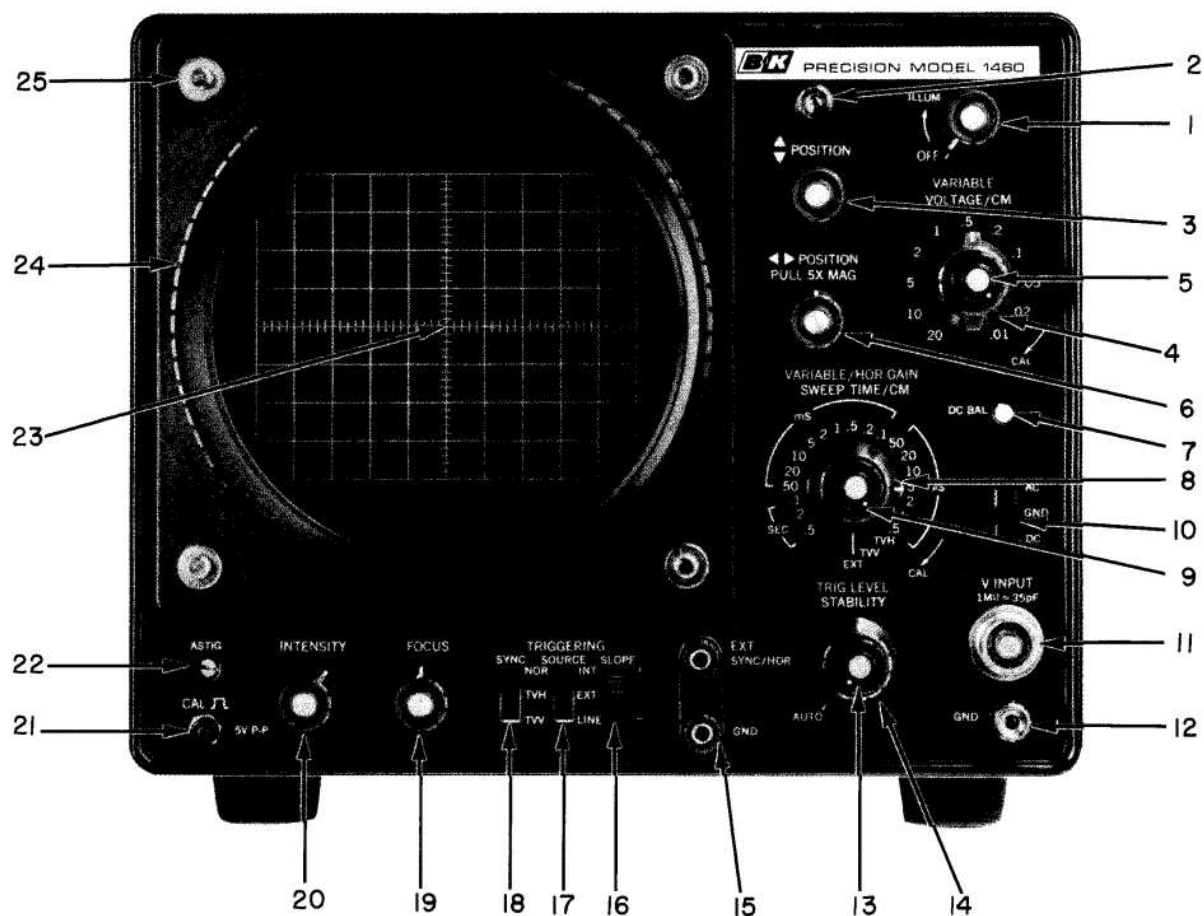



Figure 1. Controls and Indicators

## CONTROLS AND INDICATIONS

- 1 OFF/scale illumination control. Fully counter-clockwise turns off oscilloscope. Clockwise turns on oscilloscope and increases scale illumination.
- 2 Pilot lamp. Lights when oscilloscope is on.
- 3  $\blacktriangle$  POSITION control. Vertical position adjustment.
- 4 VOLTAGE/CM switch. Vertical attenuator. Coarse adjustment of vertical sensitivity. Vertical sensitivity is calibrated in 11 steps from .01 to 20 volts per cm when VARIABLE 5 is set to the CAL position.
- 5 VARIABLE control. Vertical attenuator adjustment. Fine control of vertical sensitivity. In the extreme clockwise (CAL) position, the vertical attenuator is calibrated.
- 6  $\blacktriangleleft$  POSITION control. Rotation adjusts horizontal position of trace. Push-pull switch selects 5X magnification when pulled out; normal when pushed in.
- 7 DC BAL adjustment. Vertical dc balance adjustment.
- 8 SWEEP TIME/CM switch. Horizontal coarse sweep time selector. Selects calibrated sweep times of 0.5  $\mu$ SEC/cm to 0.5 SEC/cm in 19 steps when VARIABLE/HOR GAIN control 9 is set to CAL. Selects proper sweep time for television composite video waveforms in TVH (television

- horizontal) and TVV (television vertical) positions. Disables internal sweep generator and displays external horizontal input in EXT position.
- 9 VARIABLE/HOR GAIN control. Fine sweep time adjustment (horizontal gain adjustment when SWEEP TIME/CM switch 8 is in EXT position). In the extreme clockwise position (CAL) the sweep time is calibrated.
  - 10 AC-GND-DC switch. Vertical input selector switch.  
AC position—blocks dc component of input signal.  
GND position—opens signal input path and grounds input to vertical amplifier. This provides a zero-signal base line, the position of which can be used as a reference when performing dc measurements.  
DC position—direct input of ac and dc component.
  - 11 V INPUT jack. Vertical input.
  - 12 GND terminal. Chassis ground.
  - 13 TRIG LEVEL control. Sync level adjustment determines point on waveform slope where sweep starts. In fully counterclockwise (AUTO) position, sweep is automatically synchronized to the average level of the waveform.
  - 14 STABILITY control. Sync stability adjustment.
  - 15 EXT SYNC/HOR jack. Input terminal for external sync or external horizontal input.
  - 16 TRIGGERING SLOPE switch. Selects sync polarity (+) or (-).
  - 17 TRIGGERING SOURCE switch.  
INT—waveform being observed is used as sync trigger.  
EXT—signal at EXT SYNC/HOR jack 15 is used as sync trigger.  
LINE—power line frequency sync (50/60 Hz).
  - 18 SYNC switch.  
NOR—normal.  
TVH—syncs on horizontal components of composite video.  
TVV—syncs on vertical component of composite video.
  - 19 FOCUS control.
  - 20 INTENSITY control. Adjusts brightness of trace.
  - 21 CAL  jack. Provides calibrated 5 Vp-p square wave output at approximately 1 KHz.
  - 22 ASTIG adjustment. Astigmatism adjustment provides roundness to spot on cathode ray tube.
  - 23 Scale. Provides calibration marks for voltage and time measurements. Scale can be removed and replaced with vector overlay, 26.
  - 24 Observation bezel.
  - 25 Bezel retaining nuts (4).
  - 26 Vector overlay. Used in place of scale 23 for vectorscope applications. (Not illustrated)
  - 27 Probe (Not illustrated). Combination 10:1 and direct probe available for vertical input.
  - 28 INT MOD jack. Intensity modulation (Z axis) input.
  - 29 Fuse.
  - 30 Power cable storage compartment.

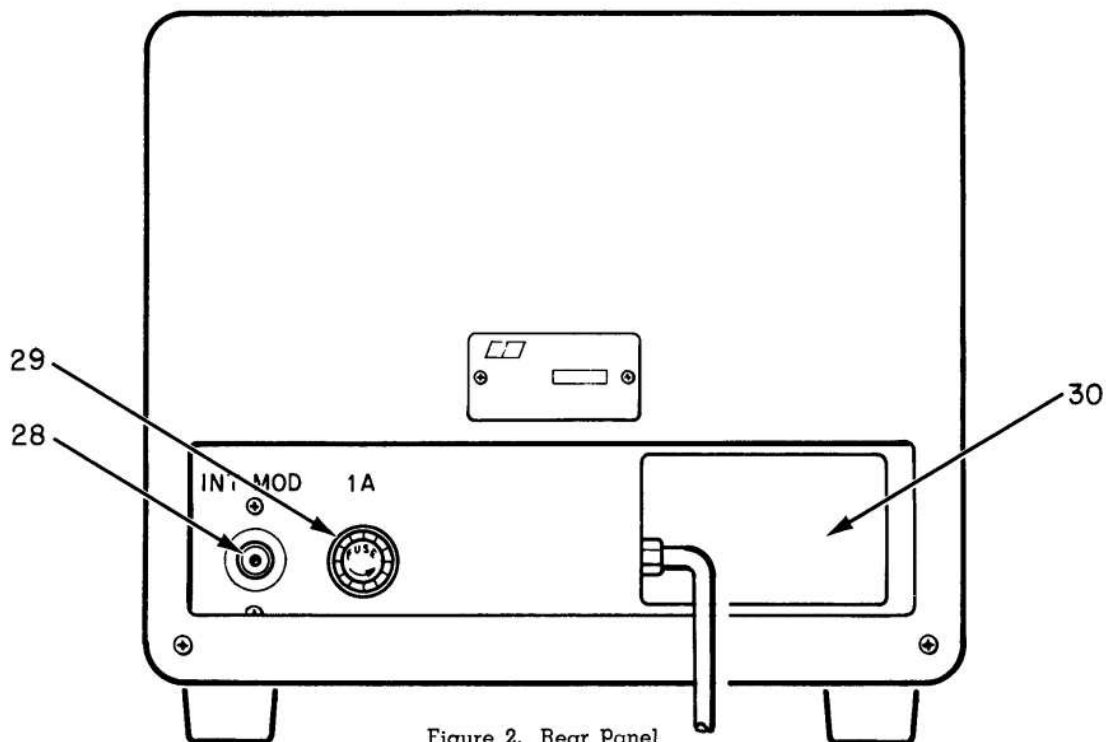


Figure 2. Rear Panel

## OPERATING INSTRUCTIONS

**CAUTION:** Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The spot may become permanently burned. Reduce intensity or keep the spot in motion by causing it to sweep.

### INITIAL STARTING PROCEDURE

1. Set the OFF/scale illumination control **1** to the OFF position (fully counterclockwise).
2. Connect the power cord to a 117 volt, 60 Hz AC outlet.
3. Set the  $\blacktriangle$  POSITION control **3** and  $\blacktriangleleft$  POSITION control **6** to the center of their ranges.
4. Set the TRIG LEVEL control **13** to the AUTO position (fully counterclockwise).
5. Set the AC-GND-DC switch **10** to the GND position.
6. Turn on the oscilloscope by rotating the OFF/scale illumination control **1** clockwise. It will "click" on and the pilot lamp **2** will light. Turn the control clockwise to the desired scale illumination.
7. Wait a few seconds for the cathode ray tube (CRT) to warm up. A trace should appear on the face of the CRT.
8. If no trace appears, increase (clockwise) the INTENSITY control **20** setting until the trace is easily observed. If trace is still not visible, turn STABILITY control **14** fully clockwise, which places the sweep generator in a free-running

mode (no sync trigger required to produce sweep).

9. Adjust the FOCUS control **19** and INTENSITY control **20** for the thinnest, sharpest trace.
10. Readjust the POSITION controls **3** and **6**, if necessary, to center the trace.
11. Check for proper adjustment of the ASTIG **22** and DC BAL **7** controls and CRT positioning as instructed in the MAINTENANCE and CALIBRATION" portion of this manual. These adjustments require checking only periodically.

The oscilloscope is now ready for making waveform measurements.

### WAVEFORM OBSERVATION

1. Perform the steps of the initial starting procedure, then connect the probe cable to the V INPUT receptacle **11**.
2. For all except low amplitude waveforms, the probe **27** is set for 10:1 attenuation. For low amplitude waveforms (below 0.5 volt peak-to-peak), set the probe for DIRECT. See Figure 3 for changing the probe from 10:1 to DIRECT, or vice versa. The probe has a 10 megohm input impedance with only 18pF shunt capacitance in the 10:1 position and 1 megohm with 120pF shunt capacitance in the DIRECT position. The higher input impedance (low capacity position) should be used when possible to decrease circuit loading.
3. Set the AC-GND-DC switch **10** to AC for measuring only the ac component (This is the normal

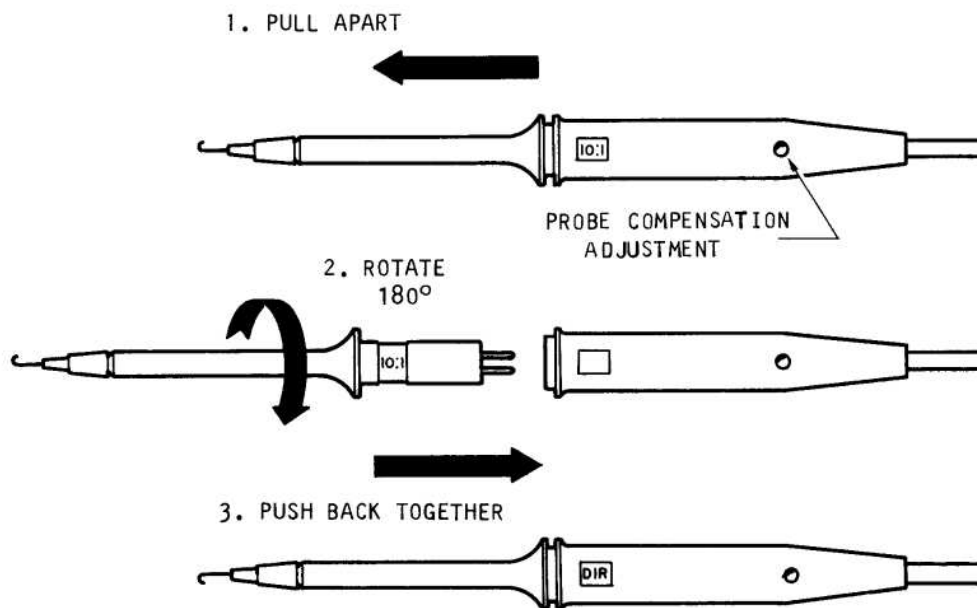


Figure 3. Changing Probe from 10:1 to DIRECT

position for most measurements and must be used if the point being measured includes a large dc component. Use the DC position for measuring both the ac component and the dc reference, and any time a very low frequency waveform (below 5 Hz) is to be observed. The GND position is required only when a zero-signal ground reference is required, such as for dc voltage readings.

4. Connect the ground clip of the probe 27 to chassis ground of the equipment under test. Connect the tip of the probe to the point in the circuit where the waveform is to be measured.

#### WARNING

1. If the equipment under test is a transformer-less ac powered item, use an isolation transformer to prevent dangerous electrical shock.
2. The peak-to-peak voltage at the point of measurement should not exceed 500 volts.
5. Set the VOLTAGE/CM control 4 to a position that gives 2 cm to 3 cm (two to six large squares on the scale) vertical deflection.

The display on the screen will probably be unsynchronized. The remaining steps are concerned with adjusting synchronization and sweep speed, which presents a stable display showing the desired number of waveforms. Any signal that produces at least 1 cm vertical deflection develops sufficient trigger signal to synchronize the sweep.

6. Set the SYNC switch 18 to the TVV position for observing television composite video waveforms synchronized with vertical sync pulses, to the TVH position for observing television composite video waveforms synchronized with horizontal sync pulses, or the NOR position for all other waveforms.
7. Set the TRIGGERING SOURCE switch 17 to the INT (internal) position when the waveform being observed is also to be used to trigger the sweep. Most waveforms should be viewed with this switch in the INT position. When an external sync source is required, use the EXT position. When observing waveforms in power circuits or other circuits that can be synchronized with 60 Hz, use the LINE position. This position synchronizes the sweep with the ac input power frequency.
8. Set the TRIGGERING SLOPE switch 16 to (+) if the sweep is to be triggered by a positive going wave, and to (—) if the sweep is to be triggered by a negative going wave. For observing television composite video signals it is desired to sync the sweep to the horizontal line sync pulses or the vertical blanking pulses. Because the polarity of the composite video signals varies according to the point at which it is observed, use the following procedure:
  - a. If the observed sync pulses or blanking pulses are positive going (upward trace deflection is produced by a positive voltage), use the (—) position of the TRIGGERING SLOPE switch.
  - b. If the observed pulses are negative, use the (+) position of the TRIGGERING SLOPE switch.
9. Set the SWEEP TIME/CM control 8 and VAR-

ABLE/HOR GAIN control 9 for the desired number of waveforms. These controls may be set for viewing only a portion of a waveform, but the trace becomes progressively dimmer as a proportionately smaller portion is displayed. This is because the writing speed increases but the sweep repetition rate does not change.

**NOTE:** When using very fast sweep speed at low repetition rates, the operator may wish to operate with the intensity control toward maximum. Under these conditions, a retrace "pip" may appear at the extreme left of the trace. This does not in any way affect the oscilloscope operation and may be disregarded.

The TVH and TVV positions are ideal for observing television video waveforms. These positions select the correct sweep time to display two complete horizontal lines or two complete vertical frames when 9 is set to CAL.

10. To synchronize the waveform, set the TRIG LEVEL control 13 fully counterclockwise to the AUTO position. Next turn the STABILITY control 14 counterclockwise until the trace disappears. Now turn the STABILITY control clockwise just past the point where the trace reappears. This should provide a stable waveform free of jitter. Do not turn the STABILITY control too far clockwise, as it will go into a free-running (non-synchronized) mode.
11. Step 10 assumes that you desire to use automatic sync, wherein the predominant point of the waveform is automatically selected as the sync trigger. If another point on the waveform is desired as the sync trigger (as is often the case in viewing sinusoidal waves), turn the TRIG LEVEL control 13 clockwise away from the AUTO position. Set the control by observing the waveform and note that it starts at the desired time. It may also be necessary to readjust the STABILITY control 14. This control has three general "modes" when rotated from one extreme to the other. On the counterclockwise end, no trace is produced, for the sync threshold level is set so none of the input signal is sufficient to trigger the sweep. At the clockwise extreme, the sync threshold is so low that anything will trigger the sweep, resulting in a free-running, unsynchronized mode. The center range provides the proper threshold for synchronization and results in the desired stable presentation. The boundaries of this center range depend upon the strength and type of signal input and the setting of the TRIG LEVEL control. However, the setting of the STABILITY control is not critical; it operates properly over this entire "center" area and the proper setting is easy to attain.
12. For a close-up view of a portion of the waveform, pull outward on the ◀▶ POSITION control 6. This expands the sweep by a factor of five (5X magnification) and displays only the center portion of the sweep. To view a portion to the left of center, turn the ◀▶ POSITION control 6 clockwise, and to view portions to the right of center, turn the control counterclockwise. Push inward on the control to return the sweep to the normal, non-magnified condition.

### CALIBRATED VOLTAGE MEASUREMENT

Peak voltages, peak-to-peak voltages, dc voltages and voltages of a specific portion of a complex waveform are easily and accurately measured on this oscilloscope.

1. Adjust controls as previously instructed to display the waveform to be measured.
2. Be sure the vertical VARIABLE control 5 is set fully clockwise to the CAL position.
3. Set the VOLTAGE/CM control 4 for the largest vertical deflection possible without exceeding the limits of the vertical scale.
4. Read the amount of vertical deflection (in cm) from the scale. The POSITION control 3 may be readjusted to shift the reference point for easier scale reading if desired. When measuring a dc voltage, adjust the POSITION control 3 to a convenient reference with the AC-GND-DC switch 10 in the GND position, then note the amount the trace is deflected when the switch is placed in the DC position. The trace deflects upward for a positive voltage input and downward for a negative voltage input.

**NOTE:** For an accurate display of high-frequency waveforms above 5 MHz, it is important that the probe be used in the 10:1 position to reduce circuit loading and that the oscilloscope controls be set so that the height of the pattern does not exceed 4 cen-

timeters and that the trace be centered vertically.

5. Calculate the voltage reading as follows:  
Multiply the vertical deflection (in cm) by the VOLTAGE/CM control 4 setting (see example in Figure 4). Don't forget that the voltage reading displayed on the oscilloscope is only 1/10th the actual voltage being measured when the probe is set for 10:1 attenuation. The actual voltage is displayed when the probe is set for DIRECT measurement.
6. Calibration accuracy of the oscilloscope may be occasionally checked by observing the 5 volt peak-to-peak square wave signal available at the CAL jack 21. This calibrated source should read exactly 5 volts peak-to-peak. If a need for recalibration is indicated, see the "MAINTENANCE and CALIBRATION" section of the manual for complete procedures.

### CALIBRATED TIME MEASUREMENT

Pulse width, waveform periods, circuit delays and all other waveform time durations are easily and accurately measured on this oscilloscope. Calibrated time measurements from 5 seconds down to .1 microsecond ( $\mu$ S) are possible. At low sweep speeds, the entire waveform is not visible at one time. However, the bright spot can be seen moving from left to right across the screen which makes the beginning and ending points of the measurement easy to spot.

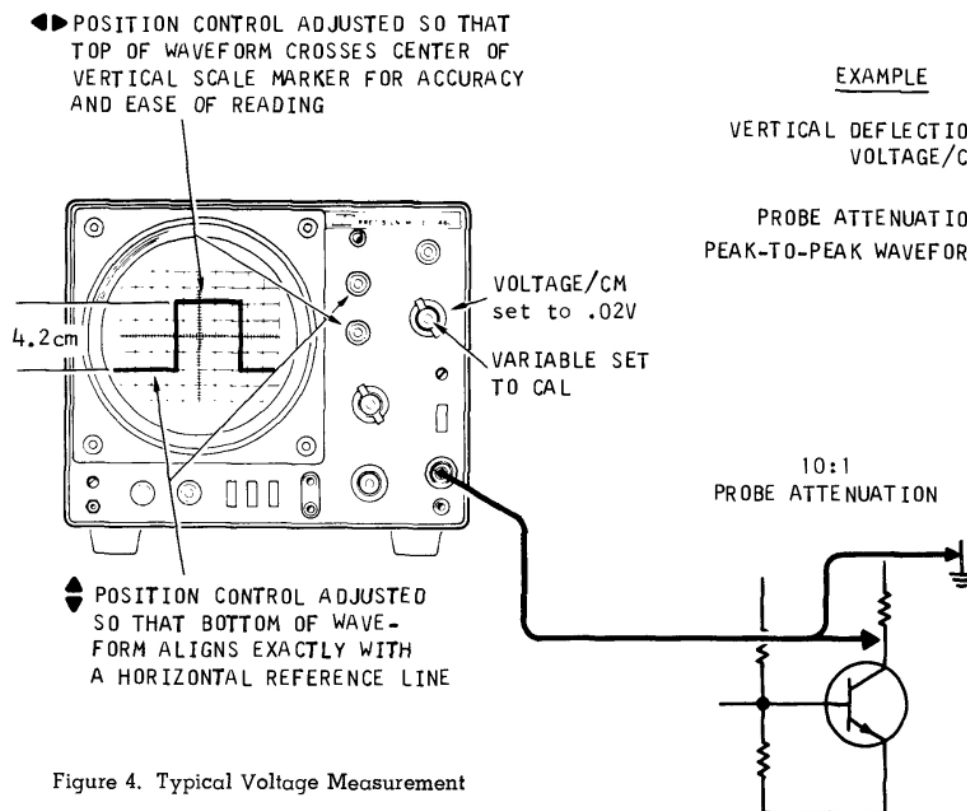


Figure 4. Typical Voltage Measurement



1. Adjust controls as previously described for a stable display of the desired waveform.
2. Be sure the VARIABLE/HOR GAIN control **9** is fully clockwise to the CAL position.
3. Set the SWEEP TIME/CM control **8** for the largest possible display of the waveform segment to be measured, usually one cycle.
4. If necessary, readjust the TRIG LEVEL and STABILITY controls **13** and **14** for the most stable display.
5. Read the amount of horizontal deflection (in cm) between the points of measurement. The **POSITION** control **6** may be readjusted to align one of the measurement points with a vertical scale marker for easier reading.
6. Calculate the time duration as follows:  
Multiply the horizontal deflection (in cm) by the SWEEP TIME/CM control **8** setting (see example in Figure 5). Remember, when the 5X magnification is used, the result must be divided by 5 to obtain the actual time duration.
7. Time measurements often require external sync. This is especially true when measuring delays. The sweep is started by a sync signal from one circuit and the waveform measured in a subse-

quent circuit. This allows measurement of the delay between the sync pulse and the subsequent waveform. To perform such measurements using external sync, use the following steps:

- a. Set the TRIGGERING SOURCE switch **17** to the EXT position.
- b. Connect a lead from the EXT SYNC/HOR jack **15** to the source of sync signal. Use a short shielded cable.
- c. Set the TRIGGERING SLOPE switch **16** to the proper polarity (+) or (-) for the sync signal.
- d. Readjust the TRIG LEVEL and STABILITY controls **13** and **14**, if necessary, for a stable waveform.
- e. Set the SWEEP TIME/CM control **8** as for other time measurements. Do not set it to the EXT position. This position is for external horizontal deflection, not external sync.
- f. If measuring a delay, measure the time from the start of the sweep to the start of the waveform.

#### EXTERNAL HORIZONTAL INPUT

For some measurements, an external horizontal deflection signal is required. This may be a sinu-

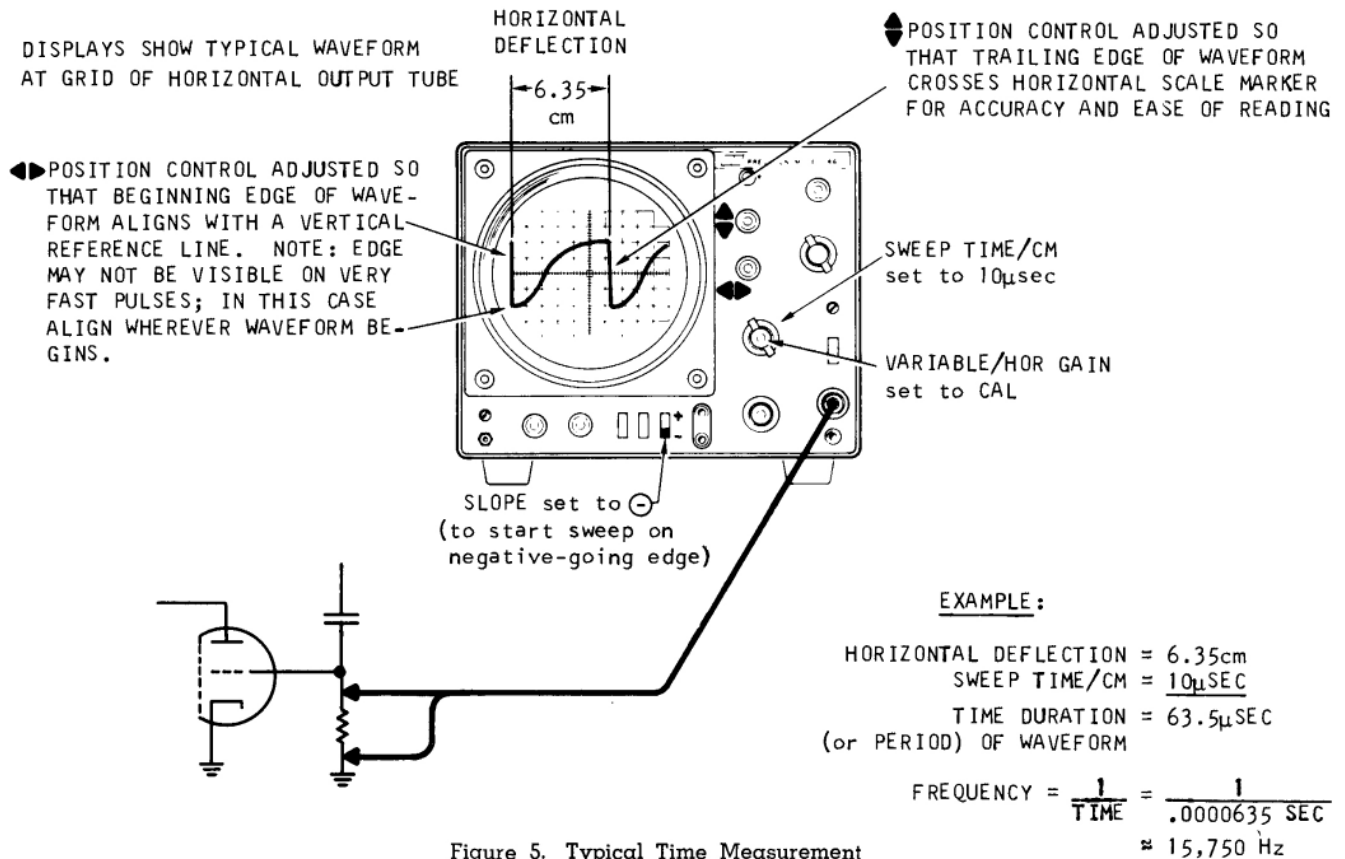


Figure 5. Typical Time Measurement

soidal wave, such as used for phase measurement, or an external sweep voltage. This input voltage must be about 250 millivolts per cm of deflection (usually 2 volts or more peak-to-peak will provide satisfactory results). To use an external horizontal input, use the following procedure:

1. Set the SWEEP TIME/CM control **8** to the EXT position.
2. Connect the external horizontal signal source through a cable to the EXT SYNC/HOR jack **15**.
3. Adjust the amount of horizontal deflection with the VARIABLE/HOR GAIN control **9**, which adjusts the gain of the horizontal amplifier.
4. All sync controls are disconnected and have no effect.

#### Z-AXIS INPUT

The trace displayed on the screen may be intensity modulated (Z-axis input) where frequency or time-scale markers are required. A 30-volt peak-to-peak or greater signal applied at the INT MOD

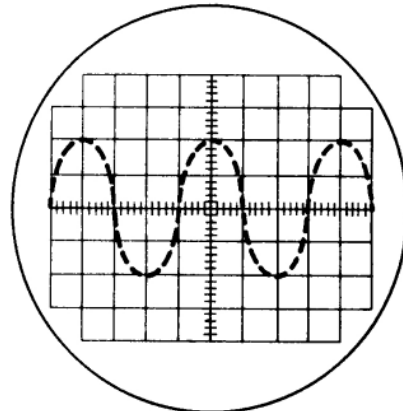
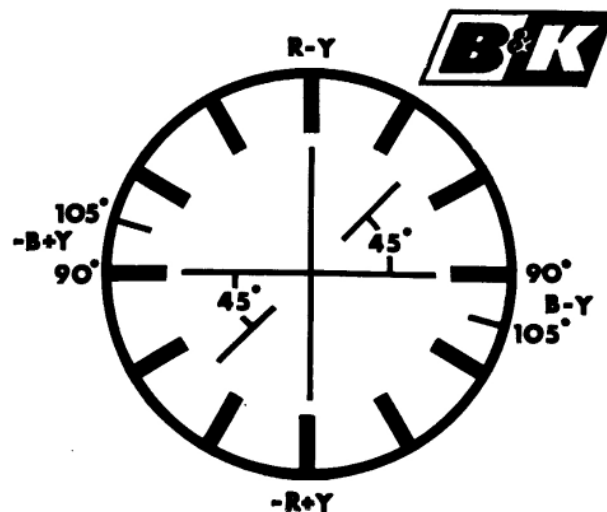


Figure 6. Oscilloscope Trace with Z-axis Input

(intensity modulation) jack **28** on the rear of the oscilloscope will provide alternate brightness and blanking of the trace. (See Figure 6.)



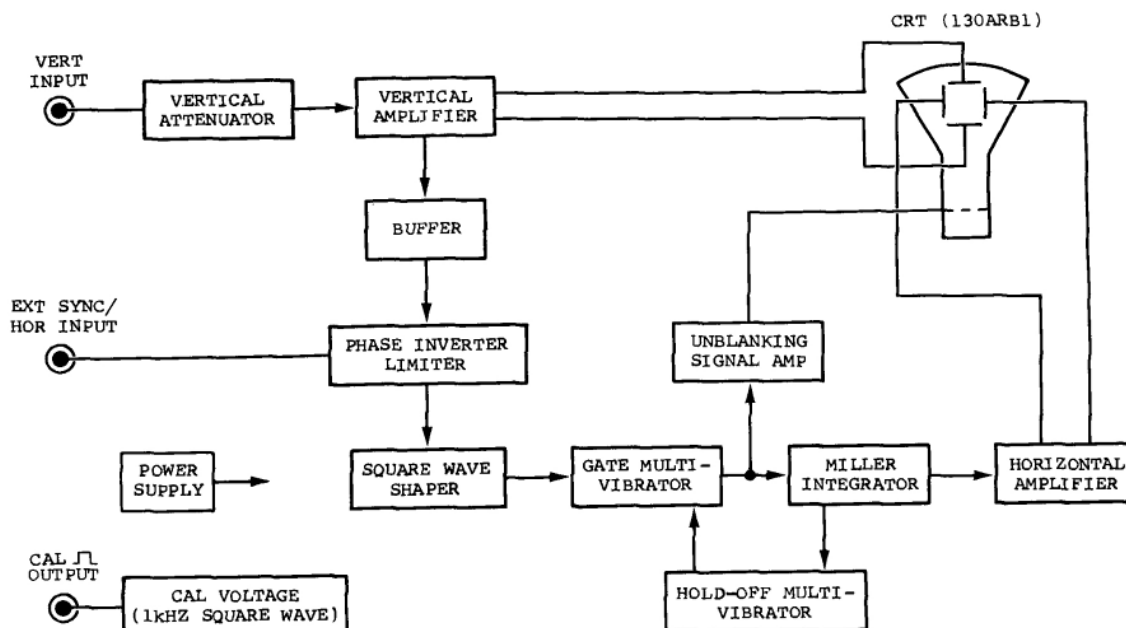


Figure 40. Block Diagram

## CIRCUIT DESCRIPTION

### GENERAL

(Refer to Figure 40)

The input signal to be displayed passes through an attenuator to the vertical amplifier. It is then applied through DC BAL, GAIN and POSITION controls to the vertical deflection plates of cathode ray tube.

The vertical section uses direct-coupling differential amplifiers throughout its circuitry from the initial to the final stages.

Part of the vertical amplifier output voltage is used as the internal triggering voltage, which is selected by the triggering circuit depending on its type and polarity and then conducted to the square-wave shaping circuit.

The output of the square-wave shaping circuit is differentiated to turn into a trigger signal which, together with the sawtooth wave conducted from the hold-off circuit, drives the gate multi-vibrator circuit.

The gate multivibrator circuit, forming a dc loop with the Miller integrating circuit and the hold-off circuits, is driven from the trigger pulse to generate the sawtooth sweep voltage. This sweep voltage is applied through the horizontal amplifier to the horizontal deflection plates.

Refer to schematic diagram for detailed circuit information.

### VERTICAL AMPLIFIER CIRCUIT

#### INPUT CIRCUIT AND ATTENUATOR

The input signal is selected as AC or DC signal by the input selector switch (AC-GND-DC) and applied to the attenuator having 11 ranges.

The attenuator offers an input impedance of 1 megohm and an input capacitance of 35pF for all positions of the VOLTAGE/CM switch.

#### AMPLIFIER

The output from the attenuator passes through an input protection circuit comprised of FET Q2 to the vertical amplifier.

The above input protection circuit, utilizing the high quality diode characteristic of the FET, suppresses excessive input signals to approximately  $\pm 1$  volt.

Transistor Q3 employed as the initial stage of the vertical amplifier is a source follower with high input impedance. Further, transistor Q3 forms a balanced circuit with transistor Q4 to reduce the drift due to variations of power source voltage and temperature.

The output of the balanced amplifier is fed to succeeding emitter followers Q5 and Q6 where its impedance is lowered further, and then applied to a differential amplifier Q7 and Q8.

The dc level of the balanced signal may be adjusted by FET source variable resistor VR101 (DC BAL).

Variable resistors VR102 (vertical VARIABLE) and VR1 in the emitter circuits of transistors Q7 and Q8 provide adjustment of the gain of the differential amplifier. Variable resistor VR103 ( $\Delta$  POSITION) adjusts the balance of the dc signal level of the differential amplifier for adjustment of the vertical position of the signal represented on the cathode ray tube.

The output of transistors Q7 and Q8 is fed through emitter follower Q9 and Q10 to another differential amplifier comprised of transistors Q11, 12, 13 and 14. These transistors are connected in a cascode arrangement and, therefore, reduce their Miller effect to the signal at higher rf frequencies. This allows the differential amplifier to provide a sufficient bandwidth.

Variable resistor VR2 in the emitter circuit of transistors Q11 and Q12 establishes the range of the front panel vertical position control.

The output signals of the differential amplifier transistors Q11, 12, 13 and 14 are fed to transistors Q15 and Q16. Here their impedances are further lowered, and then applied to the final stage amplifier as well as to emitter follower transistor Q17 serving as a buffer to the triggering circuit. The output from Q17 is used as the internal trigger signal to the triggering circuit.

The final stage amplifier, a cascode differential amplifier consisting of transistors Q18 and Q19 connected in cascode with transistors Q20 and Q21, is provided with tuning capacitors TC21 and TC22, which provide adjustment of the frequency response.

The signal is sufficiently amplified by the vertical amplifier to be applied directly to the vertical deflection plates of cathode ray tube. The overall gain of the entire vertical amplifier circuit is approximately 60 dB, which corresponds to a deflection sensitivity of 10 mV/cm.

## TRIGGERING CIRCUIT

### PHASE INVERTER AND LIMITER CIRCUIT

In this circuit, the input signal is selected as INT (internal), EXT (external) or LINE by the TRIGGERING SOURCE switch. This inverter and limiter circuit (Q6 and Q7) is a sort of differential amplifier which, because of its narrowed dynamic range, limits the level of its input signal as well as inverts the phase of the signal. Polarity of the signal is easily reversed by the TRIGGERING SLOPE switch.

The input circuit provides adjustment of the bias voltage, as performed through the use of variable resistor VR104 (TRIG LEVEL). Thus, the sync threshold level is established.

## SYNC SEPARATOR CIRCUITS

To improve the sync reliability of this instrument when viewing composite video information, a sync separator circuit (Q101 and Q102) is provided. This circuit is operative when the TRIGGERING SYNC is in the TVV and TVH positions. Signal input is provided from the polarity reversing amplifier Q7. Q101 operates as an impedance transformer stage which drives Q102. In the absence of input signal, Q102 is biased near cut-off. Positive going input signals cause increased base current to flow in Q102, charging capacitor C132. Because of the large time constant in the base circuit of Q102, an average negative voltage is developed between the base of Q102 and ground, so that the transistor is cut off until a positive signal peak of sufficient amplitude to overcome the developed cut-off bias is applied. As the input signal amplitude varies, the average base volt-

age adjusts automatically so that transistor Q102 conducts only on positive signal peaks. An output pulse corresponding to the conduction interval of the transistor is obtained at the Q102 collector.

Because the circuit generates output pulses corresponding to the peak amplitudes of input signals, it is ideally suited for generating sync pulses corresponding to the tips of vertical and horizontal pulses of the composite video signal. The sync pulse output of Q102 is applied directly to the base of Q8 when the TRIGGERING SYNC switch is in the TVH position. When the TRIGGERING SYNC switch is in the TVV position, the horizontal sync information is removed from the composite video signal by integrator capacitor C134 and a sync pulse output corresponding to the tip of the vertical blanking pulse is generated. This is also applied to the base of Q8.

## SQUARE WAVE SHAPING CIRCUIT

The square wave shaping circuit is essentially a Schmitt trigger comprised of transistors Q8 and Q9.

This circuit delivers a square wave from its output when the level of its triggering signal is raised to a certain value. The square wave output of this circuit is coupled to a differentiator circuit, where it is turned into the trigger signal to the gate multivibrator.

When switch S106 is in the AUTO position, the gate multivibrator, which normally operates as a bistable multivibrator, turns into an astable multivibrator operating at 40 to 50 Hz. Since this astable multivibrator oscillates weakly, it is easily pulled into synchronization with the input signal to generate the trigger signal for automatic triggering.

## SWEEP CIRCUIT

### GATE MULTIVIBRATOR, MILLER INTEGRATING CIRCUIT AND HOLD-OFF CIRCUIT

The gate multivibrator is a bistable multivibrator comprised of transistors Q10 through Q13, driven under control of the trigger signal from the square wave shaping circuit. The Miller integrating circuit consisting of transistors Q17 through Q20, and the hold-off circuit (transistor Q14) form a dc loop which generates a sweep sawtooth voltage.

The gate multivibrator circuit is set at the threshold of operation by use of the STABILITY control. As soon as the multivibrator receives a trigger signal from the square wave shaping circuit, it inverts the state of its transistors and turns off switching diodes D3 and D4. This charges the time base capacitors in the gate circuit of FET Q17 at a rate which is determined by the combination of the time base capacitors and resistors as selected by the SWEEP TIME/CM control. This charging signal is applied through high impedance FET Q17 to the Miller integrating circuit composed of transistors Q18, Q19 and Q20. This integrating circuit not only amplifies its input charging signal but also inverts the phase of the signal.

The low impedance output circuit of transistor Q20 is fed to horizontal amplifier Q21, from which it is fed as the sweep voltage via Q22 and Q23 to horizontal deflection plates of cathode ray tube.

Part of the Miller integrating circuit output is fed back to one side of the time base capacitors mentioned previously. This enables the capacitors to be charged with constant current, thereby providing the charging waveform with a better linearity.

Another part of the integrating circuit output is coupled through capacitor C14 and diode D5 to hold-off circuit transistor Q14. Hence, the hold-off circuit feeds back the integrating circuit output with a delay to the input of the gate multivibrator until the output reaches a specified level. It then inverts the state of the transistors of the gate multivibrator to their original condition to complete the sweep.

#### HORIZONTAL AMPLIFIER CIRCUIT

The horizontal amplifier circuit consists of emitter follower Q21 and differential amplifier transistors Q22 and Q23.

The sawtooth wave output from the Miller circuit is applied to emitter follower Q21. The output of the emitter follower is fed to the differential amplifier.

The differential amplifier circuit contains variable resistor VR6 (MAG CENT) which is in the base circuit of transistor Q23. VR6 balances the DC output voltages of the amplifier which may be unbalanced when the magnification is switched from the X1 position to the X5 positions or vice versa. The amplifier also contains variable resistor VR7 (◄► POSITION) which provides horizontal position adjustment of the sweep.

The magnification switch (push-pull switch on ◄► POSITION control) selects gain adjustment variable resistors VR8 (GAIN ADJ) or VR9 (MAG ADJ), inserted in the emitter circuit of transistors Q22 and Q23. Each resistor is adjusted for specified horizontal amplifier gain of X1 and X5.

When external sweep operation is used, the signal is fed from the EXT SYNC/HOR terminal to variable resistor VR105b (VARIABLE/HOR GAIN). The output

of variable resistor VR105b is applied to FET Q16, the output of which is then applied to the horizontal amplifier circuit.

Variable resistor VR4 (POS ADJ 2) is provided to adjust the dc voltage of the external signal to the same level as the mean voltage of the internal sweep signal at the center of cathode ray tube scope about its horizontal position. The horizontal amplifier provides a deflection sensitivity of 300 mV/cm and a frequency band of dc to 800 KHz (−3 dB).

#### CALIBRATION VOLTAGE CIRCUIT

The calibration voltage circuit consists mainly of a 1 KHz multivibrator and a Schmitt trigger circuit.

The 1 KHz multivibrator (transistors Q1 and Q2) delivers its 1 KHz output to the Schmitt Trigger circuit (transistors Q3 and Q4).

The Schmitt trigger circuit converts the 1 KHz output of the multivibrator into a square wave signal. Thus, a calibration voltage of 5Vp-p is delivered to the CAL terminals.

#### POWER SUPPLY CIRCUIT

The ac source voltage is applied to the primary winding of the power transformer.

The high voltage induced across the secondary winding is rectified by voltage doubler rectifiers D101 and D102 which provide high voltage for the cathode ray tube.

The voltage induced across the low voltage secondary winding of the transformer is rectified by diodes D103, D104, D9 and D10 to provide the B+ supply voltage.

The low voltages for the vertical and horizontal amplifiers are supplied by stabilizing the B+ supply voltage through regulator transistor Q24 and Zener diode D7.

### MAINTENANCE AND CALIBRATION

**WARNING:** Voltages as high as 1600 volts are present on the cathode ray tube and in the power supply circuits. Use extreme caution when the cabinet is removed from this instrument.

#### HOUSING REMOVAL

(See Figure 41)

1. Remove the two screws from the lower rear corners of the housing.
2. Remove the screw on the underside of the housing. This screw is located at the rear center of the housing.
3. With the oscilloscope located on a flat surface, push the chassis forward, applying pressure on the chassis at the cut-out at the rear of the housing. Carefully apply pressure until the front panel flange clears the front of the housing.
4. Supporting the front panel and chassis assembly at the lower edge of the front panel, pull forward until the chassis clears the housing.

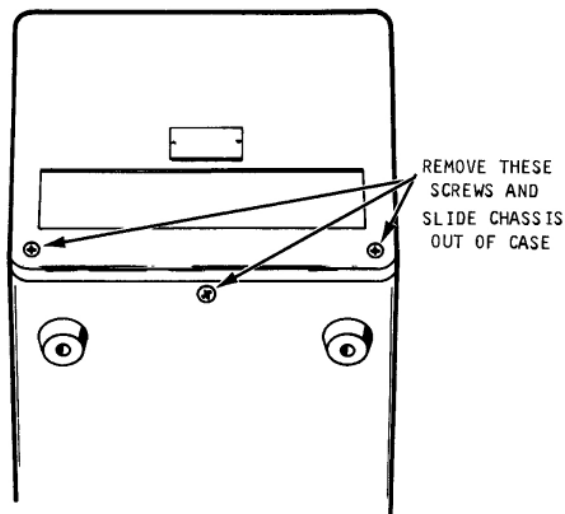


Figure 41. Housing Removal

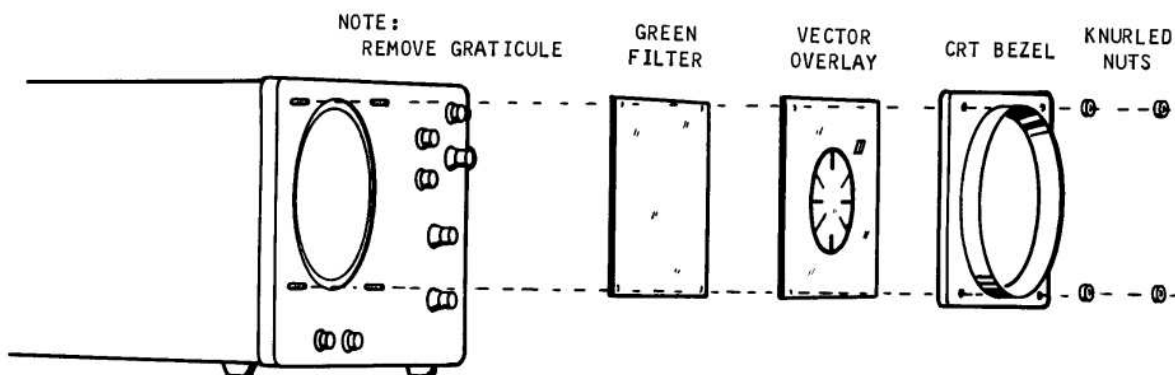


Figure 42. Graticule Removal and Replacement

### GRATICULE REMOVAL AND REPLACEMENT

(See Figure 42)

Two bulbs, located behind the bezel illuminate the scale. To replace these bulbs:

1. Remove all four bezel retaining nuts.
2. Lift off the bezel.
3. Lift off the scale.

### SCALE ILLUMINATION LAMP REPLACEMENT

1. Remove chassis from case.
2. Remove bezel and graticule.
3. Gently push on bulb from front of unit until it is free of retaining grommet.
4. Unsolder wires and replace bulb.

### CRT POSITIONING

Checking proper positioning as follows:

1. Set the AC-GND-DC switch to GND.
2. Set the TRIG LEVEL control fully counterclockwise to AUTO.
3. Adjust intensity and FOCUS controls for fine trace on CRT.
4. Adjust  $\blacklozenge$  POSITION control to place trace in center of CRT.
5. The trace should align exactly with the center horizontal marker scale.

If the trace on the CRT is not in alignment with the horizontal scale, correct it as follows:

1. Remove the oscilloscope chassis from the case as outlined previously.
2. Loosen the screws in the mounting clamps over the neck of the CRT. (See Figure 43).
3. Turn CRT for proper alignment of trace with scale.
4. Tighten CRT clamping screws. Tighten evenly to keep CRT properly positioned.

### CLEANING AND REPAIRING

As with any piece of equipment using high voltages, the electrical charge tends to capture some dust particles from the air. An occasional cleaning to remove the dust accumulation will allow components to operate cooler and give longer life. Use a soft brush and be careful not to disturb components.

If the oscilloscope does not operate properly, double check that all operator's controls have been properly set. If trouble persists, the malfunction may be isolated by conventional troubleshooting techniques including voltage and resistance checks. Compare voltage readings with those on the schematic diagram. Please refer to the Warranty Service Instructions on the last page of this manual if the reason for the malfunction cannot be determined.

### DC BALANCE ADJUSTMENT

1. Place the AC-GND-DC switch in the GND position.
2. Set the vertical VARIABLE control fully counterclockwise.
3. Adjust the  $\blacklozenge$  POSITION control to center the trace over the center horizontal line on the scale.
4. Now, turn the vertical VARIABLE control fully clockwise. If the trace shifts its position, return it to its original position with the DC BAL adjustment (screwdriver adjustment on the front panel).
5. Repeat steps 2, 3, and 4 until the trace remains stationary as the vertical VARIABLE control is rotated from one extreme to the other.

### ASTIGMATISM ADJUSTMENT

1. Adjust controls to display a stable horizontal line on the face of the CRT.
2. Adjust the INTENSITY and FOCUS controls for as fine a trace as possible.
3. Adjust the ASTIG adjustment (screwdriver adjustment on front panel) for the finest trace.

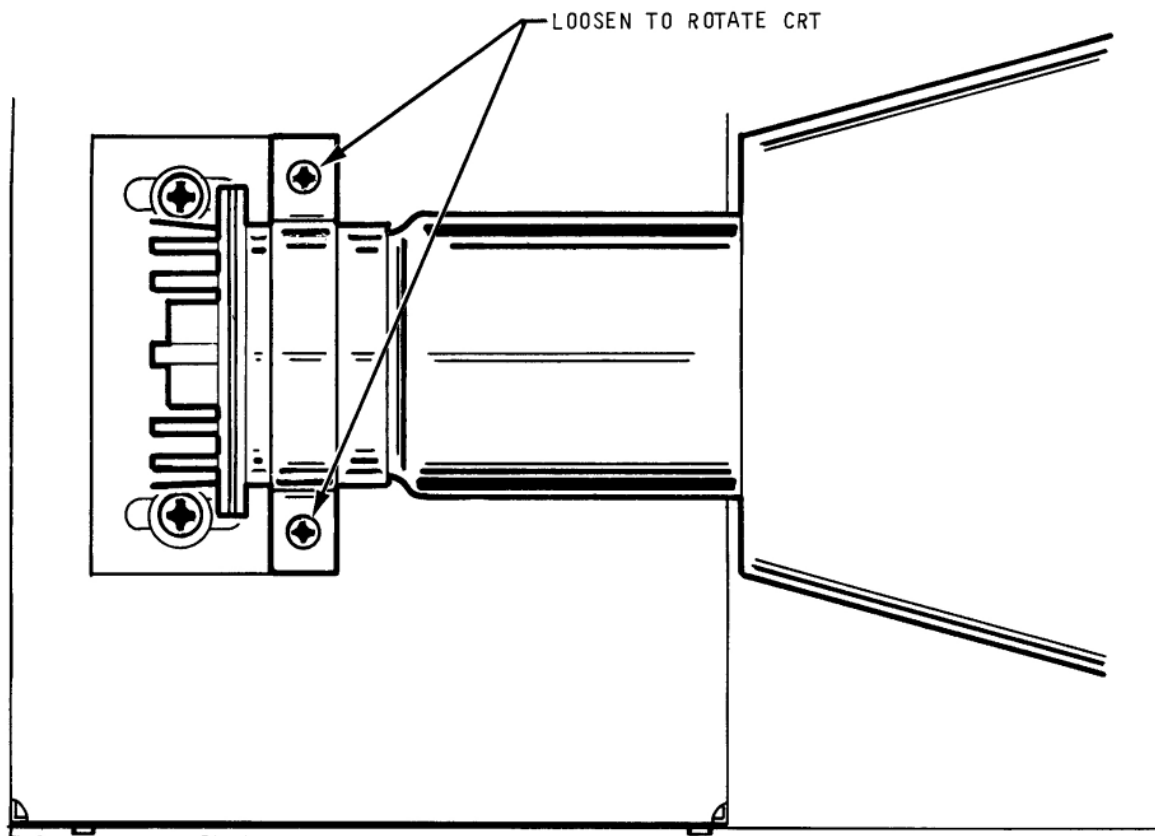
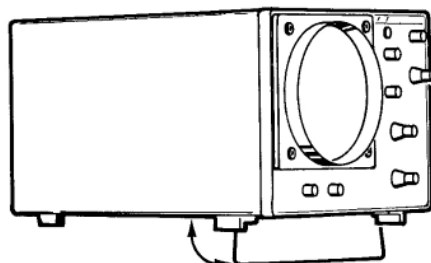


Figure 43. CRT Positioning

#### VERTICAL CALIBRATION

1. Set the VOLTAGE/CM control to the .1 V/cm position.
2. Set the vertical VARIABLE control fully clockwise to the CAL position.
3. Connect the probe cable to the V INPUT receptacle and set the probe for 10:1 attenuation.
4. Connect the tip of the probe to the CAL  $\square$  jack so that the 5V<sub>p-p</sub> square wave is displayed on the oscilloscope.
5. Adjust the sync and sweep speed controls to display two full cycles of the square wave signal.
6. The vertical amplitude of the display should be exactly 5 cm. If calibration is required, remove the oscilloscope from the case and adjust variable resistor VR1 (GAIN ADJ) for exactly 5 cm vertical deflection. VR1 is an internal adjustment located on the vertical amplifier printed circuit board. This board is horizontally located in the upper right-hand portion of the oscilloscope assembly.

#### Model 1460 with Tilt Stand



Tilt stand included under unit.  
Pull wire foot down to tilt unit.



SCHEMATIC  
SYMBOL

SYMBOL	DESCRIPTION	B & K PART NO.
C106	15pF, 5%, 500WV Disc. Ceramic Capacitor	020-086-9-002
C113, 114	100pF, 5%, 50WV Disc. Ceramic Capacitor	020-096-9-006
C122	120pF, 5%, 50WV Disc. Ceramic Capacitor	020-103-9-001
C112	1000pF, 20%, 50WV Disc. Ceramic Capacitor	020-096-9-007
C111	2200pF, 20%, 50WV Disc. Ceramic Capacitor	020-096-9-008
C110	0.02μF, 20%, 50WV Disc. Ceramic Capacitor	020-096-9-009
	Packing Case (Inside)	500-185-9-001
	Buffer, Protection	502-069-9-001
	VERT. AMP PC BOARD (X73-1051-60)	
	Peaking Coil, 28μF	041-046-9-001
Q1	Transistor, FET	182-021-9-001
Q2, 3	Transistor, FET	182-014-9-003
Q4, 5, 6,	Transistor, Silicon NPN	176-016-9-001
Q7, 10, 11	Transistor, Silicon NPN	176-016-9-001
Q8, 9	Transistor, Silicon NPN	176-016-9-001
Q12, 13	Transistor, Silicon NPN	176-028-9-005
Q14, 15	Transistor, Silicon	176-028-9-006
VR4	150Ω, 25%, 0.15W(B) Trim Pot	008-174-9-002
VR3	1KΩ, 25%, 0.15W(B) Trim Pot	008-155-9-005
VR1, 2	2.2KΩ, 25%, 0.15W(B) Trim Pot	008-169-9-007
C11	22μF, 250WV Electrolytic Capacitor	021-038-9-002
C10	47μF, 50WV Electrolytic Capacitor	022-073-9-004
C2, 3, 4, 5	100μF, 16WV Electrolytic Capacitor	022-073-9-002
C9	22pF, 5%, 50V Disc. Ceramic Capacitor	020-103-9-002
C8	47pF, 5%, 50V Disc. Ceramic Capacitor	020-103-9-003
C7	68pF, 5%, 50V Disc. Ceramic Capacitor	020-103-9-004
TC1	70pF, 500V Trimmer Capacitor	028-025-9-001
	HORIZ. AMP. PC BOARD (X65-1031-62)	
D2	Diode, Germanium	150-001-9-005
D1, 4, 6, 3	Diode, Silicon	151-028-9-007
D8	Diode, Silicon	151-028-9-002
D9	Diode, Silicon	151-028-9-003
D11	Diode, Silicon	151-028-9-006
D7, 10	Diode, Zener	152-034-9-001
Q1-4, 6-11, 16	Transistor, Silicon NPN	176-016-9-001
Q17, 21, 23, 25	Transistor, Silicon NPN	176-028-9-007
Q20	Transistor, Silicon NPN	176-028-9-007
Q15	Transistor, Silicon NPN	176-094-9-001
Q18, 19, 12	Transistor, Silicon NPN	176-028-9-008
Q5, Q14	Transistor, FET	182-021-9-001
Q13	Transistor, FET	182-021-9-002
VR8	330Ω, 25%, 0.15W(B) Trim Pot	008-155-9-006
VR6, VR7	1KΩ, 25%, 0.15W(B) Trim Pot	008-169-9-006
VR1	2.2KΩ, 25%, 0.15W(B) Trim Pot	008-169-9-007
VR4, 5, 11	10KΩ, 25%, 0.15W(B) Trim Pot	008-155-9-004
VR2, 3, 10	47KΩ, 25%, 0.15W(B) Trim Pot	008-155-9-003
VR12	100KΩ, 25%, 0.15W(B) Trim Pot	008-155-9-001
C10, C11	10μF, 25WV Electrolytic Capacitor	022-086-9-005
C14, C38	100μF, 16WV Electrolytic Capacitor	022-073-9-002
C29, 30, 32, 39	220μF, 50WV Electrolytic Capacitor	022-073-9-006
C27, C31	470μF, 16WV Electrolytic Capacitor	022-073-9-003
C28	100μF, 50WV Electrolytic Capacitor	022-073-9-007
C14, C38	100μF, 16WV Electrolytic Capacitor	022-073-9-002
C2	1μF, 50WV, Non-Polarilytic Capacitor	034-003-9-001
C12	0.022μF, 20%, 50WV Poly. Film Capacitor	025-073-9-002
C34	22pF, 10%, 1.6KWV Mica Capacitor	023-035-9-001

NOTE: Standard value resistors and capacitors are not listed, values may be obtained from schematic diagram.  
Minimum charge \$2.00 per invoice. Orders will be shipped C.O.D. unless previous open account arrangements have been made or remittance accompanies order. Advance remittance must cover postage or express charge.

SPECIFY SERIAL # WHEN ORDERING REPLACEMENT PARTS.

RR-WERNER

## B &amp; K PRECISION MODEL 1460

488-121-9-001

## PARTS LIST

SCHEMATIC  
SYMBOL

SYMBOL	DESCRIPTION	B & K PART NO.
	Case	272-082-9-001
	Green Filter	380-137-9-003
	Graticule	380-137-9-002
	Vectorscope Overlay	482-022-9-001
	Lamp	400-026-9-001
	Instruction Manual	480-133-9-001
	Binding Post, Dual 3/4" C/C	773-037-9-001
	Line Cord, 3 Wire, UL/CSA Approved	420-013-9-001
	Fuse Lamp 3AG (0.5A)	191-251-3-003
	Enclosure, Switch	253-022-9-001
	Leg, Metal	381-052-9-001
	Leg, Mold	381-052-9-002
	Leg, Rubber (Foot)	381-049-9-001
	Escutcheon (Bezel)	380-137-9-001
	Fuse Holder	742-012-9-001
	Handle (Grip), Carrying	746-018-9-001
	Bracket, Handle	251-087-9-005
	Knob (Gray), VOLTS FULL SCALE, SWEEP TIME C/M	751-077-9-001
	Knob (Gray), Controls	751-077-9-002
	Knob (Gray), STABILITY	751-077-9-003
	Knob (Black), VARIABLE HOR GAIN, TRIG LEVEL, VARIABLE	
	VOLTAGE/CM	751-077-9-004
	Power Transformer (L03-0077-05)	065-079-9-001
	Rotary Switch	083-117-9-002
S103a-g, VR107ab, VR102, S102	Rotary Switch	083-142-9-001
S106	Slide Switch	084-022-9-002
S101, 104	Slide Switch	084-022-9-001
105ab	Slide Switch	084-022-9-001
S111	Slide Switch, UL Approved	
	S31-2004-05 (M1)	084-030-9-001
	CRT	230-005-9-001
D101, 102	Diode, Silicon	151-033-9-001
D103, 104	Diode, Silicon	151-028-9-006
C116	3.3μF, 25WV Electrolytic Capacitor	022-087-9-001
C125	1μF, 250WV Electrolytic Capacitor	021-041-9-001
C128	47μF, 315WV Electrolytic Capacitor	023-038-9-001
C108, 107	1μF, 50WV, Non-polarilytic Capacitor	034-003-9-002
C127abc	47μF, 315WV 3-section Electrolytic Cap. Block	021-038-9-001
C117	1μF, 1%, 100V Metallized Film Capacitor	025-056-9-001
C118	0.1μF, 1%, 100V Metallized Film Capacitor	025-056-9-002
C119	0.01μF, 1%, 100V Metallized Film Capacitor	025-056-9-003
C102	33pF, 5%, 125WV Polystyrene Capacitor	030-019-9-001
C103	330pF, 5%, 500WV Polystyrene Capacitor	030-017-9-005
C104	3300pF, 5%, 50WV Polystyrene Capacitor	030-017-9-008
C121	90pF, 5%, 500WV Mica Capacitor	023-038-9-001
C120	1000pF, 1%, 500WV Mica Capacitor	023-028-9-003
C109	0.22μF, 10%, 50WV Poly. Film Capacitor	025-056-9-006
C123	0.033μF, 10%, 50WV Poly. Film Capacitor	025-073-9-001
C101	0.1μF, 10%, 630V Oil Capacitor	024-002-9-001
C126abede	0.5μF, 1.5KV 5-section Oil Capacitor	024-002-9-002
TC102, 104, 106, 109	10pF, 500V Trimmer Capacitor	028-020-9-004
TC101, 103, 105	10pF, 500V Trimmer Capacitor	028-020-9-004
C124	2pF, ±0.25pF, 500WV Disc. Ceramic Cap.	020-096-9-001
C105	5pF, ±0.5pF, 50WV Disc. Ceramic Capacitor	020-086-9-001
C128	10pF, ±0.5pF, 50WV Disc. Ceramic Capacitor	020-096-9-004

COMPOSITE  
499-046-9-001



