LEADER

40MHz OSCILLOSCOPE
60MHz OSCILLOSCOPE

INSTRUCTION MANUAL

LBO-314
LBO-315

LEADER ELECTRONICS CORP.

TABLE OF CONTENTS

Note:
This instruction manual covers both the LBO-314 and the LBO-315. Parts that pertain only to the LBO-315 are enclosed in brackets [ ].

1. INTRODUCTION

The LBO-314 [315] is a 5 mV/6 div (40MHz [60 MHz] and 1 mV/div (5 MHz) portable oscilloscope that offers a maximum sweep rate of 20 ms/div (MAG x 10) and a delayed sweep function. It features a metal-back 95 mm rectangular rear-accelerated CRT for high-brightness, sharply defined display. The LBO-314 [315] is extremely portable since it can be operated using one of three defferent free-voltage power sources: 85-246 VAC without switching, EXT 10-20 VDC, and a Ni-Cd battery (with a built-in charging circuit). Due to a variety of convenient functions, such as a TV sync separator and variable hold-off, the LBO-314 [315] is particularly effective when used in the production and servicing of TV receivers, VCRs, and computers.

2. SPECIFICATIONS

CRT Display	
Type	95 mm Rectangular, Internal-graticule Scale, Aluminized Screen and Flat Face with illumination lamp [LBO-315] and Percentage scale.
Accelerating Potential	12 kV/2 kV regulated
Effective display area	8 x 10 div. (1 div. = 6.35mm)
Beam Rotator	Adjustment on front panel
Intensity Modulation	Blanked by TTL Level Signal
Graticule Illumination	AC operation only [LBO-315]
Vertical Amplifier (CH1 and 2)	
Sensitivity	5 mV/div. to 5 V/div. (all bandwidth), 1 mV/div. to 2 mV/div. (5 MHz: MAG x 5) with variable in 10 steps, 1-2-5 sequence, continuously variable between steps.
Calibration Accuracy	±3% (±5%: MAG x 5)
Bandwidth (−3 dB, ref. 8 div.)	
DC coupled	DC to 40 MHz [60 MHz] (DC to 5MHz: MAG x 5)
AC coupled	10 Hz to 40 MHz [60 MHz]
Rise Time	8.8 ns [5.8 ns] (70 ns: MAG x 5)
[Signal Delay Time	Approx. 20 ns on CRT face]
Input Impedance	1 MΩ ± 1.5%, 30 pF within ± 5pF (Tolerance: within ± 2 pF)
Input Coupling	AC, GND, DC
Maximum Input	400 V (DC + ACp-p)
Display Modes	CH 1, CH-2, CHOP, ALT, ADD
Polarity Invert	CH 2 INVERT
CH 1 Output	Approx. 50 mV/div. into 50Ω (DC to 40 MHz [60 MHz], −3 dB)
Horizontal Amplifier	
Sweep Method	Trigger sweep, Automatic trigger sweep, Continuously delayed sweep, Trigger delayed sweep, and ALT sweep.
A Sweep Time	0.2 μs/div. to 0.2 s/div., 1-2-5 sequence 19 steps with continuous adjuster.
B Sweep Time	0.2 μs/div. to 0.5 ms/div., 1-2-5 sequence 11 steps.
Calibration Accuracy	±3%
Hold-off variable	One sweep or more
Delay Time Jitter	1/10,000
Setting accuracy of delay time position	±3% approx.
Magnifier	10 times ± 5%
Max. Sweep Time	20 ns/div. (MAG x 10 ON)

Synchronization

Signal Sources	ALT, CH 1, CH 2, LINE, EXT.
Coupling	AC, HF-REJ, TV-V, TV-H
Slope	+ or – and VIDEO POL
Sensitivity	

	Bandwidth	INT.	EXT.
NORM	30 Hz ~ 10 MHz 2 Hz ~ 40 [60] MHz	0.5 div. 1.5 div.	0.2 Vp-p 0.6 Vp-p
AUTO	30 Hz ~ 10 MHz 30 Hz ~ 40 [60] MHz	0.5 div. 1.5 div.	0.2 Vp-p 0.6 Vp-p

TV Synchronization	Extracts the synchronizing signal from composite video signal and provides stable synchronization. Slope switch is selected according to polarity of video signals. If the main sweep (A TIME) is synchronized to TV-V, under B triggering (B TRIG'D) the magnified sweep (B TIME) is automatically synchronized to TV-H.

X-Y Mode (X = CH 1, Y = CH 2)

Sensitivity	X axis: 5 mV/div. to 5 V/div. Y axis: 5 mV/div. to 5 V/div.
X axis Bandwidth	DC or 10 Hz to 1 MHz (–3 dB, ref. 8 div.)
X-Y phase	Less than 3° at 100 kHz

Calibrator

Output Voltage	0.5 Vp-p ±2%
Frequency	Approx. 1 kHz, square wave

Power Requirements

Line Voltage	AC; 85 to 264V Ext. DC: 10 to 20V Battery: LP-2071 or NP-1A
Power Consumption	AC23W [26W] (Need additional 7W during battery DC16W [16W] charging)
Size and Weight	230(W) x 75(H) x 290(D) mm, 4.7 (with battery)
Supplied Accessories	Direct/Low capacitance probe LP-16BX [LP-060X] . . . 2 BNC terminal adapter . . . . 2 Time lag fuse (4A/0.8A) . . . . 2 Battery pack LP-2071 . . . . 1 DC plug (with 1m lead) . . . . 1 Instruction manual . . . . 1 (Hood . . . . 1 Carring case (U.S.A. only) . . . . 1 Attache case (except U.S.A.) . . . . 1 Front cover (U.S.A. only) . . . . 1)
Optional Accessories	Carrying Case (with front cover) Hood

3. NOTES ON OPERATION

3.1 Power Source Voltage

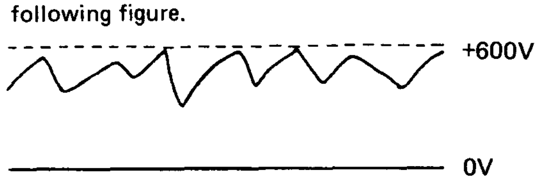
Select the appropriate supply voltage according to the rated specification. A supply voltage lower than that specified may inhibit correct LBO-314 [315] operation. Coversely, a supply voltage higher than that specified could cause the power supply unit to overheat. Therefore, be sure to check the voltage ranges and fuse ratings indicated on the rear panel of the unit.

3.2 Signal Input

A voltage higher than 400V (ACp-p + DC) applied to the VERT. Input, or Trig. Input or the low capacitance probe may damage circuit components.

Vertical input terminal
INPUT ⑯ , ⑳ MAX 400V (ACp-p + DC)
External synchronizing signal
input terminal
TRIG. IN ㉚ MAX 400V (ACp-p + DC)
Probe input (LP-16BX [LP-060X])
MAX 600V (ACp-p + DC)

The value of 600V (ACp-p + DC) is shown in the following figure.



3.3 Influence of Strong Magnetic Field

Operation in a strong magnetic field will cause distortion or swing of display waveforms or make an excessive decline of traces when the instrument is used near an equipment or transformer of large power consumption. Therefore avoid to use the instrument near such a magnetic field source.

3.4 Operation in a Hot and Humid Place

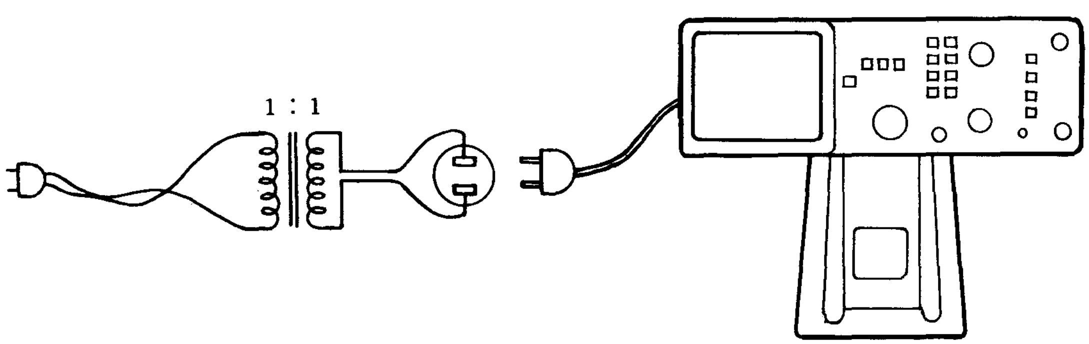
The instrument is designed to operate in a temperature range of 0°C to +40°C and relative humidity range of 10 to 90%. Operation in a severe environment may shorten the life of the instrument.

3.5 Intensity of CRT

Burn-resisting flourescent (phosphor) material is used in the CRT. But if the CRT is left with a bright dot or trace, or with unnecessarily raised intensity, its fluorescent screen may be damaged. When observing waveforms, therefore, the intensity should be maintained at the minimum necessary level. If the instrument is to be left with the power on for a long period of hours, lower the intensity and obscure the focus.

3.6 Notes on Connection with a Trans-less Equipment

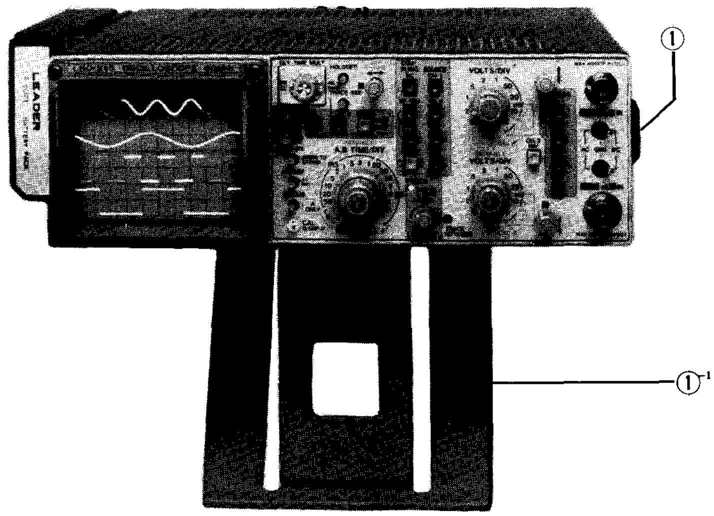
The chassis of a trans-less equipment may be applied with the primary power line voltage. When the oscilloscope is connected with such an equipment, care must be taken for the electric shock which is hazardous.
Particularly when the system is grounded to the earth for the measurement of C-MOS circuits or the like, the instrument in the system or the device to be tested may be damaged by shorted circuit.
The safest method of making the connection is to use an isolation transformer of 1:1 ratio as shown below.

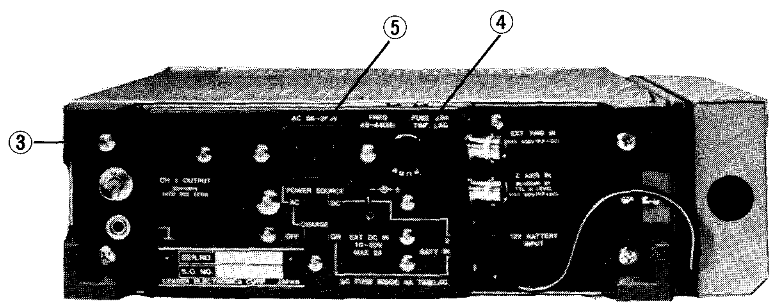


4. DESCRIPTION ON PANEL

In this instruction manual, numerals in circles indicate control knobs, switches, and the like.

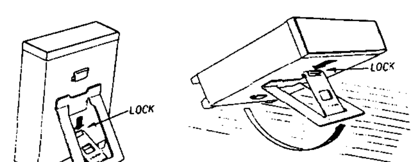
4.1 General Appearance

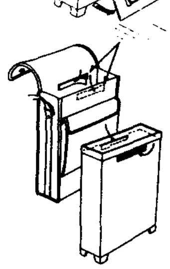




① **Hand carrier:**

①-1 **Tiltstand & Leather Case**





(1) Firstly put an oscilloscope into an carrying case in correct position.

(2) Then remove the papers covering adhesive fasteners inside the carrying case and push the sames from both sides so that the adhesive fasteners may be adhered to the oscilloscope as illustrated.

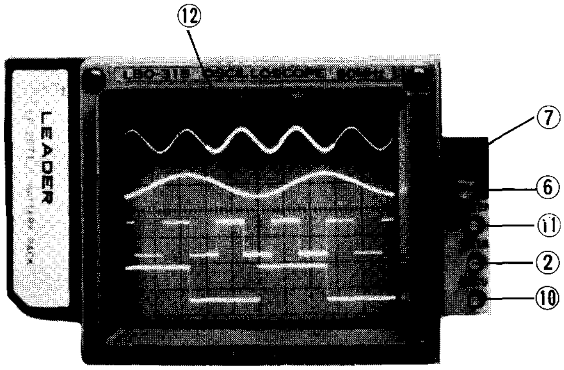
(3) Afterwards the magic fasteners work for fastening the oscilloscope in the carrying case and for removing it from the carrying case.

③ **Legs for vertical viewing:**
These are legs for vertical viewing.

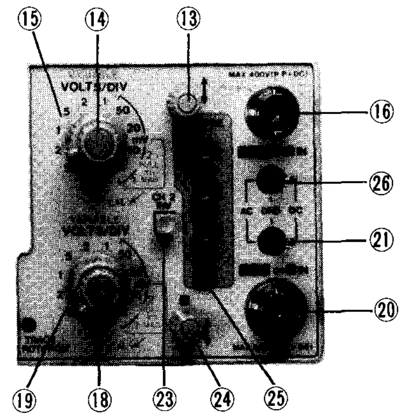
④ **FUSE:**
When the cap is turned to the counter-clockwise direction with plus-type screw-driver, the fuse can be removed. Note the type and rating of the fuse used.

⑤ **AC inlet:**
The supply voltage can be selected from 85 to 264 VAC without switching. Use this connector with POWER SOURCE ㊺ set to AC.
Note the rating voltage to be applied.

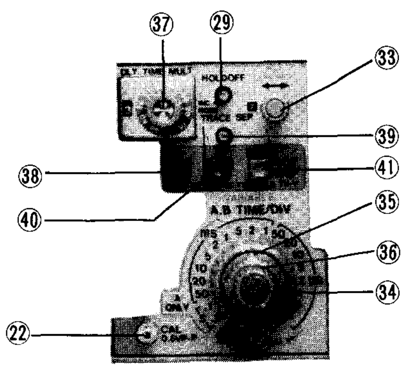
≪ Display Block ≫



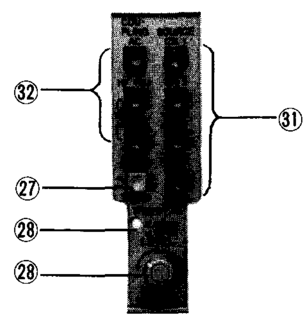
≪ Vertical Blcok ≫



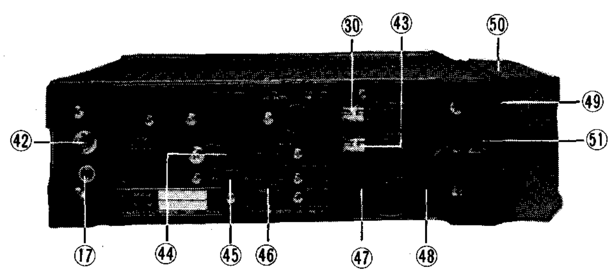
≪ Sweep Block ≫



≪ Synchronizing Block ≫



≪ Rear Panel Block ≫



4.2 Layout of Controls

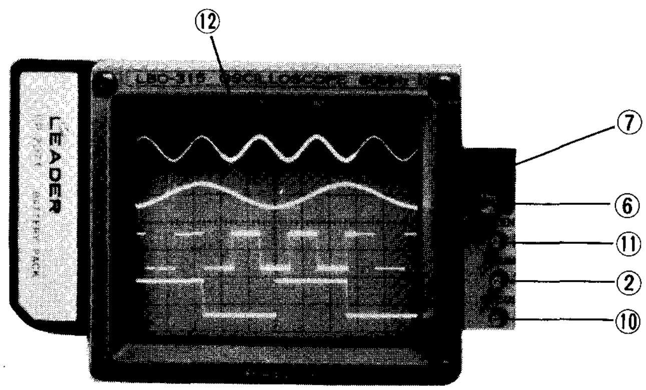
The descriptions of the controls are keyed to the numbers shown below. The following sections explain the controls in the numbered order.

4.3 Display Block

② **ILLUM.:**
Provides illumination on the scales for easy scale and trace readings. Clockwise rotation of the knob increases scale line brightness.

⑥ **Power ▬ ON/ ▙ OFF switch:**
Power supply switch. Push to turn power on and pilot lamp ⑦ will go on. Push again to turn power off. Because this is a nonlocking switch, do not leave the switch on.

⑦ **Pilot lamp:**
The lamp will light in green when power is turned on. It will start flashing on and off in case the supply voltage drops below a specified limit. The lamp will light in red when the battery is being charged or will light in organge during battery charging while operating the unit.



⑨ **⊘ ROTATION control [Sync Block]:**
Adjust the ROTATION screw adjuster using a screwdriver, when the trace line is not horizontal.

⑩ **FOCUS control:**
To attain maximum trace sharpness.

Push this control to the out position to use, and in when it is not needed.

⑪ **INTEN control:**
To adjust the overall brightness of the CRT display. Clockwise rotation increases brightness.

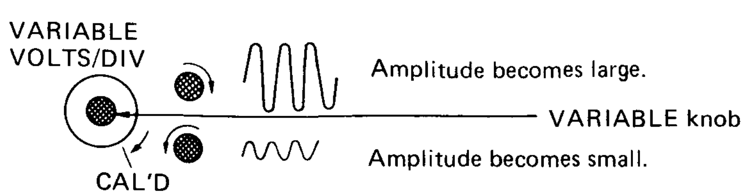
Push this control to the out position to use, and in when it is not needed.

⑫ **Graticule:**
Located inside the CRT: 8div. vertically, 10div. horizontally (1div. = 6.3mm); fine 0.2div. graticule in the center.
Vertical voltage sensitivity and horizontal sweep time are adjusted in VOLTS/DIV and TIME/DIV with reference to the graticule.
Additional 10% and 90% markings are used to measure signal rise and fall times.

4.4 Vertical Block

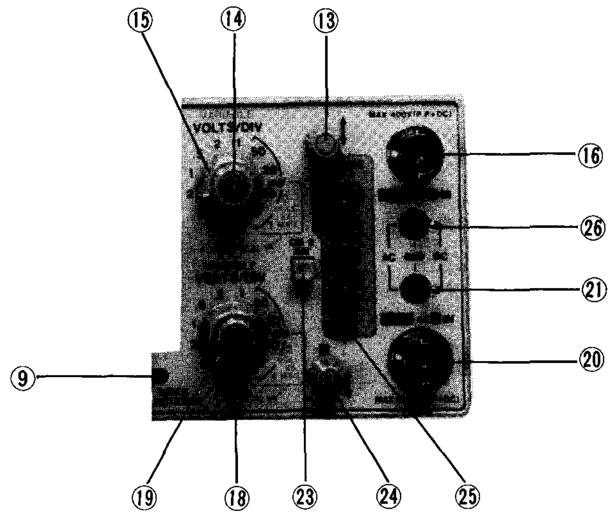
⑬ **↕ (Vertical position adjustment)**
With the knob turned clockwise, the waveforms of CH 1 move upward. When the knob is turned counterclockwise, the waveforms move downward.

⑭ **VARIABLE (CH 1 or [X] sensitivity fine adjuster), PULL x 5:**
Are the vertical sensitivity fine adjusters capable of continuously attenuating from each VOLTS/DIV range indication value to less than 1/2.5 of the value selected.
In voltage measurements, the VARIABLE knob should be turned full clockwise to the CAL'D ↻ position.



When the knob is pulled, the sensitivity is magnified by a factor of 5. In this case, noises increase and the frequency band is squeezed to a bandwidth of 5 MHz.
When the super high sensitivity (1mV/div.) is not required, keep the knob pushed-in.

≪ Vertical Block ≫



⑮ **VOLTS/DIV (CH-1 or [X] sensitivity switch)**
This is a knob for switching the sensitivity of the input signal fed to CH 1 ⑯. Switching action is accomplished in 10 steps from 5mV/div to 5V/div. On X-Y operation, the knob functions to change the sensitivity of the X-axis.
To measure by the use of the indicated voltage sensitivity, be sure to set the VARIABLE ⑭ (red knob) to CAL'D by turning it fully clockwise until it clicks. If the signal is applied to the input terminal ⑯ by the use of a 1/10 low capacitance probe, the values are ten times the indicated voltage.

⑯ **CH 1 or [X] IN:**
This is an input plug for use with the CH 1 vertical amplifier and X-axis (horizontal axis) amplifier during X-Y operation. Caution not to exceed maximum permissible input voltage, 400V (ACp-p + DC).

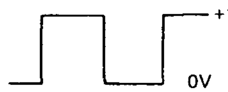
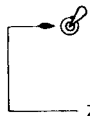
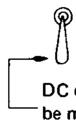
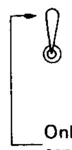
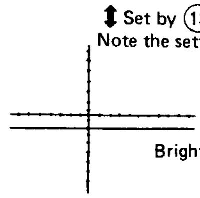
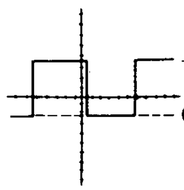
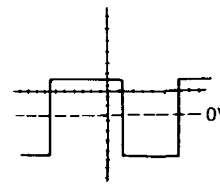
⑰ **⊥ Ground terminal [Rear Panel]:**

⑱ **VARIABLE (CH-2 or [Y] sensitivity fine adjuster), PULL x 5:**
The same as item ⑭ above for CH 2.

⑲ **VOLTS/DIV (CH 2 or [Y] sensitivity switch):**
This is a knob for switching the sensitivity of the input signal fed to CH 2 ⑳. Switching action is accomplished in 10 steps from 5mV/div to 5V/div. On X-Y operation, the knob functions to change the sensitivity of the Y-axis.
To measure by the use of the indicated voltage sensitivity, be sure to set the VARIABLE ⑱ to CAL'D by turning it fully clockwise until it clicks. If the signal is applied to the input terminal ⑳ by the use of a 1/10 low capacitance probe, the values are ten times the indicated voltage.

⑳ **CH 2 or [Y] IN:**
This is an input plug for use with the CH 2 vertical amplifier and Y-axis (vertical axis) amplifier during X-Y operation. Caution not to exceed maximum permissible input voltage, 400V (ACp-p + DC).

㉑ **AC-GND-DC (Alternating Current-Ground-Direct Current Switch), CH 2:**
Switches the coupling of the signal fed to the vertical axis input ⑳. DC coupling is obtained on the DC position, on AC position the direct current component is blocked by a capacitor. The GND position grounds the input of the amplifiers and opens the input terminal ⑳. An example of display at each switching position (AC-GND-DC) is shown by the following table.

Input signal	 Symmetrical square wave		
Position of switch (21) (26)			
Waveform and its position on the screen			

(22) **CAL 0.5Vp-p (Calibration wave) ≪ Sweep Block ≫:**
Signal output terminal for amplitude and probe calibration. Frequency is 1kHz approx.

(23) **CH 2 POL INV (CH 2 Polarity inversion switch):**
Set at (push-out) for normal operation. At INV (inversion) (push-in), the polarity of the signal applied to CH 2 will be inverted.

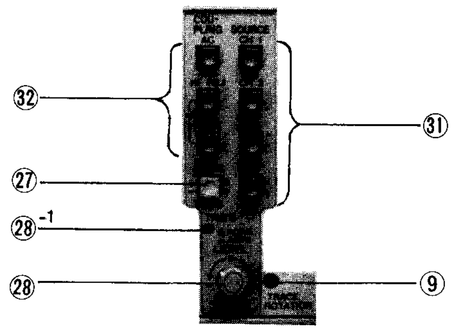
(24) **[Y] ↕ (Vertical position adjustment):**
Clockwise rotation will move pattern up, and counterclockwise rotation will move pattern down.

(25) **VERT MODE**
Selects the single- or dual-trace mode.
CH 1:
Only the channel-1 signal is displayed. To trigger the sweep on the internal signal, set the TRIG SOURCE switch (31) to CH 1. For high-sensitivity external triggering, set the switch (31) to CH 2 and apply the trigger signal to channel 2.
CH 2:
Only the channel 2 signal is displayed. To trigger the sweep on the internal signal, set the TRIG SOURCE switch (31) to CH 2. For high-sensitivity external triggering, set the switch (31) to CH 1 and apply the trigger signal to channel 1.
CHOP (high-speed chopped trace):
Dual-trace display. The beam is switched at high speed by an approximate 250kHz rectangular wave, regardless of the main sweep (A TIME), resulting in a chopped display. AT low-speed sweep ranges of 0.5ms/div and below, the chopping is barely detectable – both traces look continuous.
ALT (Alternate trace):
Dual-trace display. The display alternates between channels 1 and 2 on each main sweep (A TIME). In high-speed sweep ranges of 0.5ms/div and above, no flicker is detectable.
ADD: (CH1 & CH2 are pushed simultaneously)
Single trace, indicating the algebraic sum of the inputs on channels 1 and 2. If the CH 2 INV switch (23) is pressed to invert channel 2, the algebraic difference is displayed.

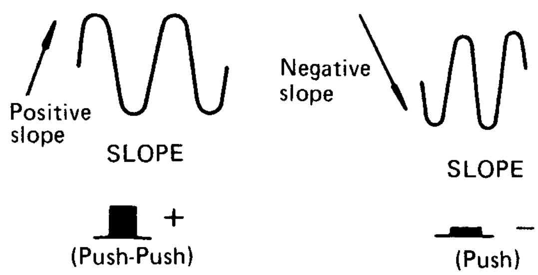
(26) **AC-GND-DC (Alternating Current-Ground-Direct Current Switch), CH 1:**
The same as item (21) above for CH 1.

4.5 Synchronizing Block

≪ Synchronizing Block ≫



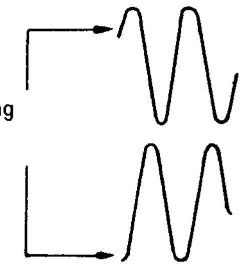
(27) SLOPE +/−, TV POL. (synchronization slope, TV polarity):
When triggered sweep is required with a positive slope of a waveform on the screen, select (+); and with a negative slope, select (−). You may select either one which is convenient.



Besides, this SLOPE switch also functions to switch the polarity for extraction of (32) TV Synchronization.
Please refer to (32)

(28) LEVEL − 0 +, PULL NORM, PUSH AUTO:
Set the knob to a convenient position for the starting of triggered sweep of the A TIME (main sweep). In this case, when the setting value is out of changing portion of the observation waveform, the synchronization sweep stops.
When the trigger mode is set to the PULL NORM position, the waveform on the screen disappears. At the PUSH AUTO position, the trace will flow.

Adjust the starting point by the LEVEL knob.

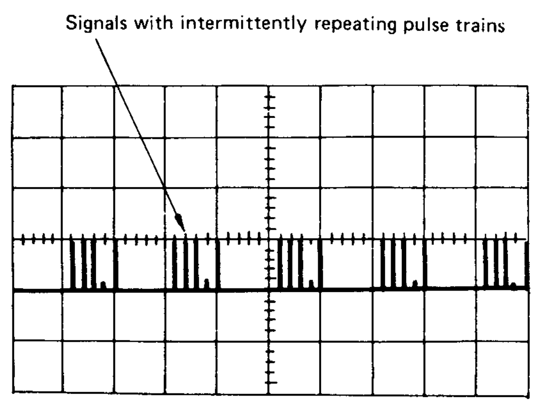


(28)-1 TRIG'D LAMP:
Indicates when the sweep generator is being triggered.

(29) A HOLDOFF (variable knob) ≪ Sweep Block ≫:
Adjusts holdoff (pause) time of the A TIME (main sweep). Pause time becomes longer when the knob is turned to the clockwise (↻ INC) direction, and the brightness of the display decreases.
Normally, turn this control fully left to NORM.

Push this control to the out position to use, and in when it is not needed.

When the pulse train is to be synchronized as shown in the figure below, the knob is turned to an appropriate position where the display stops still. (In this case, if the A VARIABLE (34) is turned to keep the display still, the time measurement is not possible because the A TIME is in UNCAL (35) condition.)



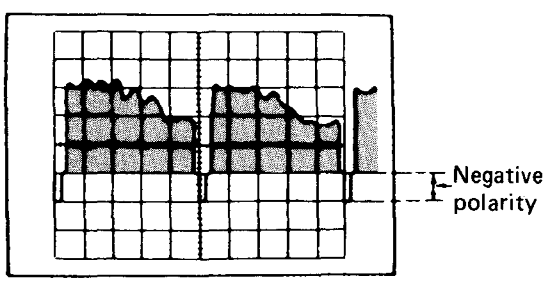
(30) EXT. TRIG. INPUT ≪ Rear Panel ≫:
Is the input terminal for external synchronization signals. As the input amplifier is in DC coupling, the DC component should be eliminated by a capacitor (about 0.1μF), when the input AC signal is superposed on

DC of more than ±5V. Further, care must be taken not to apply a voltage exceeding the maximum allowable input voltage, 400V (ACp-p + DC).

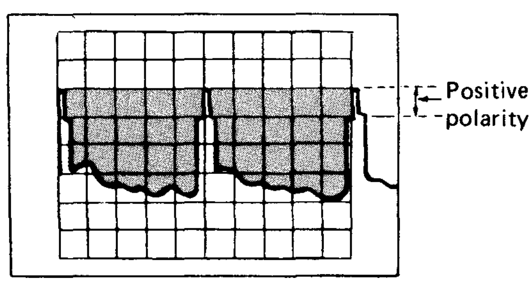
(31) **SOURCE:**
Selects the synchronization signal source as follows:
ALT:
Alternatively extracts the vertical input signals of the CH 1 and CH 2 for the synchronization. In this case, the VERT MODE (25) must be set to ALT. When the VERT MODE is set to CH 1, CH 2, or ADD, synchronization is available by setting the SOURCE to ALT. (For the ADD, the synchronization is made with the CH 2.)
CH 1:
The vertical input signal of CH 1 is extracted for the synchronization.
CH 2:
The vertical input signal of CH 2 is extracted for the synchronization.
LINE trigger (power synhcronization):
The power supply signal is used as the synchronization signal source of the A TIME.
Used to observe the ripple of a rectified power supply.
EXT. TRIG. (external synchronization):
Is used to externally apply the synchronization signal.

(32) **COUPLING:**
Selects coupling of synchronization signal as follows:
AC:
Is selected when synchronization is to be made with an AC signal of 2Hz to 40 [60] MHz. Normally, AC coupling is selected. However, when synchronization is to be made with a signal of low frequency, lower than 30Hz, the LEVEL knob (28) should be pulled to set to the PULL NORM position.
HF REJ:
For measurement of a waveform of less than 10kHz, which includes noises and parasitic oscillation of signals higher than about 100kHz, this HF REJ is used to eliminate the HF components to obtain a stable synchronization.
TV-H / TV-V } Synch separation of TV picture signal:
When the COUPLING is set to one of these modes, synchronization is available from the composite picture signal of TV/VTR to get a stable display, because the similar synch separation circuit as in a TV set is active. The SLOPE (27) setting must be selected according to the polarity of the video signal, as shown below.

SLOPE selection and polarity of video signal sync pulse.



SLOPE −

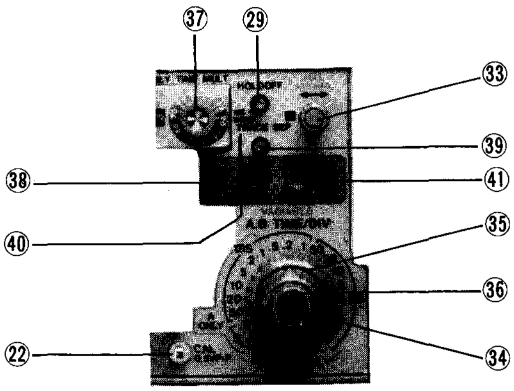


SLOPE +

4.6 Sweep Block

(33) [X] ⟷ **(Horizontal position adjustment)**
PULL x 10 MAG:
Pattern moves to the right with clockwise rotation and to the left with counterclockwise rotation.
On X-Y operation, adjust the horizontal position of the X-axis (CH 1) by this control.
Pulling the knob forward gives a x10 horizontal magnification. Since brightness is diminished, normally the knob should be pushed in. When the A TIME control (35) is set to [X-Y], the sensitivity of the X-axis input (16) is calibrated with this knob (33) pushed in.

≪ Sweep Block ≫



㉞ **TIME VARIABLE (time axis fine adjuster):**
Makes continuously variable fine adjustment between ranges of the A TIME (main sweep) ㉟ . Normally, time measurement is made åt the CAL'D position where the knob is turned fully clockwise.

㉟ **A TIME/DIV (main sweep) time axis knob:**
When the A ㊳ is selected, time measurement is made using this A TIME/DIV. In this case, the red VARIABLE knob ㉞ must be set at the CAL'D position turned fully clockwise. When the ALT SWEEP ㊳ ㊴ is selected, the time between the left end of the A TIME waveform and the left and of the B TIME intensified waveform is referred to as DELAY TIME, and this time is also measured using the A TIME/DIV. The scale value indicating the DELAY TIME equals the indication of the DEL'AY TIME dial ㊲ (see description of item ㊲).
The X-Y position enables the unit to function as an X-Y oscilloscope by using CH 1 as the X-axis.

㊱ **B TIME/DIV (magnified sweep) time axis knob:**
Using this knob, time measurement is made of a waveform magnified by the B ㊵ . VARIABLE knob is not provided for the B TIME.

㊲ **DELAY TIME 10-rotation dial:**
Sets the starting point (delay time) of the B TIME (delayed sweep) against the A TIME (main sweep).
Digits 1 through 0 displayed in a small window left the dial are precalibrated corresponding to the div. scale on the CRT. Scales 0 through 99 on the dial face correspond to subscales for single div., in a relationship of 10 = 0.1 div.
However, when the B TRIG'D ㊶ (Triggered delay) is pushed-in, the delay time does not continuously correspond to the dial, but it jumps to the next triggered point.

㊳ **A (main sweep):**
When the HORIZ DISPLAY switch is set to this position, the A TIME (main sweep: normal sweep) is selected.

㊴ **A/B TRACE SEP. (A/B sweep trace position):**
When ALT (alternate) is selected for HORIZ DISPLAY, the A TIME (INTEN BY B) and B TIME traces are switched at every main sweep. Overlay of the magnified and unmagnified waveforms is confusing, so this knob can be used to move the vertical position of the B sweep up or down.

Push this control to the out position to use, and in when it is not needed.

The intensified mark on the A sweep and magnified B sweep are displayed simultaneously (ALT), so the magnified display can be seen while observing the position of the mark. The vertical position of the B sweep can be moved to any position of the CRT by using the A/B TRACE SEP control ㊴.

㊵ **B (magnified sweep):**
Displays the portion intensify-marked by the switch ㊳ , ㊵ full in the screen. In this case, time measurement is made using the B TIME/DIV ㊱ .

㊶ **START ▆ / ▂ AFTER DELAY/TRIG'D & TV-H (at A TV-V):**
The A sweep starts sweeping in synchronization with trigger signal such as of the input signal. In this case, there are two methods of starting the B sweep; one is the continuous delayed sweep, and the other is trigger delayed sweep.
Normally, the continuous delayed sweep is used to make a magnified display, where the START button is pulled out, i.e., AFTER DELAY, and the B sweep is started immediately after the delay time set by the DELAY TIME dial ㊲ . When this method is used, the portion to be magnified can be continuously moved and be freely set.

The figures below illustrated the abovedescribed.

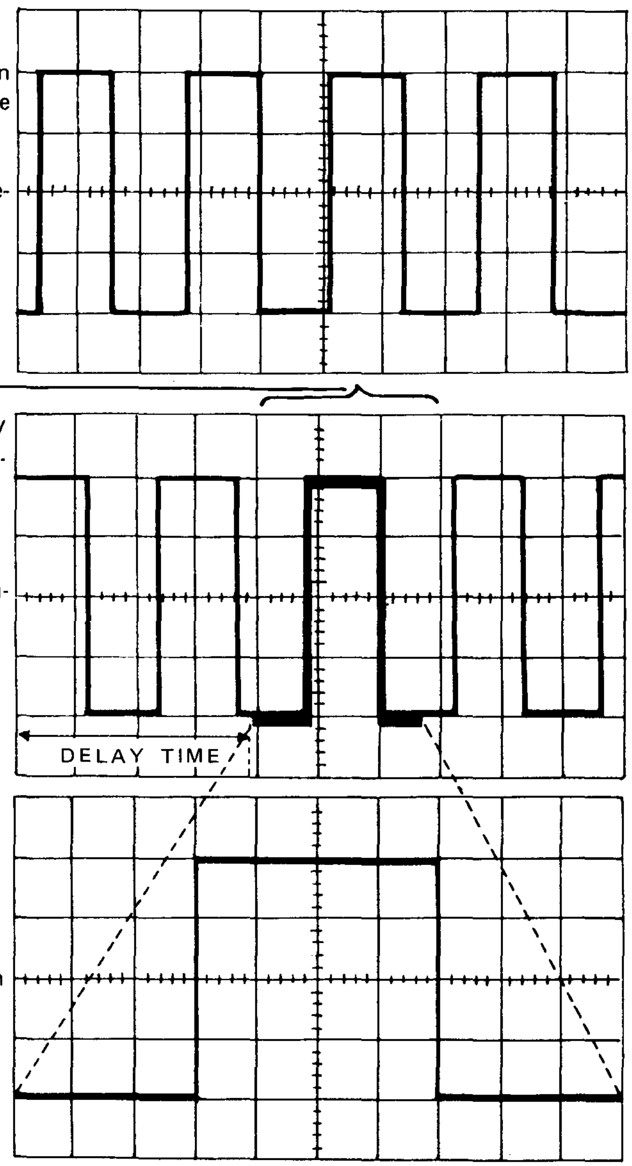
Continuous delayed sweep:
Set the START (41) to pushed-out position (general delayed magnification) and select the AFTER DELAY.

Get synchronization with the observation waveform using the A sweep (38).

Intensity modulation portion
This position can be continuously selectable by the DELAY TIME (37) and B TIME knobs (36).

Set the portion to be magnified (intensity modulation portion) by the ALT sweep (38) (39).
(The magnified waveform is also displayed.)

The portion is magnified full in the screen when the B sweep (40) is selected.

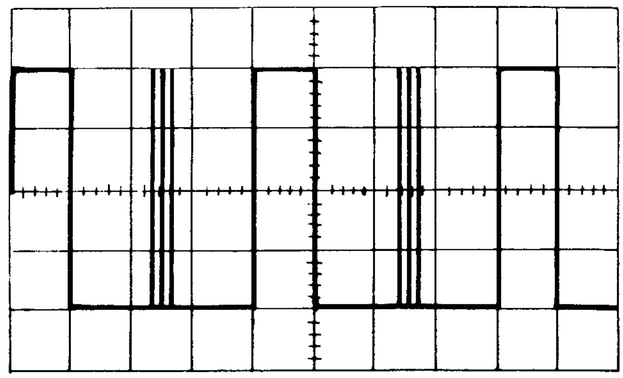


On the other hand, the B TRIG'D (41) is used, when magnification ratio is to be increased, or synchronization is to be made with a special pulse train.

For such a pulse train as illustrated, select a synchronization point using the A HOLDOFF knob ㉙

Trigger delayed sweep:
Set the B TRIG'D ㊶ to pushed-in position (special delayed magnification).

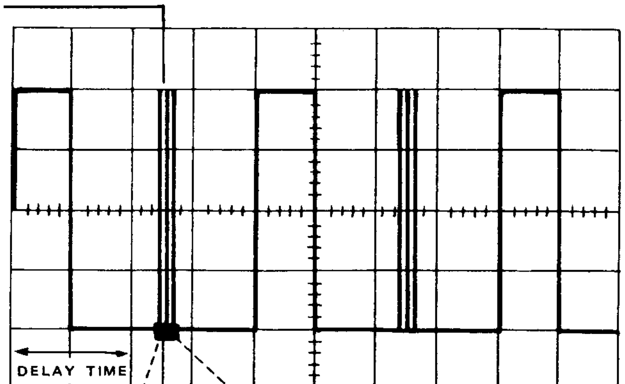
㊳ A sweep



The starting point of the intensity modulation is synchronized with the rise or fall portion by turning the DELAY TIME knob ㊲

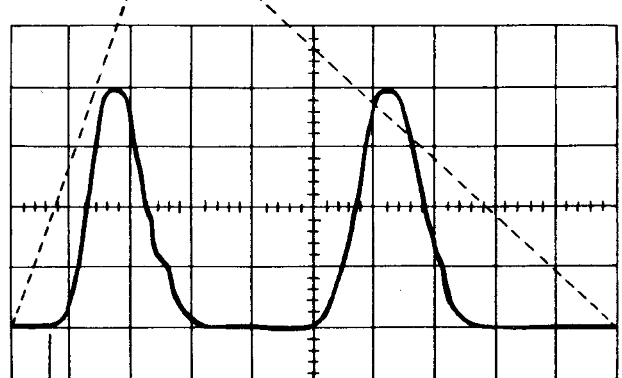
㊴ ALT sweep

(The magnified waveform is also displayed.)



Triggering of the B sweep is made by the pulse just after held by the DELAY TIME.

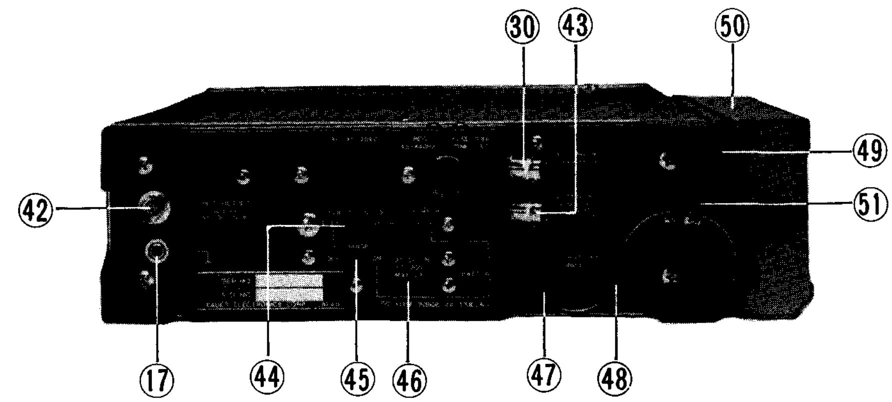
㊵ B sweep



As the B sweep is also being triggered by the input signal, jitter is decreased compared with the continuous delayed sweep.

When the B TRIG'D ▲ (41) is selected, at the ALT sweep (38) (39), the intensity modulation point does not continuously follow the DELAY TIME dial (37), but jumps to the trigger point in sequence. At the B (40), the display waveform does not continuously move, and a repetitive waveform is kept still without change.

TV-H synchronization of the B sweep:
In the vertical field of the composite video signal, a signal containing one horizontal line can be displayed without jitter. Set the COUPLING (32) of the A sweep (VITS, VIR, control signal for LD scramble, videotex, etc.) to TV-V to synchronize the A sweep to the TV vertical field, then set the START control (41) to TRIG'D. The B sweep is then automatically synchronized to the TV-H signal. The B TIME (36) and DLY TIME MULT (37) controls can be used to select and display the necessary part of the waveform.



4.7 Rear Panel

(42) **CH 1 OUTPUT:**
The input signal applied to the CH 1 is always available on this BNC terminal, via the vertical CH 1 preamplifier and the buffer amplifier of the oscilloscope.
With the 50-ohm termination, the output of about 50mVp-p per a single div. in amplitude of the screen is available. The CH 1 OUTPUT terminal will be described in section 5.8.

(43) **Z AXIS INPUT:**
The intensity modualtion signal to be applied to the display waveform is input to this terminal. This Z AXIS INPUT terminal will be described in detail in section 6.14.

(44) **POWER SOURCE AC/DC**
Used to select the source of the power to be supplied to the unit. Set to AC when using an AC line voltage through (5), set to DC when using external DC voltage through EXT DC (46), or use a battery through BATTERY INPUT (47) set the switch to AC when recharging the built-in battery.

(45) **CHARGE ON/OFF**
Used to start charging. Battery charging is started when set to the ON position. Set the switch back to the OFF position when charging is completed.

(46) **EXT DC IN**
External DC source connector. This connector accepts about 10V to 20V. Set POWER SOURCE (44) to DC. The function of the BATTERY IN (47) connector is overriden by this connector when a plug is inserted into it.

(47) **12V BATTERY INPUT**
Battery input connector. Set (44) to DC and use this connector for unit operation powered by a battery.

(48) **BATTERY CONNECTING CORD/PLUG**
Used to connect a battery to the 12V BATTERY INPUT connector (47). Plug this into (47). Leaving the plug open could cause a short in the battery.

(49) **BATTERY ATTACHMENT**
Used to convert the battery terminal into battery connecting cord (48) and to secure the battery to the battery clamp (51).

(50) BATTERY HOLDER

This battery holder is secured to clamp (51) with the battery attachment (49). The battery can be easily released from the battery holder by pressing it through a hole on the back of the battery holder.

(51) BATTERY CLAMP

Used to secure the battery to the unit. The battery clamp can be removed from the unit by unscrewing the screws on the side and back.

5. BASIC OPERATIONS

This section describes the basic operations to display the calibration waveform (CAL 0.5Vp-p ㉒) on the oscilloscope.

5.1 How to Display Trace Line

When the instrument is to be used for the first time, set the switches and knobs as indicated below, and turn on the power to display the trace line.

The same setting and the procedure as indicated can be used to check if the instrument correctly operates.

Initial settings of the knobs.

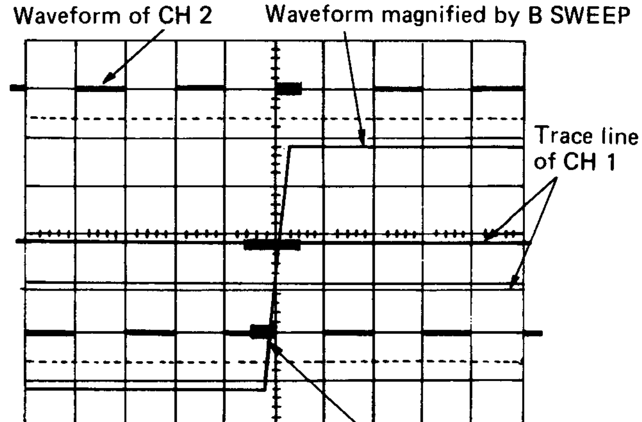
Name of element	Basic setting
ILLUM ②	Full clockwise.*
FUSE ④	Note the type and rating of the fuse used.
Power cord ⑤	After the initial setting are complete, apply the power of the rating voltage.
POWER ▬ / ▙ ON/OFF ⑥	Push on the power switch, after the initial settings.
ROTATION ⊘ ⑨	Adjust if the trace line is not horizontal.
FOCUS ⑩	Set the point at the 12 o'clock direction. *
INTEN ⑪	Set the point at the 12 o'clock direction. *
↕ (CH 1) ⑬	Set the white point at the 2 o'clock direction.
VARIABLE (CH 1) ⑭	Full clockwise to CAL'D position (notched).
PULL x 5	Push in. (OFF)
VOLTS/DIV (CH 1) ⑮	0.1V/div.
CH 1 IN ⑯	Open
VARIABLE (CH 2) ⑱	Full clockwise to CAL'D position (notched).
PULL x 5	Push in. (OFF)
VOLTS/DIV (CH 2) ⑲	0.1V/div.
CH 2 IN ⑳	Connect the probe LP-16BX [LP-060X]
AC-GND DC (CH 2) ㉑	DC
CAL 0.5Vp-p ㉒	Touch the probe tip of the CH 2 input.
CH 2 POL. ㉓	▙ Push out (NORM).
↕ (CH 2) ㉔	Set the white point at the 9 o'clock direction.

* Push this control to the out position to use, and in when it is not needed.

VERT MODE ㉕	ALT
AC-GND-DC (CH-1) ㉖	DC
SLOPE ㉗	⊥ +
LEVEL ㉘	Set the point at the 12 o'clock direction.
PULL NORM/PUSH AUTO	Push in (AUTO).
A HOLDOFF ㉙	Full counterclockwise to NORM position.**
EXT TRIG INPUT ㉚	Open
SOURCE ㉛	CH 2
COUPLING ㉜	AC
⟷ PULL x10 MAG ㉝	Set the point at the 12 o'clock direction. Push in (OFF).
TIME VARIABLE ㉞	Full clockwise at CAL'D position (notched).
A TIME/DIV ㉟	0.5 ms/div.
B TIME/DIV ㊱	50 μs/div.
DELAY TIME ㊲	5.0
A ㊳	Push-in
A/B TRACE SEP ㊴	Give a little position OFFSET between A and B Trace.**
B ㊵	Push-in, ALT SWEEP (Push A, B simultaneously).
B TRIG'D ㊶	⊥ AFTER DELAY
POWER SOURCE ㊹	AC
CHARGE ㊺	OFF

** Push this control to the out position to use, and in when it is not needed.

After the above settings, connect the power cord plug to the source of the specified rating. Then, push in the POWER switch ⑥ ; after the lamp ⑦ is lighted showing the power on, in 10 seconds square waveform and the trace line are displayed on the screen as shown in the figure right.
Further, adjust the FOCUS ⑩ to get a sharper trace line. When the horizontal trace line is not in parallel with the horizontal graticule, correct the decline adjusting the ROTATION ⑨ screw using a screwdriver.



5.2 Gain Checking by Calibration Waveform

The signal available from the CAL (22) is calibrated as the one with 0.5Vp-p, square wave, and about 1kHz in frequency. Thus, it can be used not only for the calibration of the vertical axis gain, but also for rough calibration of the time axis.
As shown in the above table of the initial settings, when the 0.5Vp-p signal of the CAL terminal is applied to the 0.1 V/div. range using the x1 probe, the vertical amplitude of 5 div. is displayed. The CH 1 is also applied with the CAL signal.
Further as the signal is symmetrical square waveform of 1kHz in frequency, the upper and lower flat portions of the square wave are displayed in every single division when the 0.5ms/div. is selected.
By the above described operation, the correct operation of the oscilloscope can be checked.

5.3 How to Use a Low-capacitance/Direct Probe

The LP-16BX [LP-060X] probe is an extremely well designed, high-performance probe equipped with x1 and x10 switching functions.

5.3.1 Specifications

Maximum input voltage: 250Vrms or 600V DC

(1) At X 10

Input resistance: 10MΩ (Connected to 1MΩ oscilloscope input)
Input capacitance: 25pF or less
Correction range: Oscilloscope with input capacitance 20 to 40pF
Attenuation factor: 1/10 ±2%
Frequency range: DC to 40MHz [60 MHz]

(2) At X 1

Input resistance: 1MΩ
Input capacitance: 250pF or less (Connected to Max. 50pF oscilloscope)
Frequency range: DC to 5MHz

5.3.2 Operation of low capacitance probe.
Slide the knob to the required position to X1 or X10.

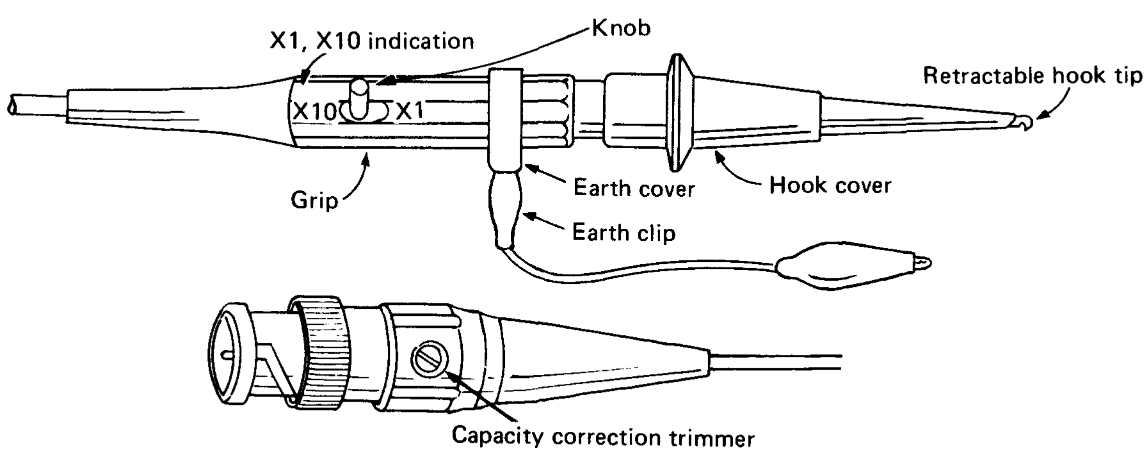
(1) Measurement at X 10
The probe exhibits high resistance and low capacity at X10. However, the input voltage is attenuated to 1/10 and, therefore, this must be accounted for in voltage measurement.

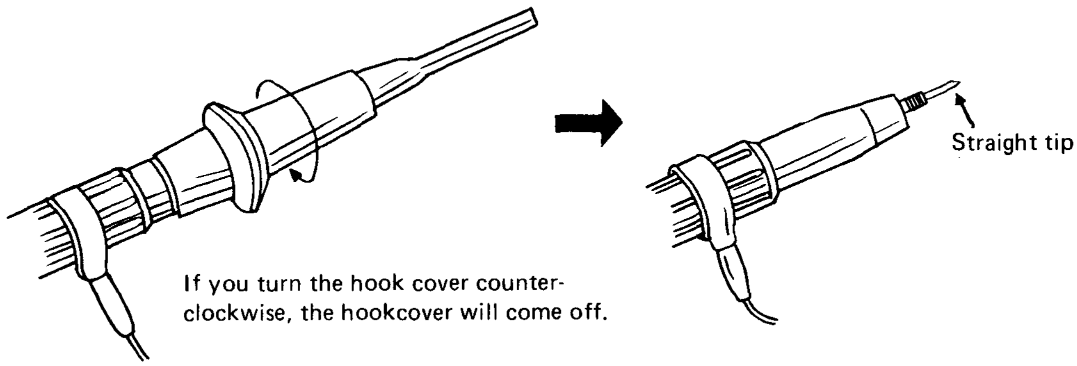
Measured voltage = Sensitivity of oscilloscope V/div X screen amplitude div X 10

At X10, it is necessary to correct the pulse characteristic by adjusting the capacitor in the probe for flat top of the square wave calibration voltage.

(2) Measurement at X1
This probe maintains high sensitivity in the X1 position so that it may be used directly with the oscilloscope. However, the input capacity is large approx. 250pF, and it is necessary to take this into account when making measurements.

(3) How to use the straight tip
For the use of straight-tip, please detach the retractable hook tip as shown in illustration.
The straight tip is extremely convenient when testing points on printed circuit boards.

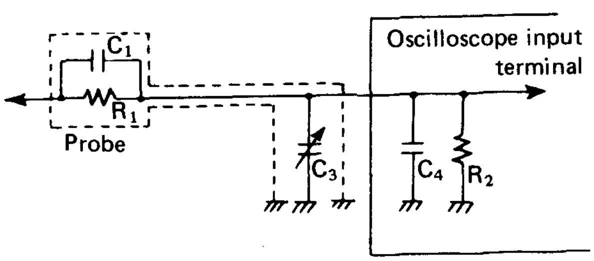




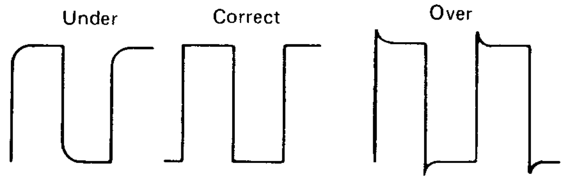
5.3.3 Adjustment of Probe

When observing the signal waveforms of high impedance circuit, the operation of the signal source and waveforms on the screen are liable to change due to the input impedance of the oscilloscope, parallel capacity of a coupling line, induction noise and other effects, leading to measurement error. The use of a low-capacity probe avoids these effects. A low-capacity probe of 10:1 attenuation type such as the LP-16BX [LP-060X] should be used for high impedance circuitry measurements. Its input impedance is 10MΩ at 25pF. The basic construction of ths probe is as shown below. Proper compensation may be obtained if the circuit constant is adjusted in such a way that the following equation will hold:

$R_1 \times C_1 = R_2 \times C_2$, $(C_2 = C_3 + C_4)$



To adjust the probe, connect as shown below and turn the variable capacitor (C_3) in the probe connector using a small screw driver, to provide proper square wave compensation.



5.4 Note on Direct Connection and Use of Probe

For small signal measurement of a high impedance signal source, as measurement error may be introduced by the noises induced to the input calbe and by the influence of parallel capacitance, use of a lead wire should be avoided and a shielded wire such as coaxial cable must be used. The length of the shielded wire should be as short as possible. For a high impedance circuit, attention should be paid to the load effect in which the sum of the input capacitance of the oscilloscope and the distribution capacitance of the shielded wire influences the signal source. When the influence of the parallel capacitance on the signal source is not neglectable, use the X10 low-capacity probe.

Note on Use of Low-capacitance Probe

To avoid many ill effects by direct connection, use a low-capacitance probe (X10) as much as possible. When this probe is used, input impedance is 10MΩ, 25pF, thus making it possible to reduce the loading effects upon the signal source to a great extent. However, when the probe is used at X10, the input signal is attenuated to 1/10, this must be taken into account in all measurements.

5.5 Ground Connection

For ground connection, use the shortest possible wire as described in Section 5.4.
When using a probe, connect to a ground point

close to the signal source, and use the probe ground wire.

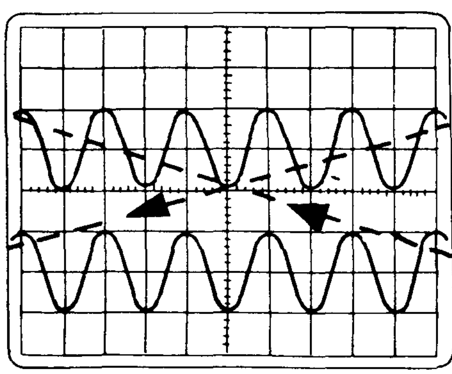
5.6 Dual Trace Measurement

Two vertical axis input circuits are provided in this instrument, and the waveforms of the two input signals are alternately shown on the screen by means of an electronic switch. However, since there is only one horizontal sweep circuit, it is not possible to have two synchronized or locked-in waveforms of two unrelated, independent input signals simultaneously on the screen. Two different methods are available for alternately switching of two signals making use of the electronic switch.

5.6.1 ALT.

ALT. (Alternation) serves to show two signals, CH 1 and CH 2, alternately sweep by sweep.

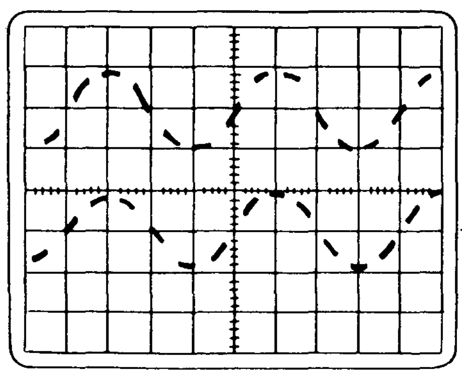
Flicker increases at a low speed sweep, slower than 0.5 ms/div., so that measurement is inconvenient. In such a case, use the CHOP mode.



Notes: 1. The dotted lines shown in the above figure do not appear on the screen.
2. The comparison and observation of two independent phenomena from one source are not possible.
3. If no signal is fed to CH 2 while the TRIG. switch (31) is set for CH 2, synchronization will not take place even though a signal is fed to CH 1.

5.6.2 CHOP

CHOP performs switching between two signals, CH 1 and CH 2, in high speed **(about 250 kHz)** and displays the two waveforms on the screen so that both waveforms look continuous.
This mode is mainly used for a slow speed sweep. When it is used for a higher speed sweep of **more than 0.5 ms/div.**, the trace may be displayed as a dotted line.



Note: Chop mode is not available when control (31) is set to ALT.

(1) Method of synchronization sweep	Auto sweep (AUTO) Sync. sweep (NORM)	(28) Push (28) Pull
(2) Selection of synchronization signal source (SOURCE)	Internal CH-1/-2 alternative Internal External	CH-1 ALT CH-2 EXT } (31)
(3) Coupling of synchronization signal (COUPLING)	AC coupling HF elimination TV-V extraction TV-H extraction	AC HF-REJ TV-V TV-H } (32)
(4) Selection of synchronization position (LEVEL, SLOPE, and HOLDOFF)	Variable of start position (LEVEL) Slope of waveform (SLOPE) Timing of synchronization (A HOLDOFF)	(28) knob (27) +/− (29) knob

5.7 Synchronization to Waveforms

The most important factor in operating the oscilloscope is to lock and display waveforms properly before measuring them.

To make the most use of the synchronizing capacity of this instrument, a proper method of operation is described below, taking waveforms as an example.

To obtain correct synchronization, the procedure of items (1) through (4) shown in the table above must be followed. The table shows the synchronization of the A TIME (main sweep). The synchronization of the B TIME (magnified sweep) is described in section 5.7.5.

By appropriate selections and adjustments of the abovementioned control knobs and switches, a stable waveform can be displayed.

For measurement of simple waveforms, set as follows: (1) TRIG MODE to AUTO (28), (2) SOURCE to CH 1 or CH 2 (31), (3) COUPLING to AC (32), (4) LEVEL (28) to 12 o'clock direction. The SLOPE (27) can be either + or −, and set the white point of the A HOLDOFF at the counterclockwise direction (NORM).

5.7.1 Mode of synchronization sweep

The synchronizing sweep circuit of this instrument stops functioning if a trigger pulse is not produced as a sweep starting pulse. It is, therefore, necessary to select this sweep according to purpose desired.

Generally, for waveforms which have a frequency of **30 Hz or more** and are not complex, **use AUTO** synchronization. At AUTO synchronization, the sweep circuit is automatically placed in the free-run state when the aforementioned trigger pulse is not produced and a horizontal trace is displayed irrespective of A sweep time set by the knob (35).

To remove waveforms on the screen when no input signal is applied or the trigger level is not correct, PULL a knob (28) to NORM.

5.7.2 Selection of synchronizing signal source

The operation called **"synchronization"** takes place to lock waveforms being observed. It is necessary to supply a synchronizing signal for this purpose to the oscilloscope. This instrument is capable of selecting either internal (INT) or external (EXT) sources of synchronization.

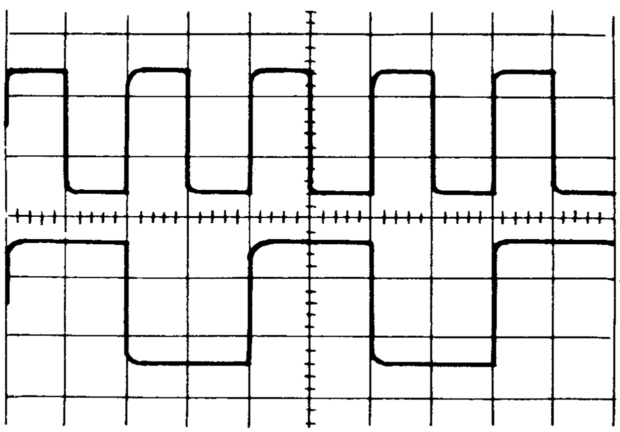
Internal:

Normally, synchronization is made by internal signal. For the CH 1 input, the SOURCE (31) is set to CH 1; and for the CH 2 input, it is set to CH-2.

When the CH 1 waveform is displayed by setting the CH 1 (25), and the synchronization signal source is assigned by setting the CH 2 (31) to apply the synchronization is available. Of course, the CH 2 waveform can be displayed by setting the ALT/CHOP.

In a dual-trace ALT display, synchronization is available by getting the synchronization signal from either one of CH 1 and CH 2 which are applied with signals having a synchronized relationship. However, by selecting the ALT (31), the both will synchronize though there is no synchronized relationship between the two signals.

The CH 1 and CH 2 waveforms being observed are in a synchronized relationship, if the frequency of the both is the same, a stable synchronization is available by selecting either signal as the synchronization signal. When the frequencies are different, by **selecting the lower one as the synchronization signal,** the traces of the both channels will be stable.



Select a synchronizing signal source to the low-frequency one.

External:

To synchronize the sweep to a signal other than the channel 1 and 2 signals, connect the signal to the EXT TRIG IN connector (30).

5.7.3 Coupling of synchronizing signals

Even when the synchronizing signal is actuating the synchronizing sweep circuit, it is possible to have unstable synchronization of the waveforms being observed.

This occurs when the synchronizing signal contains undesired components that affect sweep synchronization. The synchronizing sweep circuit may also fail to operate even when the synchronizing signal is supplied, if the synchronizing signal does not contain a sufficiently strong component synchronized to the desired waveform.

In this case, select the COUPLING switches (32) as follows so that proper synchronization is obtained.

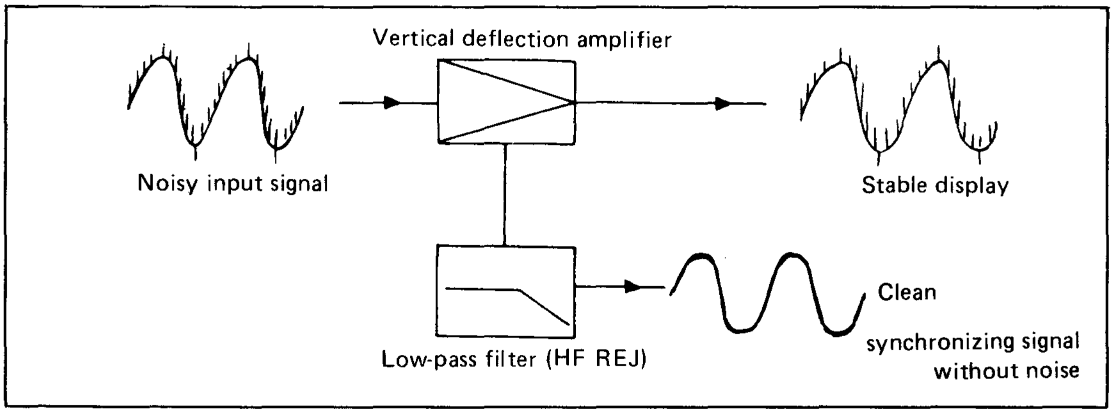
Normal waveform observation

Set switch (32) at AC. At this point, the synchronizing signal is connected to the synchronizing sweep circuit through a capacitor, thus eliminating the DC component and **provides stable synchronization over the whole bandwidth of 2 Hz or higher.** AC coupling takes place with synchronization that is not affected by a change in the DC component of the waveforms being observed.

Waveform signal superposed with noise

When synchronization is unstable, though the synchronization sweep circuit is operating, due to the synchronization signal superposed with noise such as of high frequency, the HF REJ function should be selected.

The synchronization signal goes through the low pass filter and the **unnecessary high frequency components higher than 100 kHz** are removed, so that a stable **synchronization is available.**



T.V. (Video) composite waveforms

In T.V. video waveforms, horizontal and vertical synchronizing components are combined. It is, therefore, very difficult to apply synchronization to the horizontal component or vertical component.

In this case, the horizontal and vertical synchronization signals are **automatically separated from the composite signal, and thus a stable synchronization is available.** The TV-V signal synchronizes with the vertical pulses, and the TV-H signal synchronizes with the horizontal pulses.

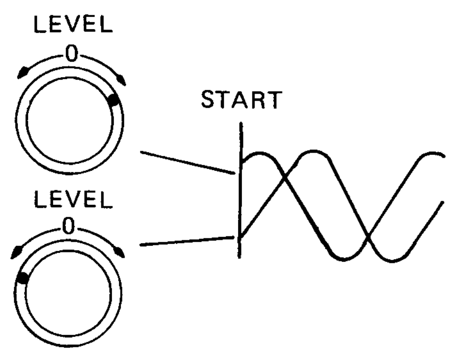
Set the SLOPE switch (27) to + or – depending on polarity of video composite signal.

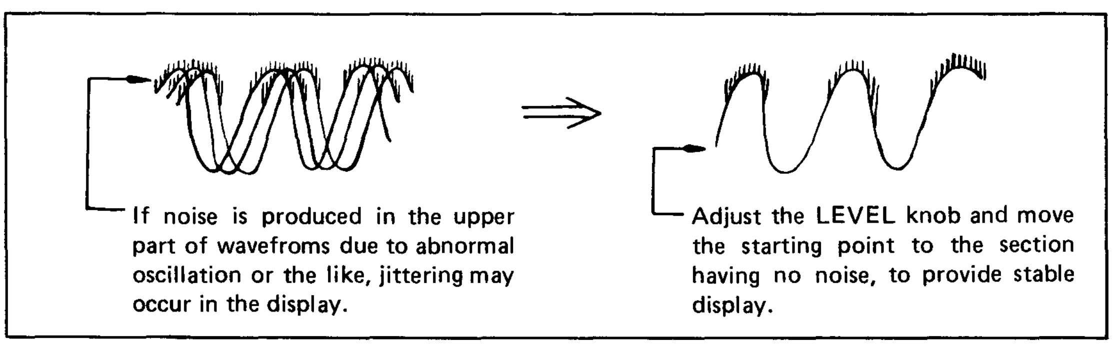
5.7.4 Selection of synchronization position

In a triggered sweep type oscilloscope, it is possible to adjust the position or timing of starting of the waveform so that stable trigger (starting) pulses may be obtained.

Adjustment of starting (trigger) position

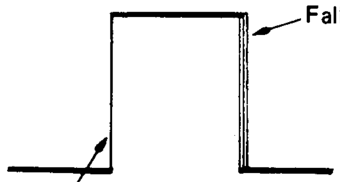
To move the synchronization position to the section where changing waveforms are stable, adjust LEVEL knob (28) as shown below.

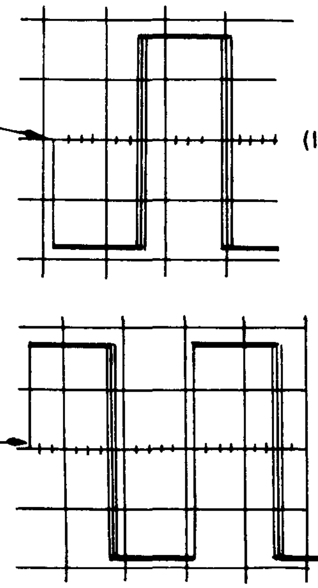


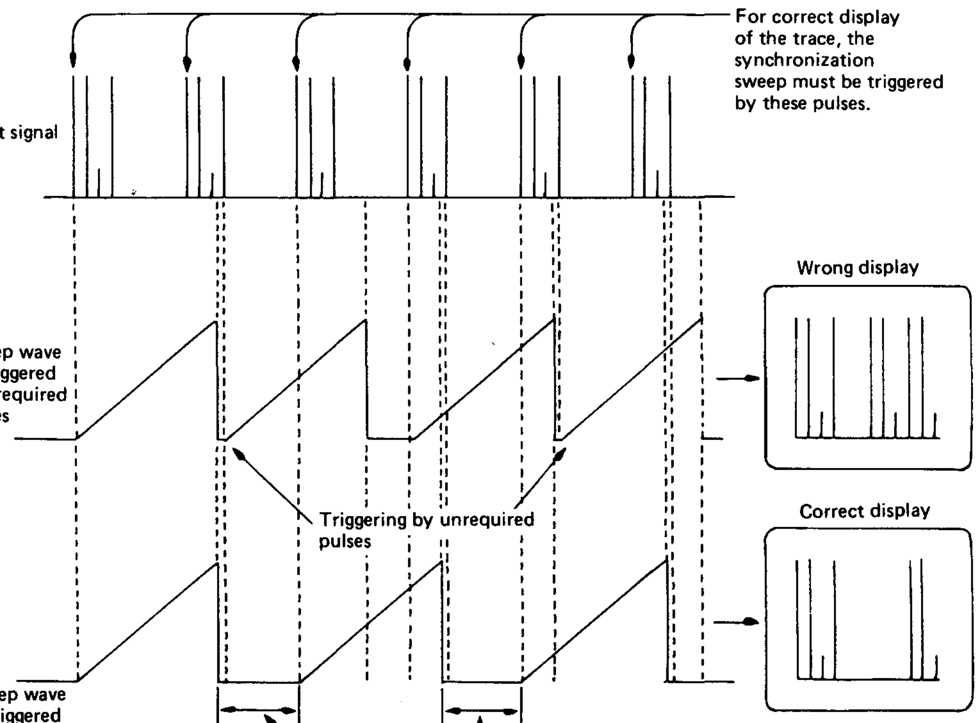


Selection of waveform slope (SLOPE +/–)

For example, **in case of a square wave,** especially **when jittering is taking place** in the fall portion, stable synchronization can be obtained if starting is performed in the rise portion. SLOPE switch (27) functions to select the slope (rise or fall section) of the starting (trigger) point of this synchronizing signal waveform.


Fall section with
jittering (−)
Stable rise section (+)


(−) Starting at
negative slope
(Incorrect)
(+) Starting at
positive slope
(Correct)


For correct display
of the trace, the
synchronization
sweep must be triggered
by these pulses.
Input signal
Wrong display
Synchronization sweep wave
of the oscilloscope triggered
by pulses other than required
synchronization pulses
Triggering by unrequired
pulses
Correct display
Synchronization sweep wave
of the oscilloscope triggered
by the correct synchronization
pulses
The pause duration is extended
properly using A HOLDOFF
knob ㉙

Synchronization for intermittent pulse train (A HOLDOFF)

For observation of signals such as intermittently repeated pulse train, the waveform may not be correctly displayed though the waveform looks synchronized. In such a case, by making the A HOLDOFF knob ㉙ variable for **adjusting the timing**, the trace can be displayed properly. In that the pause duration of the synchronization sweep is made variable, and triggering by pulses other than the required synchronization pulses is prevented. Normally rotate F.C.C.W for max. brightness.

5.7.5 B TIME synchronization

Normally, the sweep of the B TIME is driven immediately after the delay time (▲ START AFTER DELAY) set by the DELAY TIME ㊲ dial, and magnified display is made. Magnification jitter increases when the magnification ratio is increased.

Thus there is a method for applying synchronization (▲ TRIGG'D) to the input signal, which is called the TRIGGERED delay.

In that, triggering of the B TIME is suspended until the position is reached indicated by the DELAY TIME ㊲ dial, and the synchronization sweep is driven by the first pulse of the triggering pulses applied to the B TIME. The signal source and coupling for the synchronization signal of the B TIME are the common with that of the A TIME.

In addition, a stable display can be obtained of the VITS and VIR components of the vertical synchronizing field of a TV composite video signal and of the picture search control codes of video discs.

A sweep: Set COUPLING to TV-V.
Set SOURCE to CH 1 or CH 2.
Set SLOPE according to the polarity of the video signal.

B sweep: Set START to TRIG'D & TV-H (at A TV-V).

Note: When the A sweep coupling is set to TV-V and TRIG'D is set, the B sweep is synchronized to TV-H. If HORIZ DISPLAY is set to B, the DLY TIME MULT dial can be used to display the VITS or other component. If HORIZ DISPLAY is set to ALT, the magnified waveform can be observed with the intensified mark (INTEN BY B) in view on the unmagnified waveform.

5.8 CH 1 OUTPUT

The input signal applied to CH 1 is always available from this BNC terminal, through the preamplifier of the oscilloscope's vertical axis CH 1 and the buffer amplifier.

Output impedance:	50Ω
Output voltage:	approx. 50 mV per 1 div. amplitude (at the 50-Ω termination)
Frequency response:	(DC) DC to 40 MHz [60 MHz], −3 dB (AC) 10 Hz to 40 MHz [60 MHz], −3 dB

Because of the above specification, the output is proportional to the amplitude on the screen. For example, 5 div. is:

5 div. x 50 mVp-p/div. = 250 mVp-p

Thus when an appropriate waveform is displayed on the screen, roughly a constant output is available. Therefore, by connecting a frequency counter to this terminal, frequency measurement is available in parallel with the waveform observation, without adjusting the sensitivity of the counter.

On the one hand, the CH 1 OUTPUT terminal can be used as a high sensitivity and wideband amplifier.

The amplification is calculated as follows:

$$\text{Voltage gain } Gv \doteqdot \frac{\text{Output voltage 50 mV/div}}{\text{Vertical sensivity V/div}}$$

In the 10 mV/div range, for example:

$$Gv \doteqdot \frac{50\text{ mV/div}}{10\text{ mV/div}} = 5$$

In the 1 mV range,

$$Gv \doteqdot \frac{50\text{ mV/div}}{1\text{ mV/div}} = 50$$

The above values double if 50Ω termination is not connected to the output.

5.9 Battery Charging

The rechargeable battery LP-2071 supplied with the unit will begin to lose its charge after a little more than one hour of continuous use, which is indicated by the pilot lamp flashing on and off. In this case, charge the battery by using the built-in charger according to the following procedure:

First, attach the AC plug to a power source line and set POWER SOURCE (44) to AC. with the battery plug (48) connected to BATTERY INPUT (47), turn ON CHARGE (45) to start charging. The charger has a built-in 15-hour timer, which will automatically stop charging after a lapse of 15 hours. The LP-2071 (or NP-1A) becomes fully charged in about eight hours, although continuous charging up to 15 hours will not harm the battery. The battery may also be charged while operating the unit from an AC power source.

Note: Repeated battery charging when it is already fully charged will cause it to be overcharged and adversely affect its service life. To prevent this, remember to return CHARGE (45) to OFF when charging is completed.

6. MEASUREMENTS

6.1 AC Peak Voltage

When it is desired to determine only the AC voltage component of the signal being measured, set AC-GND-DC switch (21) or (26) at AC, and, from the amplitude on the screen at this time, calculate the peak voltage as follows:

Measurement using a lead wire
Peak voltage (Vp-p) = Value indicated at

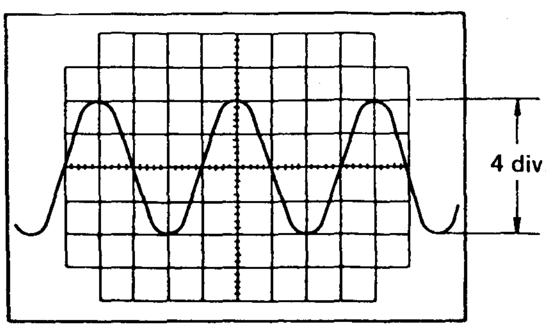
VOLTS/DIV x amplitude (div.) x $\frac{1}{MAG}$ ※

Measurement using a x10 probe
Peak voltage (Vp-p) = Value indicated at

VOLTS/DIV x amplitude (div.) x 10 x $\frac{1}{MAG}$ ※

However, the magnifiers (14) (18) act as:

※ PULL: factor of 5
※ PUSH: factor of 1



As shown above, the voltage of the signal being measured is calculated as follows:

If VOLTS/DIV = 0.05V/div. (setting MAG OFF),
Peak voltage when a lead wire is connected directly = 0.05V/div. x 4 div. = 0.2Vp-p
Peak voltage when using a x10 probe = 0.05V/div. x 4 div. x 10 = 2Vp-p

If the input waveform is a sine wave, the measured voltage (p-p) can be converted to effective voltage (rms). The following relationship exists between the peak voltage (Vp-p) and the effective voltage (Vrms).

$$\text{Effective voltage (Vrms)} = \frac{\text{Peak voltage (Vp-p)}}{2\sqrt{2}}$$

2Vp-p, for instance, is converted to rms value as follows:

$$\frac{2\text{Vp-p}}{2\sqrt{2}} = \frac{2}{2 \times 1.414} = 0.707 \text{ Vrms}$$

Notes: 1. When switch (21) or (26) is set at "AC," the low frequency characteristic is attenuated to −3dB at 10Hz. Also, note that no AUTO synchronization is accomplished at 30Hz or less.
2. When measuring a voltage, be sure to turn the VARIABLE knobs (14) and (18) fully clockwise to ↻ CAL'D.

6.2 DC Voltage

Use AUTO sweep, set AC-GND-DC switch (21) or (26) at GND. The trace (bright line) should show 0V. Set the trace to a position for easy measurement on the screen. Next, set the AC-GND-DC switch at DC and read the shift of the trace on the screen.

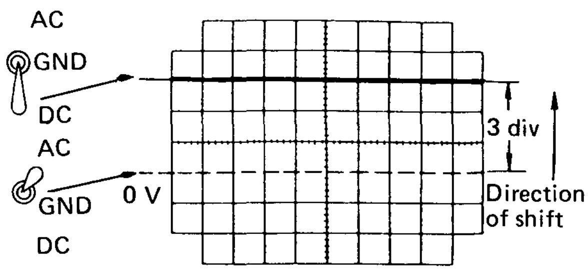
Adjust the VOLTS/DIV switch so that the trace will be displayed on the screen. An upward shift of the trace (bright line) represents (+) and a downward shift (−).

From the shift of the trace on the screen, the voltage of the signal being measured is calculated as follows:

Voltage when a x1 probe or lead wire is connected directly
Voltage (V) = Value (V/DIV) indicated at VOLTS/div x shift (div)
Voltage when using a x10 probe
Voltage (V) = Value (V/DIV) indicated at VOLTS/div x shift (div) x 10

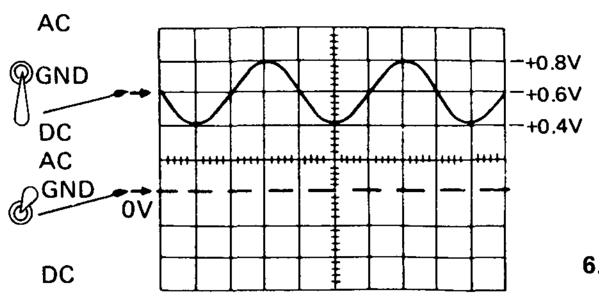
Example
If the range indicated at the VOLTS/DIV is 2V/div, the voltage of the signal being measured is calculated as follows:

When a x1 probe or lead wire is connected directly
2V/div x 3div = +6V
When using a x10 probe
2V/div x 3div x 10 = +60V



6.3 DC + AC Peak Voltage

Make measurement using the "DC" and the "GND" as in the case of the measurement of DC voltage. If the range indicated at the VOLTS/DIV is 0.2V/div, the voltage of the signal being measured is obtained as shown below.



DC Component = +0.6V
AC Component = 0.4Vp-p

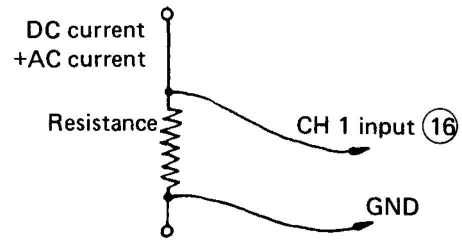
Note: When the DC component is much greater than the AC component, the waveform may be pushed off the screen making observation impossible. In this case, make measurements of the AC component and the DC component separately.

6.4 Current Measurement

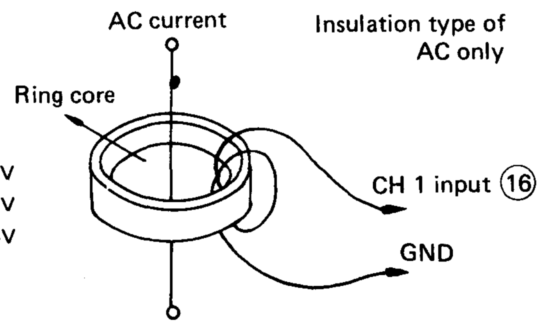
The voltage signal is the only phenomenon that can be observed by applying it to the oscilloscope directly. Accordingly, electric phenomena except for voltage, mechanical oscillation and all other phenomena must be converted into voltage and then applied to the input terminal.

When measuring current, insert known resistance into the circuit to be measured, observe a change is voltage across that resistance with an oscilloscope and convert it into current according to Ohm's law, that is V = IR. However, the resistance to be inserted must be within the range that causes no change in the operating condition of the circuit being measured.

Low frequency current measurement



High frequency current measurement

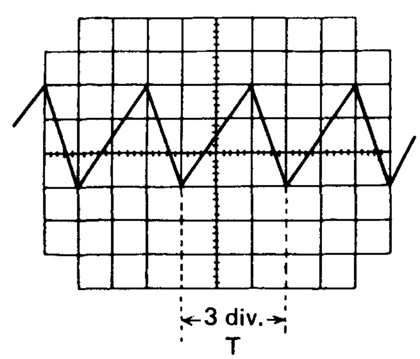


6.5 Time Interval Measurement

The time interval T is calculated as follows:

Time T (sec) = Value indicated at TIME/DIV x Interval on the screen x Reciprocal of magnification of the magnifier

The reciprocal of magnification of the magnifier is 1 when not magnified and 0.1 when magnified. The time interval T in the figure is calculated as follows:



TIME/DIV = 0.5 (0.5 ms/div.)
When the magnifier (33) is x 1, (PUSH)
T = 0.5 ms/div. x 3 div. x 1 = 1.5 msec
When the magnifier (33) is x 10 (PULL)
T = 0.5 ms/div. x 3 div. x 0.1 = 0.15 msec

6.6 Frequency Measurement

There are two methods using waveforms to measure frequency. One is to calculate the frequency from the time of 1 period, and the second method is to count the number of complete waveforms, or pulses, over the 10 div horizontal width.

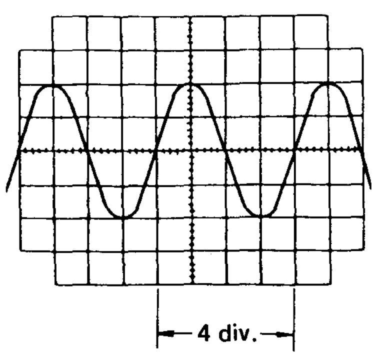
As regards to first method, the time of 1 period, T, is measured as given in the Section 6.5 above, and its reciprocal is the frequency F.

$$\text{Frequency F (Hz)} = \frac{1}{\text{T (seconds)}}$$

$$= \frac{1}{\text{Value indicated at TIME/DIV x interval of 1 period on the screen x reciprocal of magnification of the magnifier}}$$

For example, in the figure as shown below.
TIME/DIV: 0.5ms/div
Magnifier (MAG): x1
Then, T = 0.5ms/div x 4div x 1 = 2msec.

$$\text{Frequency F (Hz)} = \frac{1}{\text{T (sec.)}} = \frac{1}{2 \times 10^{-3}} = 500\text{Hz}$$



As regards the second method, that is, counting the number of complete waveforms, or pulses, over the 10 div horizontal width, the frequency is calculated as follows.

Frequency F (Hz)

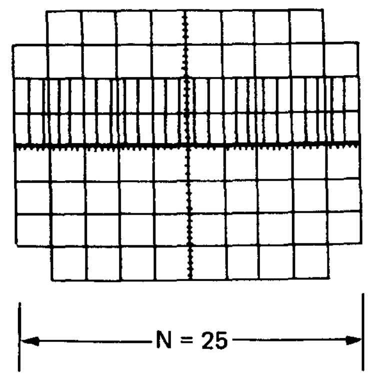
$$= \frac{\text{Number of pulses N}}{\text{Value indicated at TIME/div x Reciprocal of magnification x 10 div}}$$

Where, the reciprocal of magnification of the magnifier is 0.1 when magnified and 1 when not magnified.
For example, in the figure as follow.

TIME/DIV: 1μs/div
Magnifier: x 1

Then,
Frequency F (Hz)

$$= \frac{25}{1\mu \text{ sec/div x 10 div x 1}} = 2.5\text{MHz}$$

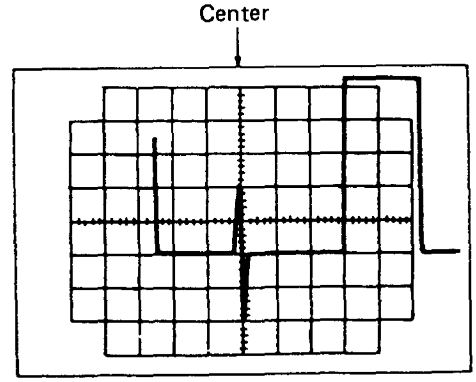


6.7 Rise Time of Pulse

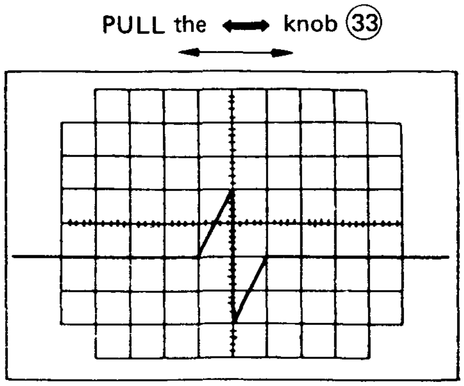
6.7.1 Measurement by A sweep only

When measuring the rise time of a pulse by A sweep (main sweep), the x10 horizontal magnifier (33) is used. Before measuring the rise time of a pulse, proper use of the magnifier will be described.

(1) Place the portion being observed on the center of the scale by means of the ⟺ knob (33)



(2) 10 times magnification to both sides.



As mentioned above, the magnifier is used for detailed observation of a portion of a waveform. This is especially convenient when the enlargement of a portion of a waveform, away from its sync. sweep starting point, is desired.

Rise Time of Pulse

(Step 1)

SLOPE ㉗ : ▲ – (Push)

MAG. ㉝ : x 1 (Push)

Set TIME/DIV ㉟ so that the leading edge of the pulse is caught on the screen. Position the VARIABLE ㉞ (red knob) to the end of its clockwise rotation.

(Step 2)

Align the flat portions of the pulse at the 0 and 100 scales of the % graticule.

(Step 3)

Place the leading edge of the pulse on the center line of the scale by means of the horizontal positioning knob.

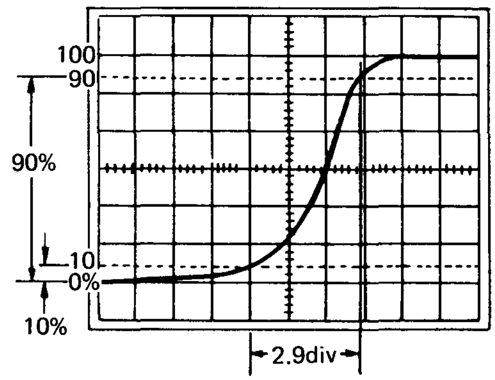
(Step 4)

Make certain the MAGNIFIER ㉝ is set at x 10 (PULL) calculation of rise time.

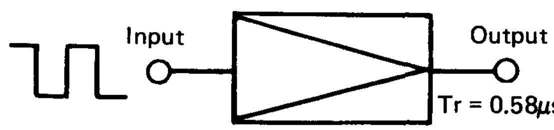
Tr = (TIME/DIV range) x (Horizontal interval on the screen, div.) x (Magnification rate, 1/10)

Example

Tr = 2μs/div. x 2.9 div. x 1/10 = 0.58 μs



On the basis of this rise time, Tr, the upper limit frequency of the amplifier, fc (−3dB), can be determined. For instance, on the assumption that the above measurement was performed with input pulses which were fast enough and that the value calculated represents the output waveform of the amplifier tested, then the upper limit frequency, fc, of the amplifier can be found.



Amplifier being tested

$$Tr \leqslant \frac{\text{Tr of Output}}{10}$$

$$\underset{(-3dB)}{fc} = \frac{0.35}{Tr} = \frac{0.35}{0.58 \times 10^{-6}} = 0.6 \times 10^{6} = 600kHz,$$

Units of time are enumerated below for reference:

Millisecond; ms $= 10^{-3}$ sec.

Microsecond; μs $= 10^{-6}$ sec.

Nanosecond; ns $= 10^{-9}$ sec.

Picosecond; ps $= 10^{-12}$ sec.

This relationship is to determine fc (−3dB) from the rise time of the square wave input pulse. In the measurement of a comparatively fast pulse, the rise time of the LBO-314 [315] must also be taken into consideration.

Rise time of The LBO-314 [315] ; Ta = 8.8ns, [5.8ns]

Rise time of the output of the amplifier being tested; Ti

Rise time observed on the screen; Tr

With this data, the true rise time Ti is calculated:

$$Ti = \sqrt{Tr^2 - Ta^2}$$

Further information relative to rise time will be found in Section 6.7.3.

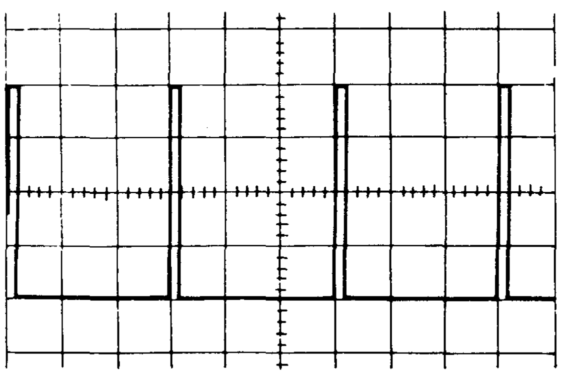
6.7.2 Measurement by B sweep (delayed sweep)

Magnification of a small portion is limited to a factor of 10, when only the above-mentioned MAG x 10 and the A sweep are used.

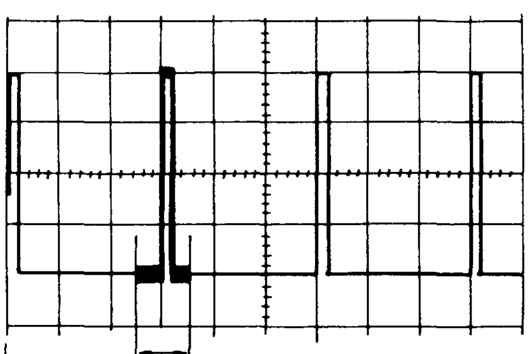
However, by using the B sweep, magnification is available up to the limit of the magnified jitter 10,000:1 of the instrument itself.

(Step 1)
After setting knobs and switches according to the description of section 5.1, apply the signal to the CH-1 input terminal (16)

(Step 2)
Push in ■ the A sweep switch (38). Adjust the A TIME/DIV (35) to display the portion to be observed on the screen.



(Step 3)
Push in the ALT sweep (38) (39) (when A and B are bushed simultaneously). The intensity-modulated portion indicates the B sweep by delayed start. (However, the figure below shows the continuous delayed sweep by setting the START (41) to ■ AFTER DELAY.)



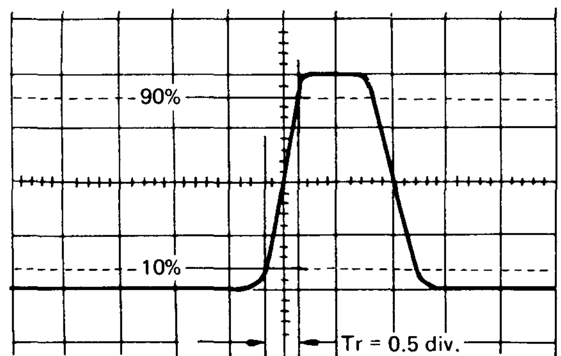
TD = 2.5 div.

This width should be set by an appropriate range turning the B TIME/DIV (36) more to the clockwise direction than the A TIME/DIV (35). The position is set by the DELAY TIME (37)

Delay time of B sweep TD = 0.5 ms/div. x 2.5 div. = 1.25 ms

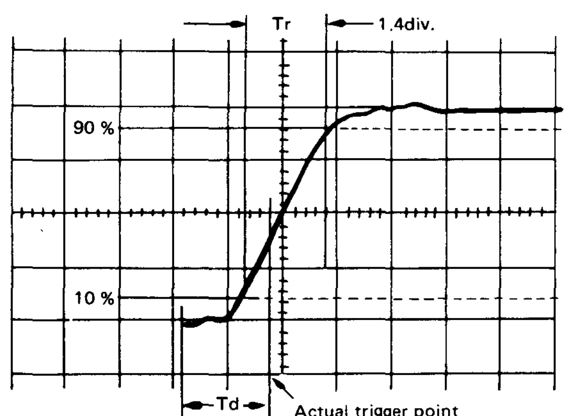
(Step 4)
By pushing in ■ the B (40), the intensity modulation waveform indicated by the (Step 3) above is enlarged and displayed on the screen.

Tr = 50 μs/div. x 0.5 div.
= 25 μs



[6.7.3 Measurement using delay line on the vertical axis]

HORIZ DISPLAY (38) : A
A TIME/DIV (35) : 0.2 μs
MAG (33) : Pulled out



Vertical signal delay line causes waveform before trigger point to be displayed.

Display of the waveform at left before the trigger point enables the rise time of high-speed pulses to be measured.

Tr = 0.2μs/div x 1/10 x 1.4div = 28ns

When the waveform is displayed using the highest sweep speed, the response time of the oscilloscope must be considered.
The rise time Ta of the oscilloscope is:
Ta ≒ 0.35/40MHz = 8.8ns,
[Ta ≒ 0.35/60MHz = 5.8ns]

The true rise time Ti of the pulse under measurement is:

$Ti = \sqrt{Tr^2 - Ta^2}$

The pulse rise time Tr measured on the scope is:

Tr = [TIME/DIV] x [length of rise on CRT in div] = 0.02μs/div x 1.4div = 28ns

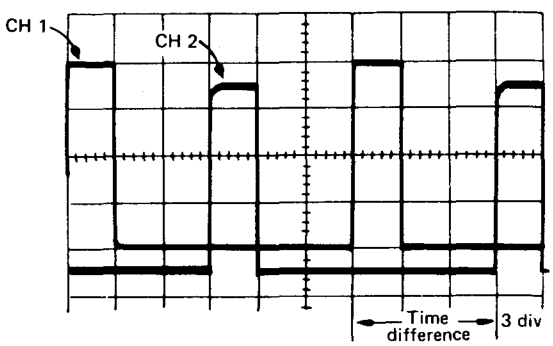
In the example above, the true pulse rise time Ti is:

$Ti = \sqrt{(28ns)^2 - (8.8ns)^2} = 26.58ns$

$[Ti = \sqrt{(28ns)^2 - (5.8ns)^2} = 27.39ns]$

6.8 Time Difference between Two Signals

By making use of the dual trace advantage, it is possible to measure a time difference between two signals. The adoption of a fixed trigger system in CH 1 or CH 2 permits measurement of the time difference without error even at **ALT or CHOP.**



When SOURCE (31) is set at CH 1, it is possible to measure a delay time difference of CH 2 on the basis of the signal of CH 1.

When this time difference is extremely small, use the MAGNIFIER at the x10 position. If it is much smaller than that, perform measurement by delay enlargement.

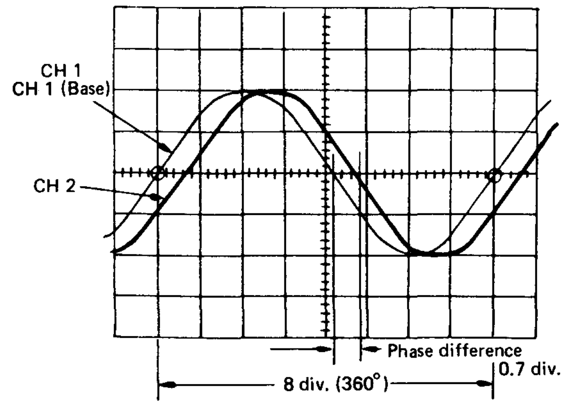
6.9 Phase Difference between Two Signals

To measure a phase difference between two signals of the same frequency, the dual trace display system can be utilized up to the upper limit frequency of the vertical amplifier.

First, position both signals on the cenber line of the scale, e.g. just 4 div., as shown in the following figure by means of the **VARIABLE** and horizontal positioning knobs.

Next, set the distance where the center of the waveform of the base channel intersects with the center of the scale to 8 div. horizontally.

If difficulty is encountered in properly displaying the phase difference as shown in the following figure because it (phase difference) is too large, use the polarity inversion switch of **CH 2**, POL. INV (23) and move the phase by 180° beforehand, and then display the phase difference. After that, this 180° should be taken into account.



As shown in the above figure, set 1 cycle, 360° to 8 div. Then,

$$\frac{360°}{8\ div.} = 45°/div.$$

Accordingly, the phase difference in the above example can be calculated as follows:

Horizontal distance on the screen: 0.7 div.
Phase difference = 45°/div. x 0.7 div. = 31.5°

If the portion of the phase difference is much smaller, use the **MAGNIFIER at the x10** position in the above setting. At this time, 360° is displayed in 8 div. x 10.

Then,

$$\frac{360°}{8\ div.\ x\ 10} = 4.5°/div.\ (0.2\ div. = 9°)$$

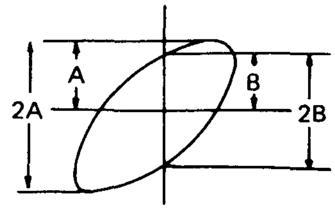
6.10 Measurement of Phase Difference by X-Y Operation

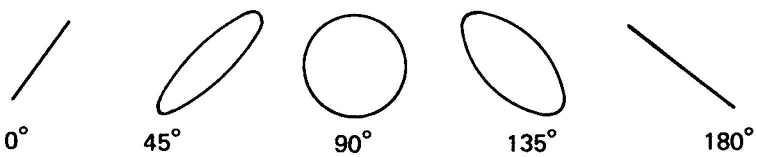
The phase difference between two signals of the same frequency can also be measured using a Lissajous' figure by X-Y operation.

In this case, however, the frequency band of the X-axis is 1 MHz (−3dB) thus causing a phase difference of 3° or less at 100 kHz between X and Y.

$$\sin\theta = \frac{B}{A} = \frac{2B}{2A}$$

$$\theta = \sin^{-1}\frac{B}{A}$$





Place the Lissajous' figure on the center line of the scale both horizontally and vertically.

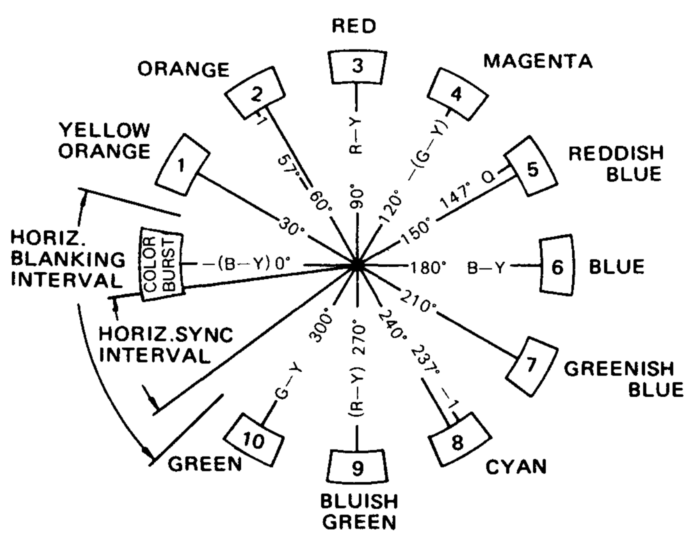
This X-Y operation can effectively be used to display the input and output characteristics of all kinds of electric circuits.

Also, to measure TV color hue, there is a method of displaying 10 colors of the gated rainbow pattern by X-Y operation (making use of a color bar pattern generator such as LEADER Model LCG-391).

Phase relationships of the gated rainbow signal

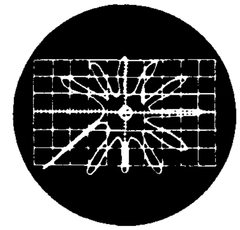
The ten gated rainbow signals have the phase relationships as shown in the following figure. The color tint pattern (VECTOR) is obtained by applying the B-Y SIGNAL to the X-axis and the R-Y SIGNAL to the Y-axis.

Feed the gated rainbow signals obtained from the color bar pattern generator to the color TV set.



The floral pattern rotates as the TINT or HUE knob of the TV set is turned. If the pattern spreads long instead of getting round, color saturation is responsible.

For more accurage measurement, use of the LVS-5850 A Vector Scope is recommended.



Vector pattern

6.11 Measurements of Error between Two Signals and Push-Pull Signal

If the addition and subtraction functions of two signals are utilized, error and push-pull waveforms can properly be displayed.

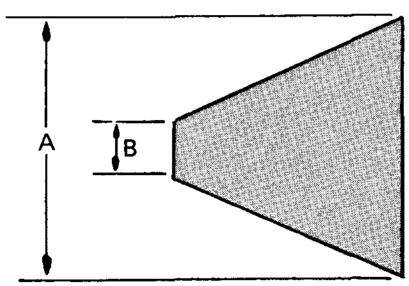
Apply an input signal to CH 1 and an output signal to CH 2 and set CH 2 POL. (polarity) so that the waveforms of the same amplitude may be displayed on the whole screen as far as possible; these signals may be out of phase with each other. Depress the ADD. button and estimate the size of the remaining waveform and the condition of waveform distortion when subtracted. Also, as regards the signal waveform of the push-pull circuit, the condition of the original push-pull operation can not be determined even if the waveform of one is observed separately. Set the polarity inversion switch of CH 2 at INV and depress the ADD. switch. Then, noise, hum and other in-phase components will compensate each other and push-pull signals will be added and displayed properly.

6.12 AM, SSB Transmission Modulated Wave Measurement

When observing modulation distortion or the like by providing synchronization to the envelope of amplitude modulated waves (SSB/DSB), apply voice waves to external synchronization.

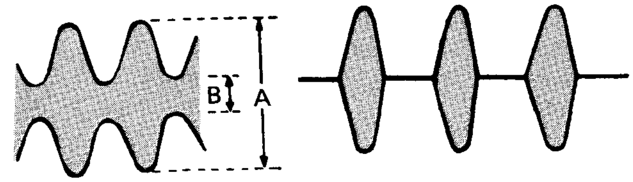
In the use of the trapezoid display, it is possible to confirm the linearity of modulation irrespective of modulated voice waves.

For trapezoid display, perform the aforementioned X-Y operation and apply voice waves to the X-axis of CH 1 and high-frequency waves to the Y-axis of CH 2.



Trapezoidal display

AM (Amplitude) modulated wave



Overmodulation

Modulation factor $m = \frac{A - B}{A + B}\ 100\ (\%)$

6.13 Description of Applications by Transducers of Various Kinds

The oscilloscope is intended to observe electric oscillation, and it is also possible to observe all sorts of phenomena if they can be converted into electric signals by the use of transducers.

(1) A change in tension is converted into an electric signal using a resistance wire or the like.

(2) A change in pressure is observed by the use of a piezo-electric device.

(3) Displacement is converted into a capacity change, and then it is further applied to an oscillator or the like and observed as a change in frequency.

(4) A magnetic variation is observed using a magnetostriction device.

(5) An optical displacement is observed using a photo transducer.

(6) A temperature change is observed using a thermistor or thermocouple.

Besides all these mentioned above, many studies have been made on sensors recently, and it is suggested that reference be made to technical books.

6.14 Intensity modulation terminal (Z axis)

Intensity modulation can be obtained when a voltage of 0V ~ +5V is applied to this terminal in DC coupling under ordinary intensity condition.

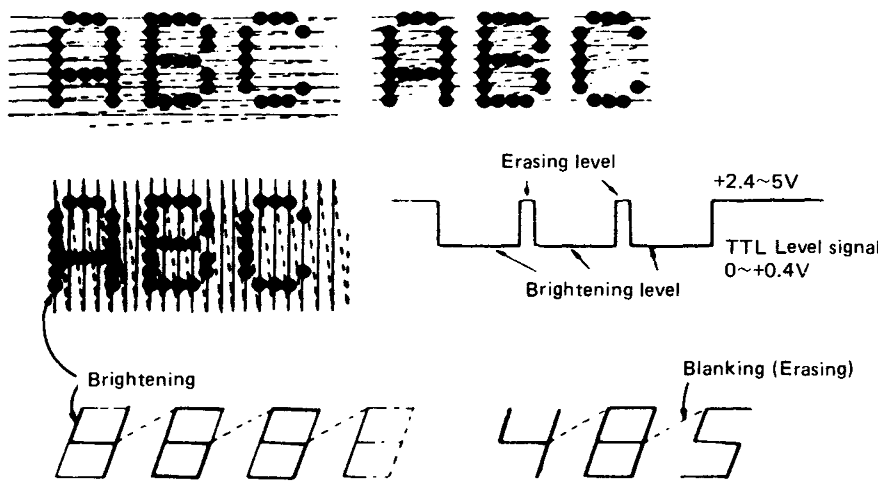
When a voltage of +2V ~ +5V (by a intensity control position) is applied, the trace line on the CRT will be erased. When a voltage of 0V ~ +1V (by a intensity control position) is applied, the trace line will be intensified. That is, the instrument is used to erase a certain part of the trace line on the CRT or to intensify a certain part of the trace line in particular.

Application examples

(1) Making character display by computer output

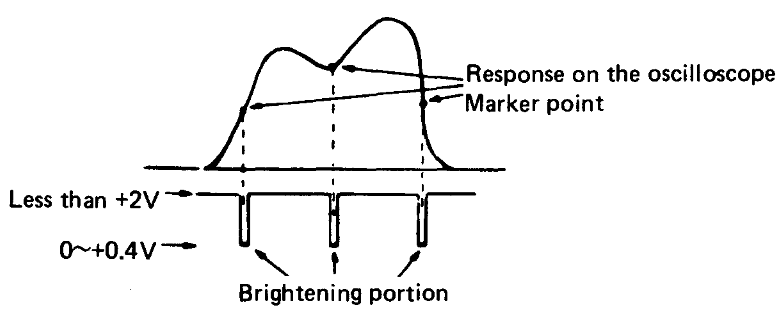
Since the intensity modulation terminal is in DC coupling, intensity modulation can be driven by a TTL level signal.

Generally, there are two methods in making character display: random scanning method and raster scanning method. In either case, a needed portion can be made bright by giving a voltage of 0 to +0.4V to it. On the otehr hand, an unnecessary portion can be erased at a level of +2 to +5V.



(2) Making marker display when measuring frequency response by means of a sweep generator

When the frequency response of a measuring circuit are drawn on the CRT by means of a sweep generator, the instrument is capable of displaying the marker frequency point more precisely. When a precise display of the marker point is desired, apply a level signal of 0V ~ +0.4V to the brightness modulation terminal. When other level exceeds +2V at this time, the response trace may disappear. Care, therefore, should be used not to exceed +2V in amplitude of the signal to be applied.



7. MAINTENANCE CALIBRATION BY THE USERS

⑨ ROTATION

The ROTATION (beam rotation) ⑨ adjustment screw provided on the front panel is used to adjust a tilt of the horizontal trace when it is caused by the terrestrial magnetism. Check if the tilt is caused by other external magnetic field source.

8. INTERNAL MAINTENANCE CALIBRATION BY SPECIALISTS

It is highly recommended that the internal adjustments described in this section be made by the specialists such as the LEADER's service engineers.

Before making the internal adjustments, the power of within ±3% of the rating voltage should be applied, and aging of at least 30 minutes must be made.

Particularly, the BAL adjustment was made considering the environment temperature, and thus it should be calibrated in a temeprature ragne of 15° to 25°C.

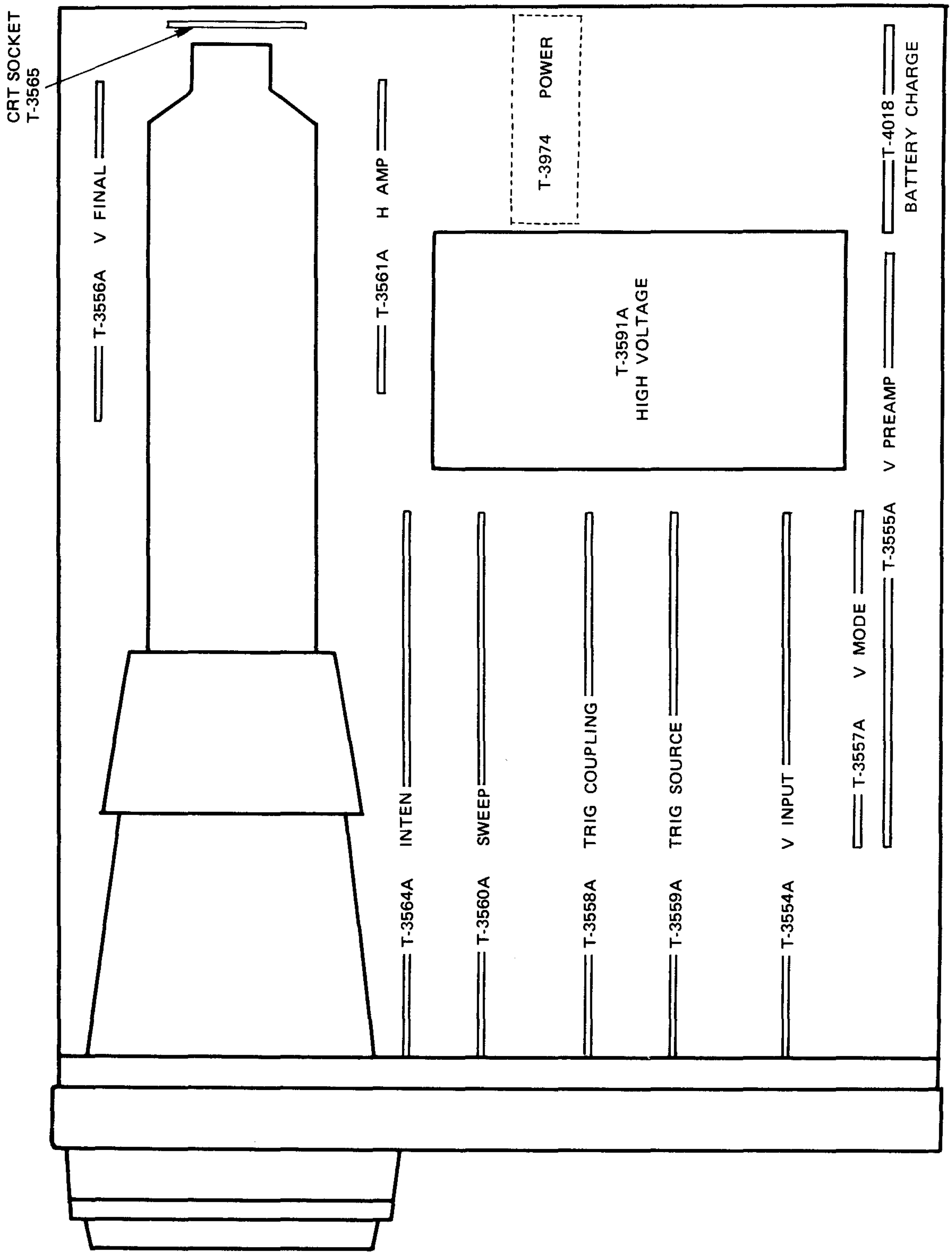
To open the cover, unscrew the upper 7 screws and lower 4 screws.

Disconnect AC power cord from the line.

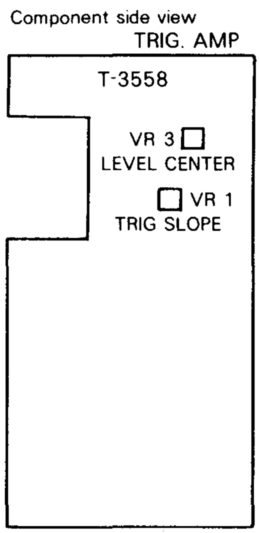
WARNING: AFTER TURNING OFF THE POWER, VOLTAGES OF –2 kV/ +10 kV STILL REMAINS INTERNALLY. WAIT 5 TO 10 MINUTES.

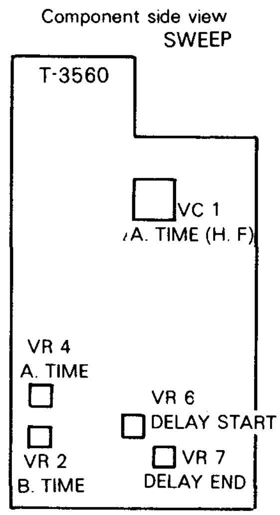
8.1 Layouts of Main Parts and Adjusters

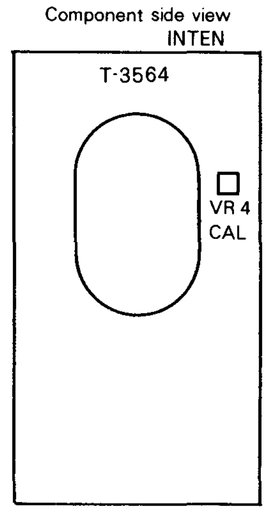
8.1.1 Layout of main parts (Top view)

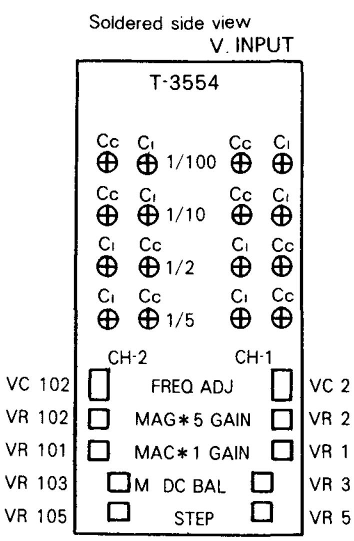


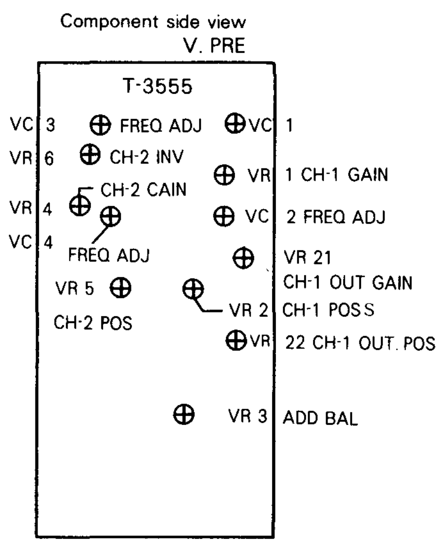
8.1.2 Layout of adjusters

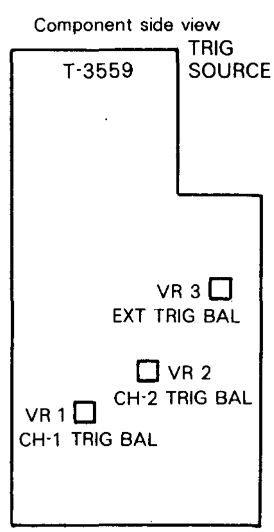




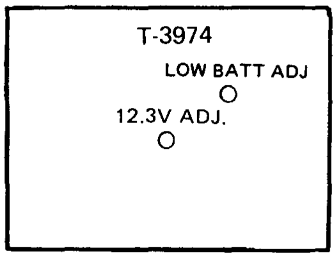




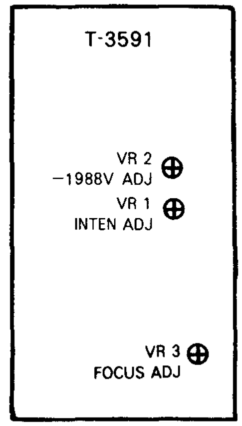




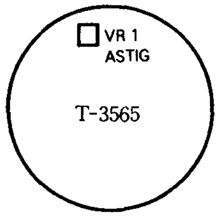
Soldered side view POWER



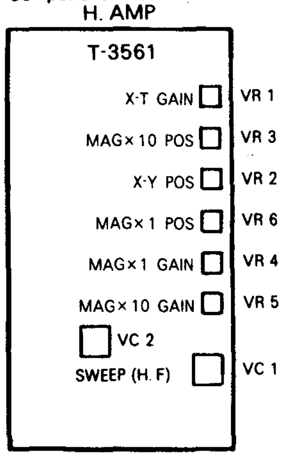
Soldered side view
HIGH. VOLTAGE



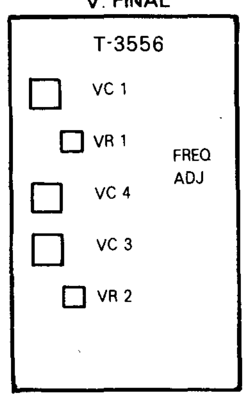
Component side view
CRT SOCKET



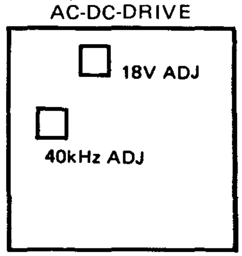
Component side view
H. AMP



Component side view
V. FINAL



Component side view
AC-DC-DRIVE



8.2 Adjustments of Main Adjusters

Adjustment method which requires no special measurement instruments will be described below. For full-scale adjustment, use of the LOC-7005 Oscilloscope Calibrator is recommended.

8.2.1 Vertical gain (T 3555) VR1, VR4

The ⊘ CH 1 GAIN and ⊘ CH 2 GAIN for both the channels should be calibrated with the same range. Particularly, for dual-trace operation, the adjustments should be made with no sensitivity difference between the channels.

(Example)

Set both the channels in 0.1 V/DIV, DC, and the VARIABLE to CAL'D position, and apply rectangular waveform of 0.5 Vp-p to their input terminals for dual-trace operation.

Then adjust the ⊘ CH 1 GAIN and ⊘ CH 2 GAIN to get the same amplitude of 5 div. each for both the display waveforms.

8.2.2 Vertical DC balance (T-3554) VR3, VR103

While the AC/GND/DC switch is set to GND, if the vertical position unusually moves, e.g., as much as 1 div., when the V VARIABLE knob is turned or the VOLTS/DIV switch is switched, adjust the ⊘ CH 1/2 DC BAL (VR3, VR103).

(1) Pull the CH 1 VAR ⑭ and CH 2 VAR ⑱ knobs to make them in the magnification of x5.
(2) Set both the AC/GND/DC switches ㉑ ㉖ to GND.
(3) Set both the VOLTS/DIV switches ⑮ ⑲ to 5 mV/div. range.
(4) Turn both the VARIABLE knobs ⑭ ⑱ full counter-clockwise.
(5) Adjust both the ↕ POSITION knobs ⑬ ㉔ to locate the trace lines in the middle of the screen height.
(6) Turn the VARIABLE knobs ⑭ ⑱ full clockwise.
(7) Restore the moved trace lines to the center by adjusting the ⊘ DC BAL (VR3, VR103).
(8) Repeat the above procedure 2 to 3 times until the trace lines do not move.

8.2.3 ⊘ ASTIG (T-3565), VR1

When a sharp trace of waveform is not available by the adjustment of the FOCUS knob ⑩ alone on the front panel, adjust the ASTIG screw.

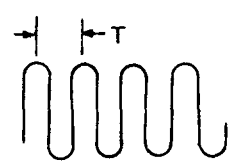
The ASTIG condition can be determined when the focus is made dull. Adjust the ASTIG to make the trace dull to all the directions equally, when it is necessary.

By the nature of a CRT used, display image on circumference of the CRT becomes dull always.

Avoid use of a spot for the adjustment; otherwise the fluorescent material on the screen may be burnt.

8.2.4 Calibration of time axis (T-3560) VR2, VR4

An oscillator having the frequency accuracy of 1% or better in combination with a frequency counter is used to obtain the calibration signals.



f	T
100 Hz	10 ms
200 Hz	5 ms
500 Hz	2 ms
1 kHz	1 ms

f	T
2 kHz	0.5 ms
5 kHz	0.2 ms
10 kHz	0.1 ms
20 kHz	50 μs

The A TIME is adjusted by the ⊘ VR4, and the B TIME is adjusted by the ⊘ VR2.

Becomes dull to the vertical direction

Becomes dull to all the directions (Good Astig)

Becomes dull to the horizontal direction

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