INSTRUCTION MANUAL

OSCILLOSCOPE

MODEL 5650

KIKUSUI ELECTRONICS CORPORATION

Power Requirements of this Product

Power requirements of this product have been changed and the relevant sections of the Operation Manual should be revised accordingly.
(Revision should be applied to items indicated by a check mark ☑.)

☐ Input voltage

The input voltage of this product is ________ VAC,
and the voltage range is ________ to ________ VAC. Use the product within this range only.

☐ Input fuse

The rating of this product's input fuse is ________A, ________VAC, and ________.

WARNING

- To avoid electrical shock, always disconnect the AC power cable or turn off the switch on the switchboard before attempting to check or replace the fuse.
- Use a fuse element having a shape, rating, and characteristics suitable for this product. The use of a fuse with a different rating or one that short circuits the fuse holder may result in fire, electric shock, or irreparable damage.

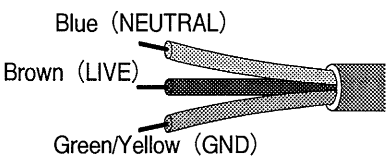
☐ AC power cable

The product is porvided with AC power cables described below. If the cable has no power plug, attach a power plug or crimp-style terminals to the cable in accordance with the wire colors specified in the drawing.

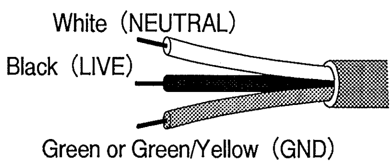
WARNING

- The attachment of a power plug or crimp-style terminals must be carried out by qualified personnel.

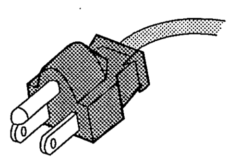
☐ Without a power plug



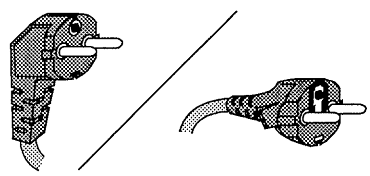
☐ Without a power plug



☐ Plugs for USA



☐ Plugs for Europe



☐ Provided by Kikusui agents

Kikusui agents can provide you with suitable AC power cable.
For further information, contact your Kikusui agent.

☐ Another Cable ______________________________

 Kikusui Part No. Z9-000-027 IB001681 KIKUSUI

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1. GENERAL

Kikusui Model 5650 Oscilloscope is a general-purpose dual-channel portable oscilloscope with a 6-inch rectangular internal-graticule 80 mm × 100 mm (3.15 in. × 3.94 in.) cathode-ray tube.

The vertical axis has a maximum sensitivity of 1 mV/DIV (when in the "5 × MAG" mode) and a frequency response of up to 50 MHz (-3 dB). An X-Y mode of operation can be attained in a one-touch control operation.

The trigger circuit is capable of selecting six different types of signal sources. It is incorporated with an alternate trigger function and a level lock function which facilitate and simplify the trigger operation.

The sweep time range is as wide as 0.5 sec ~ 0.1 μsec. The maximum sweep speed is 10 nsec/DIV (when in the "10 × MAG" mode). A waveform magnification function with sweep delay is incorporated for an alternate sweep function, enabling parallel observation of the magnified waveform and non-magnified waveform. Also incorporated is a variable trigger hold off function which facilitates observation of signals of sophisticated waveforms or digital signals of irregular repetitions.

The circuits are designed with sufficient allowances for improvement of reliability, fully employing ICs of the state-of-the-art.

2. SPECIFICATIONS

Vertical Axis

Item	Specification	Remarks
Sensitivity	5 mV/DIV ~ 5 V/DIV 1 mV/DIV ~ 1 V/DIV (with 5 × MAG)	1-2-5 sequence, 10 ranges.
Sensitivity accuracy	±3% or better ±5% or better (with 5 × MAG)	When VARIABLE knob in CAL'D position
Continuously variable adjustment of sensitivity	To 1/2.5 or less of panel-indicated value	
Frequency response	DC: DC ~ 50 MHz DC ~ 10 MHz (with 5 × MAG) AC: 2 Hz ~ 50 MHz 2 Hz ~ 10 MHz (with 5 × MAG)	With reference to 50 kHz, 8 DIV. within -3 dB
Rise time	Approx. 7 nsec (Approx. 35 nsec when in "5 × MAG")	

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Item	Specification	Remarks
Signal delay time	Approx. 40 nsec. (with delay line of approx. 120 nsec)	Displayable section of waveform before trigger point
Square wave characteristics	Overshoot: 3% or less Ringing: 2% or less Sag: 2% or less	4 DIV amplitude 200 kHz (20°C ~ 35°C (68°F ~ 95°F))
Input coupling	AC, DC, GND	
Input impedance	1 MΩ ±2%, 20 pF ±2 pF	
Maximum allowable input voltage	400 Vp-p (DC + AC peak)	Frequency 1 kHz or lower
Polarity switching	Possible for CH2 alone	
DC balance shift	±0.5 DIV ±2.0 DIV (when 5 × MAG)	
Operation modes	CH1, CH2, CHOP, ALT, ADD, X-Y (CH1 — X, CH2 — Y)	
CHOP frequency	Approx. 500 kHz	
Common mode signal rejection ratio	50:1 or better, at 50 kHz sinusoidal wave	With uniform sensitivities of CH1 and CH2
CH1 signal output	Approx. 20 mV/DIV (At load 1 MΩ) DC ~ 35 MHz (-3 dB)	Zo ≑ 50 BNC receptacle

Item	Specification	Remarks
Isolation between channels	At least 1000:1 at 50 kHz At least 30:1 at 50 MHz	at 5 mV/DIV range (except CHOP mode)

Trigger A and B (A: Main sweep, B: Delayed sweep)

Item	Specification	Remarks
Trigger signal source	A: INT, LINE, EXT, EXT ÷ 10 INT (CH1, CH2, NORM) B: INT, EXT	When in NORM, triggering is ALT TRIG. B EXT terminal is on rear panel.
Coupling mode	A: AC, HF REJ, TV, DC B: AC only	When in TV, signal is connected to trigger circuit after synchronization signal separation.
Polarity	"+" and "-"	Both A and B
A trigger sensitivity	AC: 10 Hz ~ 10 MHz 0.4 DIV (0.04 V) 3 Hz ~ 50 MHz 1.0 DIV (0.1 V) DC: DC ~ 10 MHz 0.4 DIV (0.04 V) DC ~ 50 MHz 1.0 DIV (0.1 V) HF REJ: 10 Hz ~ 50 kHz 1.0 DIV (0.1 V) TV: Video signal 1.0 DIV (0.1 V)	Figures enclosed in brackets indicate EXT input trigger voltage sensitivities.

Item	Specification	Remarks
B trigger sensitivity	10 Hz ~ 10 MHz 0.4 DIV (0.04 V) 3 Hz ~ 50 MHz 1.0 DIV (0.1 V)	AC only
AUTO operation	Satisfies the trigger sensitivity specification for signal repetition frequency of 50 Hz or over.	
NORM	When no trigger signal input is applied, trace is blanked out and is in the READY state.	Satisfies the specification of trigger sensitivity.
SINGLE	One-shot sweep with trigger signal. Can be reset to the READY state by means of RESET switch.	
LEVEL LOCK	Satisfies the values mentioned in the above items of trigger sensitivity plus 0.5 DIV (0.05 V), for a signal of duty cycle 1:5 ~ 5:1 and repetition frequency 50 Hz or over.	When in TV sync trigger, usable with video signal amplitude of 0.5 ~ 2.0 DIV.
External input impedance	A: Approx. 1 MΩ, 30 pF or less B: Approx. 1 MΩ, 35 pF or less	
Maximum allowable input voltage	100 V (DC + AC peak)	AC: 1 kHz or lower

Horizontal Axis

A sweep and B sweep

Item	Specification	Remarks
Sweep time	0.1 μsec ~ 0.5 sec/DIV 10 nsec ~ 50 msec/DIV (when in "10 × MAG")	1-2-5 sequence, 21 Ranges
Continuously variable adjustment of sweep time	Can be varied (made slower) from panel-indicated value by a factor of 2.5 or over.	For A sweep only
Sweep time accuracy	±3% or better ±5% or better (when in "10 × MAG")	
Linearity	3% or better 5% or better (when in "10 × MAG)	
Position shift caused by sweep magnification	Within ±0.5 DIV at CRT center	
Sweep mode	A, A INTEN, ALT, B	

Sweep Delay

Item	Specification	Remarks
Delay system	Continuous delay Triggered delay	
Sweep delay time	5 sec ~ 1 μsec	
Sweep delay time accuracy	Within ±3% on CRT Within ±3% of multi-dial indication (excluding 0 ~ 0.50)	
Delay jitter	1/10,000 or less $\frac{\text{B sweep time}}{\text{A sweep time}} \times \frac{\text{jitter width}}{\text{10 DIV}}$	Jitter width 1.0 DIV or less at A: 1 msec/DIV and B: 1 μsec/DIV

External Sweep

Item	Specification	Remarks
Mode	X-Y mode CH1 .... X axis (HOR.) CH2 .... Y axis (VERT.)	
Sensitivity	5 mV ~ 5 V/DIV	The same as CH1
Sensitivity accuracy	±3% or better	The same as CH1

Item	Specification	Remarks
Frequency response	AC: 2 Hz ~ 2 MHz DC: DC ~ 2 MHz	With reference to 50 kHz, -3 dB
X-Y phase difference	3° or less (DC ~ 50 kHz)	

Z Axis

Item	Specification	Remarks
Sensitivity	3 Vp-p (Trace becomes brighter with negative input, not by positive input.)	
Frequency response	DC ~ 5 MHz	
Input resistance	Approx. 5 kΩ	
Maximum allowable input voltage	50 Vp-p (DC + AC peak)	AC: 1 kHz or lower

CRT

Item	Specification	Remarks
Type	6-inch rectangular, internal graticule	
Fluorescent screen	P31	Green
Acceleration voltage	Approx. +8.5 kV/-1.5 kV	Approx. 10 kV
Effective CRT screen size	8 × 10 DIV	1 DIV = 1 cm (0.39 in.)
Graticule	Internal graticule (parallaxless), continuously variable illumination	
Unblanking	DC coupling	

Calibration Voltage

Item	Specification	Remarks
Waveform	Positive-going square wave	
Frequency	Approx. 1 kHz	
Duty ratio	Within 45:55	
Output voltage	2 V, 200 mV within ±2%	
Rise time	Approx. 0.1 μsec	
Output resistance	2 V: approx. 2 kΩ 200 mV: approx. 200 Ω	

Power Requirements

Item	Specification	Remarks
AC line voltage ranges	A: 90 ~ 110 V B: 104 ~ 126 V C: 194 ~ 236 V D: 207 ~ 253 V	Voltage ranges are selectable with respective voltage selector plugs.
Frequency	50/60 Hz	
Power consumption	Approx. 55 VA	

Mechanical Specification

Item	Specification	Remarks
Dimensions	310 W × 150 H × 400 D mm (12.20W × 5.91H × 15.75D in.)	Dimensions of main body alone
	370 W × 190 H × 480 D mm (14.57W × 7.48H × 18.90D in.)	Maximum dimensions with handle on top of casing
	370 W × 165 H × 525 D mm (14.57W × 6.50H × 20.70D in.)	When portable state
Weight	Approx. 9.7 kg (21.4 lb.)	

Ambient Conditions

- Normal operating ranges: Temperature ..... 5°C ~ 35°C (41°F ~ 95°F)
  Humidity .... 85% RH max.
- Maximum operating range: Temperature ..... 0°C ~ 40°C (32°F ~ 104°F)
  Humidity .... 90% RH max.

Accessories:

	Code number of parts	
o 960 BNC probe (10:1, 1:1)	(89-03-0220)	2
o 942 A terminal adaptor	(W4-986-011)	1
o Slow blow fuse, 0.5 A	(99-02-0100)	1
o Slow blow fuse, 1 A	(99-02-0101)	1
o Power cord	( )	1
o Short bar	(E3-070-101)	1
o Instruction manual	( )	1

3. NOTES IN OPERATION, AND PANEL DESCRIPTION

3.1 Notes in Operation

o AC line voltage:

This instrument can be operated on any one of the AC line voltages shown in the following table. The required voltage can be selected by means of the voltage selector plugs. Before operating the instrument, ensure that the AC line voltage setting of the instrument conforms with the voltage of the AC line on which the instrument is to be operated. If the instrument voltage does not conform with the line voltage, the instrument may not operate normally or may be permanently damaged.

When the instrument AC line voltage is changed, change the fuse also referring to the following table.

<table>
<tr><th>Symbol</th><th>Center voltage</th><th>Operating voltage range</th><th>Fuse</th></tr>
<tr><td>A</td><td>100 V</td><td>90 ~ 110 V</td><td rowspan="2">1 A slow blow</td></tr>
<tr><td>B</td><td>115 V</td><td>104 ~ 126 V</td></tr>
<tr><td>C</td><td>215 V</td><td>194 ~ 236 V</td><td rowspan="2">0.5 A slow blow</td></tr>
<tr><td>D</td><td>230 V</td><td>207 ~ 253 V</td></tr>
</table>

o Environments:

The normal ambient temperature range of this instrument is $0^{\circ}C \sim 40^{\circ}C$ ($32^{\circ}F \sim 104^{\circ}F$). Be sure to operate within this ambient temperature range. Note that troubles may be caused if the ambient temperature is not within this range.

Do not use the instrument in a place where strong magnetic or electric field exists. Such field may disturb the measurement.

o CRT intensity:

Do not make the CRT trace intensity excessively bright or leave the spot stationary for an unreasonably long period of time, in order to prevent shortening of the CRT life.

o Withstanding voltages of input terminals:

The withstanding voltages of the instrument input terminals and probe input terminals are as shown in the following table. Do not apply voltages higher than these limits.

CH1, CH2 inputs	400 Vp-p (DC + AC peak)
Probe input	600 Vp-p (DC + AC peak)
EXT TRIG input	100 Vp-p (DC + AC peak)
Z AXIS input	50 Vp-p (DC + AC peak)

Note : AC Frequency is 1 kHz or below.

3.2 Explanation of Front Panel

o CRT circuits:

POWER .... (21) Main power switch of the instrument. When this switch is turned on, lamp (22) is also turned on.

INTEN .... (23) Controls the brightness of the spot or trace.

B INTEN .... (24) Semi-fixed potentiometer for adjusting the trace intensity when in B sweep.

FOCUS .... (25) For focussing the trace to the sharpest image.

ILLUM .... (27) Graticule illumination adjustment.

TRACE ROTATION ..... (26) Semi-fixed potentiometer for aligning the horizontal trace in parallel with graticule lines.

o Calibration Voltage:

CALIB 2V .... (29) Terminal for 2 V calibration voltage output. Output resistance is approximately 2 kΩ.

200 mV .... (28) Terminal for 200 mV calibration voltage output. Output resistance is approximately 200 Ω.

o Vertical axis:

CH1 (X) input .... (9) Vertical input terminal of CH1. When in X-Y operation, X axis (abscissa) input terminal.

CH2 (Y) input .... (15) Vertical input terminal of CH2. When in X-Y operation, Y axis (ordinate)

GND .... (11) Ground terminal of instrument

AC-GND-DC .... (8) (16) Switch for selecting connection mode between input signal and vertical amplifier.

AC: AC coupling

GND: Vertical amplifier input is grounded and input terminals are made open

DC: DC coupling

VOLTS/DIV ...... (5) (13) Select the vertical axis sensitivity, from 5 mV/DIV to 5 V/DIV with 10 ranges.

VARIABLE .... (6) (14) Fine adjustment of sensitivity, with a factor of 1/2.5 or over of panel-indicated value. When in the CAL'D position, sensitivity is calibrated to panel-indicated value. When not in the CAL'D position, the UNCAL lamp (3) or (19) turns on.

POSITION .... (7) (12) Vertical position control of the trace or spot.

5 × MAG .... (4) (17) Magnifies by 5 times the sensitivity of vertical amplifier. When in this mode, the "5 × MAG" lamp (2) or (20) turns on.

CH2 POLARITY .... (18) This switch selectes the polarity of the signal applied to CH2 input terminal. The ⊓ state is for the normal polarity and the ⊔ state for the inverted polarity.

VERT MODE .... (1) Selects the operation mode of the vertical axis.

CH1: CH1 alone operates.

CH2: CH2 alone operates.

ALT: Dual-channel operation with CH1 and CH2 swept alternately. Suitable for observation with fast sweep speed.

CHOP: Dual-channel operation with CH1 and CH2 chopped at a frequency of approximately 500 kHz. Suitable for observation with slow sweep speed.

ADD: For measurement of algebraic sum or difference of CH1 and CH2 signals, employing the function of CH2 POLARITY switch.

X-Y: X-Y operation with CH1 for X axis and CH2 for Y axis.

INT TRIG .... (10) Selects the internal trigger signal source. The signal selected by this switch is fed to the A trigger circuit if SOURCE switch (37) is set in the INT state or to the B trigger circuit if SOURCE switch (54) of rear panel is set in the INT state.

CH1: Input signal of CH1 is used as trigger signal.

CH2: Input signal of CH2 is used as trigger signal.

NORM: Input signal which is displayed on CRT screen is used as trigger signal. When in the ALT mode, triggering also is in an alternate mode and the signals of both CH1 and CH2 are alternately used for triggering respective channels.

o Trigger Circuit:

(Refer to explanation of the rear panel for B trigger.)

EXT TRIG INPUT ...... (35) Input terminal for external trigger signal.

SOURCE .... (37) Selects the trigger signal.

INT: Internal signal selected by INT TRIG switch (10) is used as trigger signal.

LINE: AC line signal is used as trigger signal.

EXT: Input signal of EXT TRIG INPUT terminal (35) is used as trigger signal.

EXT ÷ 10: Input signal of EXT TRIG INPUT terminal is attenuated to by a factor of 1/10 and used as trigger signal.

COUPLING .... (36) Selects coupling mode between trigger source circuit and trigger circuit and also selects connection mode for the TV sync. circuit.

AC: Trigger signal is applied through an AC coupling circuit.

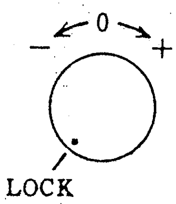
HF REJ: Trigger signal is applied through an AC coupling circuit, with attenuation of signal components higher than 50 kHz.

TV: TV sync. separation circuit is connected to the trigger circuit, and the sweep is triggered in synchronization with TV.V or TV.H signal at sweep speed selected by the A TIME/DIV switch (45).

TV V: 0.5 sec ~ 0.1 msec/DIV

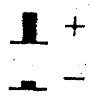
TV H: 50 μsec ~ 0.1 μsec/DIV

LEVEL .... (33) Controls the trigger level for making the displayed waveform becomes stationary and adjusting the start point of displayed waveform. As this knob is turned in the "→ +" direction, the trigger level moves upward on the displayed waveform; as the knob is turned "– ←", the level moves downward.



When set in the LOCK position, the trigger level is automatically maintained at an optimal value irrespective of the signal amplitude (from very small amplitude to large amplitude), requiring no manual adjustment of trigger level.

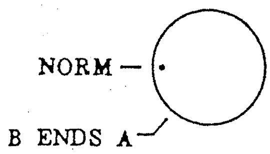
SLOPE .... (32) Selects the triggering slope.



"+": Triggering is effected when the trigger signal crosses the trigger level in positive-going polarity.

"–": Triggering is effected when the trigger signal crosses the trigger level in negative-going polarity.

A HOLD OFF .... (31)



This knob is used when the signal waveform is sophisticated and stable triggering cannot be attained with LEVEL knob (33) alone. When this knob is set in the "B ENDS A" position, the A sweep ends at the same time the B sweep ends. With this function, degradation of brightness can be prevented when in the delayed sweep with large magnification of waveform in the horizontal direction.

o Sweep Circuits

A, B TIME/DIV .... (45)
AND DELAY TIME (46)

The large knob (45) is for A TIME/DIV and DELAY TIME, and the medium knob (46) is for B TIME/DIV.

The A TIME/DIV knob sets the sweep time for the A sweep; the DELAY TIME knob sets the delaying sweep time.

The B TIME/DIV switch sets the delayed sweep time.

A VARIABLE .... (44)

Continuously-variable adjustment of A sweep time. Value indicated by A TIME/DIV switch (45) can be reduced by a factor of 2.5 or more. When set in the CAL'D position, the sweep speed is calibrated to the value indicated by the A TIME/DIV switch. When not in the CAL'D position, the UNCAL lamp (41) turns on.

10 × MAG .... (39) The A or B sweep is expanded by 10 times and, therefore, the sweep time becomes 1/10. When in this operation, the "10 × MAG" lamp (38) turns on.

POSITION ↔ .... (47) Horizontal position control of the spot or trace.

FINE .... (48) Fine adjustment of horizontal positioning. Especially useful when in the "10 × MAG" operation.

DELAY TIME MULTI .... (49) Multi-turn potentiometer for continuously variable adjustment of the delay time indicated by the A sweep knob (45) in order to select the section to be expanded of the A sweep.

SWEEP MODE .... (43) Selects the required sweep mode.

AUTO: When no adequate triggering signal is applied or when signal frequency is less than 50 Hz, sweep runs automatically.

NORM: When no adequate triggering signal is applied, sweep is in a ready state and the return trace is blanked out. Used primarily for observation of signals of 50 Hz or lower.

SINGLE: (PUSH TO RESET) Used for single sweep operation (one-shot sweep operation) in conjunction with the reset switch.

When the three buttons are in the pushed out state, the circuit is in the single sweep mode. The circuit is reset as this button is pressed. When the circuit is reset, the READY lamp (40) turns on. The lamp goes off when the single sweep operation is over.

HORIZ DISPLAY .... (50) Selects A and B sweep mode as follows:

A: Main sweep (A sweep) mode for general waveform observation.

A INTEN: This sweep mode is used when selecting the section to be magnified of the A sweep. The B sweep section (delayed sweep) corresponding to the A sweep is displayed with high brightness.

ALT: A sweep and B sweep (delayed sweep) are displayed alternately. (The A, B TRACE SEPARATION knob (34) is used in conjunction so that the waveforms can be clearly observed.

B: Displays with the delayed sweep (B sweep) alone.

B TRIG'D: Selects between continuous delay and triggered delay.

I : For continuous delay. Sweep starts immediately after the sweep delay time determined by DELAY TIME switch (45) and DELAY TIME MULTI knob (49), irrespective of B trigger signal.

▁: For triggered delay. Sweep starts with B trigger signal after the sweep delay time determined by DELAY TIME switch (45) and DELAY TIME MULTI knob (49). (Controls for B trigger circuit are located on the rear panel.)

A, B TRACE SEPARATION .... (34) Semi-fixed potentiometer for separating the vertical positions of the A and B sweeps when in the ALT mode.

3.3 Explanation of Rear Panel

o CH1 SIGNAL OUTPUT .. (63) This output terminal provides CH1 signal which is fed to a frequency counter, etc.

o B Trigger Circuit

EXT TRIG INPUT .... (51) Input terminal for external trigger signal of B sweep.

LEVEL .... (52) Trigger level adjustment of B sweep. When set in the LOCK position, trigger level is automatically maintained in an optimal irrespective of signal amplitude (from very small signal to large signal).

SLOPE .... (53) Selects the slope for the triggering point of B sweep.

SOURCE .... (54) Selects the trigger signal for B sweep.

INT: Signal selected by INT TRIG switch (10) is fed in AC coupling to trigger circuit.

EXT: Input signal applied to EXT TRIG INPUT terminal (51) is fed in AC coupling to trigger circuit.

o Z Axis

Z AXIS INPUT ....(55) (56) Input terminals for external intensity modulation signal. Binding post terminals with 19-mm (0.75 in.) spacing.

o CRT Circuit

ASTIG .... (62) Astigmatism control of CRT. This control, in conjunction with the FOCUS control, should be so adjusted that the spot or trace displayed on the CRT screen is made sharpest.

o AC Power Input Circuit

AC power input connector .... (59)

Input connector of the AC power of the instrument. Connect the AC power cord (supplied) to this connector.

FUSE .... (60) Fuse in the primary circuit of the power transformer. Fuse rating is as shown in the AC line voltage table (61) on the instrument rear panel.

AC voltage selecting connector ..... (57)

For selecting the AC voltage of the instrument in conjunction with selector plug (58).

AC voltage selector plug ..... (58)

For selecting the AC voltage of the instrument in conjunction with selector connector, as indicated with A, B, C, D symbols with reference to the AC line voltage table (61) on the instrument rear panel.

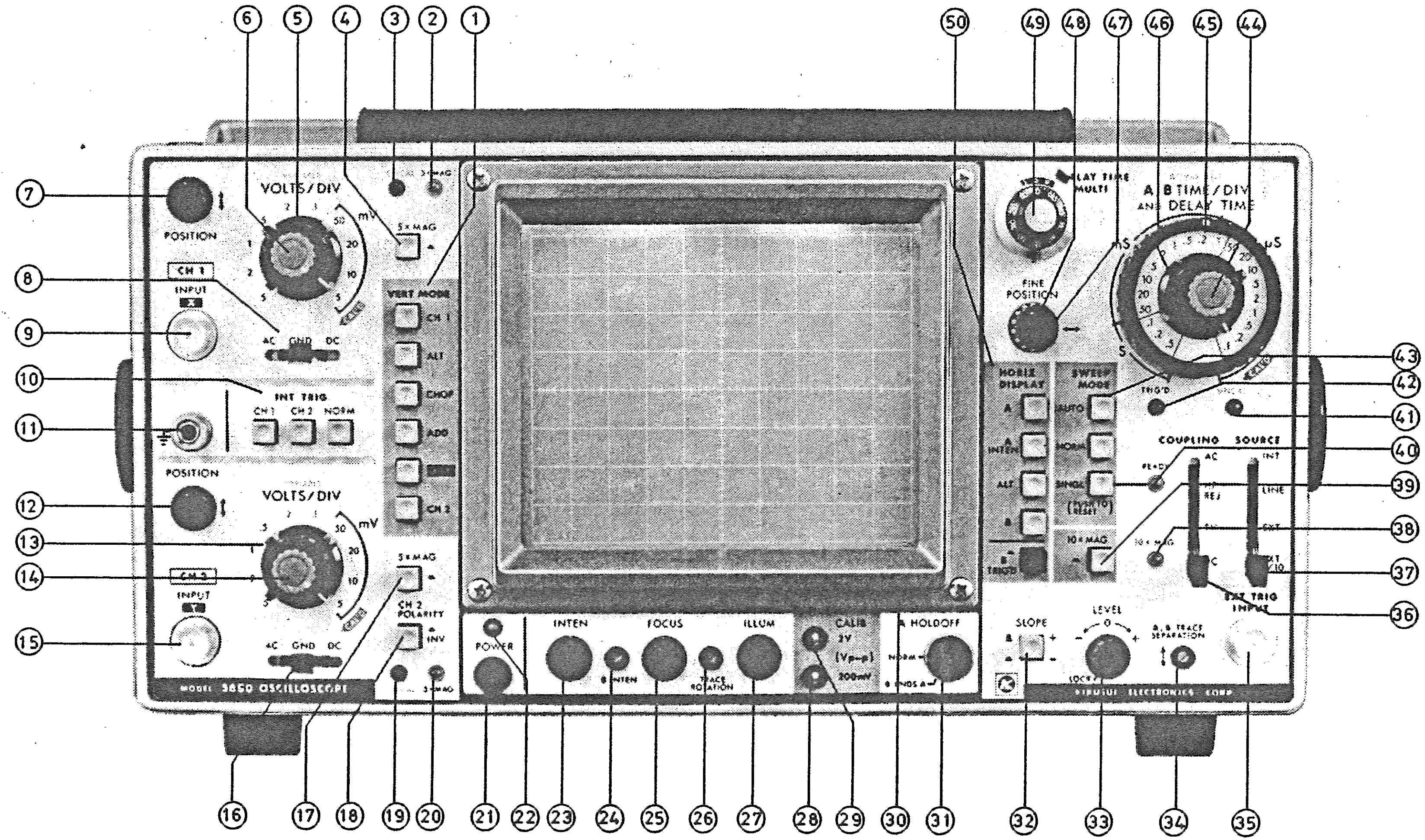


Figure 1. Front panel of the oscilloscope

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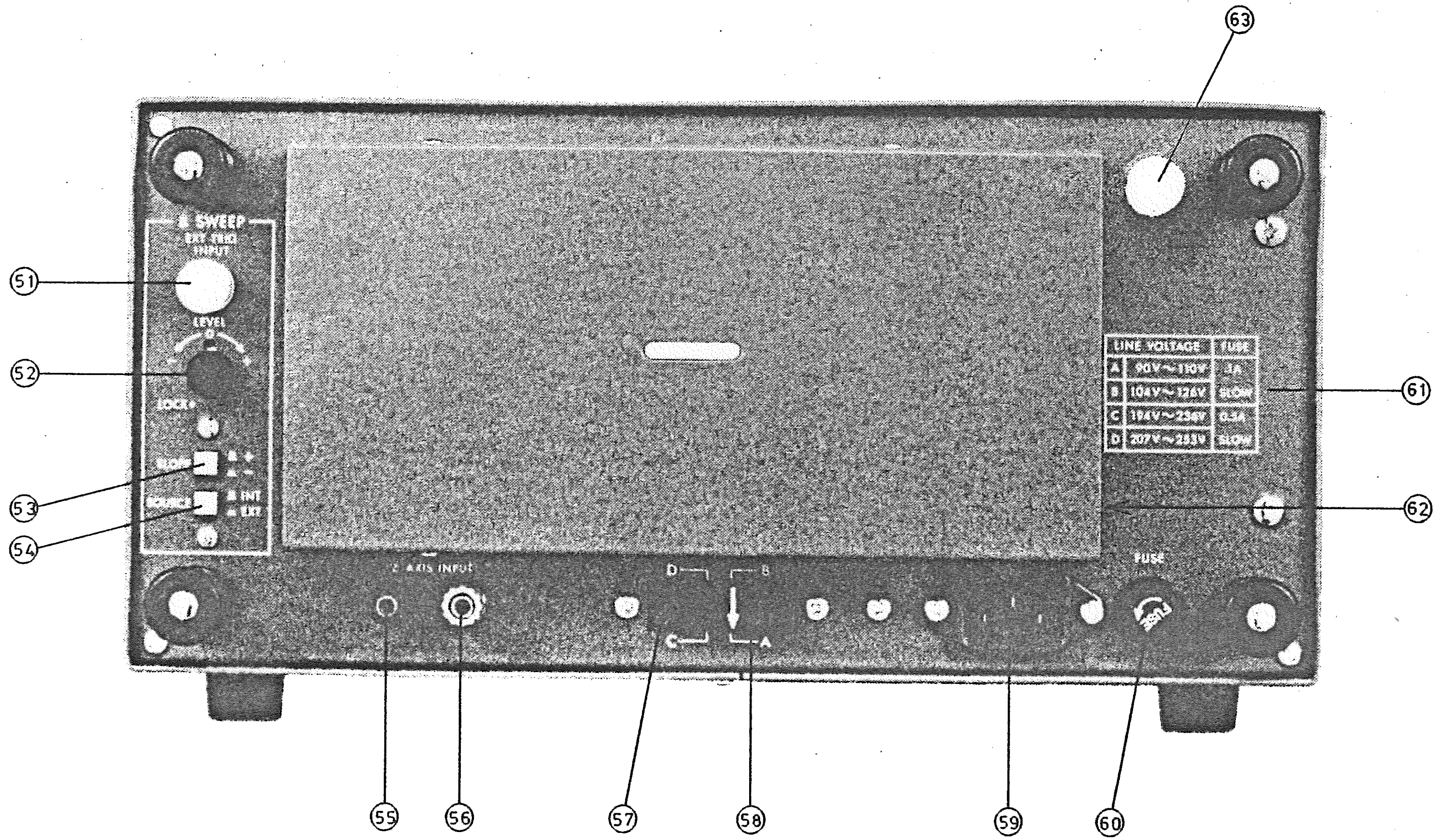

Figure 2. Rear panel of the oscilloscope

4. OPERATION METHOD

4.1 Basic Operation (Refer to Figure 1.)

Before connecting the power cord to an AC line outlet, check that the AC line voltage selector plug on the rear panel of the instrument correct set for the AC line voltage. After ensuring the voltage setting, set the switches and controls of the instrument as shown in the following table.

Item	No.	Setting
POWER	(21)	OFF position
INTEN	(23)	Clockwise (3-o'clock position)
FOCUS	(25)	Mid-position
ILLUM	(27)	Counterclockwise position
VERT MODE	(1)	CH1
↕ POSITION	(7) (12)	Mid-position
VOLTS/DIV	(5) (13)	50 mV
VARIABLE	(6) (14)	CAL'D (clockwise position)
AC-GND-DC	(8) (16)	GND
5 × MAG	(4) (17)	▮ OFF
CH2 POLARITY	(18)	▮ NORM
INT TRIG	(10)	NORM
SOURCE	(37)	INT

Item	No.	Setting
COUPLING	㊱	AC
LEVEL	㉝	LOCK (counterclockwise)
SLOPE	㉜	▮ "+"
A HOLD OFF	㉛	NORM (counterclockwise)
SWEEP MODE	㊸	AUTO
HORIZ DISPLAY	㊿	A
10 × MAG	㊴	▮ OFF
TIME/DIV	㊺	0.5 mS
VARIABLE	㊹	CAL'D (clockwise)
←→ POSITION	㊼ ㊽	Mid-position

After setting the switches and controls as above, connect the power cord to the AC line outlet and, then, proceed as follows:

1) Turn-ON the POWER switch and ensure that the power pilot lamp (LED) above is also turned on. In about 20 seconds, a trace will be appear on the CRT screen. If no trace appears in about 60 seconds, repeat the switch and control settings as shown in the above table.

2) Adjust the trace to an appropriate brightness and sharpest image with the INTEN control and FOCUS control.

3) Align the trace with the horizontal center line of graticule by adjusting the CH1 POSITION control and TRACE ROTATION control (semi-fixed potentiometer).

4) Connect the probe (supplied) to the CH1 INPUT terminal, and apply the 200mVp-p CALIBRATOR signal for the CALIB terminal.

5) Set the AC-GND-DC switch in the AC state. A waveform as shown in Figure 3 will be displayed on the CRT screen.

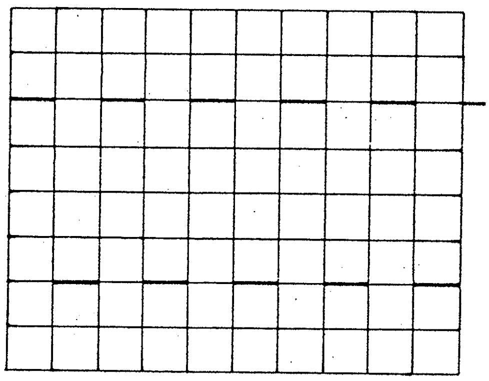

Figure 3

6) So adjust the FOCUS control that the trace image becomes sharpest.

7) For signal observation, set the VOLTS/DIV switch and TIME/DIV switch in appropriate positions so that the signal waveform is displayed with an appropriate amplitude and an appropriate number of peaks.

8) Adjust the ↕ POSITION and ↔ POSITION control in appropriate positions so that the displayed waveform is aligned with the graticule and the voltage (Vp-p) and period (T) can be read conveniently.

The above is the basic operation procedure of the oscilloscope. Further operation methods are explained in the subsequent paragraphs.

4.2 Dual-channel Operation

Two signals can be simultaneously displayed on the screen by setting the VERT MODE switch in the CHOP state or the ALT state. By using these chopped sweep mode and alternate sweep modes, signals can be successfully displayed with sweeps of from low speed to high speed.

(1) CHOP sweep (chopped sweep):

The signals of CH1 and CH2 are chopped at a frequency of 500 kHz and the chopped signals are displayed on the CRT screen. Therefore, if the sweep speed is faster than a certain speed, the traces become as dotted lines. In such a case, the ALT mode as explained in the next paragraph should be used.

(2) ALT sweep (alternate sweep)

This sweep mode is used primarily for observation of signals at faster sweep speeds, although it may be used also at slower sweep speeds when photographing the displayed waveforms or when particular trigger conditions are required.

At faster sweep speeds, the two waveforms are displayed as if they were running at the same time. At slower sweep speeds, the alternate actions of the two sweeps becomes discernible to human eyes and the displayed images become flickering to human eyes. In such a case, the CHOP mode explained in the preceding paragraph should be used.

4.3 ADD Operation

An algebraic sum of the CH1 and CH2 signals can be displayed on the CRT screen by setting the VERT MODE switch in the ADD state. The displayed signal is the difference between CH1 and CH2 signals if the CH2 POLARITY switch is set in the ▁▄▁ INV state.

For accurate addition or subtraction, it is a prerequisite that the sensitivities of the two channels are adjusted accurately at the same value by means of the VAR knobs. Vertical positioning can be done with the ↕ POSITION knob of either channel. In view of the linearities of the vertical amplifiers, it is most advantageous to set them in their mid-positions.

4.4 Triggering

Proper triggering is essential for efficient operation of an oscilloscope. The user of the oscilloscope must made himself thoroughly familiar with the triggering functions and procedures.

(1) Functions of INT TRIG (internal trigger) switch:

The signals applied to the input terminals of CH1 and CH2 are picked off from respective preamplifiers in order to be used as internal trigger signals. The INT TRIG switch select these signals. The selected signals are sent to the A trigger circuit or the B trigger circuit through the SOURCE switch circuit. The relationship of these circuits is shown in the block diagram of Figure 4.

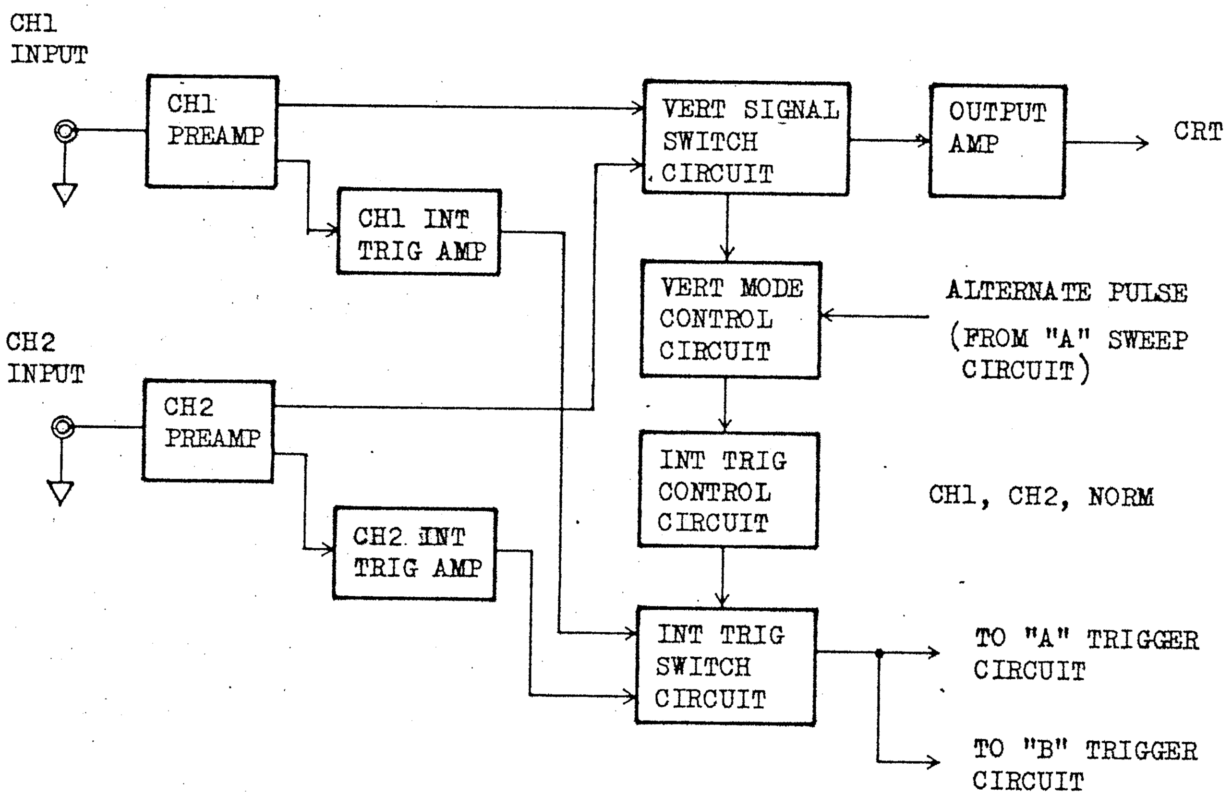

Figure 4

With the INT TRIG switch the internal trigger signal can be selected as follows, realizing a straightforward method.

CH1: Input signal of CH1

CH2: Input signal of CH2

NORM: Signal being displayed on CRT

For further improvement of ease of operation, the switch is also related to part of the VERT MODE switch as shown in the following table.

INT TRIG \ VERT MODE	CH1	CH2	CHOP	ALT	ADD	X-Y
CH1	Triggered with CH1					
CH2	Triggered with CH2					
NORM	Triggerd with CH1	Triggerd with CH2	-	*alter-nate trigger	Triggerd with CH1	-

* When in the ALT trigger mode, the same trigger circuit is used alternately by the two signals (signals of CH1 and CH2). To trigger respective signals, the two signals are required to cross the same trigger level and therefore the DC components of the two signals are required to be taken into consideration.

Further, when the SOURCE switch is set in the AC state or when the number of peaks displayed on the CRT screen is less than three cycles, jitter may be caused. In this case the instrument cannot be operated in the CHOP mode.

(2) Functions of SOURCE Switch:

To display a stationary pattern on the CRT screen, the displayed signal itself or a trigger signal which has a certain time relationship with respect to the displayed signal is required to be applied to the trigger circuit. The SOURCE switch selects such signal as a trigger source.

INT: This internal trigger method is used most commonly. The signal applied to the vertical input terminal (the measured signal) is branched off from a point in the amplifier circuit and is fed to the trigger circuit through the INT TRIG switch. Since the trigger signal is well related to the measured signal, or originally is the measured signal itself, a very stable waveform can be readily displayed on the CRT screen.

LINE: The AC power line frequency signal is used as the trigger signal. This method is effective when the measured signal is in a certain relationship with respect to the AC line frequency, especially for measurements of low level AC noise of audio circuits, AC line frequency controlled thyristor circuits, etc.

EXT: The sweep triggered with an external signal applied to the EXT TRIG INPUT terminal. An external signal which has a certain periodic relationship with respect to the measured signal is used. Since the measured signal (vertical input signal) is not used as the trigger signal, waveform display can be done independent of the measured signal.

EXT ÷ 10: The external trigger signal applied to the EXT TRIG INPUT terminal is attenuated into 1/10 before being applied to the trigger circuit. The further operations are the same with those of the EXT trigger mode. This mode is used when the external trigger signal level is too high.

(3) Functions of COUPLING switch:

This switch is used to select the coupling of the trigger signal to the trigger circuit in accordance with the characteristics of the measured signal.

AC: This coupling is for AC triggering which is used most commonly. As the trigger signal is applied to the trigger circuit through an AC coupling circuit, stable triggering can be attained without being affected by the DC component of the input signal. The low-range cut off frequency is 3 Hz (-3 dB).

When the ALT trigger mode is used and the sweep speed is slow, jitter may be produced. In such a case, use the DC mode.

HF REJ: The trigger signal is applied to the trigger circuit through an AC coupling circuit and a low pass filter circuit, in order that the high frequency signal or noise components of the trigger signal is eliminated triggering is effected with the low frequency component alone.

TV: This coupling is for TV triggering for observation of TV video signals. The trigger signal is AC-coupled and fed via the trigger circuit (level circuit) to the TV sync signal separation circuit. The separation circuit picks off the sync signal and this signal is used as the trigger signal. Thus, the video signal can be displayed very stably.

Being linked to the TIME/DIV switch, the sweep speed is switched for TV.V and TV.H as follows:

TV.V: 0.5 sec ~ 0.1 msec

TV.H: 50 μsec ~ 0.1 μsec

The SLOPE switch should be set in conformity with the video signal as shown in Figure 5.

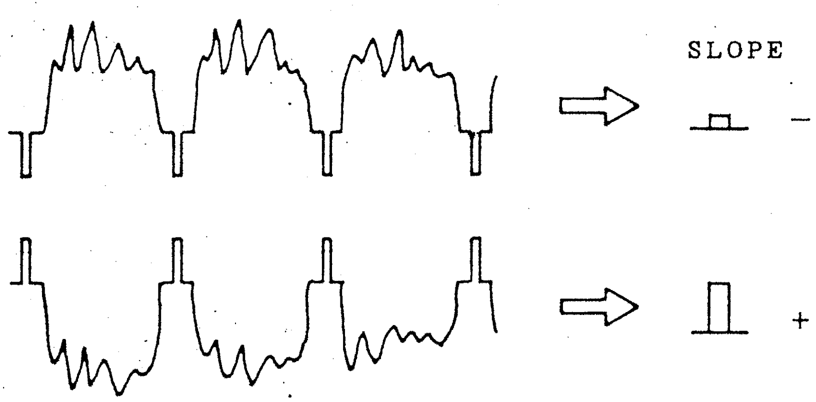

Figure 5

Note: The LEVEL LOCK is effective when the signal level is very low (2 DIV or less). When the signal level is higher than 2 DIV, release the LOCK and manually adjust the level.

DC: This coupling is for DC triggering. The trigger signal is DC-coupled to the trigger circuit. This mode is used when triggering is required to be effected including the DC component of the trigger signal or when a very low frequency signal or a signal of a large duty cycle ratio is required to be displayed.

(4) Functions of SLOPE switch:

This switch selects the slope (polarity) of the trigger signal.

"+": When set in the "+" state, triggering is effected as the trigger signal crosses the trigger level in the positive-going direction.

"-": When set in the "-" state, triggering is effected as the trigger signal crosses the trigger level in the negative-going direction.

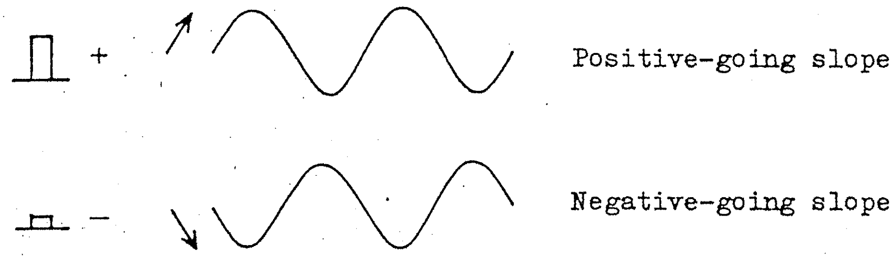

Figure 6

(5) Functions of LEVEL (LOCK) control:

The function of this control is to adjust the trigger level and display a stationary image. At the instant the trigger signal has crossed the trigger level set by this control, the sweep is triggered and a waveform is displayed on the screen.

The trigger level changes in the positive direction (upward) as this control knob is turned clockwise and it changes in the negative direction (downward) as the knob is turned counterclockwise. The rate of change is set as shown in Figure 7, taking into consideration the ease of adjustment.

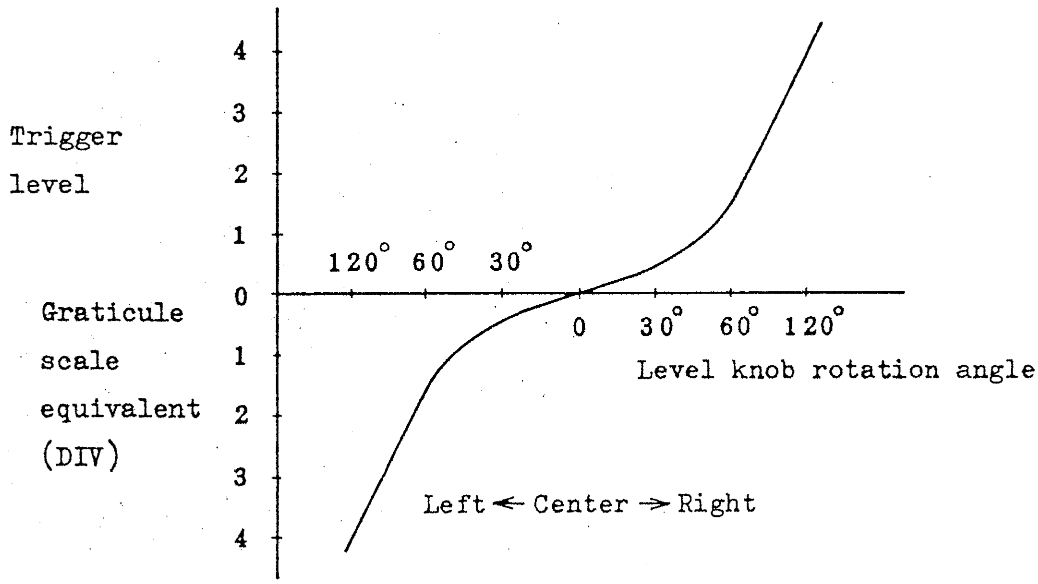

Figure 7

o LEVEL LOCK

When the LEVEL knob is set in the LEVEL LOCK position, the trigger level is automatically maintained at a stable trigger level by the level lock circuit, provided that the displayed signal level or the external trigger signal level is within the following range:

Within	3 Hz ~ 50 MHz	1.5 DIV (0.15 V)
Within	10 Hz ~ 10 MHz	0.9 DIV (0.09 V)

(6) Functions of A HOLD OFF control:

When the measured signal is of a sophisticated waveform with two or more repetition frequencies (periods), triggering with the above-mentioned LEVEL control alone may not be sufficient for attaining synchronization for stable waveform display. In such a case, the sweep can be synchronized to the measured signal waveform rather forcefully by adjusting the HOLD OFF time (sweep pause time) of the sweep waveform. Thus, the HOLD OFF knob is used to synchronize the trigger signal to sophisticated waveform by varying the HOLD OFF time. The control covers at last the time of one full sweep, for sweeps faster than 0.2 sec/DIV.

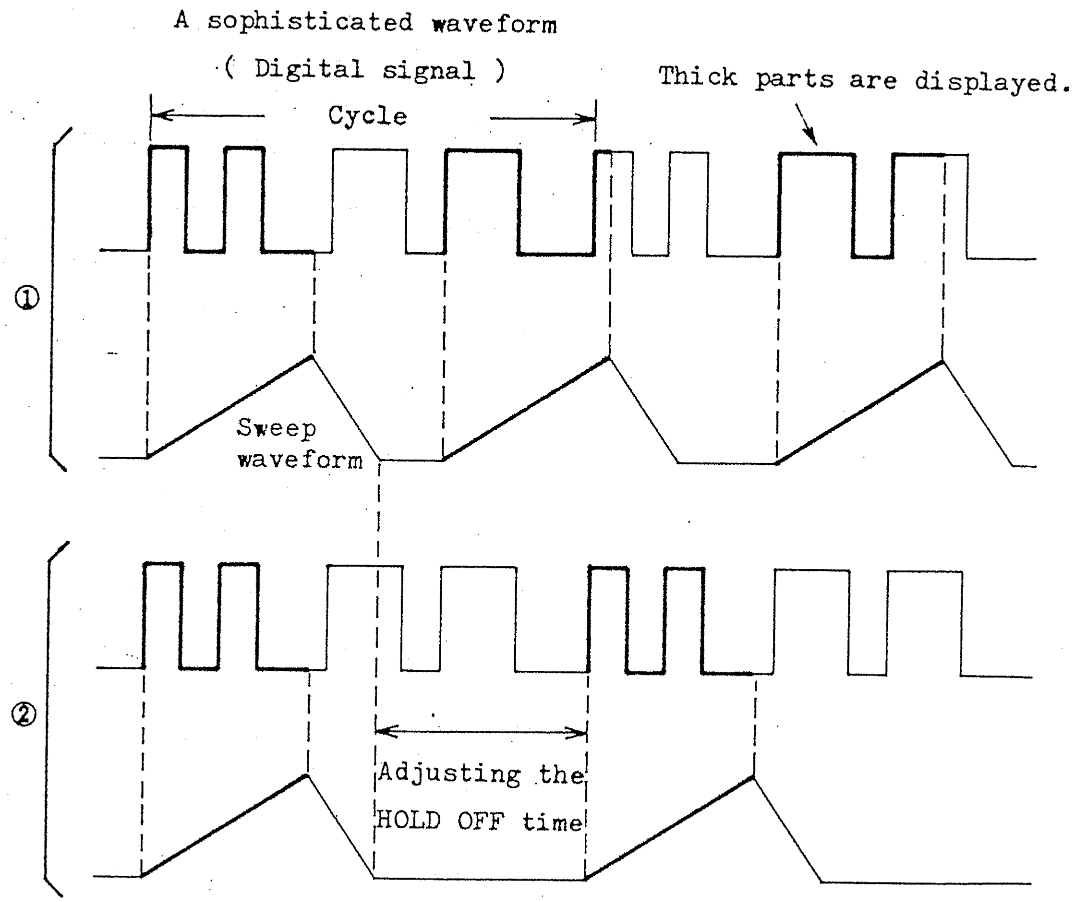

Figure 8

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4.5 Single-sweep Operation

When the measured signal is of a non-repetitive nature (has no fixed repetitive period) or when it is of a one-shot nature (transiential signal), the waveform cannot be displayed stationarily on the CRT screen. In such a case the sweep circuit should be operated in the single-sweep mode and the displayed one-shot image should be carefully observed or be photographed with a camera.

o Measurement of non-repetitive signal:

(1) Set the HORIZ DISPLAY in the "A" state and the SWEEP MODE in the NORM state.

(2) Applied the measured signal to the vertical input terminal and adjust the trigger level.

(3) Set the SWEEP MODE in the SINGLE state (the three push-button switches are pushed out).

(4) Depress the RESET button. The sweep will run for one cycle alone and the measured signal will be displayed only once for the corresponding period.

o Measurement of one-shot signal:

(1) Set the HORIZ DISPLAY in the "A" state and the SWEEP MODE in the NORM state.

(2) Apply the calibration output signal to the vertical input terminal, and adjust the trigger level at a value corresponding to the predicted amplitude of the measured signal.

(3) Set the SWEEP MODE in the SINGLE state. Apply the measured signal instead of the calibration signal to the vertical input terminal.

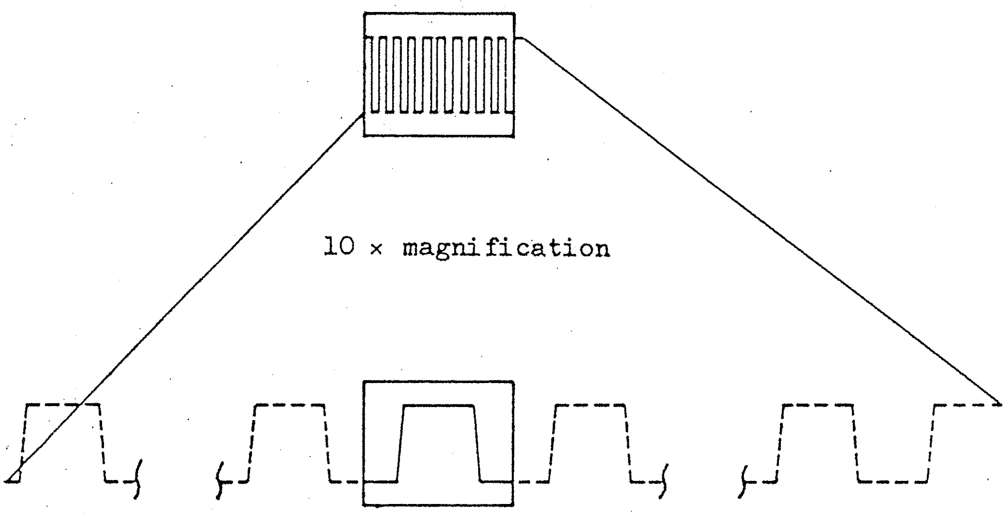
(4) Depress the RESET button. The sweep circuit will become the ready state and the READY lamp will turn on.

(5) As the one-shot signal is effected in the input circuit, the sweep runs for one cycle and the one-shot signal is displayed on the CRT screen.

The single-sweep operation can be done also with A INTEN and B sweep. However, it cannot be done in the ALT mode dual-channel operation. For dual-channel one-sweep operation, use the CHOP mode.

4.6 Sweep Magnification

When a certain part of the displayed waveform is required to be expanded timewise, a faster sweep speed may be used. However, if the required part is apart from the start point of the sweep, the required part may run out of the CRT screen. In such a case, set the "10 × MAG" switch (39) in the 10 × MAG state. When this is done, the displayed waveform is expanded by 10 times to right and left with the center of screen as the center of expansion.



Any part can be covered by means of POSITION control.

Figure 9

The sweep time when in the magnification operation is as follows:

(Value indicated by TIME/DIV switch) × 1/10

There, the maximum sweep speed (0.1 μsec/DIV) can be made faster still with magnification as follows:

$0.1\ \mu sec/DIV \times 1/10 = 10\ nsec/DIV$

When the sweep is magnified and the sweep speed has become faster than 0.1 sec/DIV, the trace intensity may be reduced. In such a case, the displayed waveform should be expanded in the B sweep mode explained in the subsequent paragraphs.

4.7 Waveform Magnification with Delayed Sweep

With sweep magnification of the preceding paragraph, although the magnification method is simple, the magnification ratio is limited at 10. With the delayed sweep method of this paragraph, on the other hand, the sweep can be expanded for a wide range of from several times to several thousands times according to the ratio between A sweep time and B sweep time.

As the measured signal frequency becomes high and the A sweep range for the non-expanded signal becomes higher, the available expansion ratio becomes smaller. Further, as the magnification ratio becomes larger, the trace intensity becomes lower and the delay jitter increases. To cope with these situations, a synchronized delay action circuit and a B ENDS A action circuit also are incorporated.

(1) Continuously-variably delay:

Set the HORIZ DISPLAY switch in the A state and display the signal waveform with the A sweep in the regular operation method.

Next, set the B TIME/DIV switch in a position faster by several steps than the A TIME/DIV switch.

After ensuring that the ▂ T TRIG'D switch is in the ▌ OFF state, turn the HORIZ DISPLAY switch to the A INTEN position. A part of the displayed waveform will be accentuated as shown in Figure 10. The part of the accentuated brightness denotes the section corresponding to the B sweep time (DELAYED SWEEP). This part is expand on the B sweep.

The period from the start of the A sweep to that of the B sweep (the period to that the trace is accentuated) is called "SWEEP DELAY TIME." This period is continuously variable by means of the DELAY TIME MULTI dial.

Next, turn the HORIZ DISPLAY switch to the B position. The B sweep time will be expanded for the full span of the CRT screen as shown in Figure 11.

The B sweep time is set by the B TIME/DIV switch and the magnification ratio becomes as follows:

$$\text{Magnification ratio} = \frac{\text{A TIME/DIV indication}}{\text{B TIME/DIV indication}}$$

The sweep delay time can be read on the CRT screen. For more accurate determination, the DELAY TIME MULTI dial should be used.

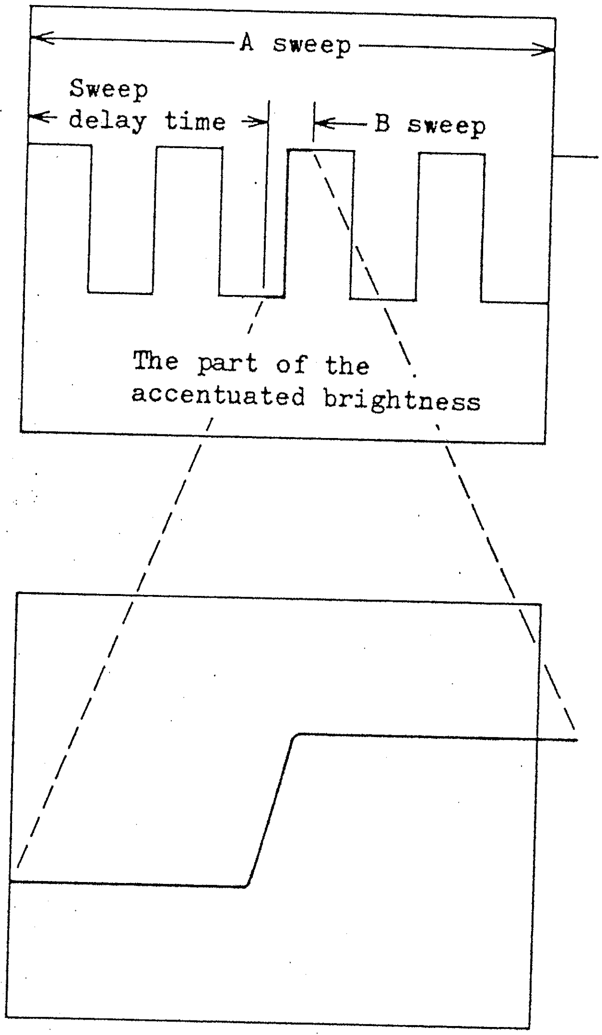
Sweep delay time = A TIME/DIV indication × DELAY TIME MULTI dial setting

HORIZ DISPLAY
A INTEN

Figure 10

HORIZ DISPLAY
B

Figure 11



(2) Synchronized delay:

When the displayed waveform is magnified by 100 times or over in the above-mentioned continuous delay method, delay jitter is be produced. To suppress the jitter, this synchronized delay method may be used.

With the synchronized delay, delay jitter is reduced by triggering the B sweep again after a certain sweep delay time as effected by the continuous delay method has elapsed.

For this operation, the B trigger circuit operates as the ■ B TRIG'D (49) switch is set in the ■ ON state and the B sweep is triggered by the B trigger pulse. Therefore, even when the delay time is continuously varied by rotating the DELAY TIME MULTI dial, the starting point does not vary continuously but varies intermittently. This operation in the A INTEN can be observed as the accentuated section moves intermittently; however, it cannot be observed with the B sweep because the accentuated section does not move.

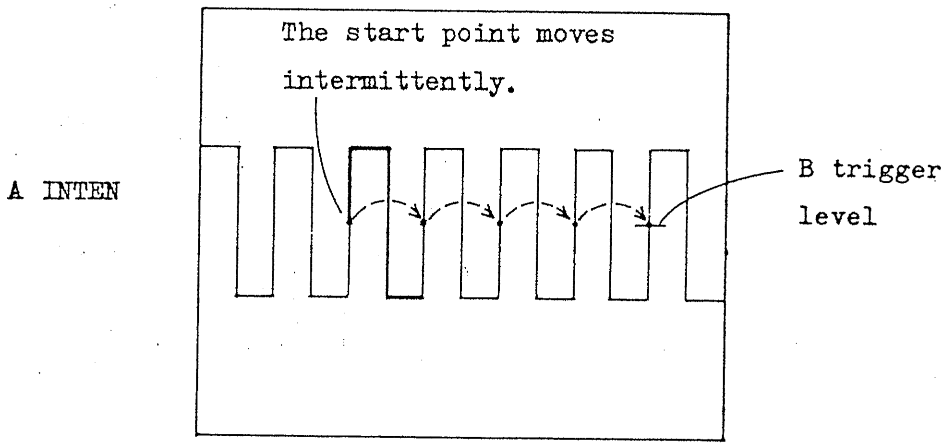


Figure 12

4.8 Delayed ALT Sweep

When in the Delayed ALT sweep mode, the A sweep and B sweep (delayed sweep) are displayed alternately on the screen, enabling you to observe at the same time the unmagnitized waveform and magnified waveform of Section 4.7.

The operation method is the same as that of the delayed sweep of Section 4.7. As you turn the HORIZ DISPLAY switch to the ALT position, the A INTEN waveform and B waveform are displayed on the screen as shown in Figure 13. To prevent the two waveforms from overlapping and to display them separately, adjust the A, B TRACE SEPARATION potentiometer ㉞.

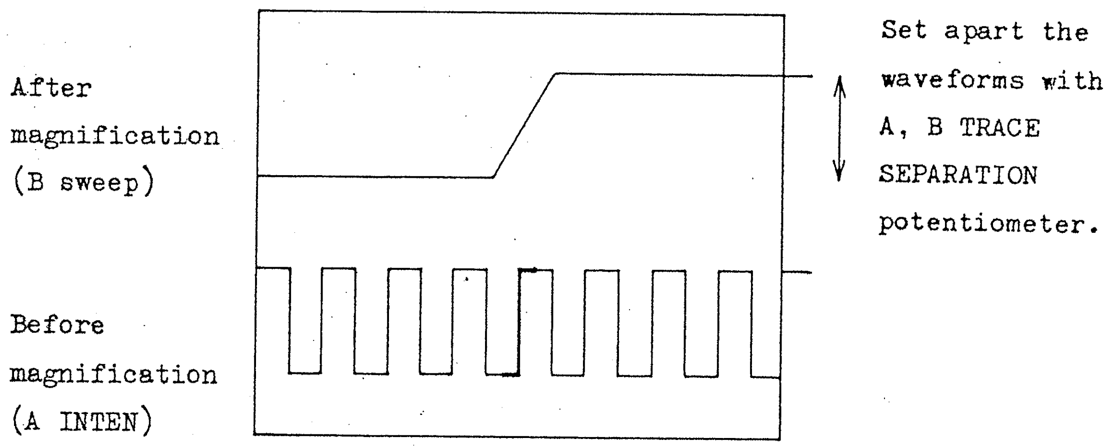


Figure 13

Note: The delayed ALT sweep mode can be used in combination with the dual-channel mode (CHOP or ALT) of the vertical axes.

4.9 B ENDS A Mode

When the trace is magnified by a large ratio with the delayed sweep, the magnified trace may become large and hardly discernible. This is because, as the slow A sweep runs for the full screen, only a very less time remains for the fast B sweep. In such a case, by ending up the A-sweep at the minimum required point, the display time for the B sweep is increased so that the trace does not become dark. This is the B ENDS A mode.

The operating method is the same with that of Sections 4.8 and 4.9. Turn the A HOLD OFF knob (31) to the extremely clockwise position (B ENDS A position). A bright magnified trace as shown in Figure 14 will be displayed.

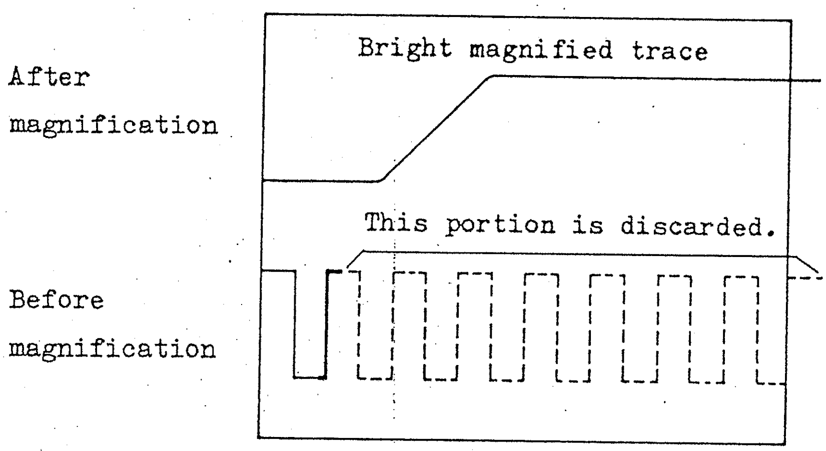


Figure 14

5. METHODS OF MEASUREMENTS

5.1 Connection Method of Input Signal

The input impedance of the oscilloscope as viewed from the vertical input terminal is 1 MΩ with capacitance approximately 20 pF in parallel. When the probe 10:1 is used, the impedance increases to resistance 10 MΩ with capacitance approximately 12 pF in parallel.

There are various methods of connection between measured signal source and oscilloscope. The most popular methods are with general wires, with shielded wires, with a probe, or with a coaxial cable. Suitable ones are used taking the following factors into consideration.

Output impedance of input signal source

Level and frequency of input signal

External induction

Distance between input signal source and oscilloscope

Types of input signals and connection methods are tabulated in the following:

Type of input signal \ Connection method			General wire	Shielded wire	Probe	Coaxial cable	Others
Low frequency	Low impedance	Near	○	○	○	○	
		Far		○		○	
	High impedance	Near		◍	○	◍	
		Far		◍		◍	
High frequency	Low impedance	Near			○	○	
		Far				○	
	High impedance	Near			○	◍	
		Far					

(○: Good, ◍: Fair)

o Connection with general wires:

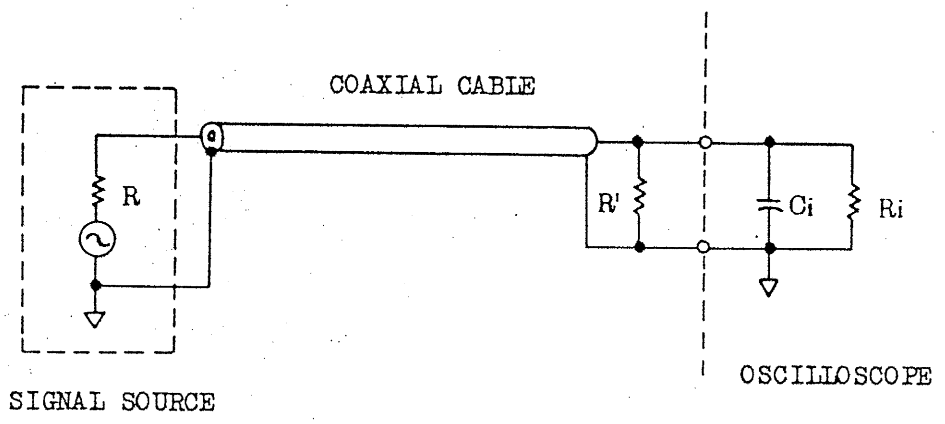
Set a BNC Type Adaptor (Type 942A) to the vertical input terminal and connect general wires to the adaptor. This method is simple and the input signal is not attenuated but is susceptible to induction noise when long wires are used or when the signal source impedance is high. Another disadvantage is a large stray capacity with respect to the ground. As compared with the case the 10:1 probe is used, larger effects are caused by the stray capacity.

o Connection with shielded wire:

The use of a shielded wire prevents external induction noise. However, the shielded wire has as large stray capacitance as 50 pF/m ~ 100 pF/m and this method is not suitable when the signal source impedance is high or the measured signal frequency is high.

o Connection with coaxial cable:

When the output impedance of the signal source is 50 Ω or 75 Ω, the input signal can be fed without attenuation up to high frequencies by using a coaxial cable which enables impedance matching. For impedance matching, terminate the coaxial cable with a 50 Ω or 75 Ω pure-resistive resistor corresponding to the characteristic impedance of the coaxial cable, as shown in Figure 15.



$R = R'$

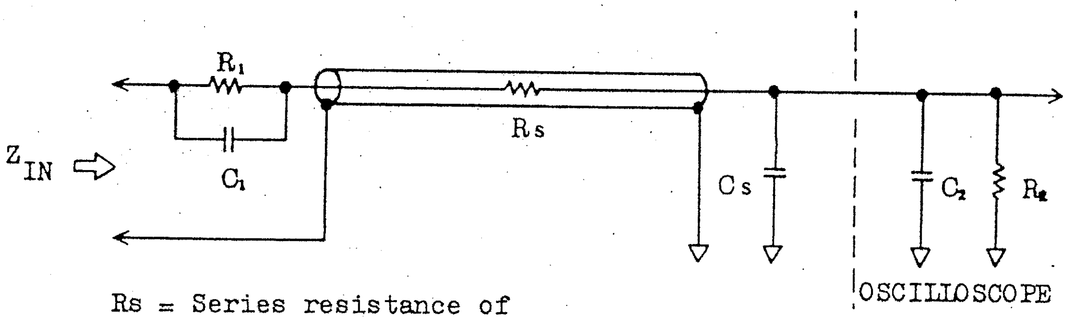
When R = 50 Ω, use a 50 Ω coaxial cable.

When R = 75 Ω, use a 75 Ω coaxial cable.

Figure 15

o Connection with probe:

A probe with an attenuation ratio of 10:1 is available as supplied. The probe circuit and probe cable are shielded to prevent induction noise. The probe circuit makes up a wide-range attenuator in conjunction with the input circuit of the oscilloscope, thereby enabling a distortionless connection from DC to high frequencies. When the probe is used, although the signal level is attenuated to 1/10, the input impedance becomes very high (resistance 10 MΩ, capacitance approx. 12 pF) and the loading effect on the measured signal source is greatly reduced as explained in the following.



Rs = Series resistance of cable

Cs = Stray capacitance plus cable capacitance

Figure 16

The probe makes up a wide-range attenuator with its resistor R1 which make up an attenuator circuit with respect to input resistor R2 of the oscilloscope and with its capacitor C1 which compensates for input capacitor C2 of the oscilloscope and stray capacitance (Cs) of the cable. The input impedance Z_{IN} is expressed as follows:

$$Z_{IN} = \frac{R1 + R2}{C \cdot (R1 + R2) + 1}$$

$$C = \frac{C1 \times (C2 + Cs)}{C1 + C2 + Cs}$$

Attenuation ratio A is expressed as follows:

$$A = \frac{R2}{R1 + R2} \quad \left(= \frac{1M\Omega}{9M\Omega + 1M\Omega} = \frac{1}{10} \right)$$

The terms enclosed in the parentheses are for the factor when the probe is used:

Precautions:

- Observe the maximum allowable input voltages mentioned in Section 3.4.
- Do not fail to use the ground lead supplied.
- Before commencing measurement, accurately adjust the phase of the probe without fail.
- Do not apply unreasonably large mechanical shocks or vibration to the probe. Do not sharply bend or strongly pull the probe cable.
- The probe unit and tip are not highly heat resistant. Do not apply a soldering iron to a circuit close to the point where the probe is left hooked up.

5.2 Voltage Measurement

To measure an AC signal which has no DC component or to measure the AC component alone of a signal which has a DC component superimposed on the AC component, set the vertical input AC/DC selector switches ⑧ and ⑯ in the AC position. To measure a signal which has a DC component, set the switch in the DC position.

Before commencing voltage measurement, set the VARIABLE attenuator knobs ⑥ and ⑭ at the CAL position and calibrate the sensitivity to the value indicated by the VOLTS/DIV selector switches ⑤ and ⑬ .

Apply the signal to be measured, display the signal with an appropriate amplitude on the screen, and determine the amplitude on the graticule. (For DC voltage measurement, determine the shifted distance of the trace.) The voltage can be known as follows:

(1) When measured signal is directly applied to input terminal:

Voltage (V) = Deflection amplitude (DIV) ×
Indication of VOLTS/DIV switch

(2) When the 10:1 probe is used:

Voltage (V) = Deflection amplitude (DIV) ×

Indication of VOLTS/DIV switch × 10

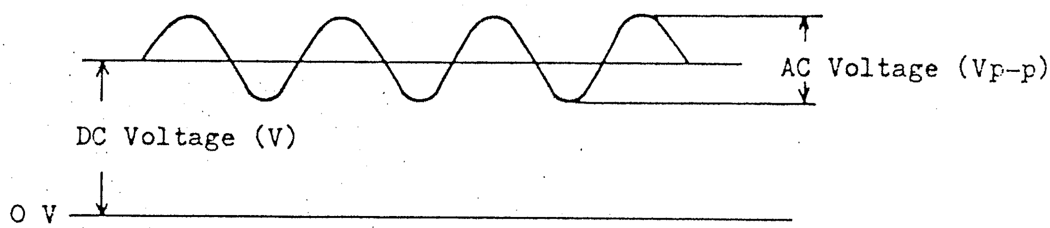


Figure 17

5.3 Current Measurement (voltage drop method)

Connect a small-resistance resistor (R) in series in the circuit in which the current (I) to be measured flows and measure the voltage drop across the resistor with the oscilloscope. The current is known from Ohm's law as follows:

$$I = \frac{E}{R} \quad (A)$$

The resistance should be as small as that it does not cause change to the measured signal source.

In the above method, currents from DC to high frequencies can be measured quite accurately. Note that the accuracy of the resistor is reflected upon the measuring accuracy.

5.4 Time Measurement

Measurement of time interval

The time interval between any two points on the displayed waveform can be measured by setting the TIME/DIV VARIABLE knob (44) in the CAL position and referring to the indication of the TIME/DIV switch (45).

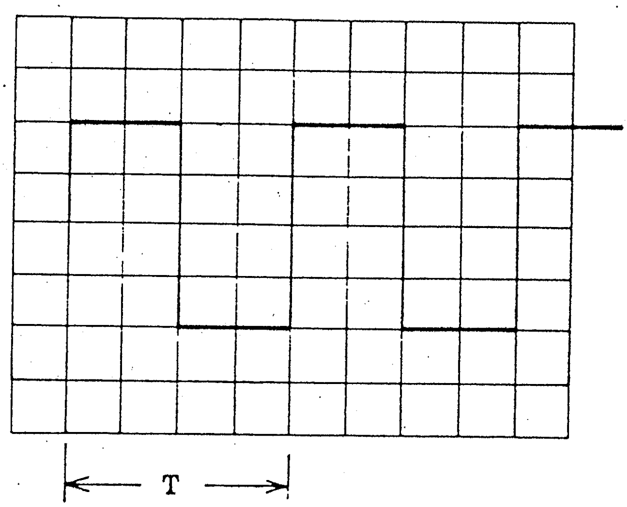


Figure 18

Time T (sec) = Indication of TIME DIV × Horizontal span (DIV)

When the sweep is magnified (10 × MAG (39)), the time is 1/10 of the value determined as above.

5.5 Frequency Measurement

- o Frequency measurement by determining time (T) per one cycle of the displayed waveform:

Time T (period) is measured as explained in Section 5.4 and the frequency is known by using the following formula.

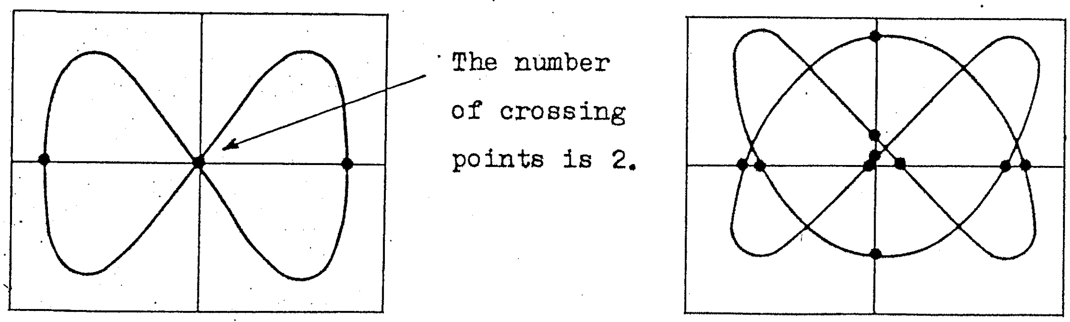
$$\text{Frequency } f \text{ (Hz)} = \frac{1}{\text{Period } T \text{ (sec)}}$$

- o Frequency measurement with Lissajous figure (See Figures 19 and 20):

Set the VERT MODE switch 1 in the X-Y state so that the oscilloscope operates in the X-Y mode.

Apply to the X-axis a known frequency from a signal generator (SG) and to the Y-axis the frequency to be measured. So adjust the required controls that a pattern is displayed on the full surface of the CRT screen. Then so adjust the frequency of the signal generator that the displayed pattern becomes stationary as shown in Figure 18. From the displayed waveform, the unknown frequency can be calculated as follows:

$$\text{Unknown frequency (Hz)} = \frac{\text{The number of crossing points over horizontal scale line}}{\text{The number of crossing points over vertical scale line}} \times \text{Frequency of signal generator (Hz)}$$



$$\frac{4}{2} = \frac{2}{1} \begin{matrix}(H)\\(V)\end{matrix} \qquad \frac{6}{4} = \frac{3}{2} \begin{matrix}(H)\\(V)\end{matrix}$$

Figure 19

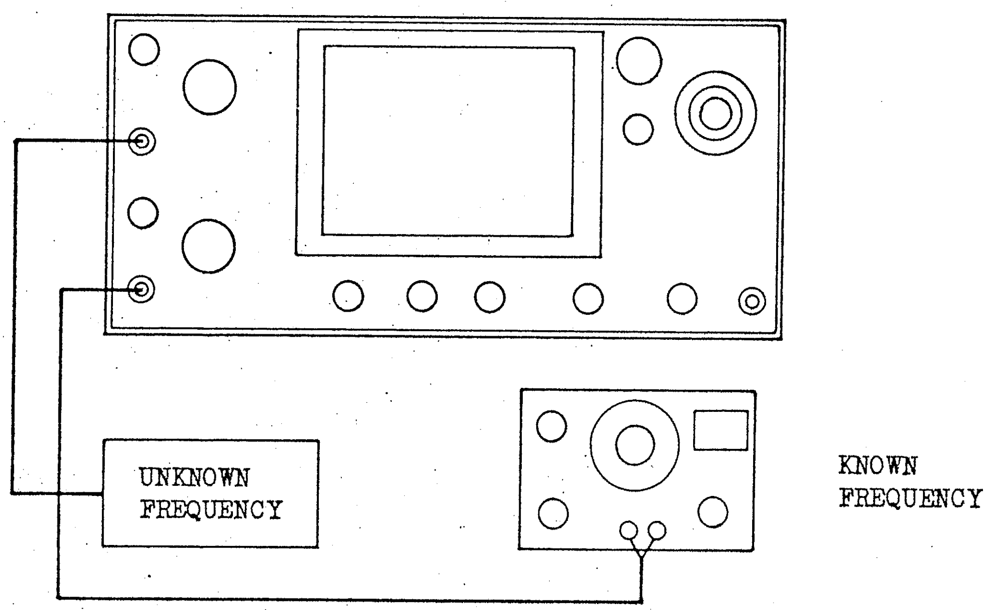


Figure 20

5.6 Measurement of Phase Difference

o Measurement of phase difference with Lissajous figure (See Figures 20, 21 and 22):

Operate the oscilloscope in the X-Y mode as explained in the paragraph for frequency measurement, and apply two signals of the same frequency (such as stereophonic signals) to the X and Y axes so that a Lissajous figure is displayed on the CRT screen. The phase difference between the two signals can be known by measuring the displayed waveform and employing the following equation:

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

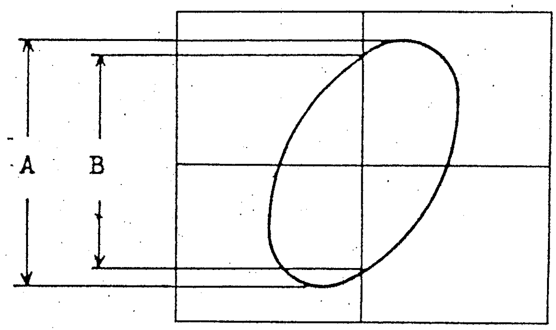


Figure 21

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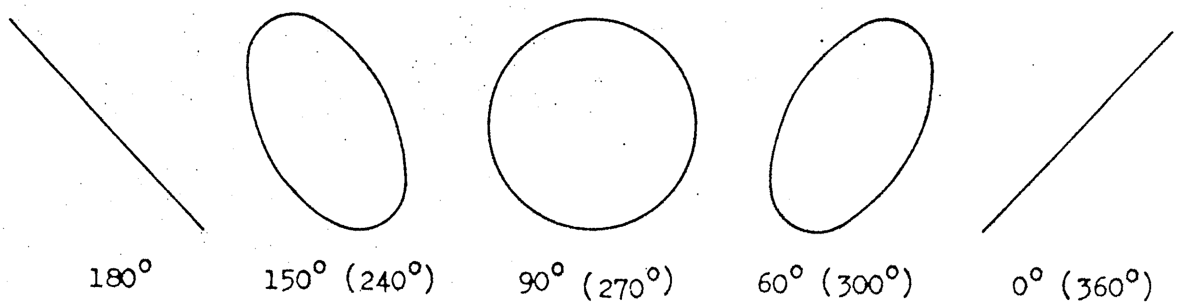


Figure 22

5.7 Characteristics of Pulse Waveform

A theoretically ideal pulse waveform is such that the signal changes instantaneously from a certain level to another level, held in this level for a certain period, and returns instantaneously to the original level. However, actual pulse waves are distorted. Nomenclature of distortions is given in Figure 23.

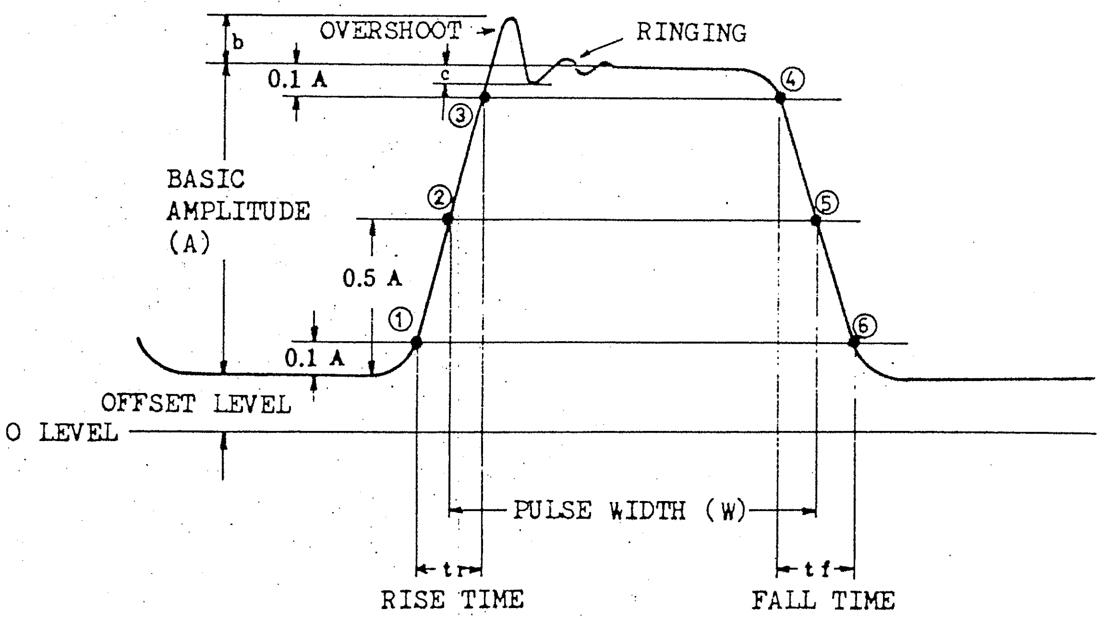


Figure 23

Pulse amplitude: Basic amplitude (A) of pulse

Pulse width: Time between points ② and ⑤ where signal amplitude is 50% of basic amplitude

Rise time: Time between 10% basic amplitude point ① and 90% basic amplitude point ③

Fall time: Time between 90% basic amplitude point ④ and 10% basic amplitude point ⑥

Overshoot: Amplitude of the first maximum excursion beyond basic amplitude. Expressed in terms of b/A × 100 (%)

Ringing: Oscillation which follows the first maximum excursion. Expressed in terms of c/A × 100 (%)

- Measurement of rise time:

The rise time of a pulse can be known by determining the value of t_r on the CRT screen in the method of "Time Measurement." It must be noted that t_r determined on the CRT screen includes the rise time of the oscilloscope itself. The closer the rise time of the oscilloscope (t_o) to the rise time of the measured pulse (t_n), the larger is the error introduced. To eliminate this error, calculation should be done as follows:

$$\text{True rise time } t_n = \sqrt{(t_r)^2 - (t_o)^2}$$

where, t_r: Rise time measured on CRT screen

t_o: Rise time of oscilloscope itself (approx. 7 nsec)

For example, when a pulse wave with rise time 20 nsec (about 3 times of that of the oscilloscope) is measured on the CRT screen, the error is approximately 6%.

o Measurement of Sag

Pulse waveforms may have slanted sections as shown in Figure 24, other than those distortions mentioned in Figure 23. (For example, slants are caused when the signal is amplified with an amplifier which has poor low-frequency characteristics, resulting from attenuation of low frequency components.) The slanted section (d or d') is called "sag" which is calculated as follows:

$$\text{Sag} = \frac{d}{A} \left(\text{or } \frac{d'}{A'}\right) \times 100\ (\%)$$

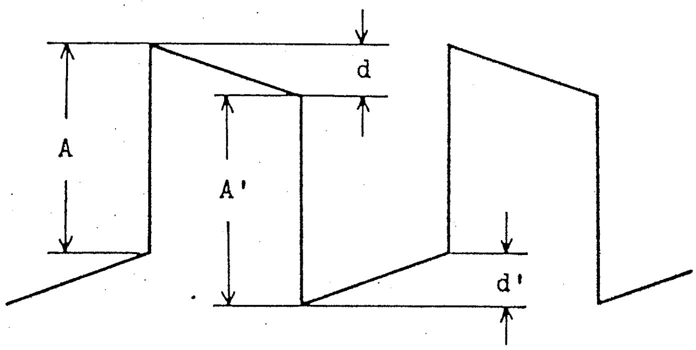


Figure 24

Note: If the AC-coupling mode is used for measurement of a low frequency pulse, sags are caused. For measurement of low frequency pulses, use always the DC-coupling mode.

6. CALIBRATION

6.1 General

After the oscilloscope has been used for a certain period of time, it should be calibrated at certain time intervals. Although calibration of overall performances is most recommendable, such partial calibration may serve the purpose that the time axis alone is calibrated when the time measuring accuracy is especially important or that the vertical axis alone is calibrated when the vertical sensitivity accuracy is of prime importance. After the oscilloscope has been repaired, overall calibration is required although it depends on the type of repair. For accurate calibration service, it is most recommendable to contact Kikusui's representative in your area.

6.2 Removing the Case

To remove the case, remove the six screws (Figure 25) and pull out the chassis forward. To remove the rear cover, remove the four screws shown in Figure 26.

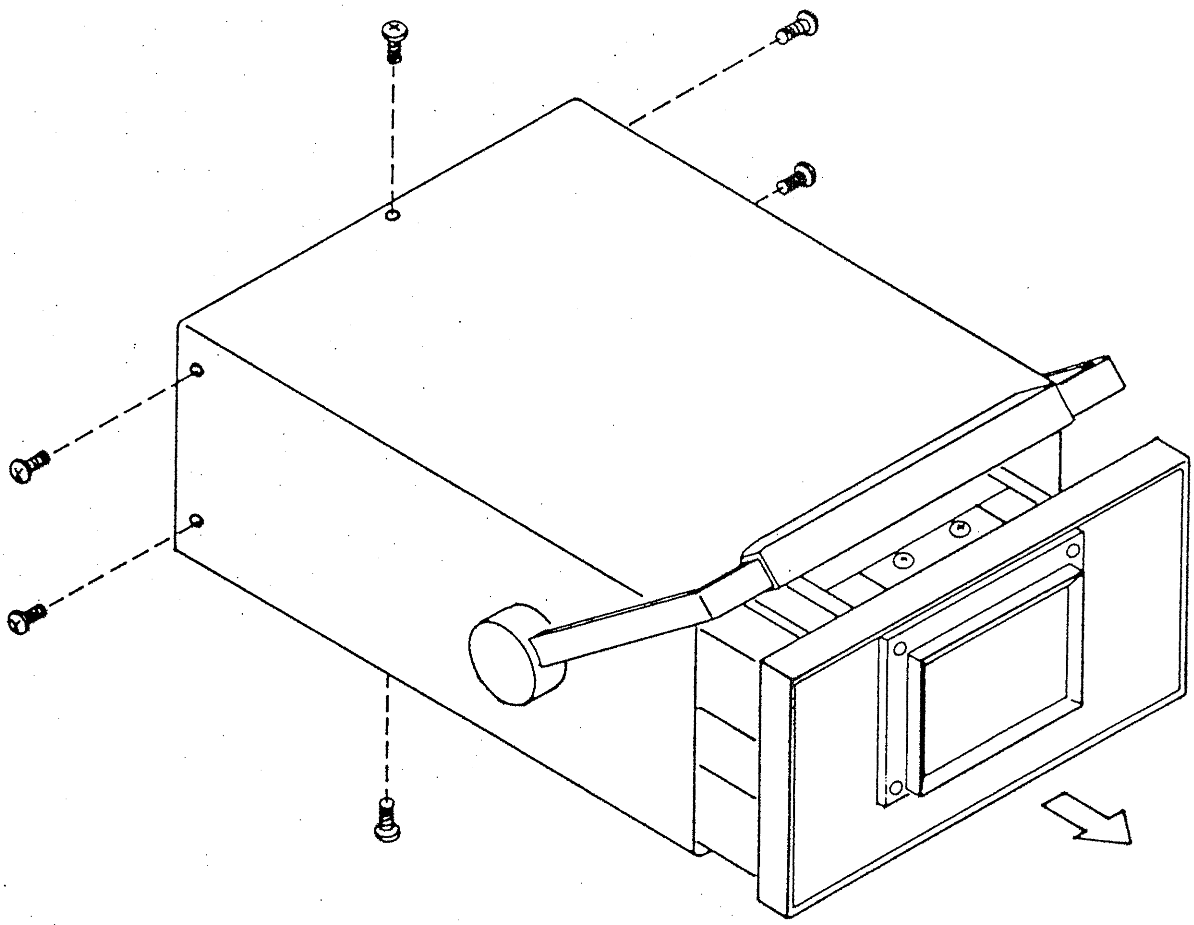


Figure 25

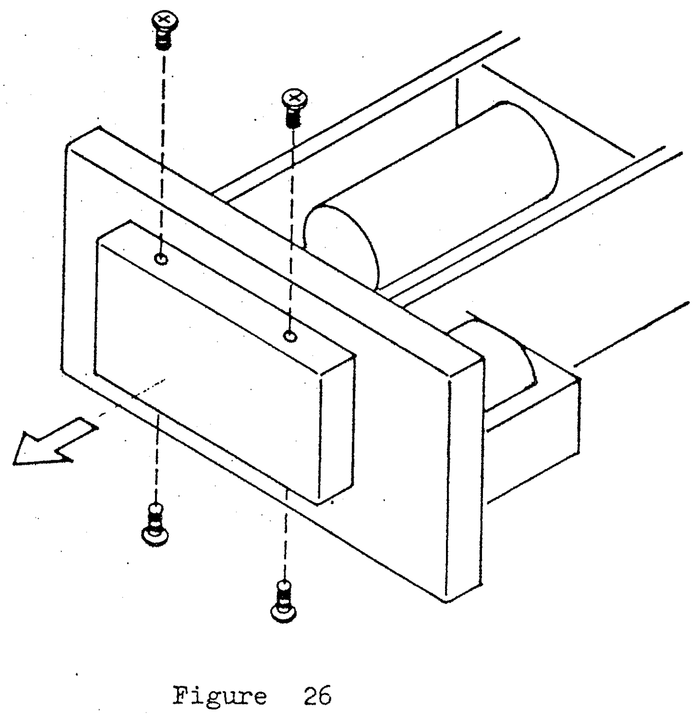


Figure 26

6.3 Check and Adjustment of DC Supply Voltages

Before calibrating the oscilloscope, its DC supply voltages should be checked and adjusted. Check and adjust the +12V supply voltage first and the other supply voltages next. The supply voltages are shown in the following table and the check and adjustment points are indicated in Figures 32 and 33.

Nominal voltage	Voltage range	Check and adjustment points
+ 5 V	+4.75 ~ 5.25 V	TP-2
+12 V	+11.95 ~ 12.05 V	TP-3 R1125
-12 V	-11.80 ~ 12.20 V	TP-1
+40 V	+42 ~ 48 V	TP-4
+90 V	+92 ~ 98 V	TP-7
+170 V	+165 ~ 185 V	TP-6
+230 V	+235 ~ 265 V	TP-5
-1500 V	-1490 ~ 1510 V	TP-8 R1056

For voltage check, measure the voltage between check point and ground using precision digital voltmeter. The +12V supply must be especially carefully adjusted because it provides a reference for other supplies. To measure the -1500V supply of which internal impedance is high, use a voltmeter of a high input impedance (10 MΩ or over).

Because adjustments of supply voltages largely affects vertical sensitivity and horizontal sweep time, the oscilloscope must be re-calibrated as explained in the subsequent paragraphs.

6.4 Adjustment of CRT Circuits

Some adjustments of the CRT circuits directly affect the CRT deflection sensitivity as is the case of "Check and Adjustment of DC Supply Voltages" of the preceding section. After the GEOMETRY, DEFLECTION SHIELD and HORIZ LIMIT are adjusted, the vertical sensitivity and sweep time must be calibrated without fail.

- Adjustment of GEOMETRY:

This control is for reducing geometrical distortions (pincushion distortions or barrel distortions) of the pattern displayed on the screen.

(1) Apply a sinusoidal signal of approximately 50 kHz to vertical input terminal ⑨ or ⑮ and display the signal with an amplitude of 8 DIV and with approximately 50 peaks.

(2) So adjust the GEOMETRY control (Figure 33, R1015) that the displayed pattern becomes as (b) in Figure 27.

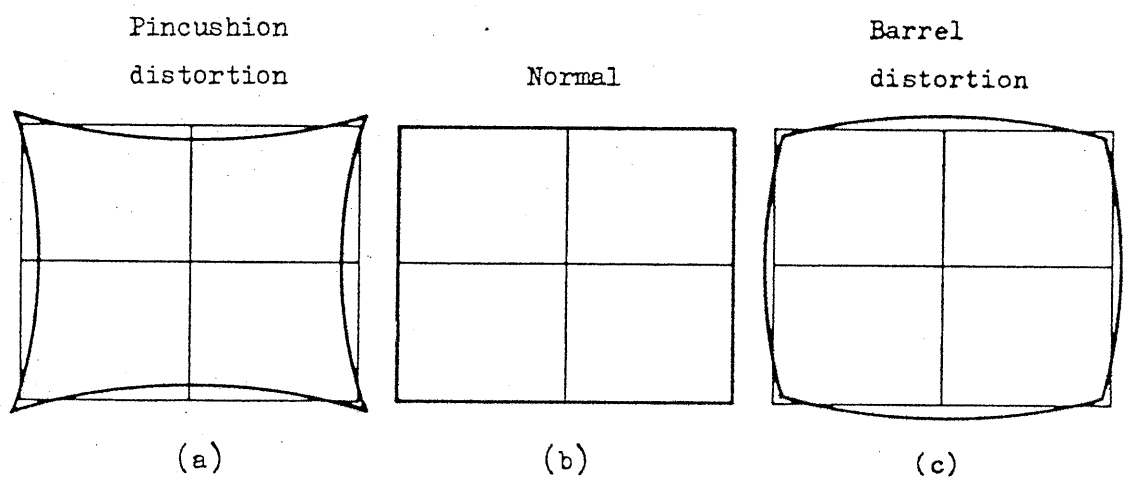


Figure 27

o Adjustment of DEFLECTION SHIELD:

This control is used to reduce halation on the screen for improving the contrast and to improve the linearity of the displayed waveform.

So adjust the DEFLECTION SHIELD control (Figure 33, R1011) that the best focus is obtained with the ASTIG voltage set at +70 to +80 volts.

o Adjustment of SUB-FOCUS:

This control is for adjusting the control range position of the FOCUS knob ㉕. With the FOCUS knob set with its white dot positioned upright (noon position), so adjust the SUB-FOCUS control (Figure 33, R1041) that the best focus is obtained.

o Adjustment of HORIZ LIMIT:

This control is used to suppress halation (caused by the electron beam reflected and scattered in the cathode-ray tube) resulting from change in the horizontal POSITION adjustment and 10 × MAG operation.

(1) Apply the CALIB signal ㉘ and ㉙ to the vertical input terminals and display waveforms of an amplitude of 4 DIV and 10 peaks.

(2) Turn ON (▃) the 10 × MAG switch ㊴. Turn the HORIZ LIMIT control (Figure 34, R961) from the extremely counter-clockwise position gradually to clockwise position and stop at the position where halation on the screen is reduced. This is the normal position for the HORIZ LIMIT control. (If you turn the control excessively clockwise, the displayed waveform may away to right and left when the LINE voltage is lower by approximately -10% than the nominal voltage.)

o Adjustment of Y AXIS ALIGN:

This control is for adjustment of the perpendicularity (90°) between horizontal trace (sweep) and vertical trace.

(1) Ground the CH1. Apply to CH2 the output of a sine wave signal generator and display the signal with an amplitude of 8 DIV on the screen.

(2) Set the VERT MODE switch ① in the X-Y mode and so adjust the TRACE ROTATION control ㉖ that the vertical trace becomes parallel with the graticule scale.

(3) Next, change the VERT MODE switch to CH1 and so adjust the Y AXIS ALIGN (Figure 35, R468) that the horizontal trace becomes parallel with the horizontal scale of the graticule.

By the above procedure, the horizontal trace and vertical trace are adjusted mutually perpendicular.

6.5 Adjustment of Vertical Axis

o Adjustment of DC BAL

This control is for minimizing the shift of the trace when the VARIABLE KNOB ⑥ or ⑭ is turned.

(1) Set the AC-GND-DC switch ⑧ or ⑯ in the GND state and display the trace on the CRT screen.

(2) Turning the VARIABLE knob, so adjust the DC BAL control that the shift of the trace becomes minimum. (Figure 35, R131 and R231).

o Adjustment of 5 × MAG BAL:

This control is for minimizing the shift of trace when the 5 × MAG switch ④ or ⑰ is changed.

(1) Set the AC-GND-DC switch ⑧ or ⑯ in the GND state and display the trace on the screen.

(2) Turning ON (▄) and OFF (█) the 5 × MAG switch, so adjust the 5 × BAL (Figure 35, R164 or R264) that the shift of trace becomes minimum.

o Sensitivity Calibration:

Calibrate the sensitivity of the vertical amplifier to the value indicated by the VOLTS/DIV switch (5) or (13). For this adjustment, use a square wave generator with an output voltage setting accuracy of 0.3% or better at 1 kHz.

(1) Set the signal generator output at 40 mVp-p and apply the signal to the vertical input terminal (9) or (15).

(2) Set the VARIABLE knob (6) or (14) at the CAL'D position and set the VOLTS/DIV switch at the 5 mV range.

(3) So adjust the 5 mV GAIN control (Figure 35, R141 or R241) that the amplitude of the displayed waveform becomes 8 DIV.

(4) Next, set the generator output at 8 mV and turn ON (▬) the 5 × MAG switch (4) or (17).

(5) So adjust the 5 × GAIN control (Figure 35, R167 or R267) that the amplitude of the displayed waveform becomes 8 DIV.

By the above procedure, other ranges also are calibrated to an accuracy of ±3% or better.

o Adjustment of INV BAL:

This control is for minimizing the shift of trace when the CH2 POLARITY switch is changed.

(1) Set the AC-GND-DC switch ⑯ in the GND state and display the trace on the screen.

(2) Turning ON (▁) and OFF (█) the CH2 POLARITY switch, so adjust the INV BAL control (Figure 35, R295) that the shift of trace becomes minimum.

o Adjustment of ADD BAL:

With both CH1 and CH2 channels operating in the single-line horizontal trace mode, so adjust this control that the traces do not shift when the VERT MODE switch is changed to the ADD mode.

(1) Set the AC-GND-DC switches ⑧ and ⑯ in the GND state and display the traces of the two channels overlapped in the center of the screen.

(2) Change the VERT MODE switch to the ADD state and so adjust the ADD BAL control (Figure 35, R402) that the trace are positioned in the center of the screen.

o Adjustment of square wave characteristics of vertical amplifiers:

This adjustment should be done to adjust the square wave characteristics of the vertical amplifiers so that their frequency response becomes flat. The adjustment should be done at a range which does not use the input attenuator (5 mV/DIV range), using two or more square waves of different frequencies.

The adjustment should be done using a quality square wave with rise time 2.3 nsec or faster, and should be done in the order of low, middle, higher middle, and high ranges, repeating adjustment in this order of different frequencies for a few times.

(1) Adjustment for low frequency range:

Set the VOLT/DIV switch at 5 mV/DIV and the TIME/DIV switch at 2 mS/DIV. Apply to the vertical input terminal a square wave of 100 Hz and so adjust the signal generator output that the waveform with an amplitude of 6 DIV is displayed.

Next, so adjust R446 (Figure 35) that the displayed waveform becomes as (b) in Figure 28.

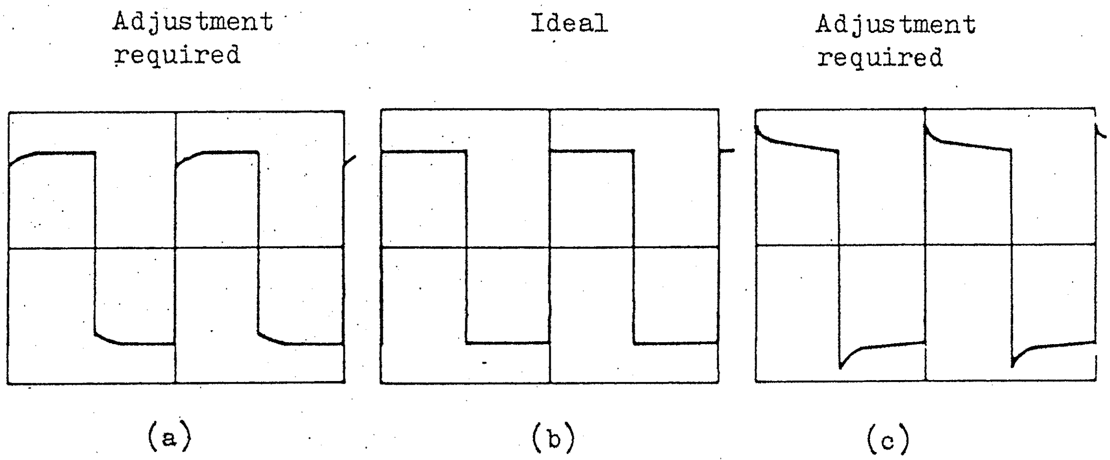


Figure 28

(2) Adjustment for middle frequency range:

Change the input pulse signal frequency to 20 kHz and set the TIME/DIV switch at 10 μS/DIV. Next, so adjust R409 and C404 (Figure 35) that a square wave as shown in (d) of Figure 29 is displayed. For this adjustment, set R409 at an appropriate position and then adjust C404 so that a waveform as close to that of (d) as possible is obtained. Repeat this procedure for a few times so that a waveform as shown in (d) is obtained.

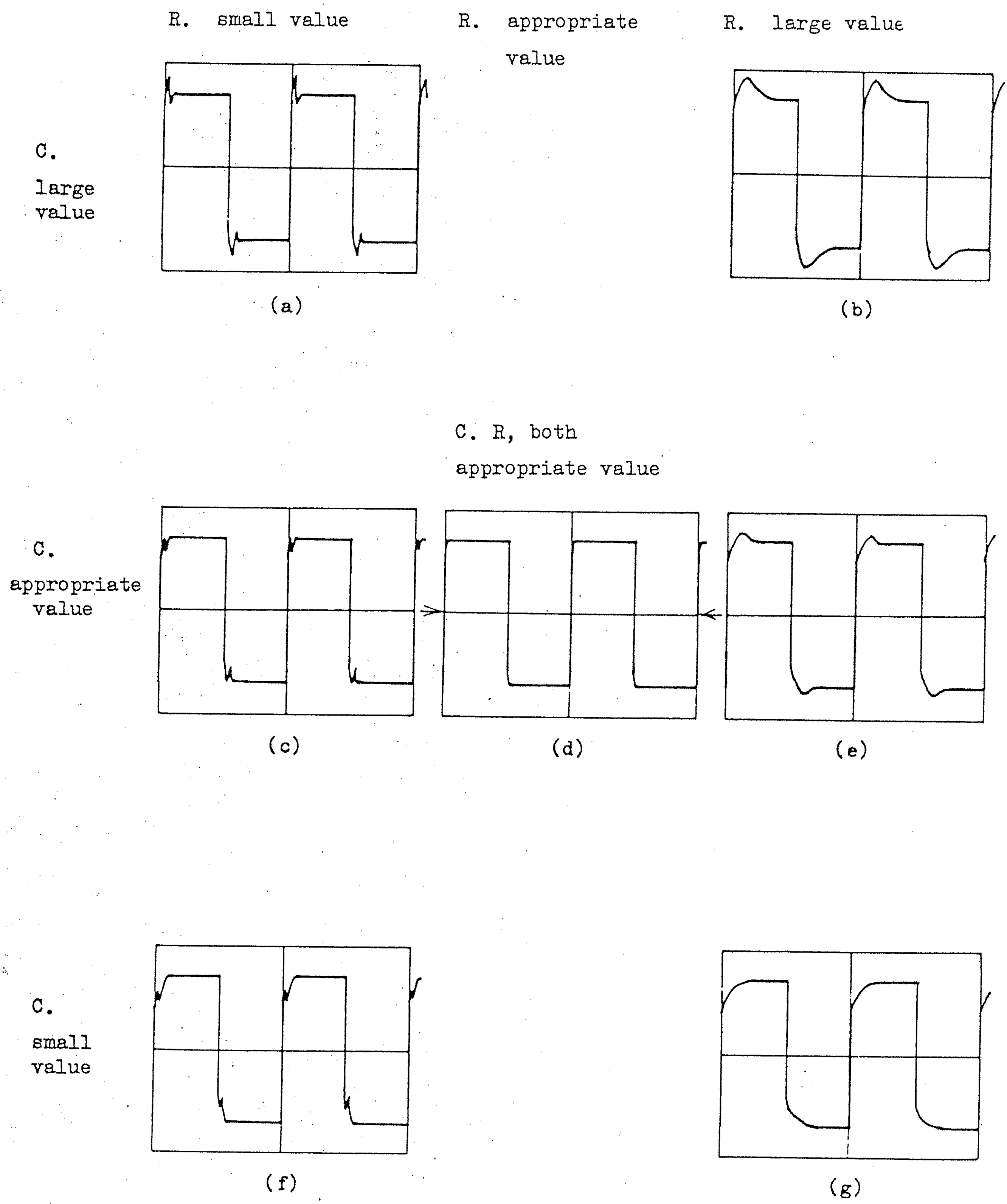

R. small value
R. appropriate value
R. large value
C. large value
(a)
(b)
C. R, both appropriate value
C. appropriate value
(c)
(d)
(e)
C. small value
(f)
(g)

Figure 29

(3) Adjustment for higher middle frequency range:

Change the input square wave signal to 200 kHz and set the TIME/DIV switch at 1 μS/DIV. Next, in a similar manner as the case for "adjustment for middle frequency range," so adjust R178 and C143 for CH1 or R278 and C243 for CH2 that a waveform as shown in (d) of Figure 29 is displayed.

(4) Adjustment for high frequency range:

Change the input square wave signal to 1 MHz and set the TIME/DIV switch at 0.2 μS/DIV. Next, in a similar manner as the case for "adjustment for middle frequency range," so adjust R408 and C403 or R447 and C429 that a waveform as shown in (d) of Figure 29 is obtained.

Next, adjust the amplitude of the pulse signal to 4 DIV and so adjust R448, C430 and C113 or C233 that the front edge of the square wave becomes flat.

o Adjustment of input ATT:

. The VOLTS/DIV switch selects the oscilloscope sensitivity by switching the attenuator circuit consisting of pre-stage attenuator (1/10-steps) and post-stage attenuator (1/2, 1/4, 1/10-steps). This procedure is for phase compensation and input capacitance adjustment of the attenuators. Adjustments should be done in the order of phase compensation and input capacitance adjustment for the post-stage attenuator and then phase compensation and input capacitance adjustment of the pre-stage attenuator.

(1) Adjustment of post-stage attenuator:

Use a square wave signal generator which provides a quality square wave of rise time 1 μsec or faster, without sags or overshoots. Apply the signal for each of the ranges (10 mV, 20 mV, 50 mV) and display a waveform with an amplitude of 6 DIV. So adjust the phase compensation capacitor shown in the following table that an ideal waveform is displayed. Next, connect a low-capacitance C-meter to the input terminal and so adjust the input-capacitance compensation capacitor that the input capacitance at each range becomes 20 pF $\pm$2 pF.

Compensation capacitor / Range	CH1		CH2	
	Phase compensation	Input capacitor	Phase compensation	Input capacitor
10 mV (1/2)	C113	C112	C213	C212
20 mV (1/4)	C116	C115	C216	C215
50 mV (1/10)	C119	C118	C219	C218

(2) Adjustment of post-stage attenuator:

In a similar manner as (1) above, adjust the phase compensation capacitor and input-capacitance compensation capacitors shown in the following table for each of the ranges (5 mV, 0.1 V, 1 V).

Compensation capacitor / Range	CH1		CH2	
	Phase compensation	Input capacitor	Phase compensation	Input capacitor
5 mV (1/1)	-	C103	-	C203
0.1 V (1/10)	C106	C105	C206	C205
1 V (1/100)	C109	C108	C209	C208

When the above adjustment is done, all other ranges also are automatically adjusted.

6.6 Adjustment of Trigger Circuits

o Adjustment of TRIG. LOCK:

This adjustment is for making optimum the TRIG·LOCK sensitivity of the trigger circuit of the A sweep.

(1) Apply a sinusoidal wave of approximately 1 kHz to the vertical input terminal and display a waveform with an amplitude of approximately 8 DIV on the screen.

(2) Turn the LEVEL knob ㉝ to the extremely clockwise position (LOCK position).

(3) Turning ON (▄) and OFF (▌) the SLOPE push button, so adjust R539 and R555 (Figure 32) that the start point of the waveform becomes the center of the displayed waveform amplitude.

(4) Next, apply a sinusoidal wave of approximately 35 MHz to the vertical input terminal and so adjust the signal generator output that the signal is displayed with an amplitude of 0.5 DIV on the screen.

(5) Under the above state, finely re-adjust R539 and R555 that the triggering does not fail when the SLOPE pushbutton is turned ON (▄) and OFF (▌).

o Adjustment of TRIG LOCK of B sweep:

This adjustment is for making optimum the TRIG LOCK sensitivity of the trigger circuit of the B sweep. Adjust R618 and R634 (Figure 32) in a similar manner as in the case of "Adjustment of TRIG LOCK."

o Adjustment of TRIG DC OFFSET (for trigger circuit of A sweep only):

This adjustment is for attaining such state that, when the trigger signal is AC-coupled and the white dot of the LEVEL knob is set in the upright position (noon position), the trigger point is at the center of the displayed waveform amplitude.

(1) Apply a sinusoidal wave of approximately 1 kHz to the vertical input terminal and display the signal waveform with an amplitude of approximately 8 DIV on the screen.

(2) So set the LEVEL knob that its white dot is positioned at the noon position. So adjust R533 (Figure 32) that the trigger point (trace start point) is positioned at the center of the displayed waveform amplitude.

o Adjustment of CH1 TRIG DC OFFSET:

This adjustment is for offsetting to zero the DC-component displacement of the CH1 internal trigger output.

(1) Apply a sinusoidal signal of approximately 1 kHz to the CH1 input terminal and set the AC-GND-DC switch at AC.

(2) Set the VERT MODE switch at CH1, set the INT TRIG switch at CH1 or NORM, and display the signal with an amplitude of 8 DIV on the screen.

(3) Set the COUPLING switch at AC and so adjust the LEVEL knob that the trigger point is brought to the center of the displayed waveform amplitude.

(4) Change the COUPLING switch to DC and so adjust the CH1 TRIG DC OFFSET (Figure 35, R307) that the trigger point is brought to the center of the displayed waveform amplitude.

* This adjustment affects the X-Y positions. Be sure to adjust the X-Y POSITION ADJ after this adjustment has been done.

o Adjustment of CH2 TRIG DC OFFSET:

This adjustment is for offsetting to zero the DC-component displacement of the CH2 internal trigger output.

For this adjustment, adjust CH2 TRIG DC OFFSET (Figure 35, R316) in a similar manner as is the case for "Adjustment of CH1 TRIG DC OFFSET."

6.7 Adjustment of Time Axis

o Calibration of A sweep time:

This adjustment is for calibrating the sweep time to the values indicated by the TIME/DIV switch. For this adjustment, use time marker signals of accurate time intervals of 1 msec and 1 sec or use signals of accurate frequencies of 1 kHz and 100 kHz.

(1) Apply to the vertical input terminal a time marker signal of 1 msec or a signal of 1 kHz, and deflect the signal with an appropriate amplitude on the screen.

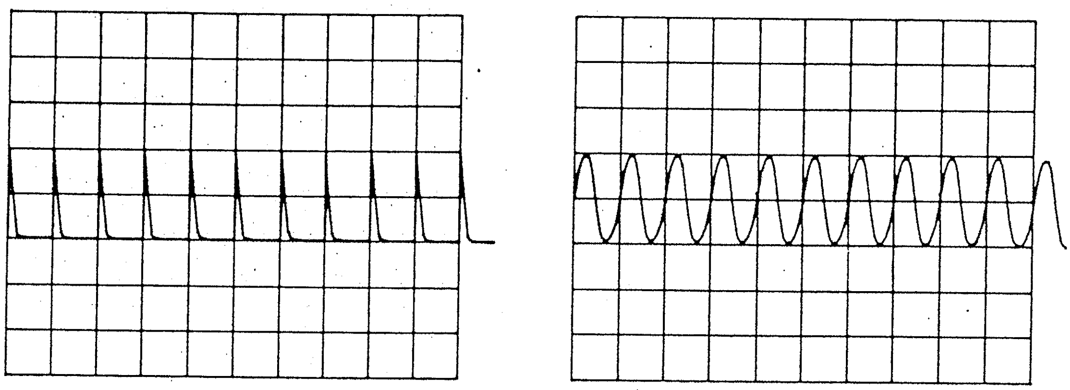
(2) Set the VARIABLE knob (44) in the CAL'D position. Set the TIME/DIV switch (45) at 1 mS.

(3) So adjust the A SWEEP CAL (Figure 36, R822) that the displayed waveform conforms with scale divisions of the graticule.

(4) Change the input signal to a time marker signal of 10 μS or sinusoidal wave signal of 100 kHz and change the TIME/DIV switch (45) to 10 μS.

(5) So adjust the A 10 μS CAL (Figure 36, C802) that the displayed signal waveform conforms with scale divisions of the graticule.

When the above calibration is complete, the sweep speeds of the remaining ranges also are calibrated at an accuracy of $\pm 3\%$.



Time marker signal   Sinusoidal wave signal

Figure 30

o Calibration of B sweep time:

Calibrate the sweep time to the indicated values of the TIME/DIV switch (46). Adjust the B SWEEP CAL (Figure 36, R871) and B 10 μS CAL (Figure 36, C852) in a similar manner as that for the case of "Calibration of A sweep time."

o Adjustment of LENGTH:

This adjustment is for setting the lengths of the A and B sweeps at 11 DIV. Set the TIME/DIV switches (45) and (46) at 1 mS and apply a time marker signal of 1 msec or a signal of repetition frequency 1 kHz, and so adjust the A SWEEP LENGTH (Figure 32, R725) and B SWEEP LENGTH (Figure 32, R735) that the sweep lengths become 11 DIV.

o Adjustment of sweep start point:

This adjustment is for attaining such state that, when the horizontal POSITION knobs (47) and (48) are set with their white dots in the noon positions, their sweeps start at the left hand end of the graticule.

(1) Set the TIME/DIV switches (45) and (46) at 1 mS, set the HORIZ DISPLAY switch (50) at ALT, and display both A and B sweeps on the screen.

(2) So set the horizontal POSITION knobs (47) and (48) that their white dots are positioned upward (noon position). So adjust the A SWEEP POSITION (Figure 36, R902) that the start point of the A sweep is brought to the left hand end of the graticule.

(3) Next, with the B SWEEP POSITION (Figure 36, R906), bring the start point of the B trace to the left hand end of the graticule.

o Adjustment of 10 × MAG DC BAL:

This adjustment is for attaining such a state that, when the 10 × MAG switch (39) is turned ON (▄), the displayed waveform is magnified to right and left from the center of the screen.

(1) Set the TIME/DIV switch (45) at 1 mS. So adjust the horizontal POSITION knob that the start point of the sweep is brought to the center of the screen.

(2) Turn ON (▃) the 10 × MAG switch. So adjust the 10 × BAL (Figure 36, R939) that the start point of the sweep is brought to the center of the graticule.

o Adjustment of 10 × MAG:

This adjustment is for calibration of the sweep time when the 10 × MAG switch (39) is turned ON (▃). Before performing this adjustment, make sure that the adjustment for "Calibration of the A sweep time" has been done.

(1) Apply to the vertical input terminal a time marker signal of 0.1 mS or a signal of 10 kHz and display the signal with an appropriate amplitude on the screen.

(2) Set the VARIABLE knob (44) in the CAL'D position and the TIME/DIV switch (45) at 1 mS.

(3) Turn ON (▃) the 10 × MAG switch and so adjust the 10 × CAL (Figure 36, R937) that the displayed waveform conforms with scale divisions of the graticule.

o Calibration of DELAY TIME MULTI:

This calibration is for calibrating the dial value of the DELAY TIME MULTI to the sweep time. Before performing this calibration, make sure that the adjustment for "Calibration for A sweep time" has been done.

(1) Apply to the vertical input terminal a time marker signal of 1 mS and display the waveform with an appropriate amplitude on the screen.

(2) Set the VARIABLE knob (44) in the CAL'D position, set the TIME/DIV switch (45) at 1 mS, set the TIME/DIV switch (46) at 10 μS, and change the HORIZ DISPLAY switch (50) to the A INTEN state.

(3) Set the dial indication of the DELAY TIME MULTI at 1.00 and align the displayed waveform with graticule.

(4) So adjust the B START LEVEL (Figure 36, R764) that the accentuated portion of the waveform is aligned to the initial pulse as shown in Figure 31.

(5) Set the dial indication of the DELAY TIME MULTI at 10.00.

(6) So adjust the B END LEVEL (Figure 36, R769) that the accentuated portion of the waveform is aligned to the 10th pulse.

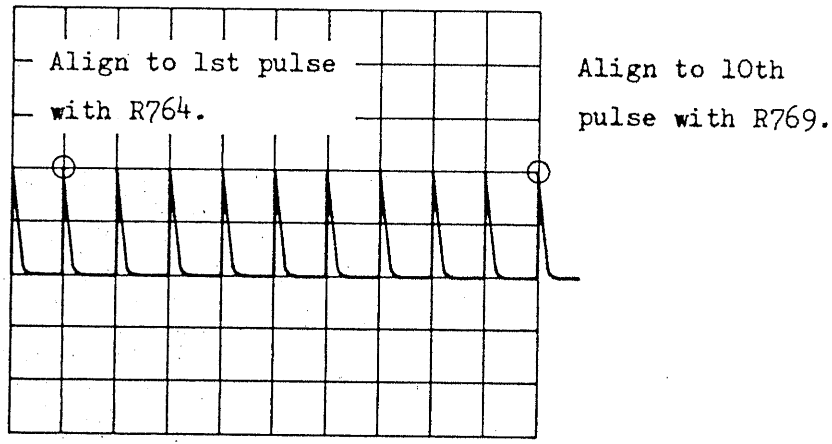


Figure 31

6.8 Adjustment of Horizontal Axis (X-axis)

o Calibration of horizontal sensitivity:

This adjustment is for calibration of the X-axis sensitivity for X-Y operation.

(1) Set at 50 mVp-p the output of the signal generator used for "Calibration of sensitivity" of section 6.5, and apply the output to the CH1 (X-axis) input.

(2) Set the VERT MODE switch (1) in the X-Y state. Set the AC-GND-DC switch (15) of CH2 (Y-axis) at GND.

(3) Set the VARIABLE knob (6) at CAL'D and the VOLTS/DIV switch (5) at 5 mV.

(4) So adjust the X-GAIN (Figure 35, R304) that the trace length becomes 10 DIV.

* This adjustment affects CH1 TRIG DC OFFSET adjustment and X-Y POSITION adjustment. Be sure to repeat these adjustments after the horizontal axis sensitivity adjustment is done.

o Adjustment of X-Y POSITION:

This adjustment is to obtain such a state that the spot is positioned in the center of the screen when the horizontal POSITION knobs (47) and (48) are set with their white dot positioned upward (noon position) in the X-Y operation.

(1) Operate the oscilloscope in the X-Y mode and set both inputs in the GND state.

(2) Set the horizontal POSITION knobs (47) and (48) with their white dot positioned upward (noon position) and so adjust the X-Y POSITION (Figure 36, R909) that the spot is positioned in the center of the screen.

6.9 Calibrating the Calibration Voltage

o Adjustment of repetition frequency:

This adjustment is for calibrating the repetition frequency of the calibration signal at 1 kHz.

(1) Connect the CALIB output (28) or (29) to a frequency counter.

(2) So adjust the CALIB FREQ (Figure 32, R1152) that the frequency counter reads 1 kHz.

o Calibration of the output voltage:

This adjustment is for calibrating the output voltage of the calibration signal in a substitution method.

(1) Set at 200 mVp-p the signal of the generator used for "calibration of sensitivity" of Section 6.5. Apply this signal to the CH1 input terminal.

(2) Display the signal on the screen with an amplitude of 8 DIV by adjusting the VOLTS/DIV switch (5) and VARIABLE knob (6).

(3) Apply the 200 mV CALIB output (28) to the CH1 input terminal. So adjust the CAL OUT (Figure 32, R1160) that the signal is displayed with an amplitude of 8 DIV on the screen in the same manner as step (2) above.

By the above procedure, the calibration operation for the calibration signal is complete.

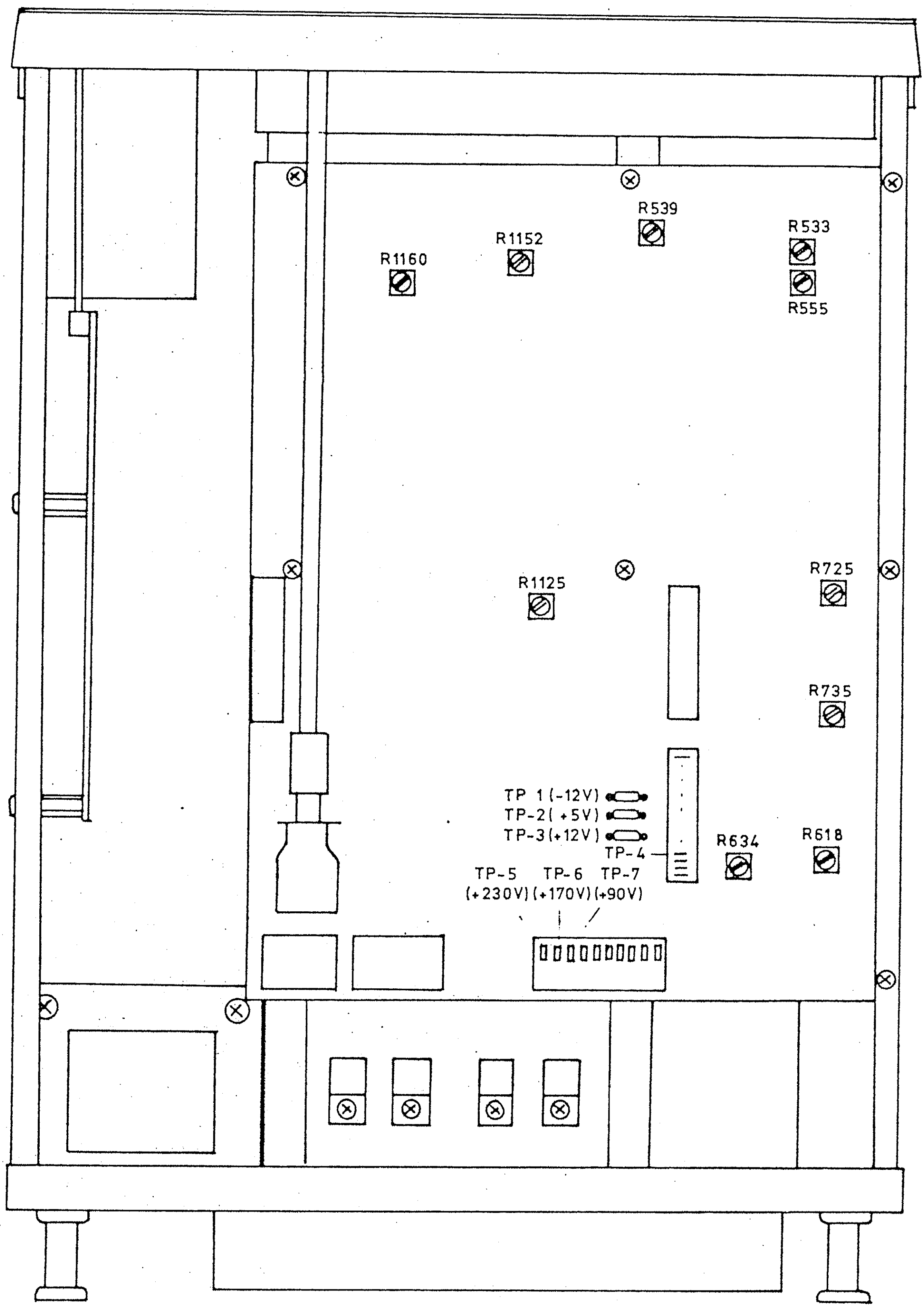


Figure 32

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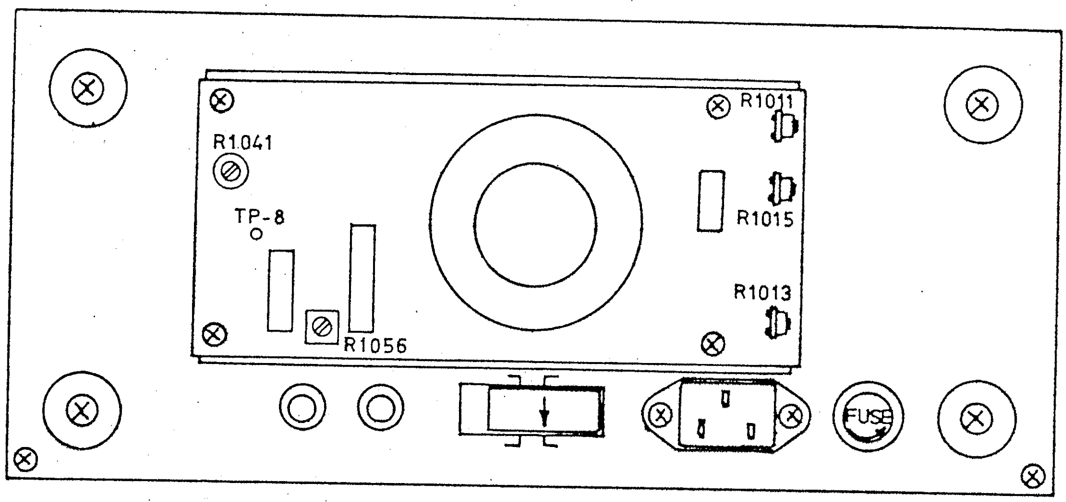

Figure 33

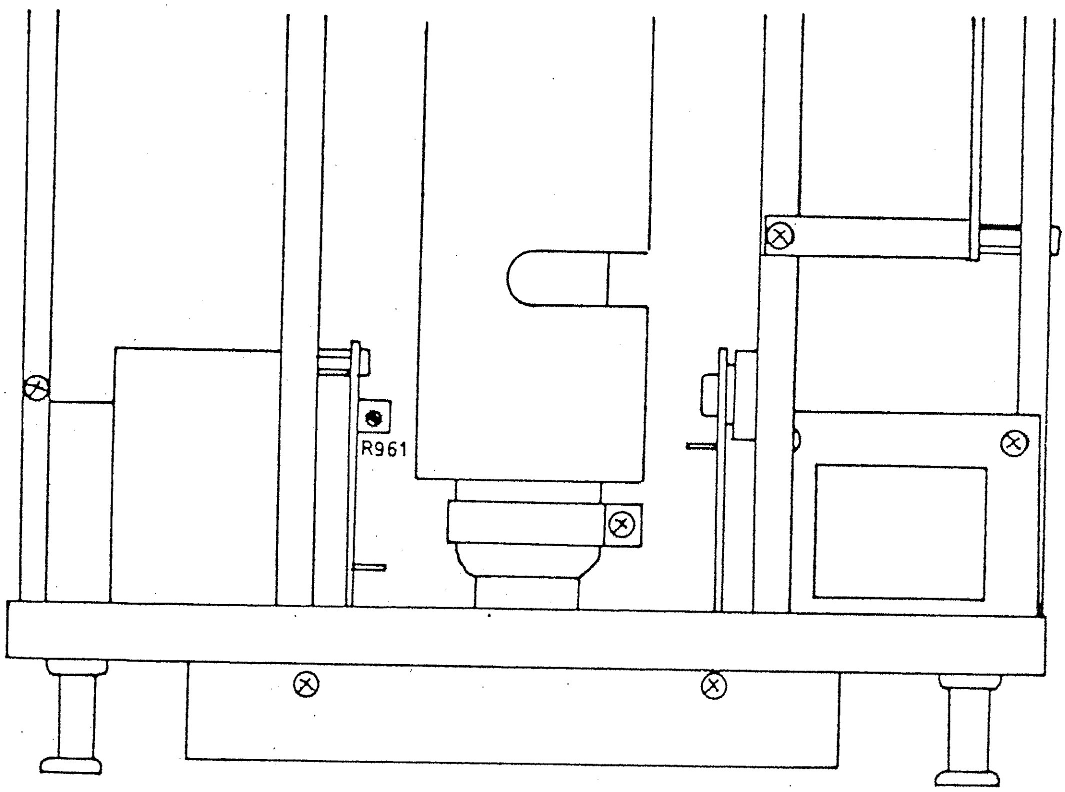

Figure 34

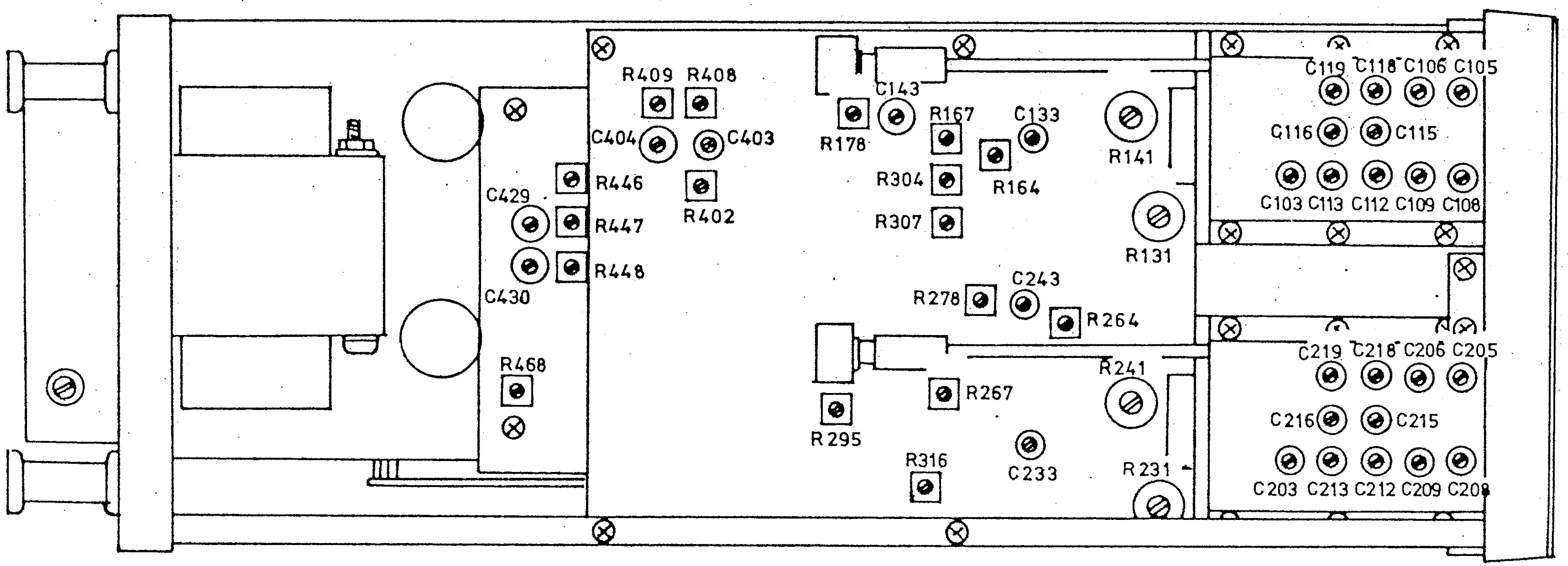

Figure 35

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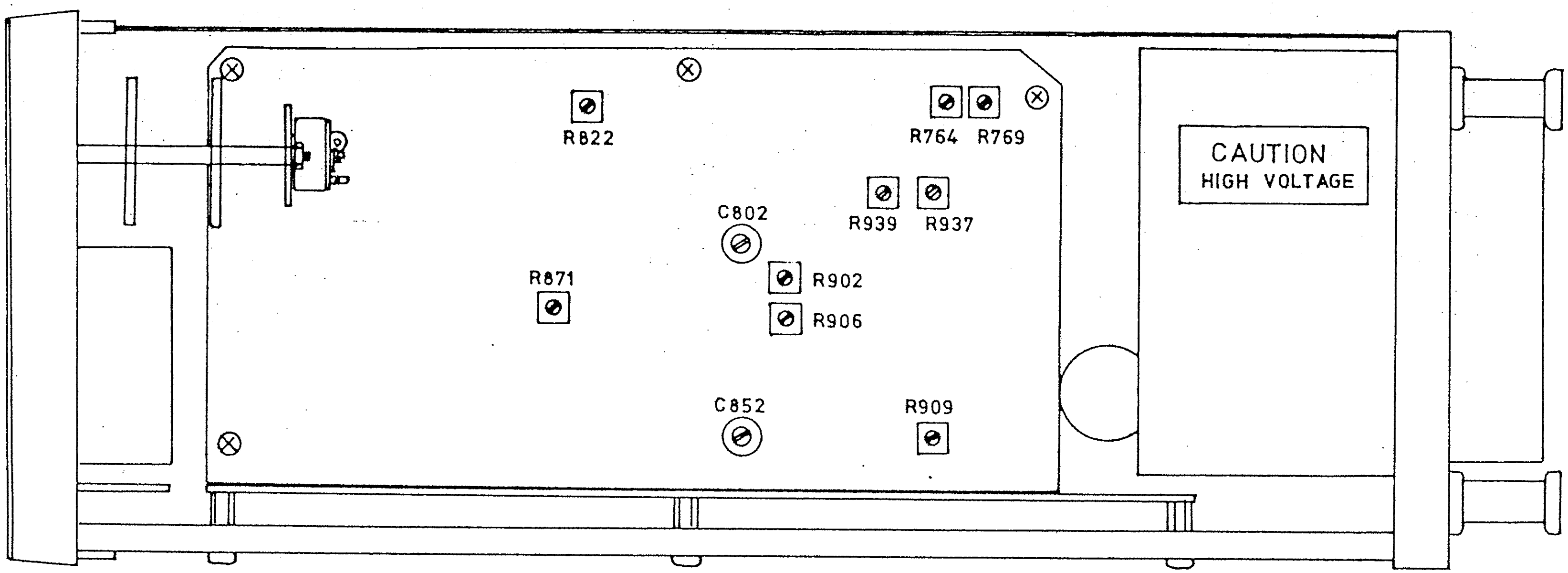
R822
R764 R769
CAUTION
HIGH VOLTAGE
R939 R937
C802
R871
R902
R906
C852
R909

Figure 36

6.10 Calibration of Probe

As explained previously, the probe makes up a kind of wide-range attenuator. Unless phase compensation is properly done, the displayed waveform is distorted causing measurement errors. Therefore, the probe must be properly calibrated before use. For probe calibration, use the signal of the calibration voltage output terminal ㉘ or ㉙ of the front panel.

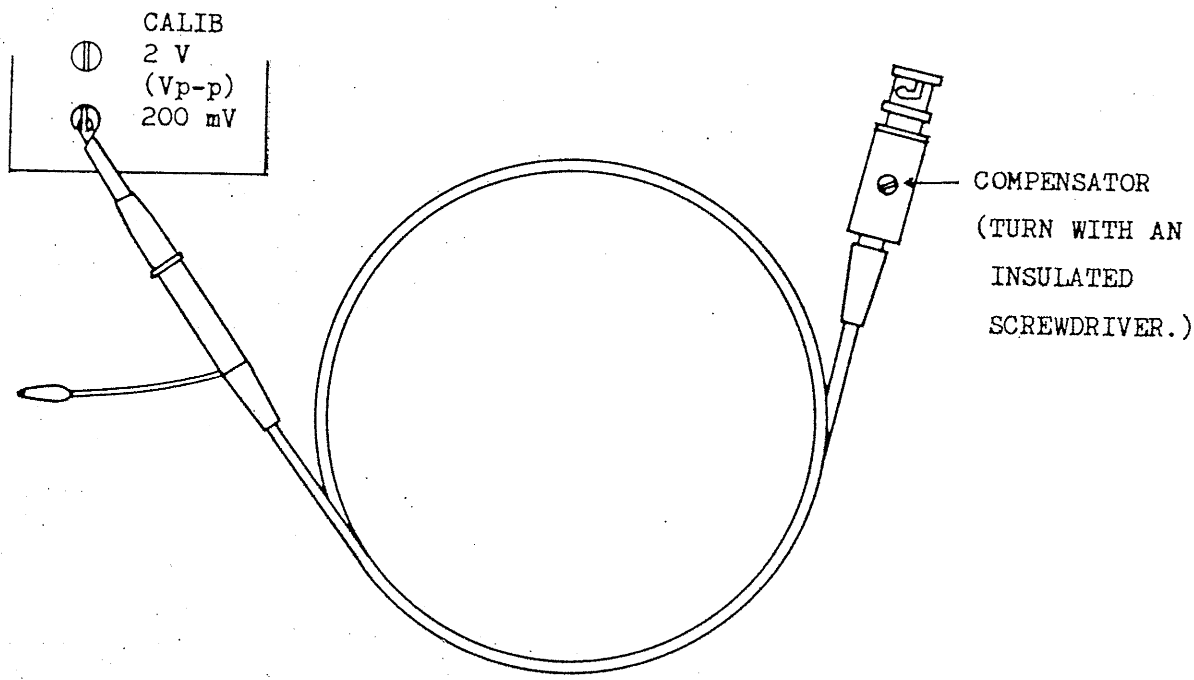

Figure 37

Connect the probe connector to the INPUT terminal of CH1 or CH2 and set VOLTS/DIV switch at 5 mV. Connect the probe tip to the calibration voltage output terminal and so adjust the COMPENSATOR control with an insulated screwdriver that an ideal waveform as illustrated below is obtained.

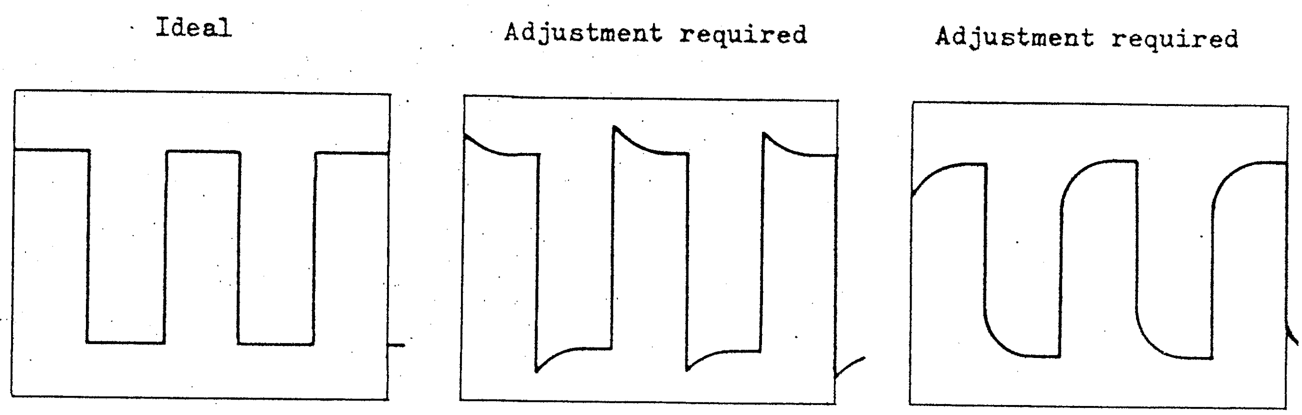

Figure 38