INSTRUCTION MANUAL

SYNCHROSCOPE

SS-6050

IWATSU ELECTRIC CO., LTD.

INSTRUCTION MANUAL

SYNCHROSCOPE SS-6050

1931081~

WARRANTY

All Iwatsu products are warranted for a period of one year from date of delivery, but not exceed 18 months after delivery F.O.B. Japan. These products are warranted to be free from defects in material and workmanship, suitable for normal use and service under normal conditions, and able to meet any applicable specifications accepted in writing by IWATSU. No claim under the warranty will be accepted unless it is made in writing to IWATSU immediatery after discovery of defect or in any case, within one year of delivery. No other warranty express or inplied exists outside this warranty. IWATSU are not liable for any commercial loss or other consequential damages incurred or sustained as a result of any defective or nonconforming product. IWATSU's obligation with respect to losses is limited under this warranty, at IWATSU's option, either to the replacement (by delivery F.O.B.) or repair of its manufactured products which prove to be defective or nonconforming. This warranty does not apply to any products improperly applied or used or which have been subjected to intentional or negligent misuse or accident, or which have been in any way modified by others without the express written agreement of IWATSU.

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CONTENTS

Abbreviations

The following abbreviations are used for units, unit multipliers and technical terms in this instruction manual.

Units:

A	ampere
dB	decibel
g	gram
Hz	hertz
m	meter
s (sec or SEC)	second
F	farad
V	volt
W	watt
Ω	ohm
rms	root mean square
p-p	peak to peak

Unit multipliers:

T	tera	10^{12} = 1 000 000 000 000
G	giga	10^{9} = 1 000 000 000
M	mega	10^{6} = 1 000 000
k	kilo	10^{3} = 1 000
h	hecto	10^{2} = 1 00
da	deca	10^{1} = 1 0
d	deci	10^{-1} = 0.1
c	centi	10^{-2} = 0.01
m	mili	10^{-3} = 0.001
μ	micro	10^{-6} = 0.000 001
n	nano	10^{-9} = 0.000 000 001
p	pico	10^{-12}= 0.000 000 000 001

Technical terms:

AC	alternate current
ADJ	adjust
ALT	alternate
ASTIG	astigmatism
ATT	attenuator
AUTO (Auto)	automatic
BAL	balance
CALIB	calibrated
CAL	calibrator
CH	channel
CHOP	chopped
DC	direct current
DLY'D	delayed
EXT	external
GND	ground (earth)
HF REJ	high frequency reject
ILLUM	illumination
INT	internal
INTEN	intensity
INV	inverted
LF REJ	low frequency reject
MAG	magnifier
NORM	normal
OUT	output
SENS	sensitivity
STAB	stability
TRIG	trigger
TRIG'ABLE	triggerable
TRIG'D	triggered
UNCALIB	uncalibrated

General

The Synchroscope SS-6050 is a universal CRT oscilloscope which covers a wide frequency bandwidth from DC up to 50MHz.

The electronically switched dual-trace vertical deflection system allows measurement of sum of two signals (ADD) or difference of two signals (with CH 2 POLARITY switch), as well as ordinary dual-trace measurements (ALT and CHOP). Both the two channels are designed for high sensitivity which reaches 5mV/cm. The vertical sensitivity can be increased up to 1mV/cm by connecting two channels in cascade.

Junction type field effect transistors (FET's) used in the input circuit provide high operating stability with which observation of signals can be started approximately 15 seconds after the power is supplied.

The horizontal deflection system can be synchronized with signals from DC to 50MHz. The FULL AUTO synchronization system eliminates the operator's troublesome load — the synchronization control. A portion of signal waveform can be magnified 10 times with the waveform magnifier and the delayed sweep function. Combined use of the delayed sweep and A SWEEP LENGTH control ensures sufficient brightness for magnified signal waveform. The X-Y scope function is readily available with a one-touch control.

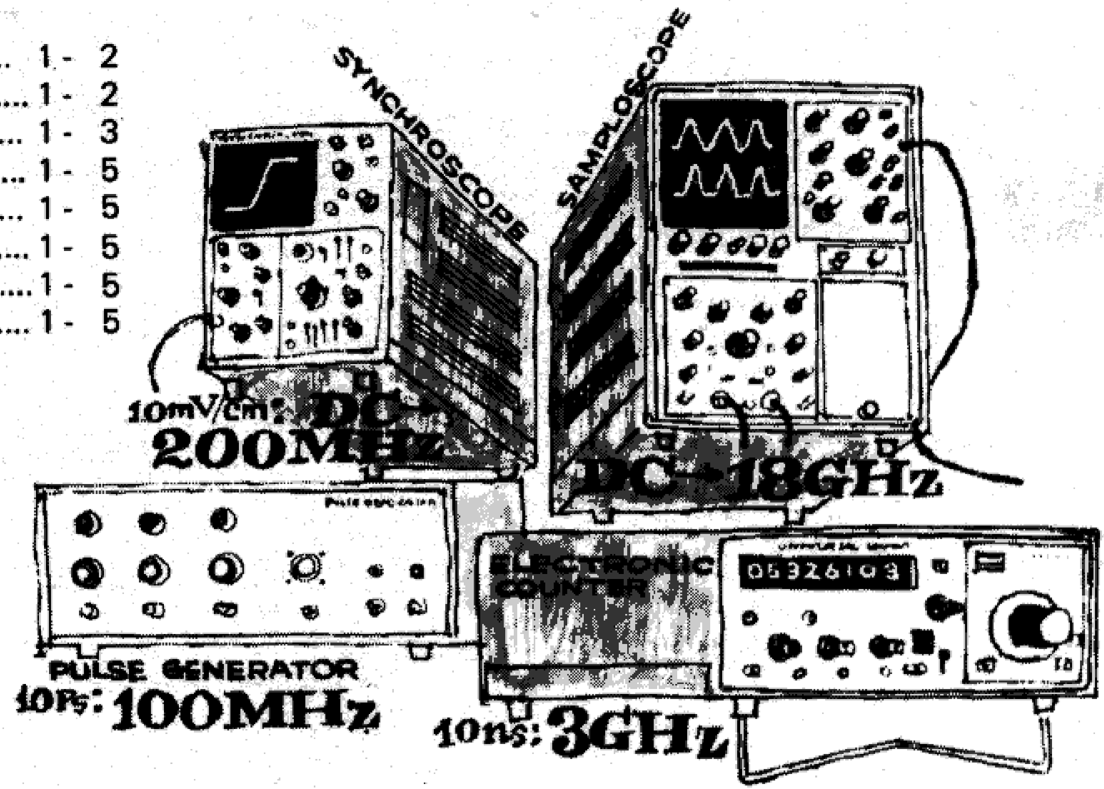
Reined panel design and control layout ensures either of these enriched, excellent functions simply available.

The cathoderay tube is a square type incorporated with parallax-free internal graticule. Effective viewing area covers 8cm (H) by 10cm (W), and signal waveforms can be correctly observed without any parallax at any corner.

Internal circuit is designed for full solid-state structure. Further, outstanding stability and reliability of operation is ensured by drastic use of integrated circuits (IC's).

SECTION 1 PERFORMANCE

This section describes performance and accuracy of SS-6050 in order to ensure your correct measurement.



CRT System

CRT

Type	Square, parallax-free internal graticule
Effective viewing area	80 mm (V) x 100 mm (H)
Accerelation voltage	Approx. 15 kV
External intensity modulation	
Input voltage	5 Vp-p or more (Intensified by negative signal)
Frequency range	DC to 50 MHz
Input resistor	15 kΩ ±10 %
Allowable input voltage	50 V (DC + peak AC)

Vertical Deflection System

(The following performance figures are applyed to dual-trace circuit located in both the CH 1 and CH 2.)

Sensitivity
5 mV/cm to 10 V/cm 1-2-5 sequence, switched in 11 steps
Accuracy: ±2 % (10°C to 35 °C)
±4 % (−10°C to 50°C)
1 mV/cm (with CH 1 and CH 2 cascaded)
Accuracy: ±3 % (10°C to 35°C)
±6 % (−10°C to 50°C)
5 mV/cm to 25 V/cm continuously variable with fine control

Frequency bandwidth
DC coupled (10 °C to 35 °C)
5 mV/cm to 10 V/cm range
DC to 50 MHz −3 dB
1 mV/cm range
DC to 20 MHz −3 dB
AC coupled (10 °C to 35 °C)
5 mV/cm to 10 V/cm range
4 Hz to 50 MHz −3 dB
1 mV/cm range
4 Hz to 20 MHz −3 dB

Rise time: Approx. 7 ns

Signal delay time: 30 ns or more (delay time at viewing area)

Square wave characteristic

Overshoot		3 %
Ringing		3 %
Matching distortion		1 %
Sag	1 MHz	1 %
	250 kHz	1 %
	100 kHz	1 %
	15 kHz	1 %
	1 kHz	1 %
	60 Hz	1 %

Signal input coupling
AC, GND, DC

Input RC
Direct
R: 1 MΩ ±2 %
C: 25 pF ±1 pF
With probe (attenuation ratio 10 : 1)
R: 10 MΩ ±3 %
C: 9.5 pF ±1 pF

Allowable input voltage
Direct 500 V (DC + peak AC)
With probe 600 V (DC + peak AC)

Mode selection
CH 1 Channel 1 only
CH 2 Channel 2 only
ALT Alternate sweep of channels 1 and 2
CHOP Chopped sweep of channels 1 and 2
Repetition (switching) frequency 1 MHz ±20 %
ADD Channel 1 ± channel 2

Polarity switching
Provided for CH 2 only

CMRR 50:1 or less at 1 kHz sine wave
20:1 or less at 20 MHz sine wave

Drift 0.2 cm/hour (typical) at 15 minutes after power ON

Internal trigger switching
CH 1, CH 2, ALT TRIG

Horizontal Deflection System

Sweep system Triggered sweep, free-run sweep, single sweep

Sweep mode
A A sweep (Main sweep)
A INTEN BY B Delaying sweep
DLY'D (B) Delayed sweep
CH 1-Y·CH 2-X X-Y scope

A sweep
Trigger system FULL AUTO, AUTO, NORM
Trigger source Internal (INT), external (EXT, EXT ÷ 10) and line frequency (LINE)
Polarity Positive and negative
Trigger coupling AC, (AC) LF REJ, (AC) HF REJ, DC
External input RC
R: 1 MΩ ±5 %
C: 25 pF ±5 pF
Allowable external input voltage
500 V (DC + peak AC)
Trigger frequency range and minimum trigger level
Shown in Table 1-1

Table 1-1 (10 °C to 30 °C)

Trigger system	Trigger coupling	Trigger frequency range	Min. trigger level: Display amplitude (mm)	Min. trigger level: Ext. input voltage (mVp-p)
NORM or AUTO (See NOTE)	AC	30 Hz to 10 MHz	2	50
		10 to 50 MHz	10	100
	(AC) LF REJ	10 kHz to 10 MHz	3	60
		10 to 50 MHz	10	100
	(AC) HF REJ	30 Hz to 10 kHz	3	60
	DC	DC to 10 MHz	2	50
		10 to 50 MHz	10	100
FULL AUTO	AC	100 to 10 MHz	10	200
		10 to 30 MHz	20	300
	(AC) LF REJ	10 kHz to 10 MHz	10	200
		10 to 30 MHz	20	300
	(AC) HF REJ	100 to 10 kHz	10	200
	DC	100 Hz to 10 MHz	10	200
		10 to 30 MHz	20	300

NOTE: In AUTO position, the lower end of trigger frequency is limited to 45 Hz.

Sweep time — 0.1 μs/cm to 0.5 s/cm
1-2-5 sequence, switched in 24 steps
Accuracy: ±2 % (10 °C to 35 °C, in an area 4 cm left and right from center of graticule)
±4 % (−10 °C to 50 °C)
±5 % for 1 to 5 s/cm (−10 °C to 50 °C)
0.1 μs/cm to 12.5 s/cm continuously variable with fine control

Linearity — 3 % (10 °C to 35 °C, in an area 4 cm left and right from center graticule)

Maximum sweep time — 10 ns/cm

Sweep length — Variable from approx. 4.5 cm to 11-cm (for sweep time of 1 ms/cm)

B sweep

Sweep system — Automatic sweep and triggered sweep

B ENDS A function — Provided

Trigger source — Internal (INT), external (EXT, EXT ÷ 10) and line frequency (LINE)

Polarity — Positive and negative

Trigger coupling — AC, (AC) LF REJ, (AC) HF REJ, DC

External input RC — R: 1 MΩ ±5 %
C: 30 pF ±5 pF

Allowable external input voltage — 500 V (DC + peak AC)

Trigger frequency range and minimum trigger level — Shown in Table 1-2

Sweep time — 0.1 μs/cm to 0.5 s/cm 1-2-5 sequence, switched in 21 steps
Accuracy: ±2 % (10 °C to 35 °C, in an area 4 cm left and right from center of graticule)
±4 % (−10 °C to 50 °C)
0.1 μs/cm to 1.25 s/cm continuously variable with fine control

Delay time — 1 μs to 50 s
Accuracy: ±3 % (10 °C to 35 °C)

Delay jitter — 20,000:1 or less

Sweep magnifier — 10 times, symmetrical magnification to the center
Accuracy (10 °C to 35 °C, in an area 4 cm left and right from center of graticule)
0.5 μs/cm to 5 s/cm range ±3 %
0.1 μs/cm to 0.2 μs/cm range ±4 %

Single sweep — Single sweep function is provided for sweep A, A INTEN BY B and DLY'D (B)

Table 1-2 (10 °C to 35 °C)

Trigger system	Trigger frequency range	Min. trigger level: Display amplitude (mm)	Min. trigger level: Ext. input voltage (mVp-p)
AC	30 Hz to 10 MHz	2	50
	10 to 50 MHz	10	100
(AC) LF REJ	10 kHz to 10 MHz	3	60
	10 to 50 MHz	10	100
(AC) HF REJ	30 Hz to 10 kHz	3	60
DC	DC to 10 MHz	2	50
	10 to 50 MHz	10	100

CH 1-Y·CH 2-X

Sensitivity	Equal to CH 2 sensitivity of vartical deflection system Accuracy: ±3 % (10 °C to 35 °C) ±5 % (−10 °C to 50 °C)
Frequency bandwidth	DC to 1 MHz −3 dB
Input RC	Equal to CH 2 input RC of vartical deflection system
Allowable input voltage	Equal to allowable input voltage of vertical deflection system
X-Y phase difference	Within 3 ° (in frequency band DC to 1 MHz)

Signal outputs

Calibration voltage output

Waveform	Square wave
Repetition frequency	1 kHz Accuracy: ±1 % (10 °C to 35 °C)
Duty ratio	Better than 48:52
Output voltage	20 mV, 0.2V, 2 V Accuracy: ±1 % (10 °C to 35 °C) ±1.5 % (−10 °C to 50 °C)
Output resistance	20 mV and 0.2 V range 50 Ω 2 V range Approx. 270 Ω

Calibration current

Output	5 mA square wave, accuracy ±1 %

Gate output (for both sweep A and B)

Output voltage	Approx. 5 V
Output resistance	Approx. 1 kΩ

Power Supply

Line voltage range
Shown in Table 1-3

Table 1-3

Center voltage	Voltage range	Remark
100 V AC	90 to 110 V	Voltage range are selectable by changing plug connection.
117 V AC	106 to 128 V	
217 V AC	196 to 238 V	
234 V AC	211 to 257 V	

Frequency range 50/60 Hz

Power consumption
Approx. 105 W (at 100 V AC)

Weight

Approx. 18 kg
Approx. 18.5 kg with panel cover

Dimensions

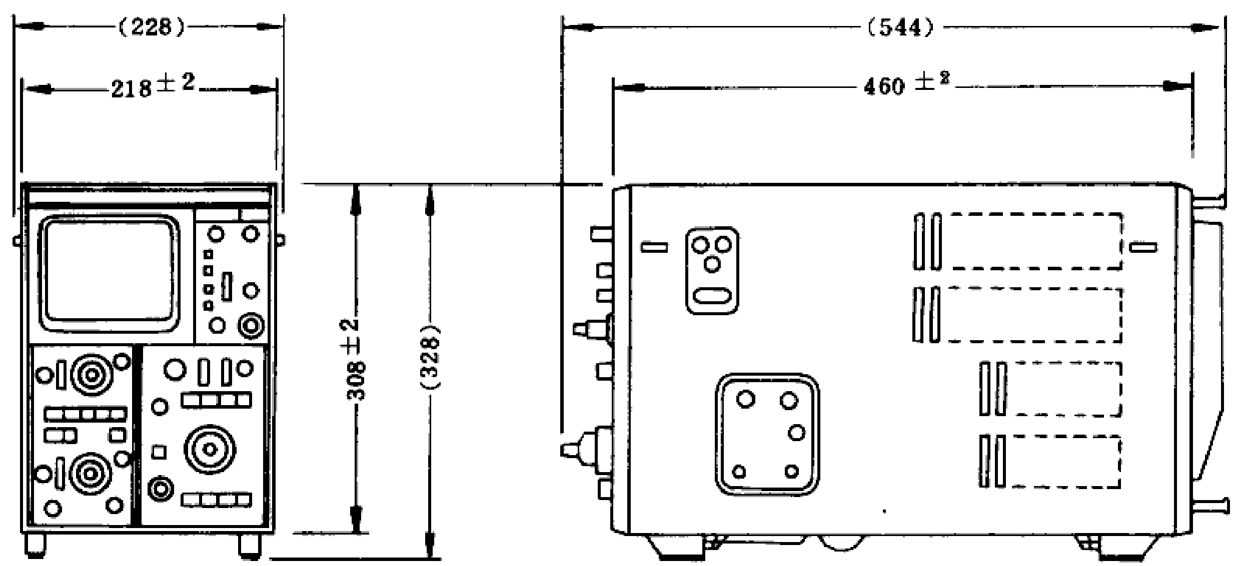
218 ± 2 (W) x 308 ± 2 (H) x 460 ± 2 (L) (mm)
Refer to Fig. 1-1

Ambient Condition

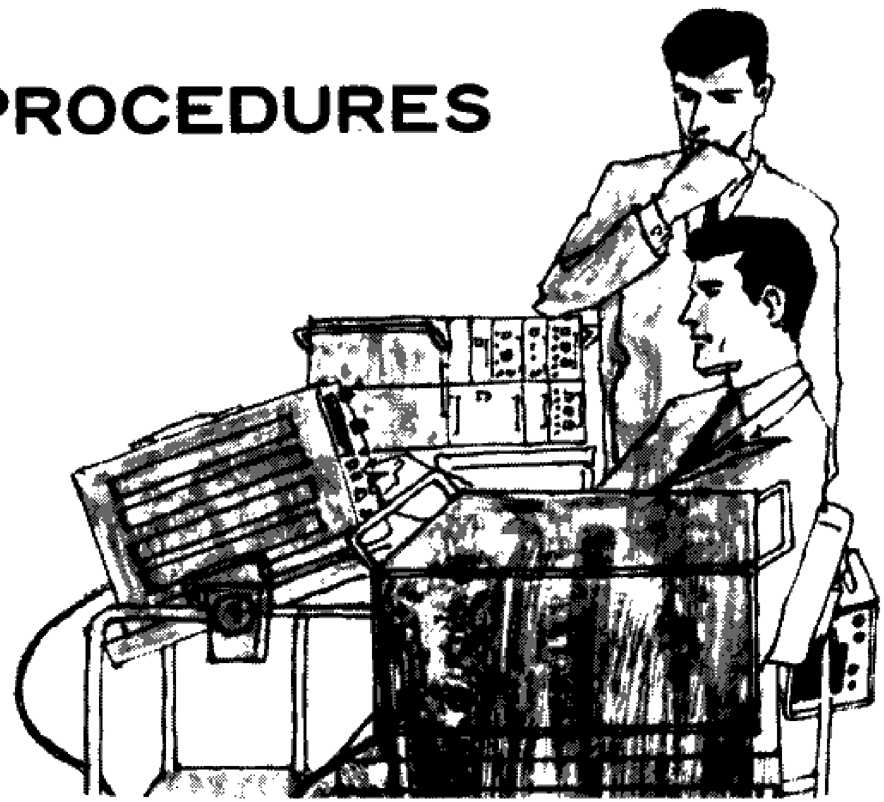
Operating temperature
−10 °C to 50 °C

Operating humidity	90 % R. H., 40 °C
Storage temperature	−20 °C to 70 °C
Altitude	Operating time: 5000 m max. balometric pressure 409 mm Hg Not in operation: 15000 m max. balometric pressure 91 mm Hg
Vibration test	Reciprocal sweep between 10 Hz and 35 Hz in 1 minute. Peak-to-peak amplitude 1 mm, 30 minute testing for three major axes. Total test time 1.5 hours.
Shock test	One side of cabinet is fifted 5 cm above a hard wood bench (or 30 ° drop test is repeated 3 times for each side.
Drop test	Transpotation-packed and droped from a height 75 cm above floor.

Fig. 1-1 Outline and dimensions



SECTION 2 OPERATING PROCEDURES



For effective use of this synchroscope, it will be essential to become acquainted with wide versatility of this instrument, functioning of controls and correct operation steps, as early as possible.

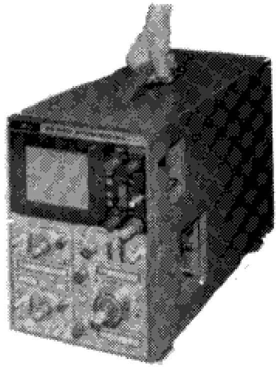
This section will describe, first, very basic operation of this instrument which is followed by functioning of controls and practical operation procedures.

BASIC OPERATION

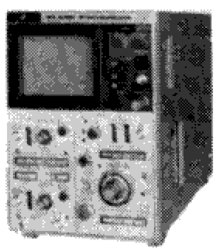
Carrying and placing on bench

Fig. 2-1 Carrying this instrument and placing on the bench

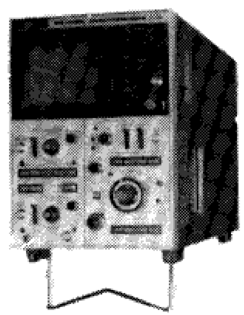
carryimg



Placing on the bench — Place and position this instrument for easier observation of display. The instrument may be positioned at any optional viewing angle if used with a scope wagon. When it is placed on the bench, the following variation of positioning is possible.



Ordinary positioning



With auxiliary leg

Precautions before operation

Check Your Line Voltage

Desired oeprating voltage can be selected from four voltage ranges shown in Table 2-1, by changing the setting of voltage selecting plug located on the rear panel.

Check your line voltage, and plug the selecting plug so that the arrow mark of plug will be lined with a voltage range indication on the panel which covers your line voltage.

Connection of the instrument to a voltage source not covered by the voltage range selected will result in trouble of the instrument (IWATSU prepares Automatic Voltage Regulator which will stabilize AC power supply against excessive fluctuation of line voltage.)

Also, check · if the provided fuse meets the rating shown in Table 2-1. If the set is used at a line voltage not covered by Table 2-1, contact IWATSU for an appropriate remedy.

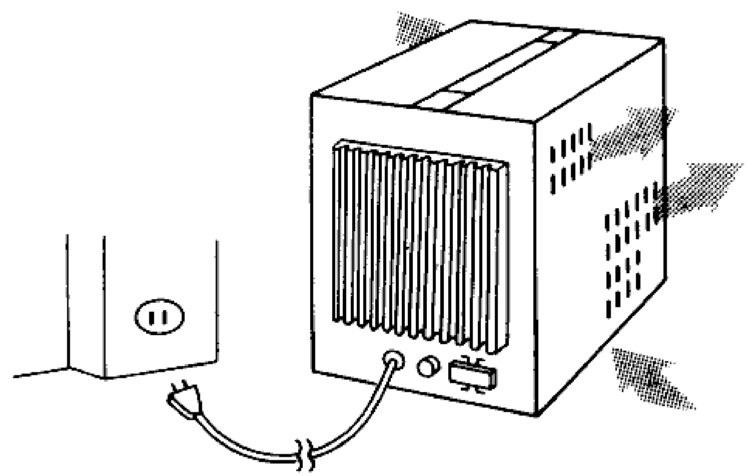
Table 2-1 Voltage range

Plug setting position	Center voltage	Voltage range	Fuse
A	110V	90 ~ 110V	2A slow
B	117V	106 ~ 128V	
C	217V	196 ~ 238V	1A slow
D	234V	211 ~ 257V	

Ambient Temperature and Ventilation

Normal operation of this instrument is guaranteed for ambient temperatures ranging from −10°C to +50°C. The rear panel is provided with a blower fan for forced circulation of air to pretect inner circuits from temperature rise. The air sucken in the rear cools inner circuit and radiated from ventilation holes on the side and bottom panels (see Fig. 2-2). Be sure not place any obstacle, which may hamper ventilation, close to the instrument, or not to position the rear panel immediately against wall.

Fig. 2-2 Voltage selector and ventilation



Basic Operation

Operation of major controls and connectors are described in the following. For effective use of this instrument, it is essential to try all the controls as given in this manual and to become familiar with functions offered by each control. Try to operate the controls referring to drawings, in the given sequence, and confirm functioning of controls. In the succeeding operations, use proper lead wire when connecting the output from the CAL OUT to a pair of input connectors. For detail of functions and operating procedures, refer to Sections "Function of Controls" and "Operating Procedures" which will be described later.

1. Setting Controls

(1) This instrument is designed so that the trace will appear in the viewing area by setting all controls to the mid-position, lever switches to upper position and pushing the leftmost button of pushbutton switches. Set controls and switches as given below.

--Power supply and CRT--	
POWER	OFF
INSTENSITY	Fully counterclockwise (CCW)
FOCUS	Mid-position
SCALE ILLUM	Fully CCW
--Vertical--	
MODE	CH 1
TRIGGER	CH 1
CH 2 POLARITY	NORM
AC-GND-DC (CH 1. CH 2)	DC
VOLTS/CM (CH 1. CH 2)	50mV
VARIABLE (CH 1. CH 2)	CALIB
POSITION (CH 1. CH 2)	Mid-position
--Horizontal--	
HORIZONTAL DISPLAY	A
MAIN (A) SWEEP MODE	FULL AUTO
A TIME/CM	·5mSEC
B TIME/CM	·1mSEC
A VARIABLE	CALIB
B TIME/CM VARIABLE	CALIB (located at lower part of right side panel)
A WEEP LENGTH	FULL
DLY'D(B) MODE	AUTO
DELAY TIME MULTI	1.20
POSITION	Mid-position (1 o'clock position)
FINE(PULL x10 MAG)	Mid-position with button pushed
--Triggering--	
SOURCE (A.B)	INT
COUPLING (A.B)	AC
LEVEL (SLOPE) (A)	Fully clockwise with button pushed
LEVEL (B)	Mid-position
SLOPE (B)	+
--Calibrator--	
CALIBRATOR	0.2V

(2) Set the voltage selecting plug (on the rear panel) to your line-voltage position, and connect the power cord to the line.

(3) Push POWER. The pilot lamp at the right of the switch should light. Leave the instrument at this condition for 10 minutes to allow warming up.

(4) Indicators, UNCALIB, TRIG'D, UNCALIB A OR B, RESET and MAG x10, should not light. SLOPE + indicator should light.

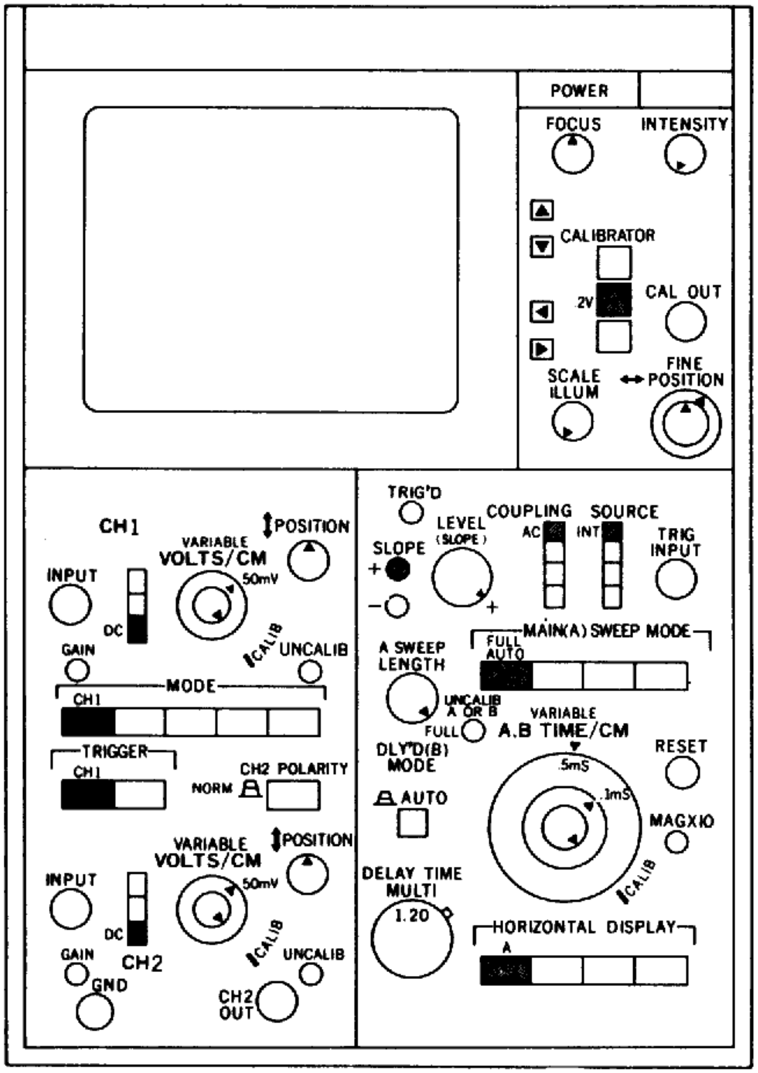
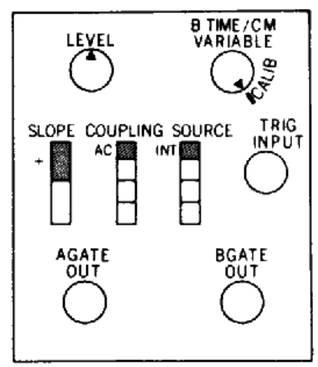


Fig. 2-3 Front view



Right side panel

2. Trace Intensity, Parallelness and Scale Illumination

(1) Turn INTENSITY clockwise until a trace appears in the viewing area.
(2) Turn POSITION of CH 1 to line the trace with the horizontal center line of graticule.
(3) Turn SCALE ILLUM clockwise to obtain an adequate scale illumination. Refer to Fig. 2-4 (b).

NOTE: If the trace can not be set parallel to the horizontal line of scale in step (2), refer to item "TRACE ROTATION adjustment" in Section 3.

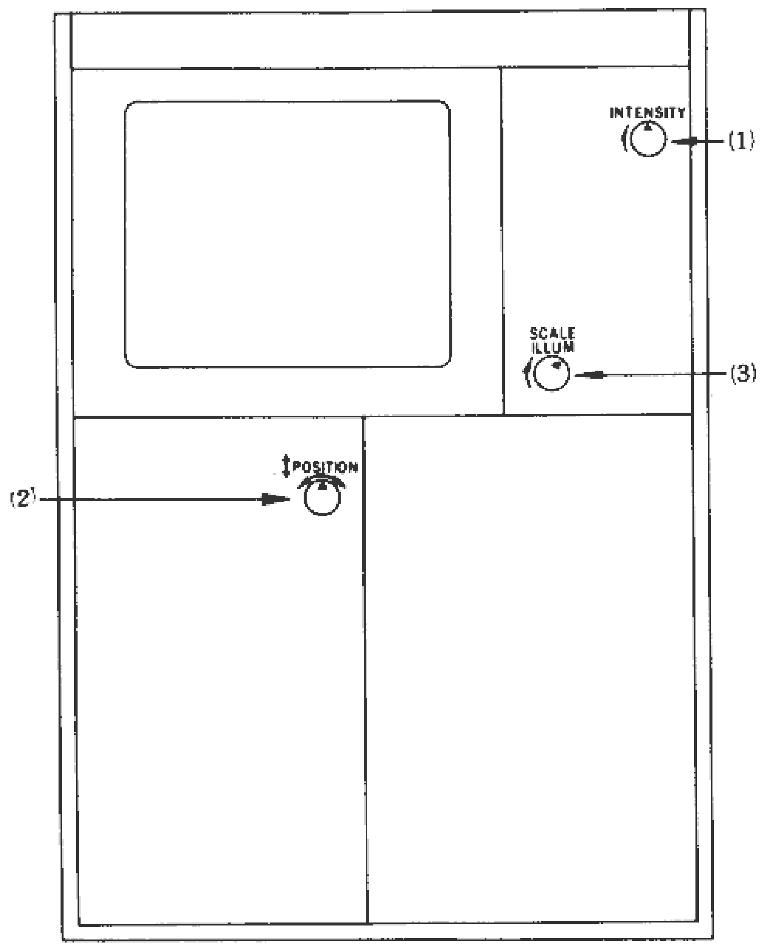
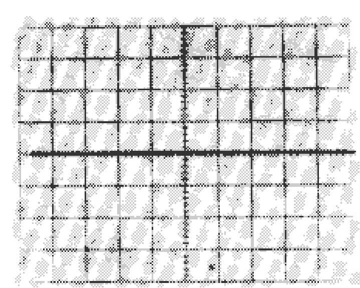


Fig. 2-4 (a)



(b)

3. Vertical Positioning and Balance

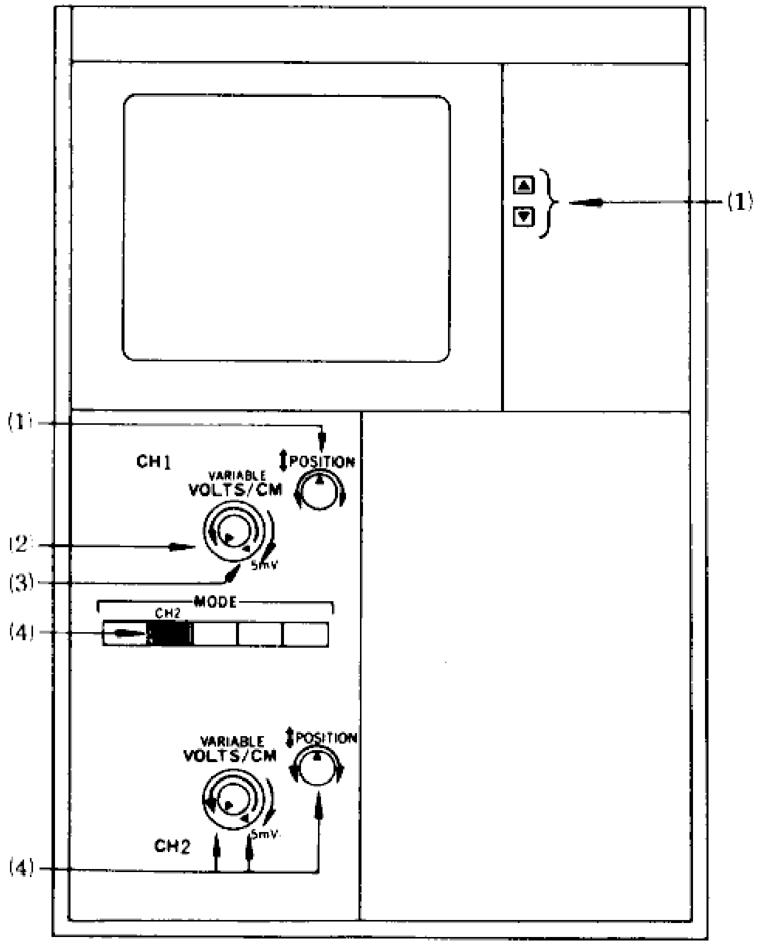
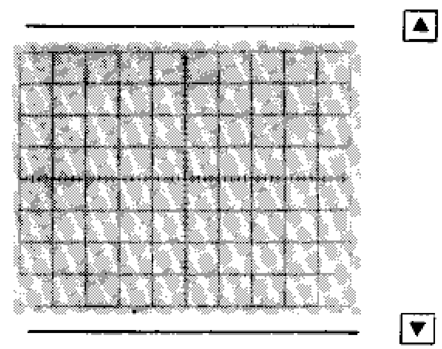


Fig. 2-5 (a)

(1) Turn POSITION of CH 1 to move the trace out of viewing area. Either of direction indicator ▲ or ▼ should light indicating the direction the trace has been driven. Refer to Fig. 2-5 (b). Return the trace into the viewing area.
(2) Vertical position of trace should not shift against rotation of CH 1 VARIABLE.
(3) The vertical position of trace should not shift against switching of CH 1 VOLTS/CM to the 5mV position.
(4) Change MODE to CH 2, and repeat steps (1) to (3) above for CH 2 trace.
(5) Return VOLTS/CM to 50mV, and change MODE to CH 1.

NOTE: If the trace moves vertically in step (2) or (3) above, refer to item "VARIABLE adjustment" of "STEP ATTEN BAL adjustment" in Section 3.



(b)

4. Vertical Amplitude and Waveform of Cal Signal

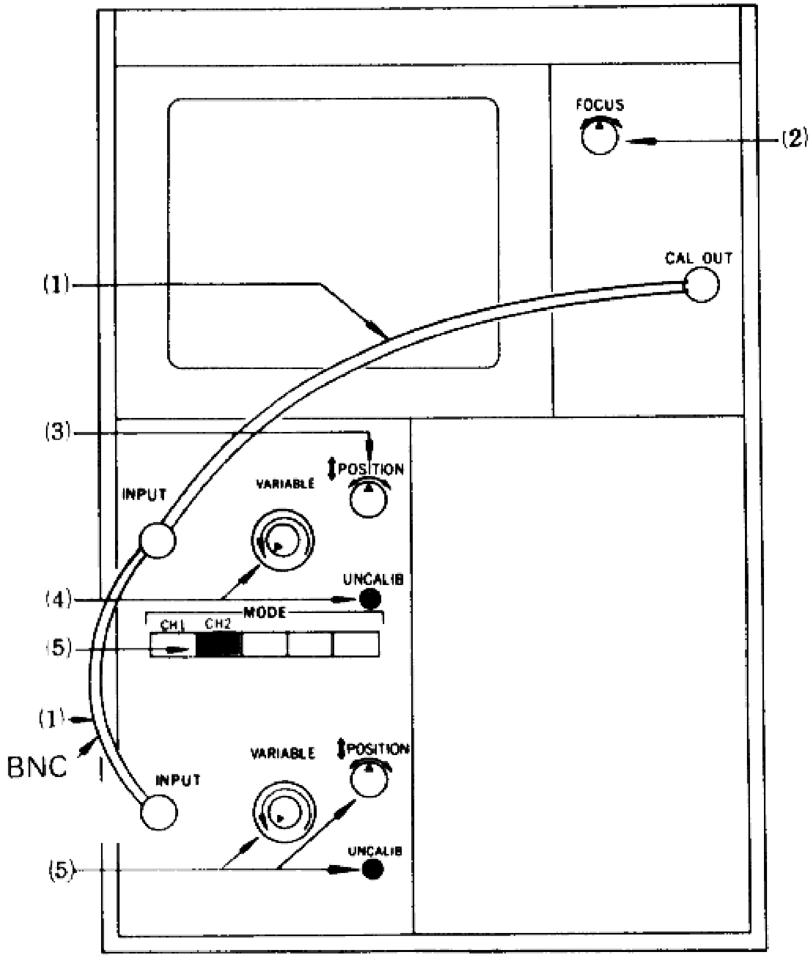
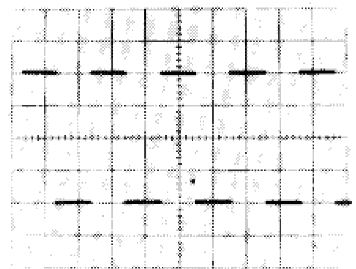


Fig. 2-6 (a)

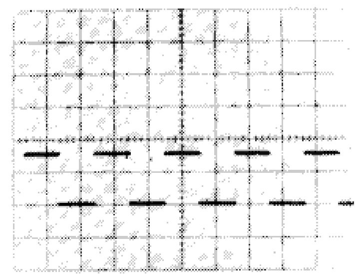
(1) Connect CH 1 and CH 2 inputs and CAL OUT as shown in Fig. 2-6(a). Calibration signal (CAL) waveform should be displayed and stably triggered.
(2) Adjust FOCUS for clean signal viewing.
(3) Position the signal waveform to the vertical center of viewing area. Vertical amplitude of the CAL signal should be exactly 4cm, as shown in Fig. 2-6(b).
(4) Turn VARIABLE of CH 1. UNCALIB indicator should light immediately when the control is turned CCW. The amplitude of CAL waveform should decrease with CCW rotation of VARIABLE. At the leftmost end of VARIABLE rotation, the signal amplitude should be reduced to 1.6cm or less, as shown in Fig. 2-6(c).
(5) Change MODE to CH 2. Repeat steps (2) to (4) above for the CH 2 trace.
(6) Return VARIABLE to CALIB and MODE to CH 1.

NOTE: If sharp focusing is not obtained in step (2), refer to item "ASTIG adjustment" in Section 3.
If vertical amplitude of CAL waveform does not reach 4cm, in step (3), refer to item "GAIN adjustment" in Section 3.

(b)



(c)



5. Input Signal Coupling

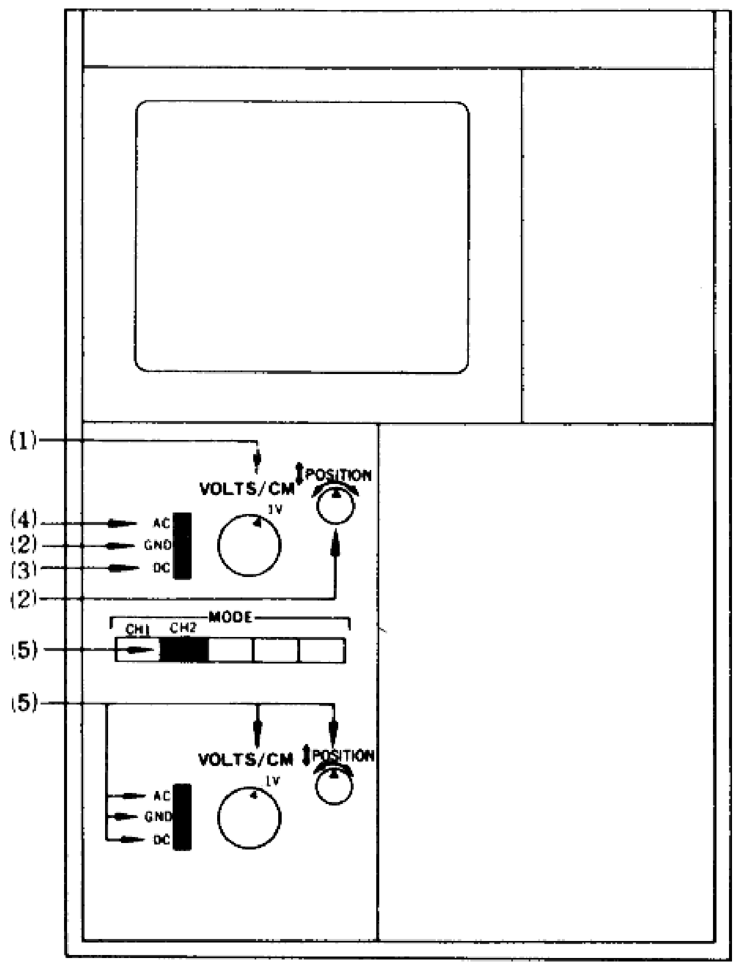
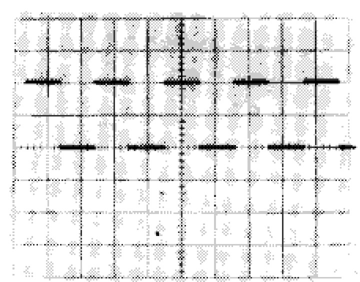
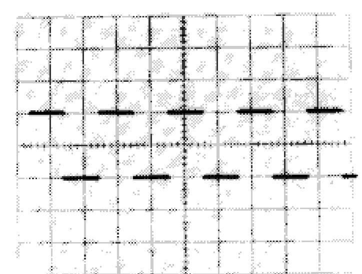


Fig. 2-7 (a)

(1) Change VOLTS/CM of CH 1 to 0.1V
(2) Change AC-GND-DC to GND. Fine adjust POSITION to set the trace exactly on the horizontal center line of graticule (reference level).
(3) Return AC-GND-DC to DC. The input signal is DC coupled and CAL waveform should start from the horizontal center line as shown in Fig. 2-7(b).
(4) Change AC-GND-DC to AC. The input signal is AC coupled and the CAL waveform should be displayed symmetric to the reference line as shown in Fig. 2-7 (c).
(5) Change MODE to CH 2, and repeat steps (2) to (4) for CH 2 display.
(6) Return AC-GND-DC of both channels CH 1 and CH 2 to DC.



(b)



(c)

6. Dual-trace Display and Measurement of Sum and Difference of Two Signals

(1) Change MODE to ALT and adjust POSITION of both channels to obtain a display shown in Fig. 2-8 (b).

(2) The dual-trace display is possible at any position of A TIME/CM (the outer knob).

(3) When MODE is set to CHOP, the dual-trace measurement is also possible at any position of A TIME/CM.

(4) Return A TIME/CM to 0.5mSEC, and change MODE to ADD. Vertical amplitude of signal waveform should be doubled (to 4cm) as shown in Fig. 2-8(c). Vertical position of signal can be changed by either of POSITION of both channels.

(5) Push CH 2 POLARITY (INV position). The amplitude of display should become approximately zero (a straight line).

(6) Push CH 2 POLARITY again (it returns to the NORM position), change MODE to CH 2, and disconnect CAL signal cable.

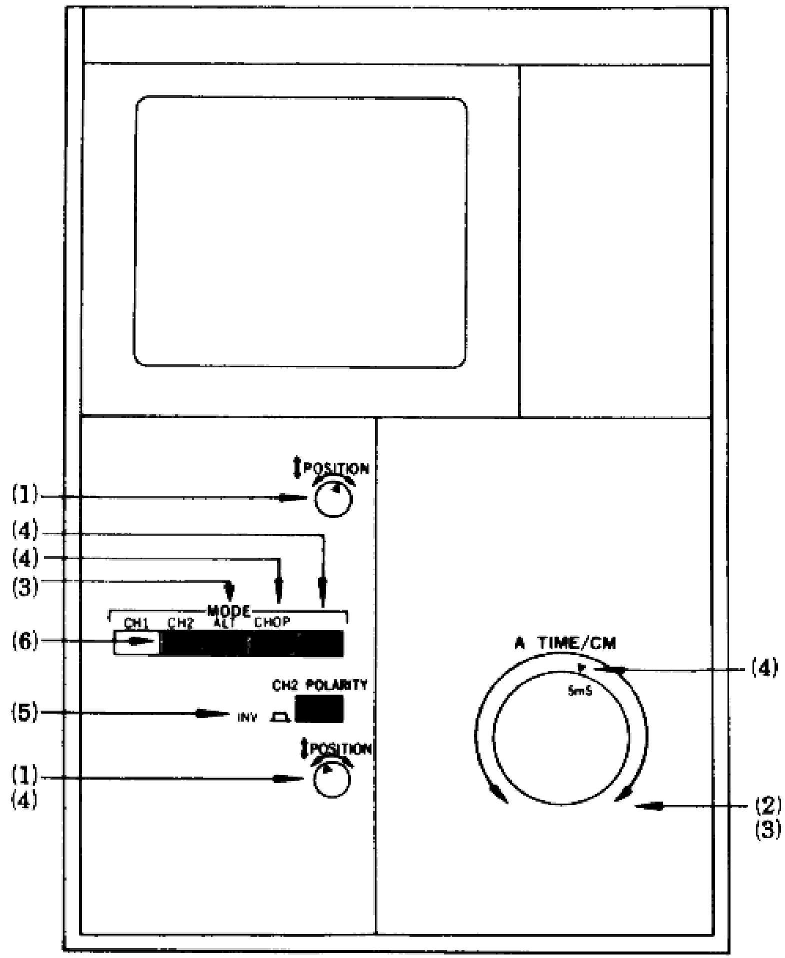
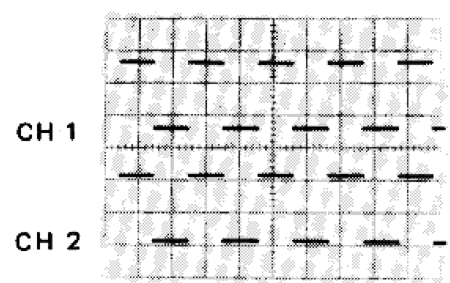
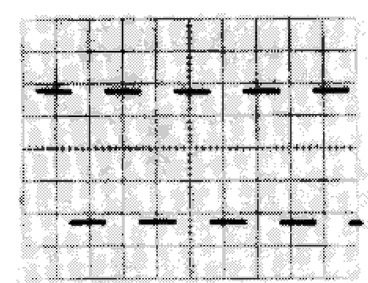


Fig. 2-8 (a)



(b)



(c)

7. Cascade Connection (Vertical sensitivity is magnified 5 times to 1mV/cm)

(1) Connect the signal as shown in Fig. 2-9(a) and set CH 1 VOLTS/CM to 5mV position, CH 2 VOLTS/CM to 0.2V position.

(2) Adjust POSITION of CH 2 to set the signal waveform to the center of viewing area. Vertical amplitude of signal should be 1cm as shown in Fig. 2-9(b).

(3) Change MODE to CH 1, and adjust positioning of signal waveform by using POSITION of CH 1. The vertical amplitude of signal should be multipled 5 times to 5cm.

(4) Change the signal cabling as shown in Fig. 2-6(a).

NOTE: Herein described is the methode to obtain sensitivity of 5 times (cascade-connection) by using the CAL waveform. In order to obtain 1mV/cm sensitivity, CH 2 VOLTS/CM has to be set to 5mV position.

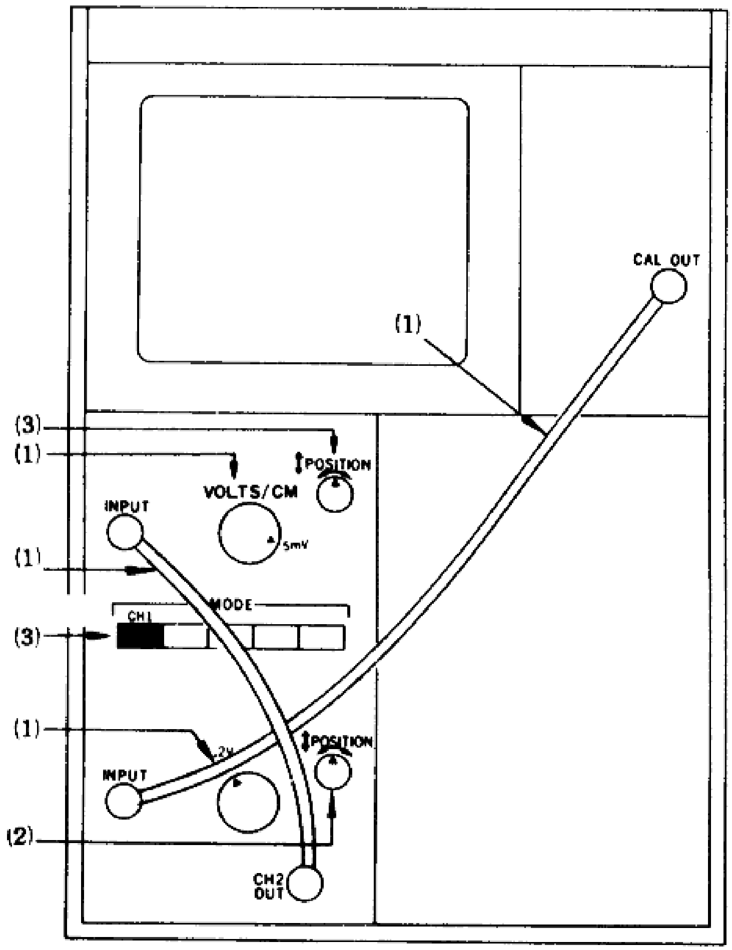
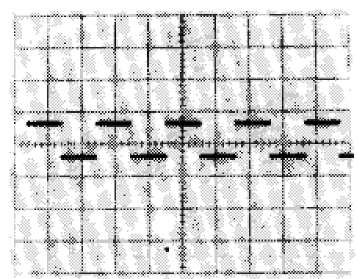
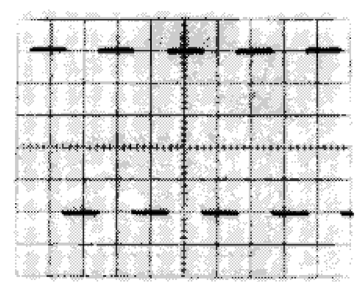


Fig. 2-9 (a)



(b)



(c)

8. Internal Trigger

(1) With this control setting (FULL AUTO mode), the signal waveform can be triggered the entire adjustment range of LEVEL.

(2) Change MAIN(A) SWEEP MODE to AUTO. The display should start free run and the TRIG'D indicator lamp should go off when LEVEL is turned toward the end of adjustment range (to the left or right).

(3) Change COUPLING to DC. Similar to the case in AC mode, the display should be triggered only around the mid-position of LEVEL.

(4) Change MAIN(A) SWEEP MODE to NORM. The display should disappear when LEVEL is turned left or right from the mid-position.

(5) Return MAIN (A) SWEEP MODE to FULL AUTO and pull LEVEL (SLOPE). The – SLOPE should light, and the display should change as shown in Fig. 2-10 (b).

(6) Change MODE to ALT and TRIGGER to CH 2. The CH 1 signal should start free run as shown in Fig. 2-10(c). The signal should be triggered again when TRIGGER is changed CH 1.

(7) Set MODE to CH 1, COUPLING to AC and push LEVEL (SLOPE) (to the + slope).

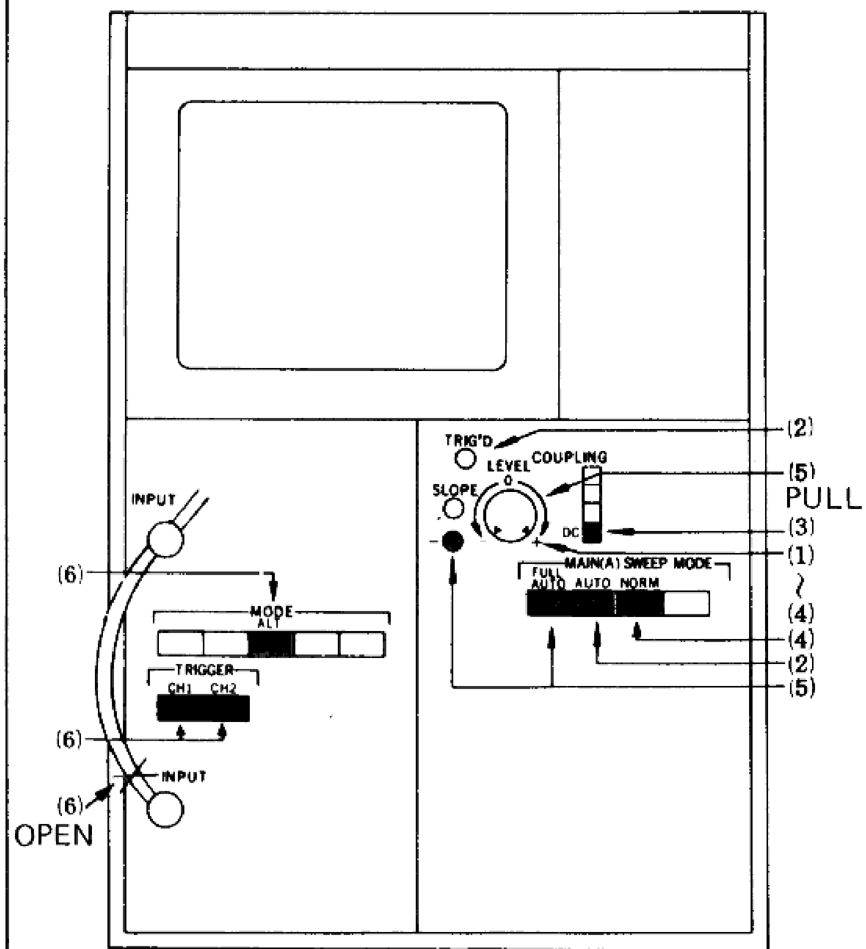
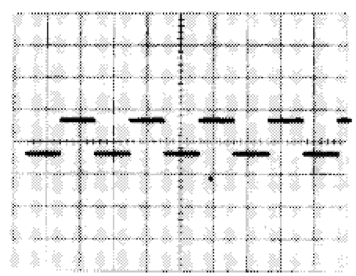
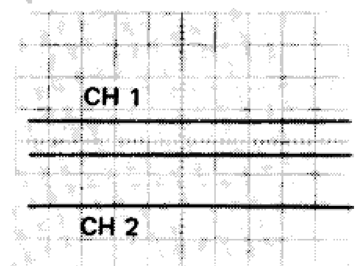


Fig. 2-10 (a)



(b)



(c)

9. External Trigger

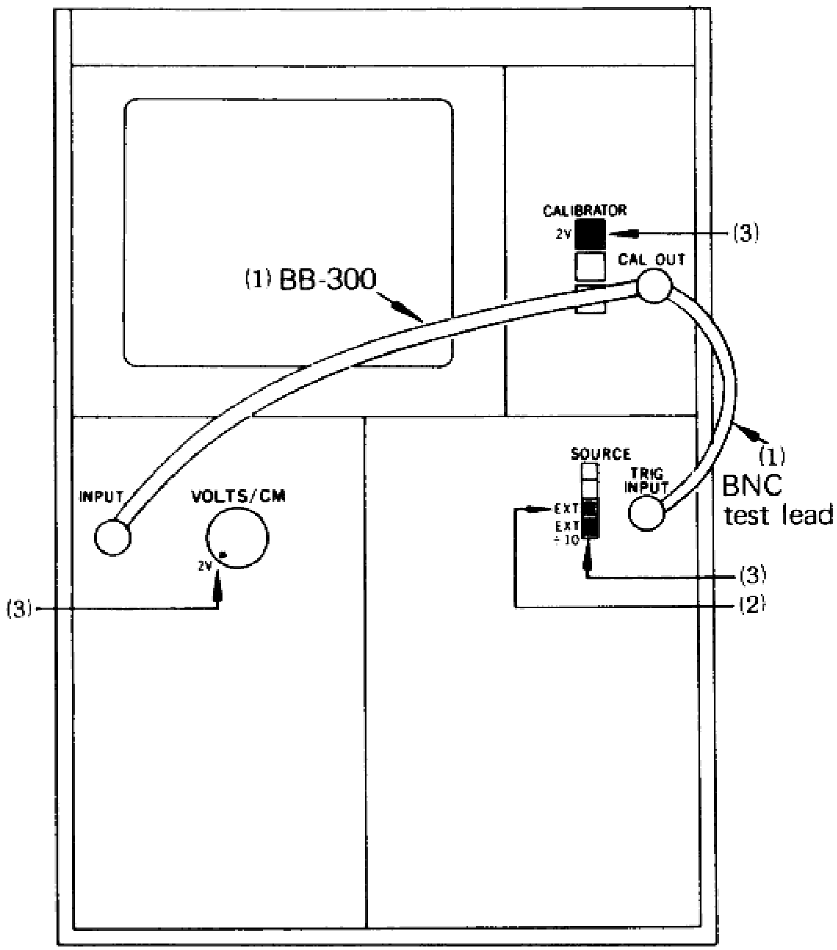
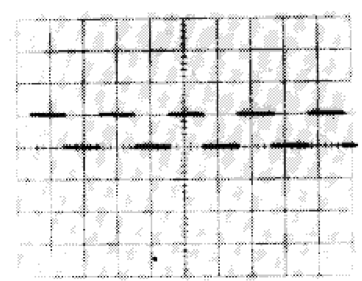


Fig. 2-11 (a)



(b)

(1) Connect the signal as shown in Fig. 2-11(a).
(2) The signal waveform should be triggered as shown in Fig. 2-11(b), when SOURCE is set to EXT. Repeat steps (1) to (5) of item 8 Internal Trigger.
(3) Change SOURCE to EXT÷10. The triggered display should become unstable. The stable trigger should be recovered when VOLTS/CM is changed to 2V, and CALIBRATOR to 2V.
(4) Return CALIBRATOR to .2V, VOLTS/CM of both channels to 50mV and SOURCE to the INT. Disconnect the cable between CAL OUT and TRIG INPUT.

10. Sweep Time (a) and Sweep Magnifier

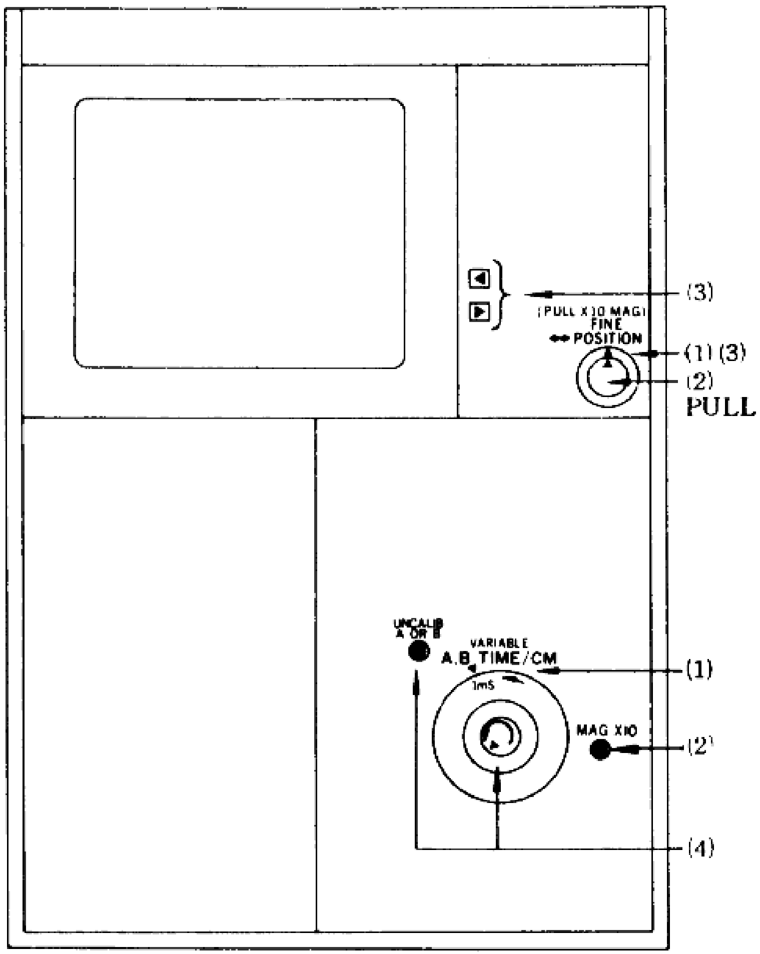


Fig. 2-12 (a)

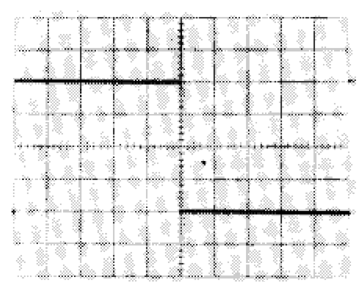
(1) Change TIME/CM to 1mS, and adjust the horizontal POSITION so that the display will be started exactly from the leftmost end of graticule.
The displayed waveform should be a squarewave train which cycles at every 1cm, and the starting point of 11th cycle will be approximately at the rightmost end of graticule.

(2) Pull FINE (PULL x10 MAG) (inner of POSITION), and position the leading edge of square wave at the leftmost end of graticule. The sweep should be magnified as shown in Fig. 2-12(b), and MAG x10 indicator should light.

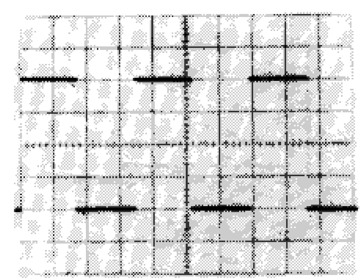
(3) Adjust horizontal POSITION to move the waveform out of viewing area. Direction indicator ◀ or ▶ should light indicating the direction the display has been moved.

(4) Turn A VARIABLE counterclockwise. UNCALIB A or B indicator should light. When A VARIABLE reached the leftmost end of rotation, the display should exceeds 2.5 cycles or more, as shown in Fig. 2-12(c)

(5) Return A VARIABLE to CALIB and push FINE (PULL x10 MAG). Fine adjust the horizontal POSITION until the sweep is started exactly from the leftmost end of graticule.



(b)



(c)

11. Automatic Sweep and Sweep Time (b)

(1) Change HORIZONTAL DISPLAY to A INTEN BY B. A part of displayed waveform should intensified as shown in Fig. 2-13 (b).

(2) Turn B TIME/CM VARIABLE (in the lower part of right side panel) counterclockwise. UNCALIB A or B indicator should light. The intensified part of displayed waveform should be extended horizontally by 2.5 times or more. Return B TIME/CM VARIABLE to CALIB.

(3) The intensified part of displayed waveform should move continuously over waveform by turning DELAY TIME MULTI.

(4) By changing HORIZONTAL DISPLAY to DLY'D (B), only the intensified part of the displayed waveform should appear over the entire part of the viewing area (magnified). The waveform is continuously moved in the viewing area by turning DELAY TIME MULTI.

(5) Adjust DELAY TIME MULTI until the leading adge of displayed waveform starts exactly from the left-most end of graticule. The second cycle of displayed waveform should start approximately at the right-most end of the graticule, as shown in Fig. 2-12 (b).

(6) Return DELAY TIME MULTI to 1.20.

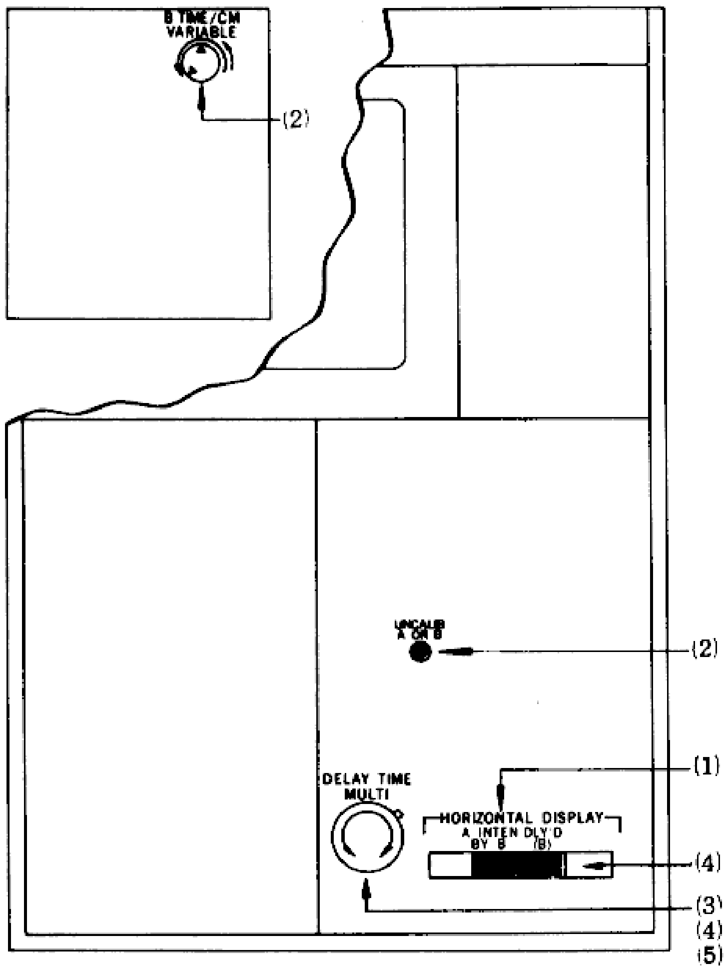
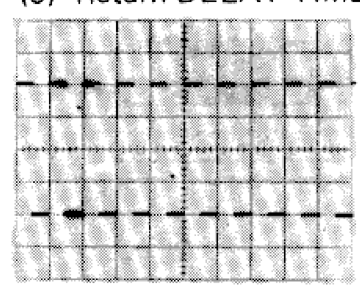
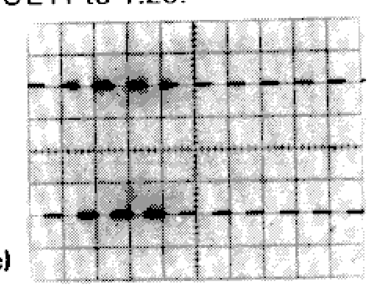


Fig. 2-13 (a)



(b)



(c)

12. Triggered Sweep (b)

(1) Change HORIZONTAL DISPLAY to A INTEN BY B and push DLY'D (B) MODE (to TRIG'GABLE). The waveform should be partially intensified as shown in Fig. 2-14 (b).

(2) By turning DELAY TIME MULTI, the intensified part of display should jump cycle to cycle. Polarity of intensified display is reversed by changing SLOPE (B TRIGGERING) (B) to the – (negative) position. Then, the intensified part jumps cycle by cycle with rotation of DELAY TIME MULTI.

(3) The intensified part of display disappears when triggering is lost by turning LEVEL (B). Return SLOPE (B) to the + (positive) position and LEVEL (B) to triggerable position.

(4) By changing HORIZONTAL DISPLAY to DLY'D (B), only the intensified part is magnified in the viewing area, as shown in Fig. 2-12 (b). In this case, the display stays still against rotation of DELAY TIME MULTI.

(5) Similar to the case in AC coupling mode, the display is triggered also in case COUPLING (B) is set to DC only when the LEVEL (B) control is set to approximately mid-position.

(6) Connect the signal as shown in Fig. 2-14 (a), and repeat the steps given in item 9 External Trigger. Then, return DLY'D (B) MODE to AUTO.

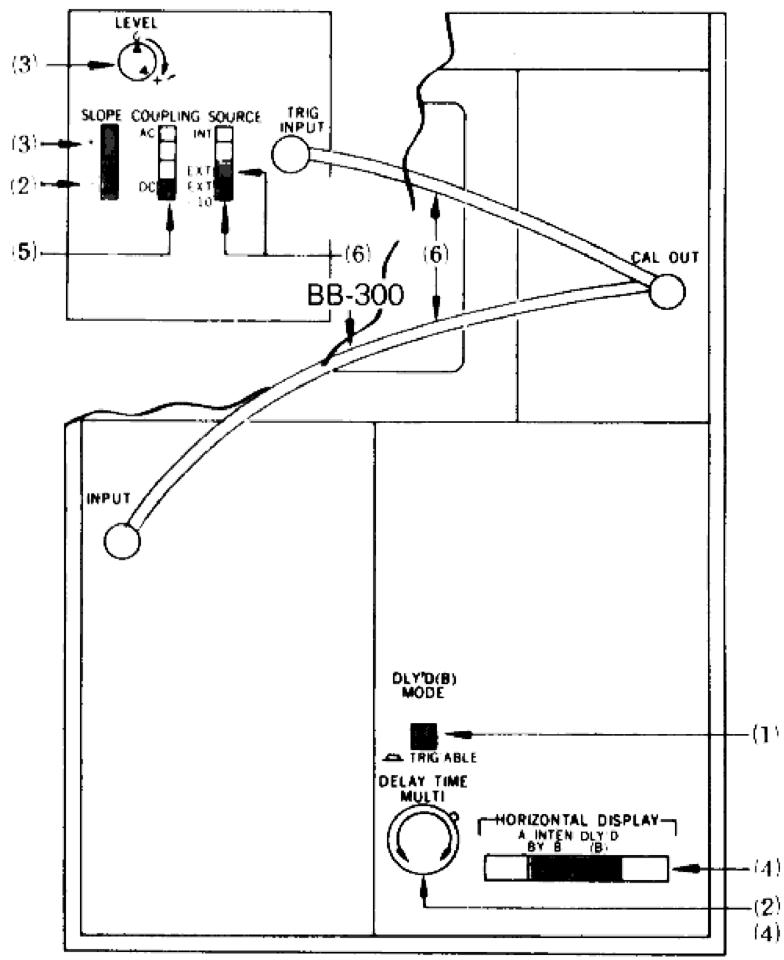
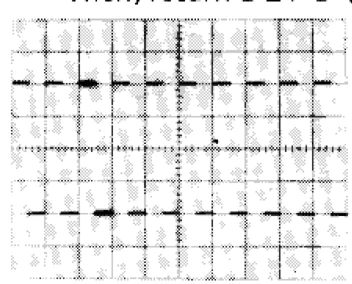
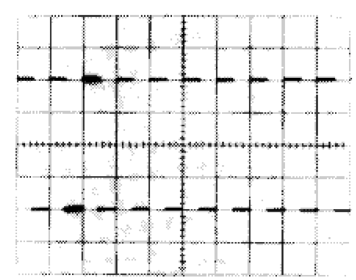


Fig. 2-14 (a)

(b)



(c)



13. A Sweep Length

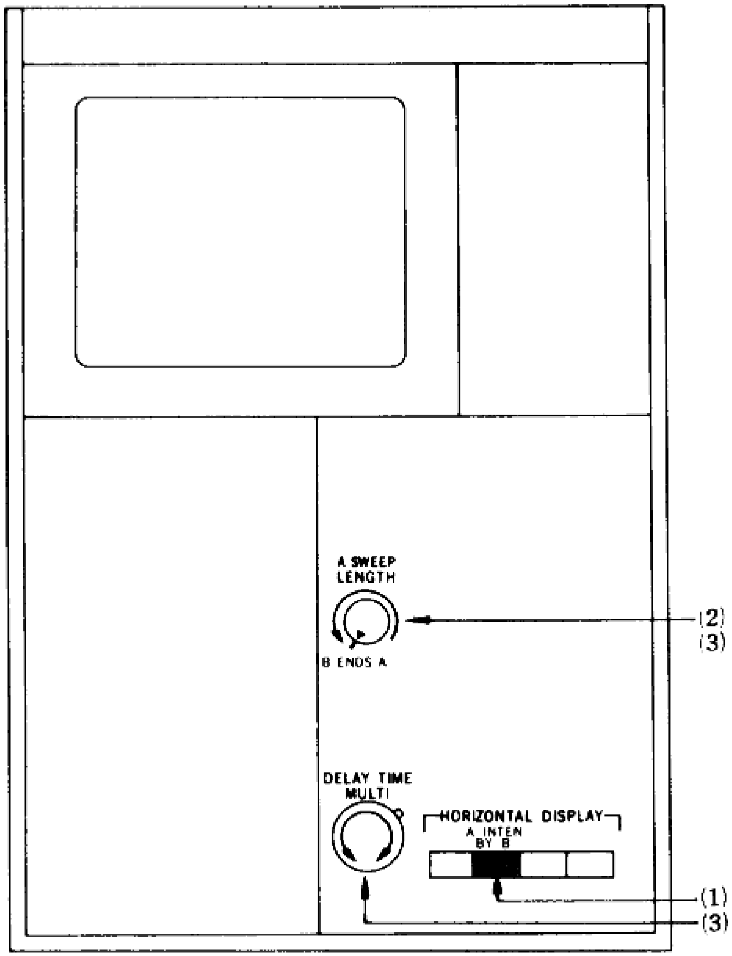


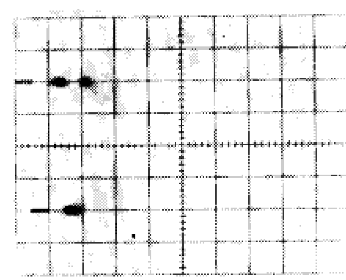
Fig. 2-15 (a)

(1) Change HORIZONTAL DISPLAY to A INTEN BY B.

(2) Horizontal length of displayed waveform is shortened with counterclockwise rotation of A SWEEP LENGTH. The length is reduced to approximately 4.5cm when this control is turned immediately before B ENDS A.

(3) At B ENDS A of A SWEEP LENGTH, the sweep of display ends immediately after the end of the intensified part. The sweep length varies with rotation of DELAY TIME MULTI, as it changes positioning of the intensified portion.

(4) Return HORIZONTAL DISPLAY to A, and A SWEEP LENGTH to FULL.



(b)

14. Single Sweep

(1) Change MAIN(A) SWEEP MODE to SINGLE.
(2) Sweep is carried only once everytime RESET is pushed.
(3) Change AC-GND-DC to GND. No waveform will be displayed when RESET is pushed, but RESET indicator lights and the reset condition is retained.
(4) Sweep should occur once again, when AC-GND-DC is returned to DC. RESET indicator should go off.
(5) Return MAIN(A) SWEEP MODE to AUTO.

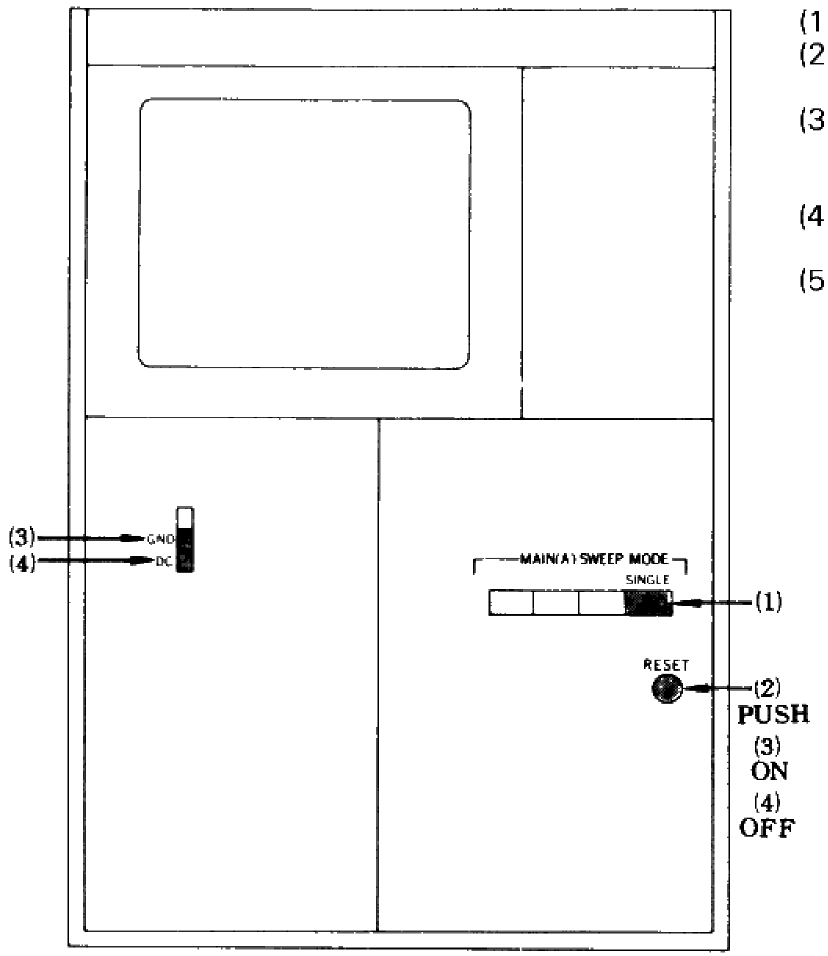


Fig. 2-16

15. X-Y Scope Operation

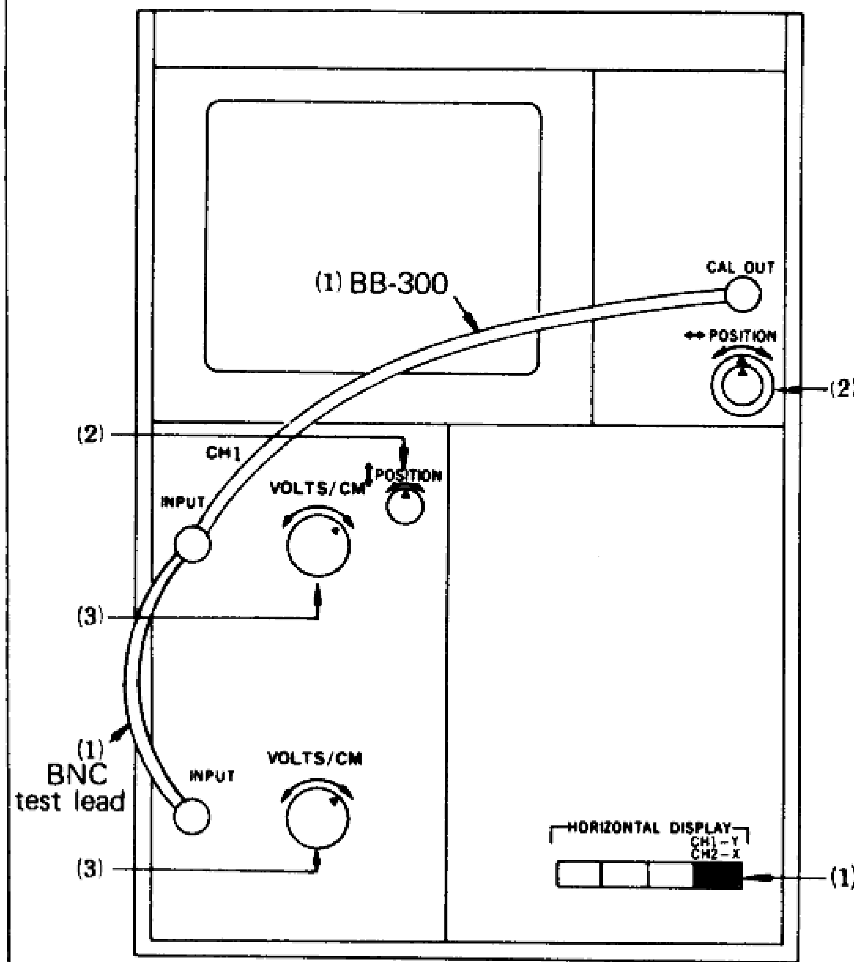


Fig. 2-17 (a)

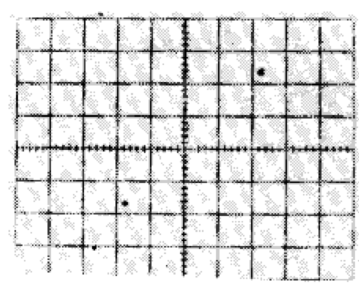
(1) Connect the signal as shown in Fig. 2-17 (a), and set HORIZONTAL DISPLAY to CH 1-Y. CH 2-X.

(2) Two intensified spots should appear in orthogonal direction of viewing area, by adjusting horizontal POSITION. Vertical positioning of spots can be moved by using vertical POSITION, and the spots move in horizontal direction by turning horizontal POSITION.

(3) Vertical distance between the spots is varied with changing of CH 1 VOLTS/CM.
Similarly, changing of CH 2 VOLTS/CM changes horizontal distance of spots.

(4) Return HORIZONTAL DISPLAY to A.

NOTE: In the case of X-Y scope operation, keep the spot intensity appropriate by adjusting INTENSITY.



(b)


SS-6050 SYNCHROSCOPE DC-50MHz
POWER
FOCUS
INTENSITY
CALIBRATOR
CAL OUT
SCALE ILLUM
POSITION
CH 1
VOLTS/CM
POSITION
MODE
TRIGGER
CH 2 POLARITY
VOLTS/CM
POSITION
INPUT
CH 2
A TRIGGERING
TRIG'D
LEVEL
SLOPE
COUPLING
SOURCE
TRIG INPUT
MAIN(A) SWEEP MODE
A SWEEP LENGTH
A.B TIME/CM AND DELAY TIME
RESET
DLY'D(B) MODE
DELAY TIME MULTI 1-10
HORIZONTAL DISPLAY


TRACE ROTATION
Z AXIS INPUT
PROBE LOOP
LEVEL
VARIABLE
SLOPE
COUPLING
SOURCE
A GATE OUT
FUSE

FUNCTION OF CONTROLS

This section will describes function of controls, connectors, semi-fixed controls and other controls located on the front panel, right side panel and rear panel. The dual controls are identified by color, black control is represented by black markings (or white markings on black panel), and a red control is represented by red markings. Refer to Fig. 2-18.

Front Panel

– Power Supply and CRT –

POWER

Power switch. The power is supplied to circuit by pushing this switch, and a pilot lamp lights at the right side of this switch. When this switch is pushed again, the power supply stops and the lamp goes off.

INTENSITY

Control to adjust the brightness of spot or trace in the viewing area. The intensity is increased by turning this control clockwise and decreased with counterclockwise rotation.

FOCUS

Control to sharpen the spot or trace.

SCALE ILLUM

Control to adjust the scale illumination. The brightness of scale is intensified by turning this control clockwise.

– Vertical Deflection System –

Controls in both the CH 1 and CH 2 have the same marking function identically. Thus, only one of the pair will be described in this section.

MODE

A switch to select functioning of dual-trace amplifier. The following functions are selected.

CH 1 Only the CH 1 amplifier operates. This instrument operates as an ordinary single-trace oscilloscope. In case of internal trigger mode, the display is triggered by CH 1 signal regardless of setting position of the TRIGGER switch (described later).

CH 2 Only the CH 2 amplifier operates. This instrument operates as an ordinary single-trace oscilloscope. In case of internal trigger mode, the display is triggered by CH 2 signal regardless of setting position of the TRIGGER switch (described later).

ALT CH 1 and CH 2 amplifiers are alternately switched at the end of each sweep. Since CH 1 and CH 2 signals appear alternately in the viewing area, simultaneous observation of two signals will be unable, if the sweep time is set to an excessively slow position (slower than 2 msec/cm). Thus, the dual-trace diaplay by ALT is suitable for input signals of comparatively high frequency. In case of internal trigger, the source of trigger signal is selected by the TRIGGER switch.

CHOP Operation of CH 1 and CH 2 amplifiers is alternately switched at a repetition of approximately 500kHz. Two signals appear at the same time, in the viewing area. Since the displayed trace is not a line, but a train of successive dots, identification of waveforms may become troublesome, if sweep speed is set too high (approx. 5μsec/cm or higher). The CHOP mode is suitable for observation of input signals of comparatively low frequencies. In case of internal trigger, the triggering source is selected by the TRIGGER switch.

ADD The CH 1 and CH 2 amplifiers are simultaneously operated, and the sum or difference of two signals is displayed. Signals are added when the CH 2 POLARITY putton (described later) is set to the NORM position, and difference of two signals is displayed when this button is set to the INV position.

TRIGGER

Pushbutton switch to select the trigger signal source of internal trigger. By setting this switch to the CH 1 position, only the input signal supplied to the CH 1 INPUT is led to the trigger generator. Similarly, the signal supplied to CH 2 INPUT is led to the trigger generator when this switch is set to the CH 2 position.

When the MODE switch is set to the ALT position and both the CH 1 and CH 2 are pushed simultaneously, input signals supplied to the CH 1 and CH 2 inputs are alternately led to the trigger generator, thus, two signals are triggered even when there is no timing relationship between them.

When only the CH 1 or CH 2 of MODE switch is pushed, the TRIGGER switch loses functioning, and the displayed waveform is triggered by input signal selected by the MODE switch.

CH 2 POLARITY

Push switch to reverse polarity of CH 2 signal. When not pushed, this switch stays at NORM position. Once pushed, the switch is set to the INV position, and polarity of CH 2 signal is inverted. A further pushing returns this switch to the NORM position.

INPUT

BNC connector for connecting input signal or measurement probe output signal.

AC-GND-DC

Switch to select input signal coupling mode. By setting this switch to the AC position, the input signal is AC coupled to the vertical amplifier and the DC component, if any, contained in the input signal, is cut off. By setting this switch to the DC position, the input signal is DC coupled, and the DC component of input signal as well as the AC component, can be observed.

By setting this switch to the GND position, the vertical amplifier input terminal is desconnected from input signal, but is grounded. This position facilitates checking of the ground potential (ordinarily, this is used as the reference level of measurements).

VOLTS/CM (a black knob)

Switch for selecting sensitivity of vertical amplifier from 5mV/cm to 10V/cm in 11steps. According to amplitude of input signal, this switch must be set to an adequate position.

The voltage values of setting positions represent the voltage of input signal required for a vertical deflection of 1cm in the viewing area, when the VARIABLE control is set to the CALIB position (turned fully clockwise).

VARIABLE (a red knob)

Fine adjusting control to attenuate the input signal continuously. The maximum attenuation, 1/2.5 or larger, is obtained when this control is turned fully counterclockwise. Thus, the vertical sensitivity can be continuously varied across two adjacent positions of VOLTS/CM switch.

For quantative measurement of input signals, the VARIABLE control should be set to the CALIB position.

UNCALIB

Warning indicator which lights when the VARIABLE control is set to a position other then the CALIB. It indicates that the VOLTS/CM switch is not calibrated at the entire range.

GAIN

Semi-fixed control to calibrate the vertical axis sensitivity for the VOLTS/CM indication.

STEP ATT BAL

This control is prepared to obtaine voltage balance of vertical deflection system. This control must be adjusted so the vertical positioning of trace will be held against alternative switching of VOLTS/CM switch to 10mV and 5mV positions.

POSITION

Control to move the spot and trace in the vertical direction.

A display in the upper part (or lower part) of viewing area can be returned to the center by turning this control counterclockwise (clockwise).

CH 2 OUT

Output connector from which input signal to CH 2 can be output multiplied by 5 times. The output resistance is 50 ohms.

GND

Ground terminal. This terminal must be connected to the ground of measured object for the common earth.

▲▼ (Position indicators)

Either of these indicators lights when the spot or trace moves out of the viewing area (in vertical direction). When this indicator lights, the spot or trace can be returned to the viewing area by turning the POSITION control.

— Horizontal Deflection System —

HORIZONTAL DISPLAY

A switch to select the following display modes:

A The most popular sweep mode. The spot is swept on the viewing area at a rate controlled by sawtooth waves generated from the A sweep generator. The sweep time is determined by the A TIME/CM switch.

A INTEN BY B A mode to provide a delaying sweep (by which a part of input signal displayed is intensified to facilitate the delayed sweep below).

DLY'D (B) A delayed sweep mode by which a part of input signal waveform is magnified in the viewing area. Refer to Delay Operation in later half of this Section for details of DLY'D(B) operation.

CH 1-Y CH 2-X In this mode, the instrument operates as an X-Y scope. The display is moved horizontally by turning the horizontal POSITION control, but all other controls and connectors in the horizontal and trigger circuits are lost. Controls and connectors in CH 2 circuit function to control horizontal deflection of display.

Main (A) Sweep Mode

A switch to select the following sweep modes:

FULL AUTO Trigger mode is set to the Full Auto trigger and the display is triggered in the full range of LEVEL control, regardless of input signal amplitude. However, the sweep is automatically changed to free running when trigger signal frequency is lower than 100Hz or when the triggering signal is lost.

AUTO The trigger mode is set to the Auto trigger. The sweep is automatically changed to free running when trigger signal frequency is lower than 50Hz or when the LEVEL control is erroneously set beyond normal triggering level (proper triggering point of the input signal waveform).

NORM The trigger mode is set to the Normal trigger. The sweep stops when trigger signal is lost or the LEVEL control is erroneously set exceeding the normal triggering level.

SINGLE A sweep mode to provide single sweep. The single sweep is carried out in all sweep modes other than the CH 1-Y CH 2-X mode of the HORIZONTAL DISPLAY.

RESET

This is an internally illuminated pushbutton which can serve for a switch and an indicator.

As a switch, this button initiates the single sweep or is used to set the circuit in ready state (input signal will be triggered and displayed only once when a trigger signal is received). As an indicator, this button functions to indicate that the single sweep circuit is in ready state.

A, B TIME/CM AND DELAY TIME
(Outer black knob adn top black knob)

These switches are used to select the sweep time. The outer black knob is used to select A TIME/CM and DELAY TIME, while the top black knob (at the center) is used to select B TIME/CM.

The A TIME/CM (DELAY TIME) switch select the A sweep time from 0.1 μsec/cm to 5 sec/cm, in 24 steps. In accordance with frequency and rise time (or fall time) of input signal, a sweep time range which may ease observation of signal waveform must be selected. This switch is also used to select the delay time for delayed sweep operation. Actual sweep time (or delay time) can be directly read from marking on the panel being selected, when the A VARIABLE control is turned fully clockwise (to the CALIB position).

The B TIME/CM switch selects the sweep time at delayed sweep (DLY'D BY B) from 0.1μsec/cm to 0.5sec/cm, in 21 steps. Actual delay time can be directly read from marking on the panel being selected, when the B TIME/CM VARIABLE control (at lower part of right side panel) is turned fully clockwise (to the CALIB position).

A VARIABLE (a red knob)

This is a fine control for A sweep time which can decrease (to slower speed) the A sweep time by 1/2.5 (or more). A counterclockwise rotation of this knob slowers the sweep time. For quantative measurements, this control must be set fully clockwise (to the CALIB position).

UNCAL A OR B

This is an uncalibration indicator commonly used for A and B sweep time. When either one or both of A VARIABLE and B TIME/CM VARIABLE (on the right side panel) controls is not at the CALIB position, this indicator lights indicating that either of sweep time being used is not calibrated.

A SWEEP LENGTH

This is a control to vary sweep length of A sweep. The full sweep length reaches approx. 11cm when this control is turned fully clockwise (to the FULL position), and it is decreased to the minimum, approx. 4.5cm, when the control is set immediately before the B ENDS A position (the end of leftward rotation).

When this control is turned to the B ENDS A position (it is click-stopped at this position), the A sweep ends immediately at the end of B sweep, with the HORIZONTAL DISPLAY switch being set at the A INTEN BY B position.

DLY'D (B) MODE

This is a push switch to select automatic sweep or triggered sweep mode of B sweep. The automatic sweep is selected when this switch is left unpushed (in AUTO position). Once pushed, this button starts the triggered sweep operation (in the TRIG'ABLE position). A further pushing of button releases it to the AUTO position. (Refer to Delay Operation in later half of this section for details.)

DELAY TIME MULTI

A multi-turn control to vary delay time continuously in order to select a portion of input signal waveform for magnified display.

POSITION (a black knob)

A control to determine horizontal positioning of spot or trace. To return spot or trace to the center of viewing area, turn this control clockwise when it is in the left half of the area, or turn the control counterclockwise when spot or trace is in the right half on the area.

FINE (PULL x10 MAG) (a red knob)

This control functions as a potentiometer and a push-pull switch. As a potentiometer, this control serves as a fine control of horizontal POSITION control. By pulling the knob, sweep time of display is magnified 10 times. The fine control function, which is possible for both normal and magnified display, is particularly useful when display is magnified.

MAG x10

An indicator which lights while horizontal display is magnified by 10 times with the FINE (PULL x10 MAG) switch.

◀ ▶ (Position indicators)

Either of these indicators lights when spot or trace is moved horizontally out of viewing area to indicate location of phantom spot or trace. When this indicator is lit, spot or trace must be returned to the viewing area by turning the POSITION control.

– A Triggering –

SOURCE

A switch to select the following trigger modes. (Refer to Triggering in later half of this Section for details.)

INT Display is triggered by an internal signal (internal trigger). A part of input signal supplied to the INPUT connector is led to the A trigger circuit to use it as a trigger signal.

LINE The display is triggered by AC line voltage (line triggering).

EXT The display is triggered by an external signal. Frequency of the external signal supplied to the TRIG INPUT connector to trigger display must be in an integer relation to frequency of input signal to be displayed.

EXT÷10 Normal external triggering may be unobtainable, if amplitude of external signal is too large exceeding the adjustment range of triggering level (the LEVEL control). By setting the SOURCE switch to this position, amplitude of external trigger signal is attenuated to 1/10.

TRIG INPUT

A connector to Apply the external trigger signal. applied as the external trigger source.

COUPLING

This is a switch to select coupling mode of trigger generator to trigger signal source so that stability of triggering may be improved. (Refer to Triggering in later half of this Section for details.)

AC At this position, the trigger circuit is AC coupled to signal source. Since DC component of input signal is rejected, display can be triggered only by frequency component of trigger signal regardless of the DC component.

LF REJ This is an AC coupling mode which will improve stability of triggering when the trigger signal contains low frequency noise component.

HF REJ This is an AC coupling mode, but is suitable for dual trace measurement by CHOP or when trigger signal contains high frequency noise component. This position is also suitable for triggering by using the vertical sync signal of the TV signal.

DC The trigger input circuit is directly coupled to the source allowing the triggering by using DC signal.

LEVEL (SLOPE)

This control functions as a potentiometer and a push-pull switch. As a potentiometer, the LEVEL control continuously varies the trigger point. As a switch, the SLOPE switch allows the triggering by positive going slope of waveform, when the switch is pushed. When it is pulled, the triggering becomes possible at the negative going slope of waveform.

TRIG'D

An indicator which lights only when the display is correctly triggered.

SLOPE

Indicators to indicate that from which slope (negative or positive going slopes) the trigger is starting. These indicators are linked with the SLOPE switch. When positive slope is selected for triggering, the (positive) indicator lights. The (negative) indicator lights when display is triggered by negative going slope of waveform.

– Calibrator –

CALIBRATOR

A switch to select the calibration voltage output. The calibration voltage to be supplied from CAL OUT connector can be selected in 3 steps, 2V, 0.2V and 20mV.

CAL OUT

A connector to output the calibration voltage (amplitude of the voltage is indicated by the CALIBRATOR switch). Frequency of the calibration square wave is 1kHz. Output resistance of this connector is 50 ohms when the CARIBRATOR switch is set to either of 0.2V or 20mV (these positions are marked red), and approx. 270 ohms when 2V range is selected.

Right side panel (upper part, controls mounted on main chassis)

ASTIG

A semi-fixed control used auxiliary to improve focusing of spot or trace, when it can not be correctly focused by the FOCUS control.

TRACE ROTATION

A semi-fixed control to aline the trace with horizontal scale of graticule.

Z AXIS INPUT

A signal input connector for external intensity modulation (display is intensity modulated by external signal supplied to this connector).

PROBE LOOP

A calibration loop for gain of Current Probe. A 1kHz, 5mA signal (square wave) flows this loop in the direction marked with an arrow.

Right side panel (lower part, on a plug-in unit)

The B triggering SOURCE, TRIG INPUT, COUPLING and LEVEL controls located on this panel function identically to those provided for the A sweep. Refer to the Front Panel Controls – A Triggering – for details of function of these controls.

SLOPE

A switch to select polarity of slope by which the B sweep will be triggered. By setting this control to + position, the display is triggered by positive slope of trigger signal waveform. The display is triggered by the negative going slope of signal when this switch is set to – position.

B TIME/CM VARIABLE

A fine control for B sweep time. This control can slower the B sweep time selected by the B TIME/CM switch (located on the front panel) to more than 1/2.5.
A counterclockwise rotation of this control makes the sweep time longer. For quantative measurement, this control must be set to the fully clockwise position (to the CALIB position).

A GATE OUT

An output connector to supply positive square wave signal (amplitude approx. 5Vp-p) which are synchronized with A sweep. Output resistance is approx. 1kΩ.

B GATE OUT

An output connector to supply positive square wave signal (amplitude approx. 5Vp-p) which are synchronized with B sweep. Output resistance is approx. 1kΩ.

Left Side Panel

Controls on this panel and prepared for both CH 1 and CH 2 provide the same function.

VARIABLE BAL

A semi-fixed control to obtain voltage blanace of vertical deflection system. This control must be adjusted so that vertical positioning of trace will be firmly held against rotation of VARIABLE control.

PROBE POWER

A connector to supply the power to Source Follower Probe. The connector is an option.

Rear panel

POWER CORD

A cord to supply the line power to this instrument.

2A SLOW

A fuse holder which contains a 2A slow blow fuse (for operation on a 100 or 115V line power system). When this instrument is used for a 200V line power system (with the voltage selecting plug set to the C or D position), the internal fuse must be replaced with a 1A slow blow fuse.

Voltage Selecting Plug

A plug to select an operation voltage range of this instrument. The voltage range being selected is marked above plugging positions. A line the arrow mark of plug with the marking, and push it in position.

OPERATING PROCEDURES

Described in this section are operating procedures of controls and accessories.

Though the controls and internal circuit are designed to be safety-proof against any erroneous setting or manipulation of controls, the following precautions and special instructions given for particular controls should be observed.

Precautions Before Operation

Used Pushbutton Switches Correctly

The pushbutton switches used in this instrument includes push switches (CH 2 POLARITY, etc.) which changes functioning of circuit alternately everytime it is pushed, as well as conventional mechanically linked pushbuttons whose functioning is determined by a button being pushed (four switches, MODE, TRIGGER, MAIN(A) SWEEP MODE and HORIZONTAL DISPLAY).

Precautions on the use of these linked pushbutton switches are as follows:

(1) Priority of functioning is given in the sequence of button position in a group of buttons the leftmost one has the highest priority except when two TRIGGER buttons for CH 1 and CH 2 are pushed at a time under the ALT mode, different function appears (see Fig. 2-10 (a) and item TRIGGER in former half of this section). When two or more buttons are simultaneoulsy pushed, only the leftmost button functions normally, resulting in no particular function. Therefore, take care not to push two or more buttons at a time.

(2) Different from rotary switches or lever switches, there will be the chance, for pushbutton switches, that all of buttons in a switch may be left unpushed. In order to avoid confusion in operation, the pushbutton switches are designed to function as given below when all buttons are left unpushed;

MODE	CH 1
TRIGGER	CH 1
MAIN(A) SWEEP MODE	FULL AUTO
HORIZONTAL DISPLAY	A

Do Not Intensify the Spot or Trace Unnecessarily

Do not intensify the spot or trace unnecessarily. Excessively intensified spot or trace will irritate the operator. If the spot or trace is left intensified and stopped at a position, it may result in burning of phosphorescence coating of CRT. When the instrument must be left with the spot intensified, such as in the case where triggering is lost in the NORM triggering mode or when it is operating as an X-Y scope, lower the intensity (and if possible, soften the focus).

Input Signal Coupling

Input signal supplied to the INPUT connector is led to vertical amplifier through the AC-GND-DC switch. Coupling mode of input signal to amplifier is determined by setting of the AC-GND-DC switch as given below. These functionings are common to the switches in both channels.

DC

The DC coupling mode is used most popular. Since DC component of input signal is directly connected to the amplifier input, this mode is used to observe both the

AC and DC components of input signal or for DC voltage level measurement. For observation of very low frequency AC signals, the DC mode must be used, because the AC mode will attenuate amplitude of very low frequency signals.

AC

When the AC mode is selected, the DC component of input signal is cut by an input capacitor, and amplitude of AC signal (sine wave) is reduced by 3dB at 3Hz. Square wave signals of low frequency will be displayed with a sag at the top and bottom part of waveform. Thus, the DC mode should be used for observing these signals. The AC mode is suitable for observing of AC signal components superimposed on a comparatively large amplitude of DC.

GND

At this position, the amplifier input is connected to the ground potential of this synchroscope. As shown in Fig. 2-19, the amplifier input is disconnected from input signal but directly connected to the ground level (this is ordinarily used as the reference level of measurement). The GND position is, therefore, used for setting of reference level or for vertical balancing adjustments (VARIABLE BAL and STEP ATT BAL).

Do Not Supply Excessively High Input Voltages to the INPUT

The rated maximum allowable input voltage for INPUT connectors of CH 1 and CH 2 is 500V (DC + peak AC) and that at the probe tip is 600V (DC + peak AC). Observe this restriction on voltage.

Dual-trace Operation

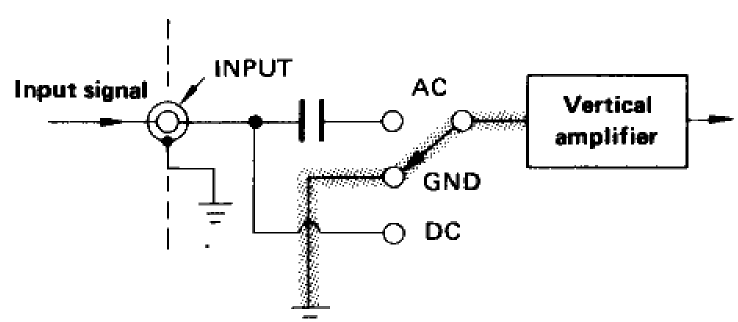
In order to allow dual-trace measurement of two input signals, the vertical deflection system of this instrument is composed of 2 channels. According to frequency of input signals, the dual-trace mode, ALT or CHOP, must be properly selected.

Dual-trace Operation in ALT Mode

The alternate (ALT) dual-trace measurement is started by supplying two input signals to CH 1 and CH 2 INPUT connectors, setting the AC-GND-DC switch to the AC or DC position, as required, and pushing the ALT button of MODE switch. Channels are switched, in sequence, after each sweep as shown in Fig. 2-20. The alternate switching of display will be easily visualized by selecting a very slow sweep speed.

The alternate display of signals is possible for all positions of TIME/CM switch, however, simultaneous observation of two signals will be impossible when sweep

Fig. 2-19 Ground coupling



time is set too slow. Thus, dual-trace measurements which require the TIME/CM switch to be set at the position slower than approx. 2mSEC should be done in the CHOP mode.

Dual-trace Operation in CHOP Mode

For smooth dual-trace display of two low frequency signals, the CHOP position of MODE switch should be selected. However, the chopped display of two shignals will make displayed waveform to be trains of dotted lines, if the TIME/CM switch is set to a high sweep time position (approx. 5μSEC or higher).

Since two channels are switched, in sequence, at a repetition rate of approx.500kHzas shown in Fig. 2-21, the dual-trace display in CHOP mode is not suitable for signals which require the TIME/CM switch to be set at the position faster than approx. 5μSEC, or signals whose rise time (or fall time) to be measured is too high. Use the ALT mode for dual-trace display of such signals.

Stability of triggering will be improved by changing the COUPLING switch to the HF REJ position.

Selection of Trigger Signal Source

When a dual-trace display is triggered by internal signal, the source of triggering signal must be selected by the TRIGGER switch. The dual-trace display is triggered by CH 1 signal or CH 2 signal by setting the TRIGGER switch to the CH 1 or CH 2 position.

In ALT mode only, each channel may be triggered independently by pushing both the CH 1 and CH 2 buttons of TRIGGER switch (then, CH 1 display is triggered by CH 1 signal and CH 2 display by CH 2 signal). This function is not available in the CHOP mode. (Refer to item Triggering of this section.)

Fig. 2-20 ALT display

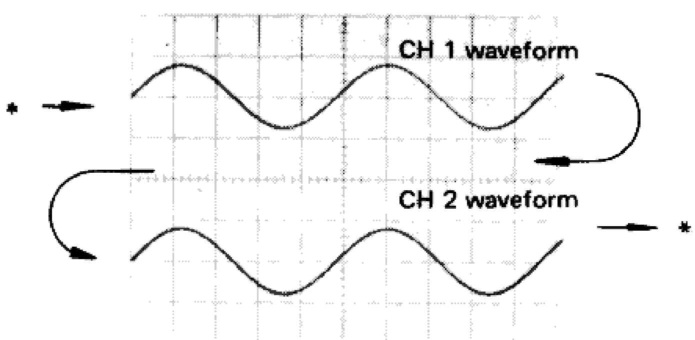
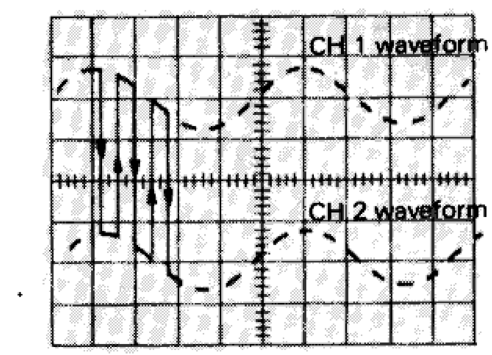


Fig. 2-21 CHOP display



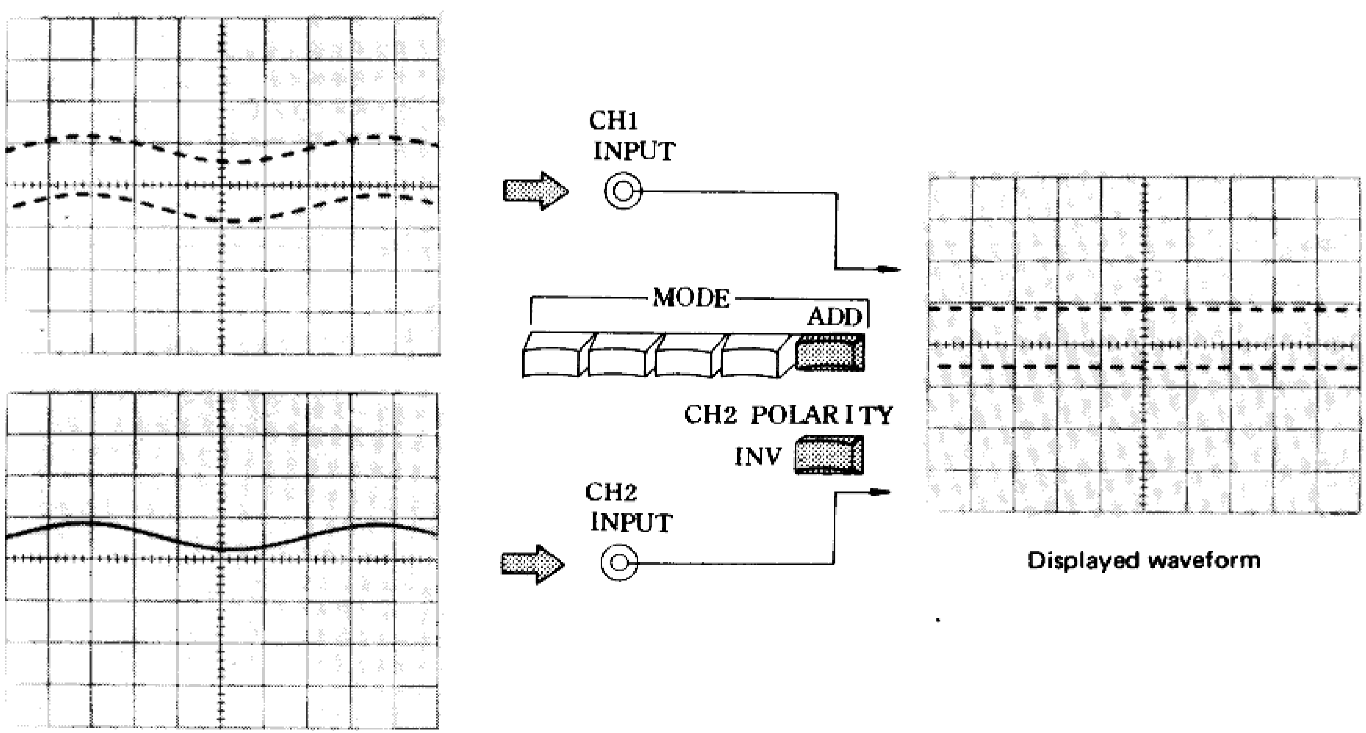
ADD Operation

The following functions are provided by combining the ADD (of MODE switch) and CH 2 POLARITY operations.

The sum of CH 1 and CH 2 signals is displayed by setting the MODE switch to the ADD position and the CH 2 POLARITY switch to the NORM position.

A differential amplifier circuit is composed, and difference of two input signals, CH 1 + (−CH2), is displayed by pushing the CH 2 POLARITY switch to the INV position. Example of differential display is shown in Fig. 2-22. When desiring square wave component of a signal in whcih the square wave signal is modulated by a low frequency sine wave signal, the composite signal is led to CH 1 INPUT and the sine wave signal (modulating signal) to CH 2 IN-

Fig. 2-22 Differential display



PUT. By adding the inverted CH 2 signal to CH 1 signal, the common component (sine wave) is rejected and only the square wave signal is displayed on the CRT.

The differential amplifier configuration is useful to expand the capability of this instrument to much wider applications such as comparison of two signals or measurement of signals floated from the ground.

For internal triggering of ADD display, the trigger signal source is selected by the TRIGGER switch.

Precautions on ADD Operation

(1) The common mode rejection ratio (CMRR) of this instrument 20:1 or more at 10MHz. For measurements requiring high CMRR, sensitivity of two channels must be equal.

(2) The AC-GND-DC switch may be positioned as required, but, when operating the synchroscope as a differential input scope, the same input coupling mode must be used for two channels and channels must be set to equal sensitivity.

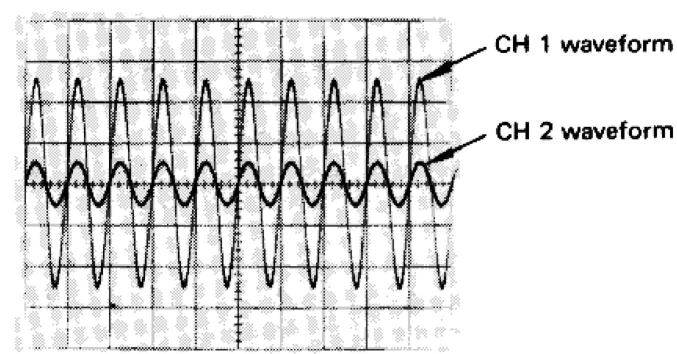
(3) Vertical positioning of display can be controlled by the POSITION control of either channel, however, for accurate measurement the POSITION controls must be set to approximately center position.

Operations for Cascading Connection

The maximum sensitivity for both CH 1 and CH 2 of this instrument is 5mV/cm. This sensitivity can be improved to 1mV/cm by establishing the cascading connection between the CH 2 OUT and the CH 1 INPUT.

First, set the MODE switch to the CH 2 position and the VOLTS/CM switches of both channels to the 5mV position. Under this condition feed the sine wave signal with 5mVp-p amplitude to the CH 2 INPUT connector. The sine wave with 1cm amplitude may be observed on the viewing area. Then, connect between the CH 2 OUT and the CH 1 INPUT with the accessory cable (BB-500) and set the MODE switch to the CH 1 position, and the amplitude of the waveform displayed on the viewing area may become 5cm. This variation in amplitude can be observed distinctively by allowing the dual-trace as shown in Fig. 2-23. Namely, the sensitivity which is equal to 5 times of the value determined by the setting position of the CH 2 VOLTS/CM switch (1mV/cm, 2mV/cm, 4mV/cm, 10mV/cm,.....) can be obtained only by establishing the cascading connection, setting the CH 1 VOLTS/CM switch to the 5mV position and by changing the setting position of the CH 2 VOLTS/CM switch. Thereby, observation of the minute signal which is difficult to observe at the 5mV range is made possible. In case of the cascading connection, the trace

Fig. 2-23 Cascading Connection



may become fat because of noise components. However, the trace is limited to 3mm from the performance of this instrument.

Moreover, the trigger condition may becomes unstable but stable trigger condition can be obtained by setting the COUPLING switch to the HF REJ position.

Precautions on The Cascading Connection

When the cascading connection is established, the displayed waveform can be moved in the vertical direction by turning the POSITION controls of both channels. However, it is recommended that the displayed waveform be observed by setting the POSITION controls of both channels at the mid-position as in the case of ADD mode.

Triggering

Correct triggering of display is the key to use a synchroscope to the full extent. The following conditions must be proptly determined before triggering an input signal; (these conditions are common to the A TRIGGERING and B TRIGGERING)

(1) SOURCE This is a selection to trigger the display by input signal itself (INT), by an external signal source (EXT or EXT÷10) or by line frequency (LINE).

(2) TRIGGER This is a selection for INT triggering. With this switch, the display may be triggered by CH 1 signal or CH 2 signal.

(3) COUPLING This is a selection in accordance with characteristic of triggering signal (AC or DC) or extent of interference of noise or unwanted components to triggering signal (LF REJ or HF REJ).

(4) SLOPE A selection to trigger display at positive going slope, or negative going slope, of triggering signal.

In this Section, these conditions to examine type of triggering will be described in detail, but practical triggering steps will be briefly described, because the triggering is the user's practice to expect the possible best display of signals from a variety of external conditions.

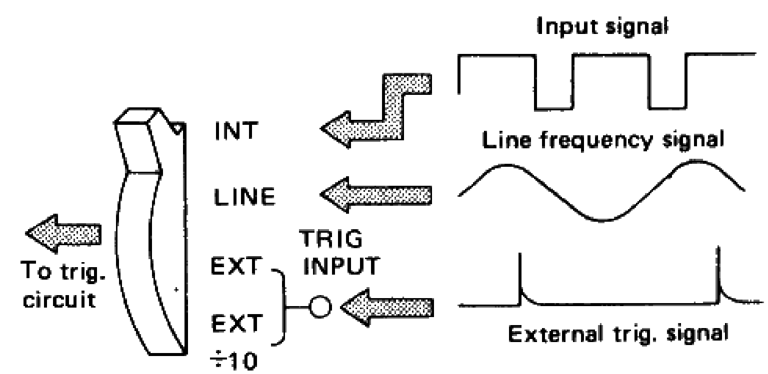
SOURCE Switch

For stable display of input signal waveform in viewing area, the input signal itself or a signal having an integer relationship, in frequency, with respect to the input signal must be supplied to the trigger circuit, in order to actuate the trigger generator which generates trigger pulses and conducts horizontal sweeping of display.

The internal triggering is obtained by setting the SOURCE switch to the INT position. A portion of input signal supplied to the INPUT connector is branched (from a stage in vertical deflection system) to the triggering circuit. (Refer to Fig. 2-24 .)

The external triggering is obtained by setting the

Fig. 2-24 Selection of trigger signals by SOURCE



SOURCE switch to the EXT or EXT÷10 position. The external input signal to the INPUT connector or the signal whose frequency has an integer relationship to the input signal frequency is supplied to the trigger circuit.

With the line triggering, which is effected by changing the SOURCE switch to the LINE position, the power line frequency signal is supplied from power transformer to the triggering circuit and display is triggered by the line frequency signal.

Internal Triggering By the internal triggering, the input signal supplied to the INPUT connector is amplified (in the vertical deflection system) before a portion of the signal is supplied to the trigger circuit. Therefore, the display can be automatically triggered even when the input signal level is low. The internal triggering is very simple in operation and does not adversely affect the trigger signal source (the external triggering can affect the external trigger signal source by lowering the load impedance). In these aspects, the internal triggering is very popular for ordinary measurements.

External Triggering Though the external triggering provides certain defects, i.e. the advanges of the internal trigger becomes directly the disadvantages for the external trigger, it has the following unique features which the internal triggering can not offer;

First, the external triggering is free from influence of vertical deflection settings. For example, if vertical amplifier sensitivity (VOLTS/CM) is changed, the voltage level of internal trigger is changed too. It often requires readjustment of LEVEL control to resume proper triggering level. On the other hand, the external triggering needs no readjustment of the LEVEL control against any changing of vertical amplifier sensitivity, so long as the external trigger signal amplitude is retained unchanged.

Second, display of a signal may be started at the time before variations occur in the input signal waveform, or after a certain time from the input signal variation, provided that such timing signal is available and supplied to the TRIG INPUT connector.

If amplitude of external trigger signal is too large, selection of trigger point by the LEVEL control becomes difficult. The EXT÷10 position of SOURCE switch attenuates the trigger signal amplitude and facilitates the selection of trigger level.

Line Triggering In case of triggering by line frequency signal, the LINE position of SOURCE switch simplifies the matter very much. The line frequency signal is directly supplied from power transformer to the trigger circuit, at an adequate level. It requires no additional wiring and level setting. Similar to the EXT triggering, it is free from influence of amplifier gain setting, and similar to the INT trigger, operation of control is simple.

This mode is suitable for measurement of signals of line frequency or of the harmonics of the line frequency.

TRIGGER Switch

In ordinary single-trace measurement using CH 1 or CH 2, the internal trigger signal is supplied from CH 1 or CH 2 whichever being used, however, in dual-trace mode (ALT or CHOP) or ADD mode, the source of internal trigger signal must be selected by using the TRIGGER (CH 1 or CH 2) switch.

By pushing the CH 1 button, the trigger signal is obtained from CH 1 signal, and when the CH 2 button is pushed the source is switched to CH 2 input signal. Therefore, when input signal frequencies (CH 1 and CH 2) are the same, it is recommended to select a channel, which can supply signals to the trigger circuit at higher amplitude and lesser noise component.

When frequency of signals differs with channel (but, the frequencies are in an integer relation) as shown in Fig. 2-25, the display must be triggered by a channel operating at lower frequency. If the trigger signal is supplied from the other channel, operating at higher frequency, triggering of low frequency channel is impossible.

For example, if the signals are as shown in Fig. 2-25, the trigger signal must be obtained from the sawtooth wave. If the trigger signal is obtained from square wave, the display of sawtooth wave will not be correctly triggered (see Fig. b).

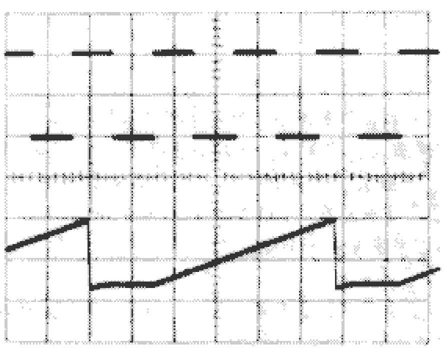
If the dual-trace display is intended for measurement of phase difference in two signals, the display must be triggered by a channel whose phase is in leading.

Different from the selection of CH 1 and CH 2 as the trigger signal, when both of these buttons (CH 1 and CH 2) are pushed at a time in an ALT mode, the trigger signal source is switched, in sequence, after each sweep. It should be noted, however, that the alternate switching of source is not applicable to the phase difference measurement, because, display of waveform will start from the same point even if phasing of signals is not equal. The alternative switching of trigger signal source is useful to compare width of two pulses because the selective switching of trigger signal source is not required, and two pulse waveforms will start at the same point.

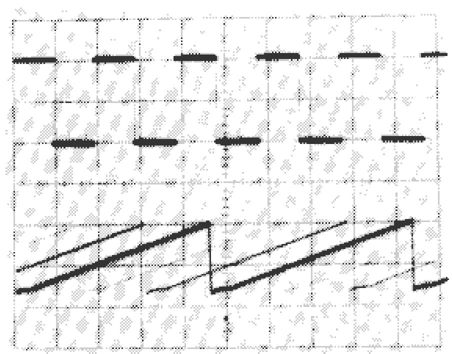
COUPLING Switch

The COUPLING switch is used to select the coupling mode of trigger signal and trigger circuit. Four coupling

Fig. 2-25 Triggering of signals in integer frequency relation



(a) Display triggered by sawtooth wave



(b) Display triggered by square wave

ponent as shown in Fig. 2-27 (b).

This mode is also useful to provide stable measurement of TV signal to be triggered by vertical sync signal.

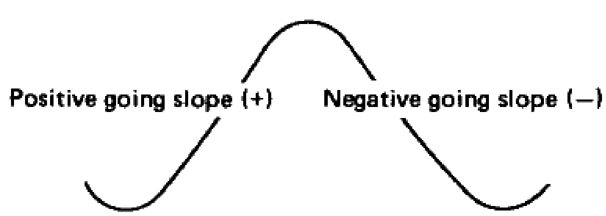
DC The trigger signal is directly supplied to trigger circuit as shown in Fig. 2-26. Triggering of sweep is possible from DC level of trigger signal. However, when trigger signal is superimposed on a DC voltage level, triggering may be impossible if the DC voltage level is beyond the control range of LEVEL control.

SLOPE Switch

When this button switch is pushed to the + (positive) slope position, sweep is triggered at positive going slope of trigger signal. At the – (negative) slope position (pulled), the sweep is triggered at negative going slope of trigger signal. Polarity of slope being selected is indicated by the SLOPE + and – indicators.

The selection of slope may not be so significant when measuring repetitive sine wave or square wave, however, when input signal is repetitive narrow pulses, leading edge of the pulse may not be displayed, if selection of slope is incorrect. Be sure to select a correct slope when measuring impulses.

Fig. 2-28 Selection of slope



Triggering (1) (AUTO)

So long as aforementioned controls are properly set, displayed waveform should be firmly triggered by setting the MAIN (A) SWEEP MODE switch to the AUTO position and turning the LEVEL control slightly rightward or leftward. Now, when only the SLOPE switch and the LEVEL control are operated as illustrated in Fig. 2-29 the relationship of these are made.

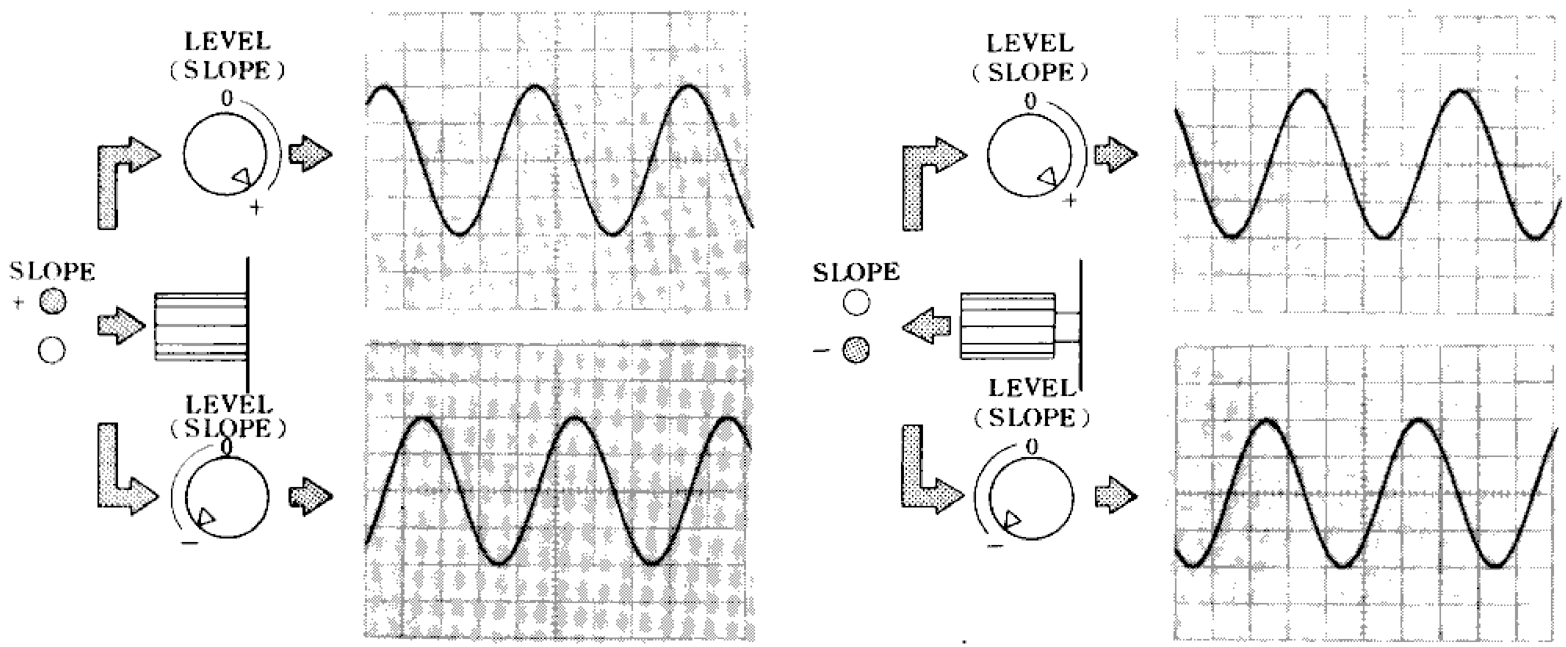
Though Fig. 2-29 shows an example of sine wave, the triggering point can be continuously selected also for square wave. For square wave, it is recommended to use a faster sweep time so that the leading edge or falling edge of the waveform will be displayed on the viewing area. This is useful for observing the rise time or fall time of the pulse waveform and to understand the move of triggering point with adjustment of the LEVEL control.

The triggering point is available on the leading or falling edge of waveform, between approx. 10% point to approx. 90% point on the slope. Note that the amplitude of triggering signal is reduced with decreased vertical amplitude of displayed signal (e.g. when the VOLTS/CM switch is set to a high VOLTS/CM value for the signal) and the AUTO triggering may be lost the display turns to a free-running mode in accordance with setting of the LEVEL control. If it started free-running, normal triggering may be resumed by readjusting the LEVEL control.

The AUTO triggering mode will enter the free-running when the triggering signal is lost, or the LEVEL control is set out of the triggerable range. This feature of AUTO triggering is useful to check the ground level of high frequency input signal.

The AUTO triggering is unobtainable when input signal frequency is lower than 45Hz. Use the NORM triggering (described in next section) for such low frequency signals.

Fig. 2-29 Setting of SLOPE and LEVEL controls and obtainable display



Troggering (2) (NORM)

The NORM trigger mode is obtained by setting the MAIN(A) SWEEP MODE switch to the NORM position and adjusting the LEVEL control similar to the AUTO mode.

With the NORM mode, the sweep of display will stop and no signal will be in the viewing area, when trigger signal is lost or the LEVEL control set beyond the triggerable range. By turning the INTENSITY control clockwise, a spot will appear in the viewing area. If stable NORM triggering is not obtainable for signals close to 50MHz, change the trigger mode to the AUTO operation. The signal will be stably triggered.

Triggering (3) (FULL AUTO)

The AUTO and NORM modes can be used to trigger the trigger circuit by the internal trigger mode, so long as the triggering level is properly set for vertical amplitude of the signal (see Fig. 2-30a). However, the triggering may be lost, or starting point of display may be changed, when the input signal amplitude is decreased or DC level of the signal is changed (in DC coupling).

When the input signal amplitude is excessively low, setting of the LEVEL control will become critical.

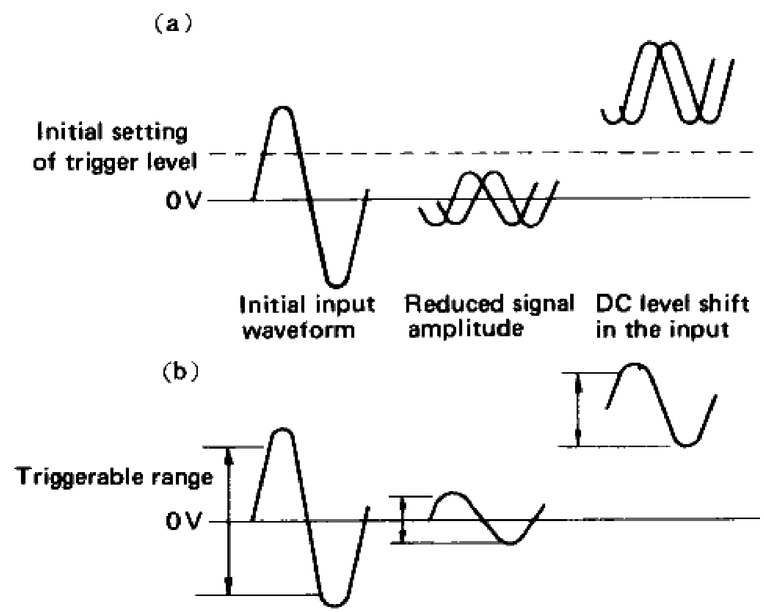
These troubles in triggering level can be eliminated by changing the MAIN(A) SWEEP MODE switch to the FULL AUTO position, at which the triggerable level is automatically adjusted regardless of amplitude, or DC component level, of input signal as shown in Fig. 2-30(b). Even a small amplitude signal can be amplified automatically allowing correct triggering at full control range of the LEVEL control and the LEVEL control to be used simply to select a triggering point as desired.

The advantage of FULL AUTO operation will be clear when you turned the LEVEL control fully.

Maximum Allowable Input Voltage of TRIG INPUT

Since the max. allowable input voltage to TRIG INPUT connector is limited to 500V (DC+AC peak), do not supply the voltage higher than above when supplying an external trigger signal to the connector.

Fig. 2-30 Triggerable range of LEVEL control

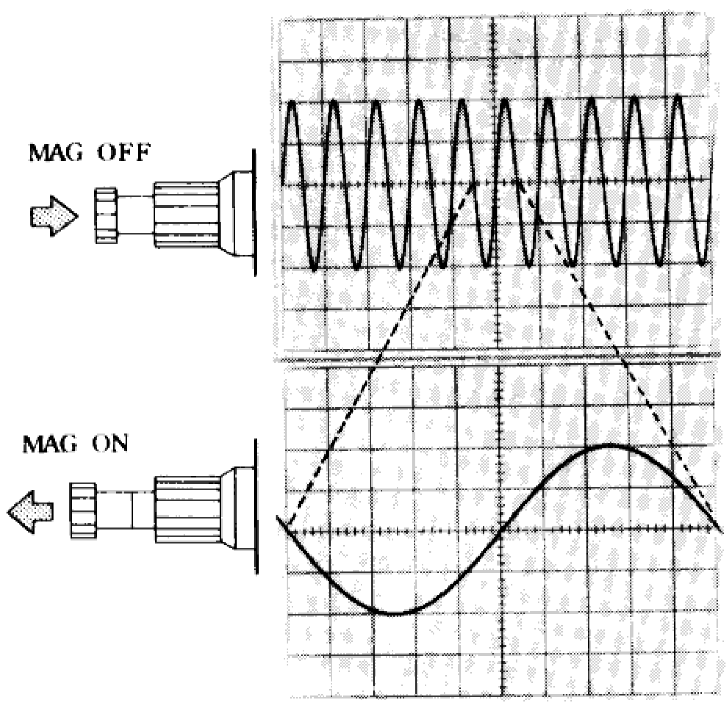


The arrow marked range is automatically enlarged or reduced to meet the full-control range of LEVEL control.

Magnified Sweep Operation

A part of input waveform may be enlarged, with regard to time, by using faster sweep time, but, it magnifies waveform of entire part. Thus, the desired part, may be out of the viewing area, particularly when the sweep time is set for fast sweep in order to magnifies the waveform from the sweep start.

Fig. 2-31 Sweep Magnification by MAG



The desired part of waveform (which has been dumped out the viewing area) can be pulled back to the center of viewing area by turning the horizontal POSITION control, then, this part can be magnified 10 times horizontally, by pulling the FINE (PULL x10 MAG) knob (the MAG x10 indicator lights). The waveform is magnified by 10 times and displayed in both the leftward and rightward from the center (see Fig. 2-31).

Entire length of trace is magnified to 100cm, through only the center 10cm is displayed in the viewing area. The magnified trace can be fully observed by sequentially adjusting the horizontal POSITION and FINE controls. The FINE control gives precise selection of horizontal positioning of display.

The sweep time at the x10 magnification must be calculated by multiplying the TIME/CM indication value by 1/10. Thus, the available maximum sweep time, with be 0.1μsec/cm (which is the max. sweep time without magnification) x 1/10 = 0.01μsec/cm.

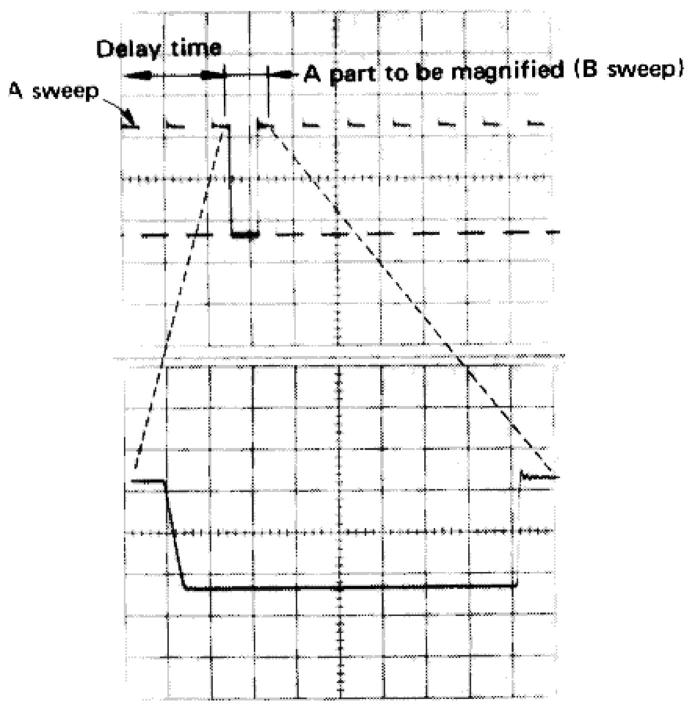
Delay Operation

The magnification of display, by x10 MAG switch, is simple to operate and useful to obtain faster max. sweep time than the rated TIME/CM setting. However, magnification factor is limited to 10 times.

The limitation of magnification factor can be enlarged, by using the sweep magnification by delayed sweep, to an extent determined by the ratio of A sweep time to B sweep time. Note that the magnification by delayed sweep has a limitation in applicable input signal frequencies. In other words, if the input signal frequency is so high that the A TIME/CM switch, before magnification, must be set to the

0.1 μSEC position, no further magnification is obtainable. It should be understood that the sweep magnification by delayed sweep is very useful when desiring to magnify a portion of a comparatively low frequency signal. The magnification by delayed sweep includes the following two modes; the automatic sweep and the triggered sweep.

Fig. 2-32 Magnification by automatic sweep



Automatic Sweep

Assuming you are trying to magnify a portion of pulse signal, set the DLY'D(B) MODE switch to the AUTO position (unpushed) and the HORIZONTAL DISPLAY switch to the A INTEN BY B position.

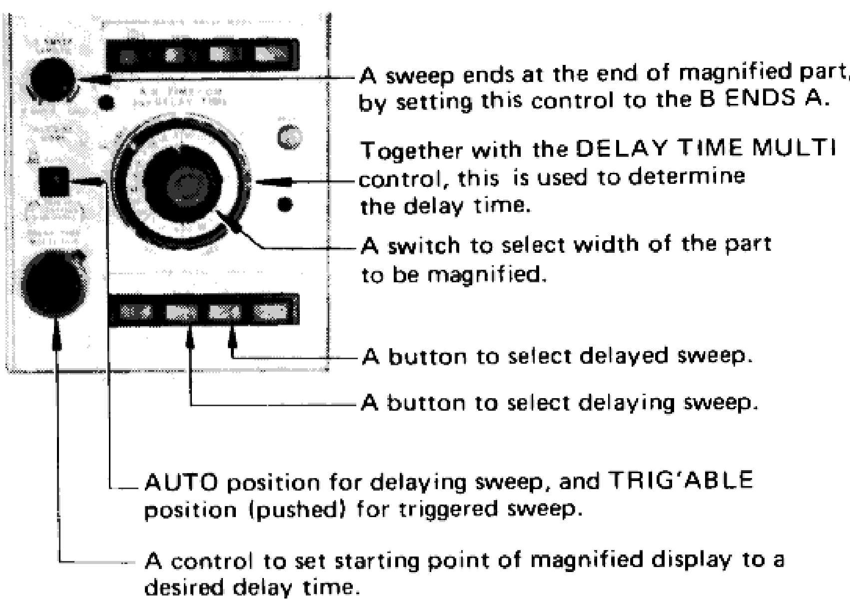
A portion of displayed waveform will be further intensified, and the intensified part will move continuously rightward, by turning the DELAY TIME MULTI control clockwise from the leftmost position. The intensified part is the portion to be magnified (by B sweep) and width of the intensified portion in the viewing area is determined by setting of the B TIME/CM switch.

The delay time between the start points of A sweep and B sweep is determined by the setting of A TIME/CM and DELAY TIME MULTI controls. For example, when the DELAY TIME MULTI control is set to 2.5, the starting point of B sweep on the viewing area will be 2.5cm apart from the starting point of A sweep. Actual delay time of B sweep can be calculated by multiplying this value to the setting value of A TIME/CM switch. The setting value of the DELAY TIME MULTI control is calibrated from 1 to 10. For the measurement by setting the DELAY TIME MULTI control to the fixed value, the control can be locked by pushing downward the lever provided in the upper right position of the knob.

After the setting of a portion to be magnified is completed, change the HORIZONTAL DISPLAY switch to the DLY'D(B) position. The intensified portion of waveform will be magnified fully in the viewing area. Actual sweep time is determined by the setting of B TIME/CM switch, and the magnification factor is given by the ratio of the A sweep time by B sweep time. Note that the intensified part of waveform moves with rotation of the DELAY TIME MULTI control, which, thus, enables optional selection of a part to be magnified, freely. (Also see Fig. 3-33 for controls used for delaying of signal display.)

If the A TIME/CM switch is set to the 1mSEC position and the B TIME/CM switch to a position faster than 0.2μSEC, for example, delay jitter will appear at the rising (or falling) edge of displayed signal hampering easy observation.

Fig. 2-33 Controls used for delay operation



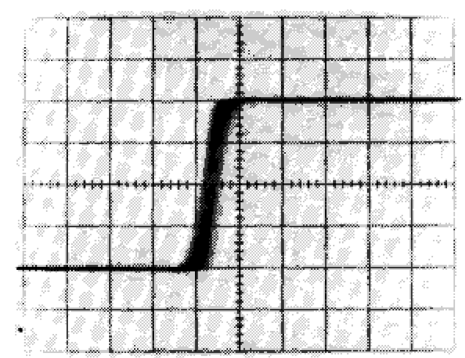
The automatic sweep has a limitation in available magnification factor, due to the delay jitter. The influence of delay jitter can be reduced, and a higher magnification factor is obtainable by using the triggered sweep technic (described in next section).

Triggered Sweep

The triggered sweep magnification is obtained by repeating the steps required for the automatic sweep, before pushing the DLY'D(B) MODE switch to the TRIG'ABLE position. The magnified part will be firmly displayed as shown in Fig. 2-35 if the B triggering is properly set.

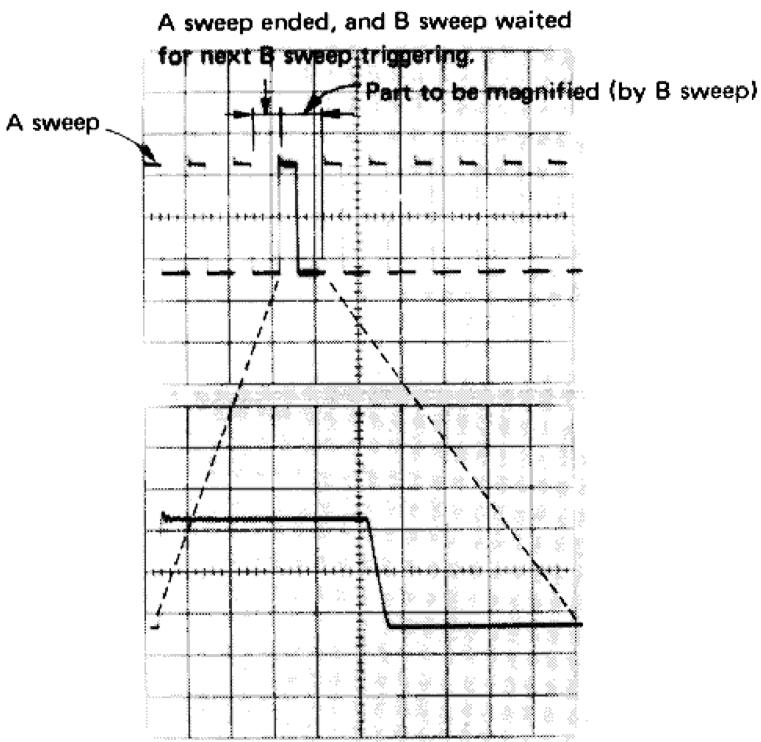
Triggering of magnified part (B sweep) starts at a preset triggering point for B sweep, after the delay is given as determined by the DELAY TIME MULTI control.

Fig. 2-34 Delay jitter



A particular difference will be seen when turning the DELAY TIME MULTI control clockwise — the intensified part (to be magnified) jumps from rising edge of a pulse to the rising edge of the other. The jumping will occur at each falling edge of pulses when the B TRIGGERING SLOPE switch is changed to the − (negative) position. Similar to the automatic sweep, the width of part to be magnified is determined by setting of the B TIME/CM switch.

Fig. 2-35 Controls used for delay operation



The intensified part of waveform will be magnified fully in the viewing area, by changing the HORIZONTAL DISPLAY switch to the DLY'D(B) position. At this time, the sweep time is determined by the B TIME/CM switch, and the magnification factor is given by the ratio of the A sweep time and B sweep time. The magnified waveform will not move in the viewing area against rotation of the DELAY TIME MULTI control, but the magnified part is the intensified part (selected by the A INTEN BY B operation) of unmagnified waveform.

The delay jitter will not appear when the A TIME/CM switch is set to 1mSEC position and the B TIME/CM to a position faster than 0.2μSEC. Different from the magnification by automatic sweep, free choice of magnifying part is impossible with the triggered sweep, because it causes the magnified display to jump, but, this mode is useful to obtain higher magnification factor than the automatic sweep for observing the rising (or falling) edge of a pulse.

Precautions on Triggered Sweep

If the triggering at B sweep is not properly set, the magnified part will not be displayed in the viewing area against adjustment of the DELAY TIME MULTI control. In this case, trigger the magnified part by turning the B TRIGGERING controls on the lower part of right side panel.

A SWEEP LENGTH Operation

Ordinalily, the sweep length is set to approximately 11cm to cover the viewing area. The sweep length, however, can be controlled continuoulsy between approx. 4.5cm and

11cm, by turning the A SWEEP LENGTH control. When this control is turned fully counterclockwise (until it is locked in the B ENDS A position), the A sweep in an automatic sweep ends immediately at the end of intensified portion (B sweep).

The A SWEEP LENGTH control can mainly, be used for the following purposes:

Intensifying the Brightness of Display

In general, intensity of display is lowered with higher sweep time. This trend of intensity is accelerated when the display is magnified by delayed sweep or x10 MAG.

When magnifying display, a higher intensity can be obtained by setting the part to be magnified as close as possible to the start point of A sweep and eliminating unwanted A sweep left behind the part to be magnified by operating the A SWEEP LENGTH control so that the magnified B sweep part (including the initial A sweep at starting and after the end of B sweep) will be scanned more frequently at the same sweep speed. The increased scanning frequency for limited sweep length can increase intensity of display.

Particulary, when using the magnification function by delayed sweep, the magnified part can be observed at high intensity, by selecting the part to be magnified with the HORIZONTAL DISPLAY switch set to the A INTEN BY B position, turning the A SWEEP LENGTH control to the leftmost position (B ENDS A), and changing the HORIZONTAL DISPLAY switch to the DLY'D(B) position.

This operation can be automatically performed by setting the A SWEEP LENGTH control to the B ENDS A position. Then, the A SWEEP LENGTH control may be left unchanged against resetting of delay time or magnification factor. See Fig. 2-36.

Observation of Complicated Pulse Train

The A SWEEP LENGTH control can be effectively used, in addition to the improvement in trace intensity, to expect firm triggering for cimplicated input pulse train.

For example, when the input signal is a complicated pulse train as shown in Fig. 2-37 (a), it will be difficult to observe a point at which the pulses are triggered. Very often, such a pulse train is displayed in duplication as shown in Fig. 2-37 (b).

The A SWEEP LENGTH control is useful in such sequence.

By turning the A SWEEP LENGTH control slightly counterclockwise from the FULL position (fully clockwise position), period of sweep can be varied and, in many cases, stable triggering can be obtained when the sweep is adjusted so that it will start at the same point of signals.

Fig. 2-36 B ENDS A operation

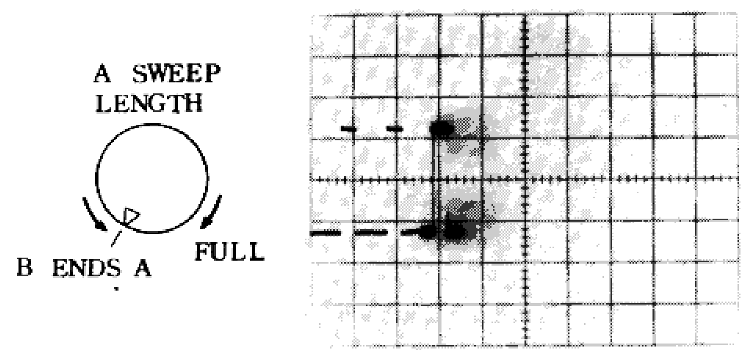
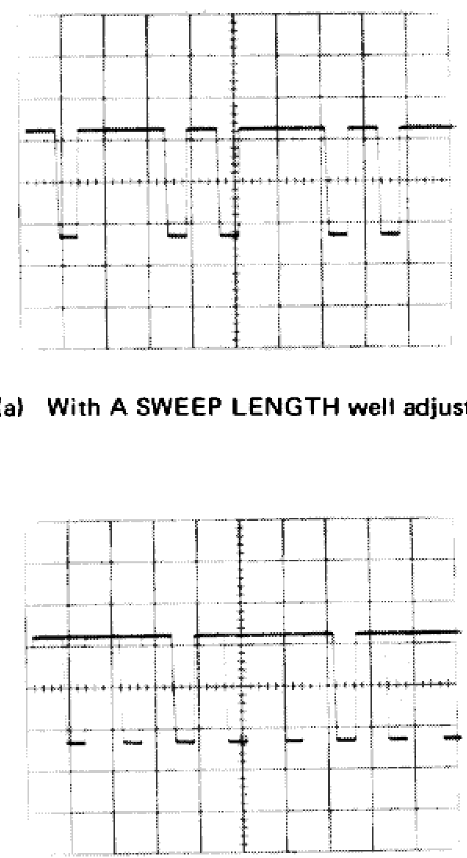


Fig. 2-37 Triggering of complicated pulse train



(a) With A SWEEP LENGTH well adjusted

(b) Without using the A SWEEP LENGTH function

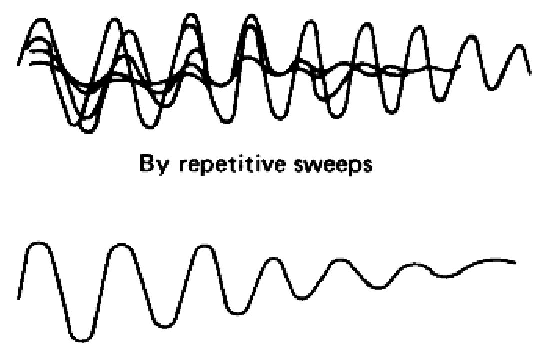
Single Sweep Operation

The triggering technics mentioned above are useful for repetitive signals. If the input signal varies with time, in amplitude, waveform or repetition frequency, stable triggering will be impossible.

For example, many transient effects are seen in daily services, such as discharging waveform or chattering of relay contact. They will give a very complicated, composite waveform when triggered in normal mode (see Fig. 2-38). Such transients can be observed correctly by using the single sweep function in which sweeping of display takes place only once when triggered.

When an effect will occur randomly, or only once at unexpectable timing, this phenomenon is ordinarily recorded by taking a photo. The photo may be shot, by setting

Fig. 2-38 Single sweep waveform



By repetitive sweeps

By a single sweep

the MAIN(A) SWEEP MODE to the NORM position, and leaving the shutter of camera opened. But, it results in recording of many effects on a photo, because, the chance where a phenomenon will occur and the signal is be triggered is left quite unknown. This problem can be solved and a phenomenon can be clearly recorded on a film, by using the single sweep function. (See Photographic Recording of Waveform in Section 3, Photo-taking Procedures of Waveform.)

In this part, the basic operation for single sweep will be described assuming that a repetitive signal is supplied to the input. The signal must be supplied to the INPUT connector, and display must be triggered to the signal by setting the MAIN(A) SWEEP MODE to the AUTO or NORM position. (See the Section Triggering.) Then, the MAIN(A) SWEEP MODE switch is changed to the SINGLE position. The display will disappear, but, it will be triggered only once when the RESET button is pushed.

Remove the INPUT connection, and push the RESET button again. The circuit enters the ready state (a state which will be triggered by input signal only once, when it is supplied again), the RESET indicator will light indicating that the circuit is ready. By supplying the input signal again, triggering takes place only once, and the RESET indicator goes off at the end of a single sweep.

When the input signal is not a repetitive one, the similar control steps are applied.

The single sweep operation is available for either of ordinaly single sweep or delayed single sweep. External triggering is also possible. Triggering by the external signal must be tested similar to that for the internal trigger signal at internal single sweep. The single sweep is impossible for the simultaneous dual trace using the ALT function.

When the Circuit Fails to Enter the Ready State

The internal circuit can fail to enter the ready state at a particular setting of the LEVEL control (at approximately the center of control range). Turn the LEVEL CW or CCW slightly. The RESET indictaor will light and the circuit will enter the ready state when the RESET button is pushed again.

X-Y Scope Operation

This instrument can be used as an X-Y scope in which the vertical deflection system is driven by the input signal supplied to CH 1 and the horizontal deflection system is driven by the signal supplied to CH 2, by setting the HORIZONTAL DISPLAY switch to the CH 1-Y CH 2-X position.

Assume two sine wave signals are differs from each other in the phase by 90 degrees. These signals may be displayed by the dual trace mode or by an X-Y scope mode.

By supplying these signals to the CH 1 and CH 2 INPUT connectors respectively, and setting the MODE switch to the ALT position, signals will be displayed in the dual-trace mode as shown in Fig. 2-39 (a) when they are properly triggered.

Leaving the input connection unchanged, a Lissajou's pattern for these signals can be displayed by changing the HORIZONTAL DISPLAY switch to the CH 1-Y CH 2-X position and adjusting positioning of signals by the CH 1 and horizontal POSITION controls. (Be sure to adjust the INTENSITY control for an appropriate display intensity.)

Positioning of the signal and sensitivity, in Y-axis (vertical) ase controlled by the CH 1 POSITION and CH 1 VOLTS/CM and VARIABLE, respectively. Similarly, positioning and sensitivity of X-axis are controlled by the horizontal POSITION and CH 2 VOLTS/CM and VARIABLE.

The Lissajou's pattern for two signals of 1:1 in frequency ratio and 90° in phase difference is shown in Fig. 2-39 (b). Various Lissajou's patterns will be obtained by changing the frequency ratio and phasing of signals. (See Fig. 3-32.)

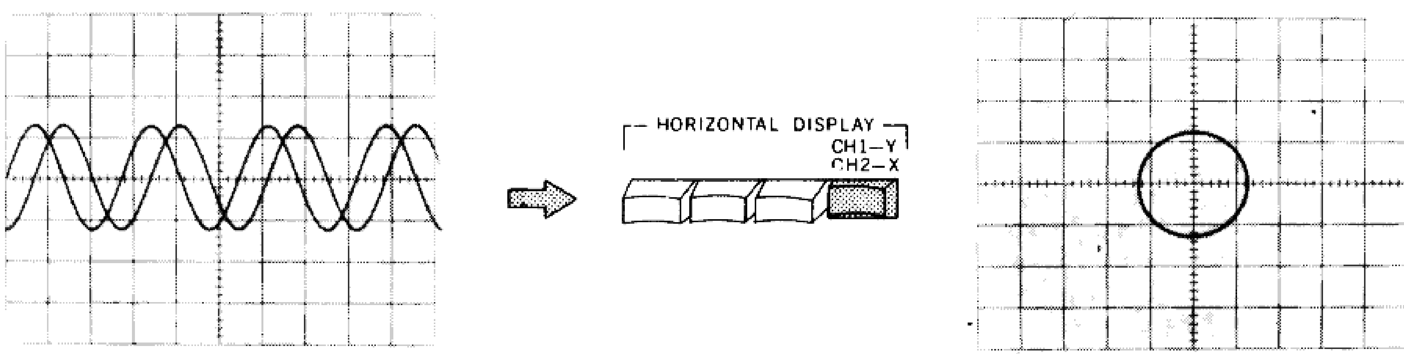
The X-Y scope function is useful for frequency or phasing measurement or for observation of hysteresis loops.

Intensity Modulation

The trace can be intensity-modulated by supplying an external signal to the Z AIXS INPUT connector on the upper part of right side panel. The supplied signal is led to the control grid of CRT, thus, intensity of display is increased making a spot in the viewing area, when the polarity of signal in negative. A positive pulse supplied to the terminal lowers intensity of the part of display. In this section, time larkers using the intensity modulation will be described.

Though the horizontal graduation is calibrated for sweep time, it is valid only when the TIME/CM VARIABLE is turned fully clockwise to the CALIB position. When the TIME/CM VARIABLE is turned from the CALIB position, or the instrument is operating as an X-Y scope driven by sawtooth wave supplied from external circuit, the horizontal graduation cannot be calibrated. When recording such uncalibrated waveform or externally controlled X-Y curves in a photo, recorded waveform can be easily calibrated for correct time, by supplying a calibrated time marker signal to the intensisy modulation input, and double-shooting of photos, one for the signal and the other for the time marker, without changing the setting of VARIABLE control.

Fig. 2-39 X-Y-scope operation

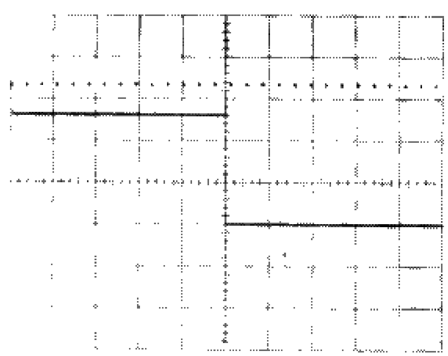


(a) Dual-trace display

(b) X-Y scope display

Without providing accurate synchronization between the displayed signal and time marker output, the time marker signal will not be intensified at the same position on the signal waveform, and picture-taking of marker is impossible. If they can be synchronized, there will be no need to superimpose the time marker signals in the viewing area. The timing can be readily known from the calibrated time marker. The single sweep function is useful, because the time marker pulses need no synchronization with the signal waveform, but, the position at which the markers will be superimposed is quite unknown. These problems can be solved by shooting the signal waveform and time marker solved by shooting the signal waveform and time marker signals separatedly on the same film. This method is particularly advantageous for example, when desiring to display one sycle of square wave signal lined with the graticule and to read timing sequence from time marker signals shot in the same photo.

Fig. 2-40 Intensity modulation, an example of application



A double-exposure of square wave and time marker signal

One cycle of square wave can be easily displayed fully in the viewing area by adjusting the TIME/CM VARIABLE control, but, it loses functioning of graticules as a calibrated timing indicator. The timing signal can be double-exposed on the same photo, as shown in Fig. 2-40, by supplying the time marker signal later, to the Z AXIS INPUT and connecting the sync output of the time marker generator to the TRIG-INPUT connector of the synchroscope. The time marker signals are firmly synchronized with the sweep serving as the timing scale.

A sufficient intensity modulation will be obtained by supplying input signals of 5Vp-p or higher.

Max. Allowable Input Voltage to Z AXIS INPUT

Observe the max. allowable input voltage to Z AXIS INPUT which is 50 V (DC+peak AC).

How to use GATE OUT Connectors

Gate signal synchronized with A or B sweep time can be obtained from the A or B GATE OUT connector located on the lower part of right side panel. The signal output from these connectors are 5Vp-p in amplitude (positive) and pulse width of signal is eaual to the sweep time of each sweep. These signals can be effectively used for many purposes. In this section, the following two typical applications will be described.

External Drive Signal for Pulse Generator

When a Pulse Generator to be checked is provided with an external input connector to trigger timing of pulse outputs, the gate out signal can be supplied to the external input connector of the generator to ensure firm triggering of pulse signals to be observed.

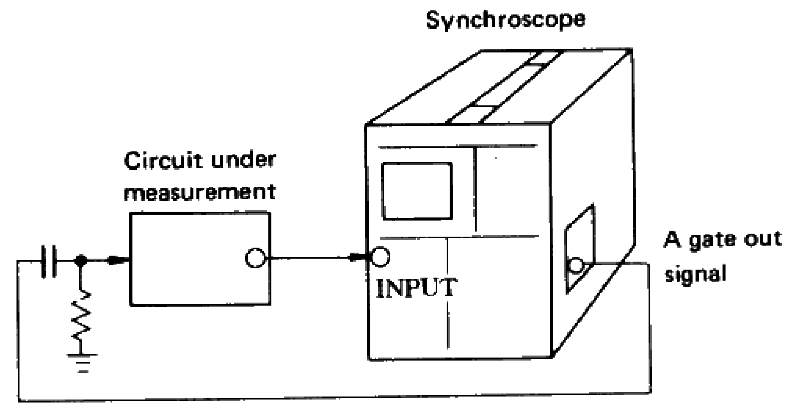
Signal Source to Drive Circuit Under Measurement

When measuring operation of an external circuit, the external signal is ordinarily used as the trigger signal, however,if therising characterictic of external signal is poor, it will be hard to observe correct rising of the signal.

When the circuit under measurement can be driven externally for obtaining the circuit response, the external circuit may be driven by the gate out signal as shown in Fig. 2-41.

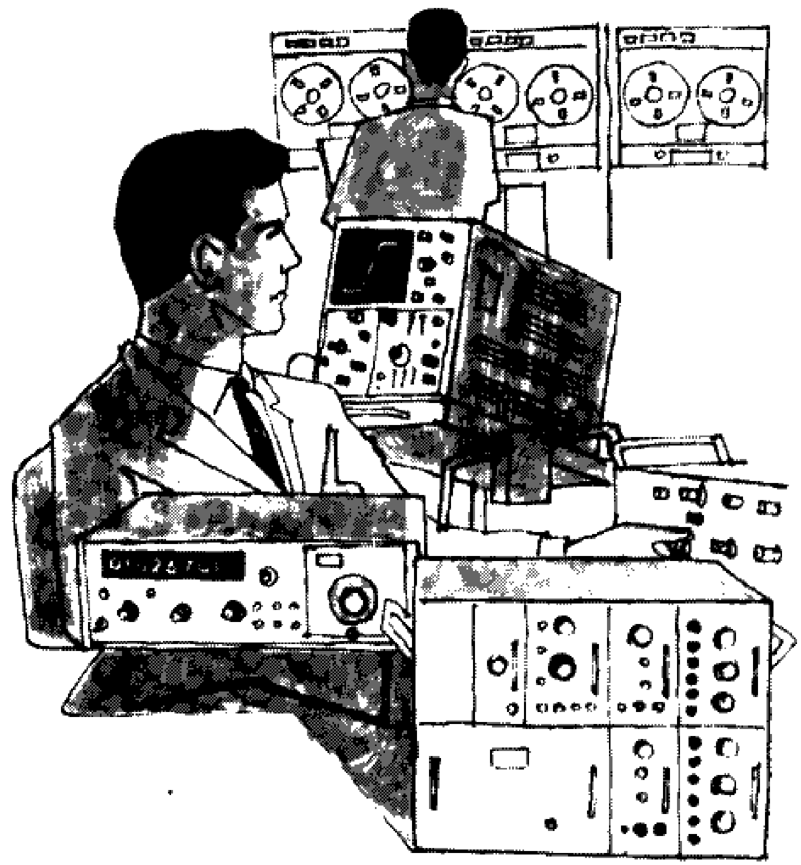
Thus, the rising edge can be perfectly observed. This method is particularly useful when the measured response is a single phenomenon.

Fig. 2-41 Example to use GATE OUT



SECTION 3 MEASUREMENT PROCEDURES

This section describes, first, with input signal connection and preadjustment of this instrument required for measurement, and measurement procedures covering various applications.



PREPARATION FOR MEASUREMENT

Input Signal Connection

Every measuring instrument has load effect to some extent due to the input impedance of circuit. Synchroscope can not be an exception. The load effect gives, particularly, an influence to amplitude (voltage) and rise time of signals to be measured. For correct measurement, thus, the load effect of input circuit must be minimized by connecting the instrument correctly to the measured object. According to the signal connection method, signal waveform can be interfered with external signal induced on the cable. Therefore, an appropriate method must be selected from various connection method.

Load effect when cable is directly connected to the INPUT connector;

Fig. 3-1 shows an equivalent circuit of the input circuit of this instrument.
The impedance viewed from INPUT connector side is 1 megohm with respect to DC signal. For an AC signal, the input impedance is given by a parallel circuit of a 1 megohm input resistance and a 23pF input capacitance. The AC input impedance can be given by equation (3-1) which shows that the input impedance varies when the signal frequency changes.

$$Zi = \frac{1}{1/R - j\,\omega\,C} \quad \ldots\ldots\ldots(3\text{-}1)$$

Since the input impedance is connected in series to the output impedance of signal source, certain load effect

Fig. 3-1 Equivalent circuit of input

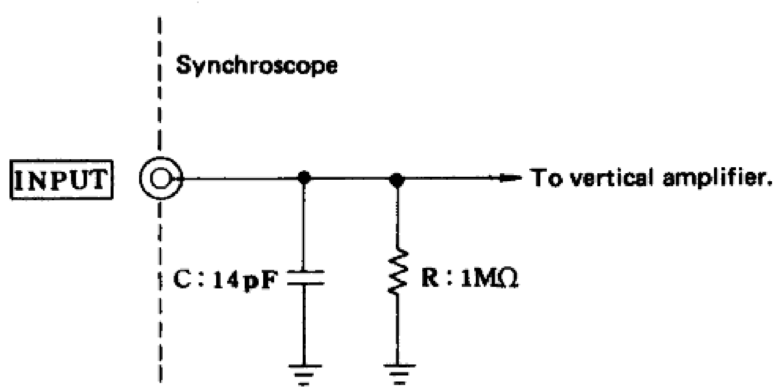
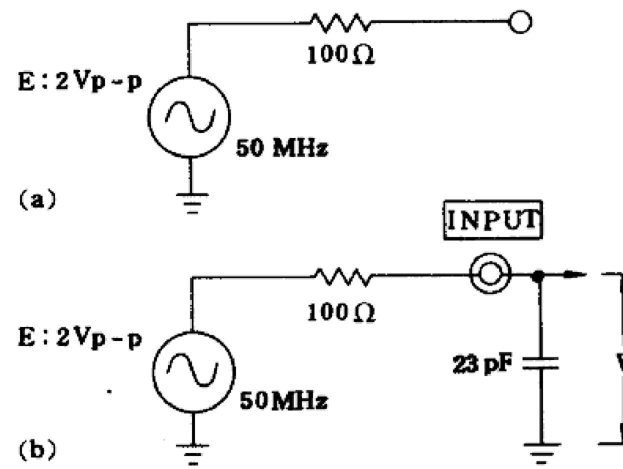


Fig. 3-2 Signal source and voltage division at input



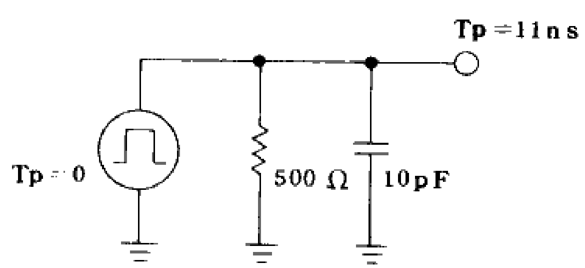
is caused in accordance with frequency and output impedance of input signal adversely affecting accurate measurement of peak voltage or rise time of the signal.

For example, is a signal source, shown in Fig. 3-2(a) is directly connected to the INPUT connector, the input impedance becomes equivalently equal to $1/j\omega C$ ($Zi=1/j\omega C$, the R component can be neglected because of very high signal frequency). The capacitive component of input impedance is connected to the output resistance (100 ohm) of signal source thereby forming a voltage divider.

In this case, the actual input voltage across INPUT connector will be;

$$V = \frac{Xc}{\sqrt{R^2 + Xc^2}} \cdot E = \frac{138.5}{\sqrt{100^2 + 138.5^2}} \times 2 = 1.6\ (V)$$

Fig. 3-3 Signal source



$$\text{where } Xc = \frac{1}{\omega C} = \frac{1}{2\pi \times 50 \times 10^6 \times 23 \times 10^{-12}} = 138.5(\Omega)$$

Thus, it attenuates the 2V input signal to 1.4V (approx. 3/4).

If the INPUT connector is directly connected to a signal source as shown in Fig. 3-3, the input impedance of this instrument will affect the rise time of signal source, because the direct coupling of INPUT connector to signal source will result in a rise time Ti to the input circuit;

$Ti = 2.2\ R{:}C$ .... (3-2)

where R: a parameter given by signal source resistance and input resistance of synchroscope.

C: input capacitance of synchroscope

The rise time of displayed signal is to be a sum of initial rise time of signal and a rise time determined by frequency bandwidth of synchroscope. This additional input rise time is given by the equation (3-3);

$To = \sqrt{Tp^2 + Ts^2 + Ti^2}$ .... (3-3)

where To: rise time of displayed signal

Tp: rise time of signal source

Ts: rise time of the synchroscope (determined by its frequency bandwidth)

Ti: rise time of input circuit

Therefore, rise time of displayed signal in Fig. 3-3 will be;

$$To = \sqrt{(11\ ns)^2 - (7ns)^2 - (2.2 \times 500\Omega \times 23pF)^2} = 19.25ns$$

Thus, a 8.25 ns error will occur. However, this error can be compensated by using an equation $Tp = \sqrt{To^2 - Ts^2 - T_i^2}$ (from eq. 3-3).

The measurement errors due to input impedance of synchroscope can be reduced by using either of the following probes or by converting the characteristic impedance.

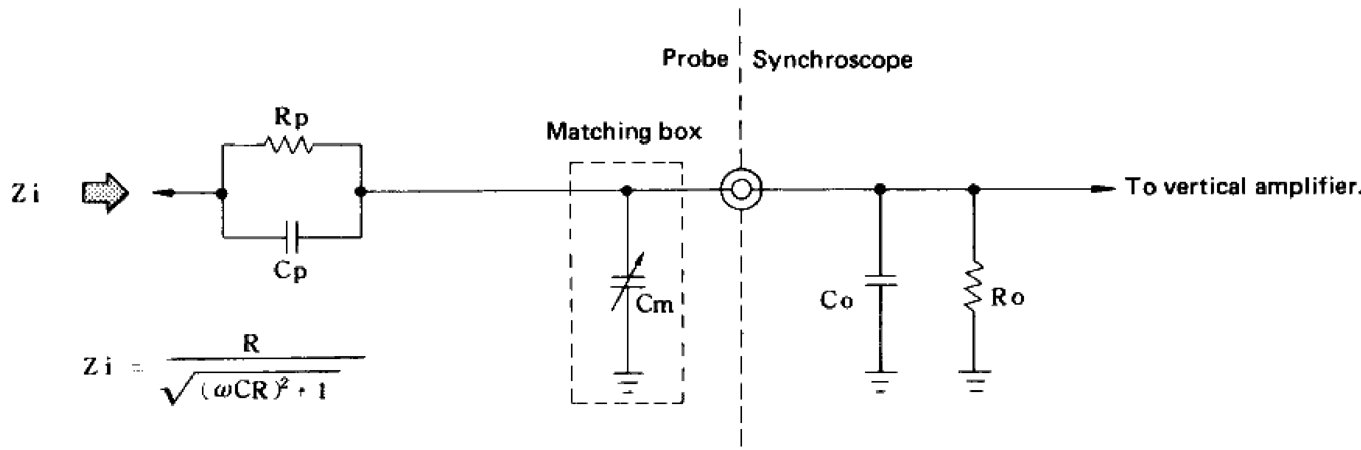
(1) 1 megohm series passive probe
(2) 50 ohm series passive probe
(3) An active probe
(4) Synchroscope input impedance is converted into a characteristics impedance of the signal source which has a characteristics impedance, such as 50Ω, 75Ω or 93Ω.

1 megohm Series Passive Probe

The 1 megohm series probe is a widely used resistive divider type probe (input resistance: 10 megohm, attenuation ratio 10:1). Type 1030 (standard accessory, cable length 1m) and type 1031 (an optional item, cable length 2m) are available for this instrument.

As shown in the equivalent input circuit with a use of 1 megohm series probe, Fig. 3-4. the input RC are given by 10MΩ/9.5pF giving contribution to reduction in load effect to signal source. For example, when the signal source in Fig. 3-2 is connected to the probe, the voltage on the INPUT connector will be given by;

Fig. 3-4 Equivalent circuit of input with a 1 megohm series passive prove



$$Zi = \frac{R}{\sqrt{(\omega CR)^2 + 1}}$$

$$R = Rp + Ro = 10M\Omega$$

$$C = \frac{Cp\,(Cm + Co)}{Cp + (Cm + Co)} = 9.5\,pF$$

$$V = \frac{Xc}{\sqrt{R^2 + Xc^2}} \cdot E = \frac{335}{\sqrt{100^2 + 335^2}} \times 2 = \frac{335}{350} \times 2 = 1.91(V)$$

where
$$Xc = \frac{1}{\omega C} = \frac{1}{2\pi \times 50 \times 10^5 \times 9.5 \times 10^{-12}} = 335(\Omega)$$

Compared with that measured with direct connection to signal source, the value measured with a probe fairly approaches the true value, 2V. The 3dB down frequency (due to the input impedance) plotted for signal source output impedance is shown in Fig. 3-5, for the user's reference.

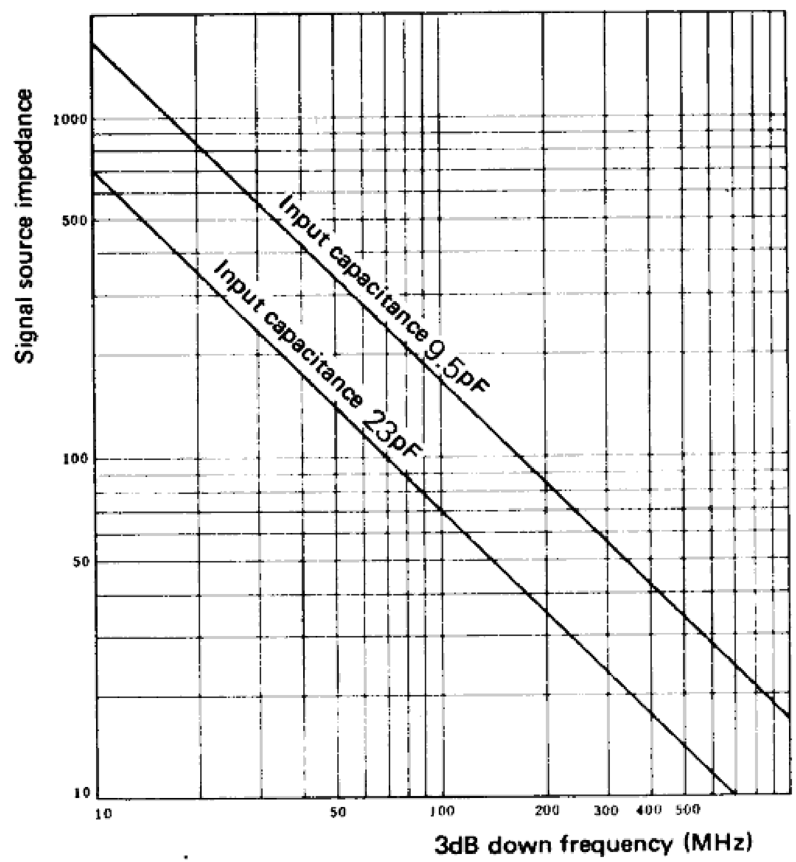
The rise time of signal in Fig. 3-3 will be measured to be 16.7ns, when this probe is used.

50 ohm Series Passive Prove

This prove is of a resistive divider type probe having low input capacitance. Two types of proves, HZ-501 A (500Ω, 0.7pF) and HZ-502 A (5kΩ, 0.6pF), are available. Though input resistance of this probe is comparatively low, very low input capacitance is suitable for measurement of high frequency or high speed signals for which the 1 megohm series passive probe may result considerable measurement error. The comparatively low input resistance will not affect DC operation of ordinary high frequency signal source, because output impedance of such high frequency or high speed signal source is as low as in the order below 10 ohm.

If a 50 ohm series probe is directly connected to a signal source having comparatively high output impedance, such as in Fig. 3-3, the resistive load to the source will be lowered to 1/2, and normal operating condition of the source will be lost. To help the matter, the input resistance of probe may be used as the output load to the source, by disconnecting the 500 ohm output resistor from the source. When the source is as shown in Fig. 3-6, correct output

Fig. 3-5 Signal source impedance and 3dB down frequency



load, 250 ohm, can be ensured with the 500 ohm probe directly coupled to the circuit, by disconnecting the 250 ohm resistance and loading the source with a 500 ohm resistor, instead.

Before using a 50 ohm series probe, the input connector of this instrument must be terminated by a 50 ohm terminator and a 6dB attenuator to make it a 50ohm input. Equivalent circuit of input circuit is shown in Fig. 3-7. The input RC of this circuit will be 500Ω/0.7pF.

In order to expand the applicable range of low-capacitance probe for higher signal voltage or source impedance, type HZ-502 A Probe is prepared (input resistance 5 kilohms).

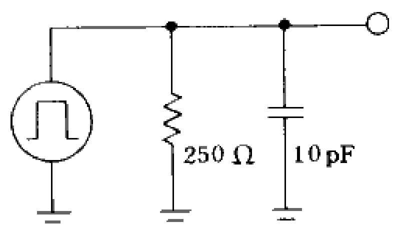
Outline and performance of these low-capacitance probes are shown in Fig. 3-8.

Active Probe

A cathode follower probe and a source follower probe are prepared as the active probe.

Very high input impedance is ensured for the source follower probe by a source follower in the probe head, as shown in Fig. 3-9. Output impedance is lowered to 50 ohm to ease connection to synchroscope. It gives high input

Fig. 3-6 Example of source suitable for HZ Probe (HZ-501A)



resistance (1 megohms) and low input capacitance for example, 2.5pF at attenuation ratio 10:1, allowing accurate measurement of high frequency signals or high speed pulses without disturbing DC operation of signal source. It should be noted, however, conpared with the passive probes, the active probe has certain limitations in operation range, such as low input voltage limit (an attenuator must be used before connecting the active probe to a high voltage signal source) and comparatively small dynamic range.

Connection of Signals having Characteristics Impedance

When the signal source has a characteristics impedance, such as 50 ohm, 75 ohm or 93 ohm, a coaxial cable of matched characteristics impedance must be used and the circuit must be impedance matched so that signals up to high frequencies will be correctly transmitted without attenuation.

The impedance of circuit must be matched, as shown in Fig. 3-10, at the INPUT connector of this instrument.

How to Connect Input Signal of 50 Ohm Impedance

High VSWR performance of synchroscope input circuit is essential to measure signals having a characteristics impedance correctly. The input circuit of this instrument can be easily converted into a 50 ohm system which ensures high VSWR performance for the typical characteristics impedance of 50 ohm.

The input circuit can be used as a 50 ohm input system by connecting a 50 ohm terminator and an attenuator at the INPUT connector, as shown in the equivalent circuit, Fig. 3-12. The VSWR performance of input circuit in Fig. 3-12. is shown in Fig. 3-13.

Outline and performance of Terminator and Coaxial Attenuator are shown in Figs. 3-14 and 3-15.

Fig. 3-7 Equivalent input circuit using an HZ Probe (HZ-501A)

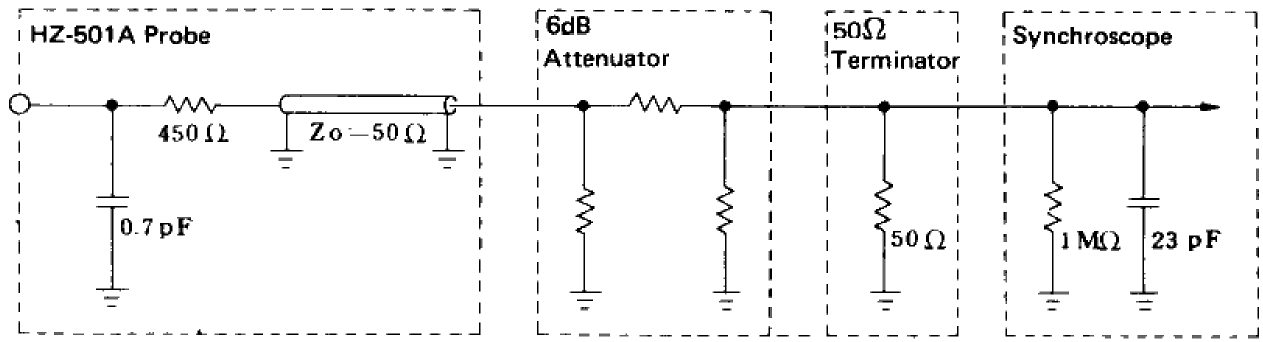
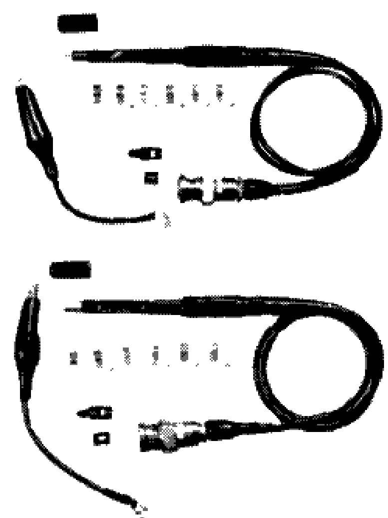


Fig. 3-8 Outline and performance of HZ-501A and HZ-502A Probes

HZ-501A

HZ-502A



Features

(1) Very low input capacitance; HZ-501A 0.7pF
HZ-502A 0.6pF

(2) Compact and light weight. Easy to handle.

(3) Similar to 1 megohm series probe, sensitivity and input caupling can be switched in the synchroscope side.

(4) Comparatively high allowable input voltage;
HZ-501A 16 Vrms
HZ-502A 50 Vrms

Performance

Type	Attenuation ratio	Input RC		Frequency bandwidth	Allowable input voltage	
		R	C		Average	Peak
HZ-501A	10:1	500Ω	0.7pF	DC~3.5GHZ	16V	400V
HZ-502A	100:1	5kΩ	0.6pF	DC~1.7GHZ	50V	400V

Fig. 3-9 Circuit configuration to use a source follower probe

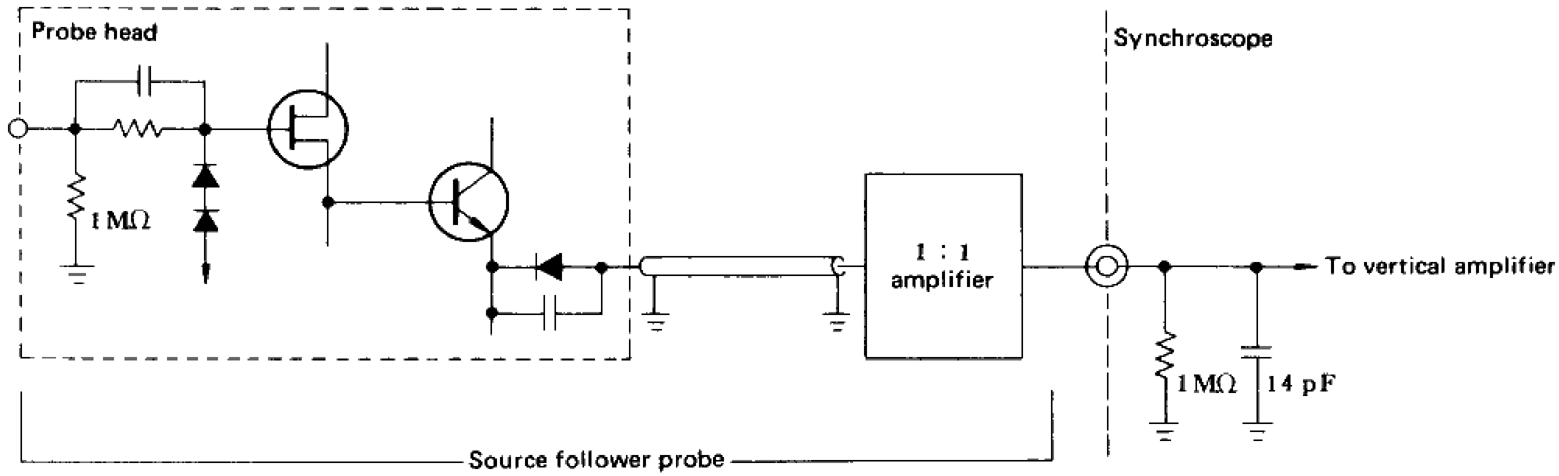
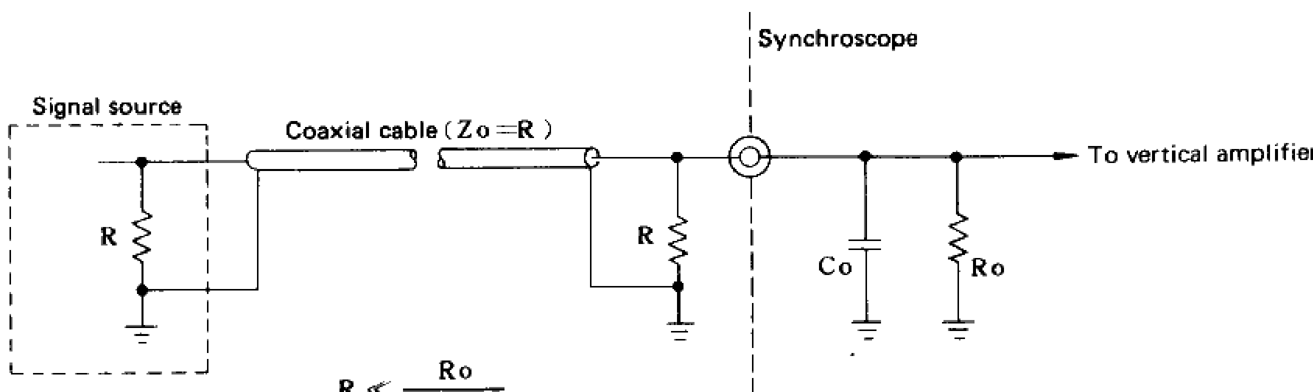


Fig. 3-10 Transmission of signals having characteristics impedance



$$R \ll \frac{Ro}{\omega Co\ Ro}$$

Fig. 3-11 Conversion into a 50 ohms input

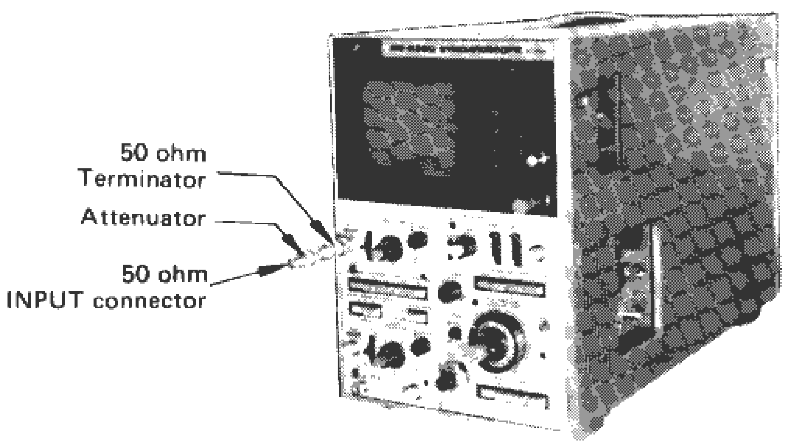


Fig. 3-12 Equivalent circuit of 50 ohm input circuit

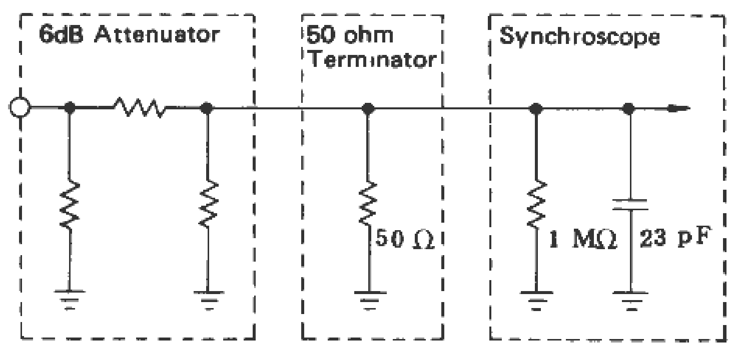
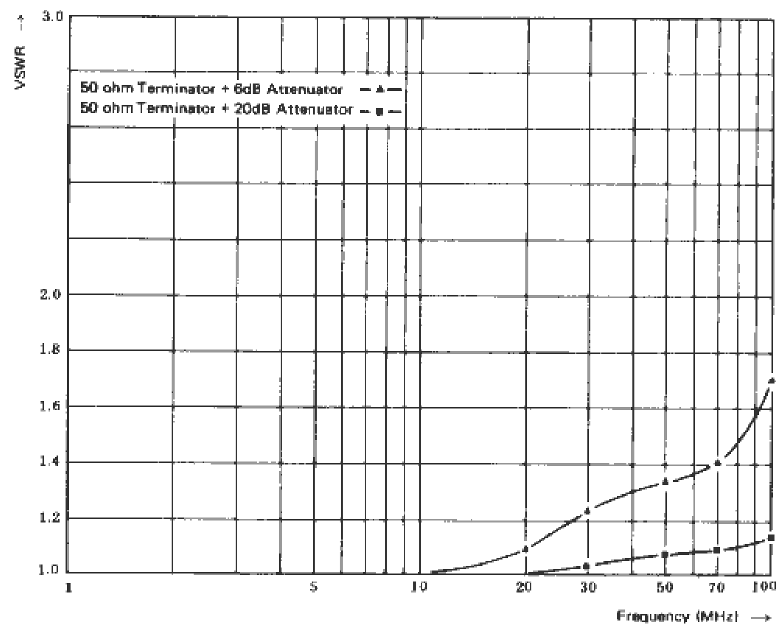


Fig. 3-13 VSWR performance of 50 ohm input circuit

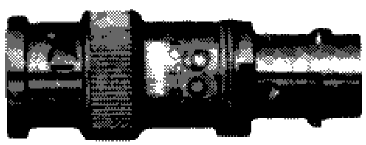


Use of Shielded Cable and Elimination of Interference

Input signals may be coupled to the input of this instrument simply by using a sheathed (insulated) wire. The input lead wire can be secured to the INPUT connector with an insulation adapter (provided as the standard accessory).

This method is simple but comparatively safety against attenuation of signals within the cable. However, interference noise will be induced on the cable, if it is extended excessively, or when used in an ambient close to a ferro-electric field source. The external interference will be unacceptably strong particularly when impedance of signal source is high. The external interference can be eliminated by using the 1:1 passive prove, type 116 (cable length;1m) or type 117 (cable length;2m). These passive probes will not attenuate low frequency input signals. Ordinary shielded cables may be used for input connection. They can protect the measurement from external interference to some extent.

Fig. 3-14 50 ohm Terminator BB-50M1

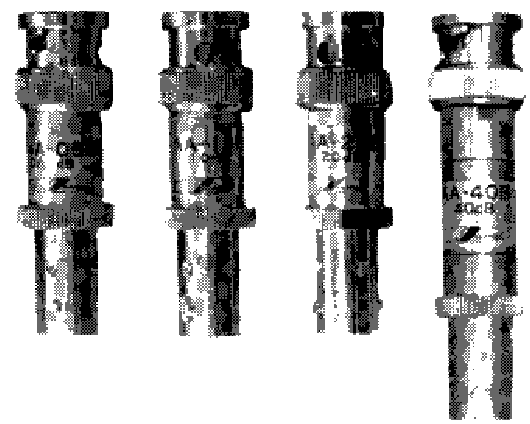


Performance

Frequency range	DC to 1GHz
Impedance	50ohms
Max. VSWR	1.1 or less at DC to 500MHz, 1.15 or less at 500 to 700MHz, 1.25 or less at 700 MHz to 1GHz
Mean input power	0.5W
Peak input power	500W (max. pulsewidth 5μs)
Connector	BNC

Fig. 3-15 AA-Series Coaxial Attenuators

AA-06B AA-10B AA-20B AA-40B



Performance

Attenuation	6 to 40dB (4 types)
Accuracy	±1dB
Frequency range	DC to 2GHz
Impedance	50 ohms
Max. VSWR	1.2 (at 1, 1.5 and 2GHz)
Mean input power	0.5W
Peak input power	500W (max pulsewidth 5μs)
Connector	BNC

Pre-Adjustments

For accurate measurement, semi-fixed controls on the panel must be adjusted correctly. Also, phasing adjustment of probe is essential. The adjustment of controls and phasing of probe must be performed by using the provided adjustment screwdriver.

For these pre-adjustment, the synchroscope will have to be warmed-up approximately 30 minutes.

ASTIG Adjustment

The trace must be adjusted as sharp as possible, otherwise, accuracy of amplitude or time readout will become incorrect resulting in an erroneous measurement. The FOCUS control is mainly used to make trace sharp, but, optimum sharpness is not obtainable from the focusing, the ASTIG (astigmatism) control located on the upper part of right side panel will have to be readjusted.

Adjust the INTENSITY control to obtain an adequate trace intensity, then slightly adjust the ASTIG control followed by a readjustment of FOCUS control. The ASTIG and FOCUS controls must be alternately adjusted until an optimum sharpness of trace is obtained.

TRACE ROTATION Adjustment

If the trace is not correctly in parallel to the horizontal graticule of CRT, amplitude reading of signals becomes errorneous at the both sides of waveform within the viewing area. Parallelness of trace with horizontal graticule can be adjusted by setting the trace to the vertical center of graticule by turning the vertical POSITION control, and fine adjusting the TRACE ROTATION control (located on the upper part of right side panel).

Note that the parallelness of trace to graticule will be affected when positioning of the synchroscope is changed (due to influence of ground magnetism). For accurate measurement, it is recommended to position the synchroscope (direction of length axis) equal to that at the initial ASTIG adjustment.

GAIN Adjustment

The vertical sensitivity must be checked for correct calibration, before using the synchroscope for accurate measurement.

Set the VOLTS/CM switch to the 50mV position, CALIBRATOR switch to the 0.2V position, and connect the INPUT and CAL OUT connectors with a coaxial cable (BB-300). Check that vertical amplitude is correctly 4cm. If not, readjust the GAIN control (on the front panel).

When using a probe, the vertical sensitivity may be calibrated including the probe. Connect the probe between the INPUT and CAL OUT connectors, and change the CALIBRATOR switch to the 2V position. The vertical amplitude of displayed signal must be set to 4cm, by using the GAIN control.

STEP ATT BAL Adjustment

When the vertical deflection system is not balanced well, vertical positioning of trace is shifted with setting of VOLTS/CM switch (from other position to 5mV position). Adjust the STEP ATTEN BAL control (located on the left side panel) until the vertical positioning of trace is firmly held against alternative changing of VOLTS/CM switch positions, 5mV and 10mV.

Once completed, the STEP ATT BAL control will not need frequent readjustment. However, an excessive variation in ambient temperature may require readjustment of these control.

Probe Phase Adjustment

Incorrect phasing of probe will result erroneous waveform measurements.

For phasing adjustment, set the VOLTS/CM switch to the 50mV position, the CALIBRATOR to the 2V position and connect the probe between INPUT and CAL OUT connectors. Vertical amplitude of displayed squarewave should be correctly 4cm. Fine adjust the variable capacitor of probe as shown in Fig. 3-16. It changes the displayed waveform as shown in Fig. 3-17. Set tops of waveform as shown in Fig. 3-17 (a)

Fig. 3-16 Phasing adjustment of probe

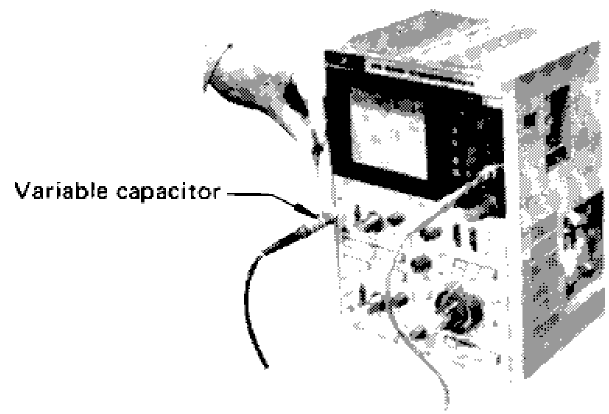
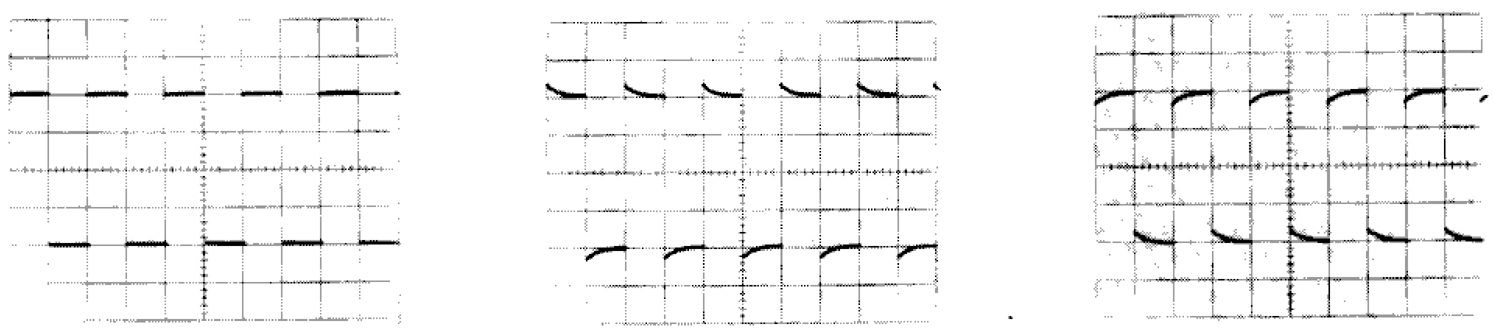


Fig. 3-17 Phasing of probe and displayed waveform



(a) Correct phasing   (b) Incorrect (over-compensation)   (c) Incorrect (poor compensation)

MEASUREMENT PROCEDURES

Voltage Measurement

On the Quantative Measurement

The quantative measurement of voltage should be performed with the VARIABLE control turned fully clockwise (to the CALIB position), because voltage amplitude of signal can be directly read from setting of the VOLTS/CM switch.

If the VARIABLE control must be set to a position other than the CALIB position, by any reason, quantative measurement of voltage is possible by following the steps below;

(1) Read and record amplitude of signal in the viewing area.
(2) Leaving the VOLTS/CM and VARIABLE controls unchanged, supply CAL output signal to the INPUT connector, and select a CALIBRATOR switch position so that the CAL signal will be displayed in the viewing area with an easily readable amplitude. Sensitivity of vertical deflection system at this setting can be calculated from equation below;

$$\text{Vertical sensitivity (V/cm)} = \frac{\text{Setting of CALIBRATOR(V)}}{\text{Vertical amplitude of CAL signal (cm)}} \quad \text{.................. (3-4)}$$

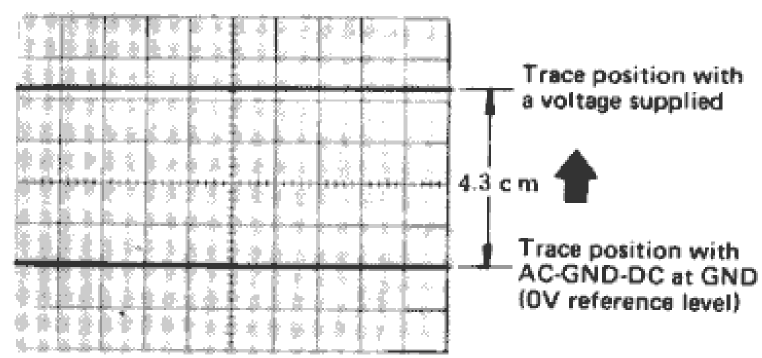
Then, voltage amplitude of input signal can be given as;
Input signal voltage (V)
= vertical sensitivity (V/cm) x recorded vertical amplitude of signal (cm) .... (3-5)

DC Voltage Measurement

For DC voltage measurement, a synchroscope functions as a high input resistance, high sensitivity, quick response DC volt meter. Operate the sweep circuit in free-running mode, and select a TIME/CM value so that the trace will not flicker.

Change the AC-GND-DC switch to the GND position. Vertical position of trace at this time is used as the zero volt reference line, shown in Fig. 3-18. If necessary, adjust the vertical POSITION control to place the trace exactly on a horizontal graticule. It facilitates reading of signal voltage. Return the AC-GND-DC switch to the DC position, and supply the voltage to be measured to the INPUT connector. Vertical displacement of trace give the voltage amplitude of signal. If the trace moves out of the viewing area, change the VOLTS/CM setting to a larger value (reduce amplifier sensitivity) to lead the trace within the viewing area, and repeat the GND position check.

Fig. 3-18 DC voltage measurement



When the measured voltage is a positive value, with regard to the ground potential, the trace moves upward. For a negative voltage, it moves downward. (When using CH 2 for a DC voltage check, set the CH 2 POLARITY switch to the NORM position). Letting the displacement of trace in the viewing area as A (cm), the voltage can be calculated by using equation (3-6) or (3-7) below.

When the voltage is directly supplyed to the INPUT;

Voltage(V) = VOLTS/CM value (V/cm) x A(cm) ....(3-6)

When the voltage is supplied through a 10:1 (attenuation ratio) probe;

Voltage (V) = VOLTS/CM value (V/cm) x A (cm) x 10 ....(3-7)

For example, if displacement of trace was 4.3cm as shown in Fig. 3-18, and the voltage was directly supplied to the INPUT (VOLTS/CM switch was at 2V/cm position), the voltage amplitude is given from equation (3-6);

2V/cm x 4.3cm = 8.6V

If a 10:1 probe was used for this measurement, the voltage is;

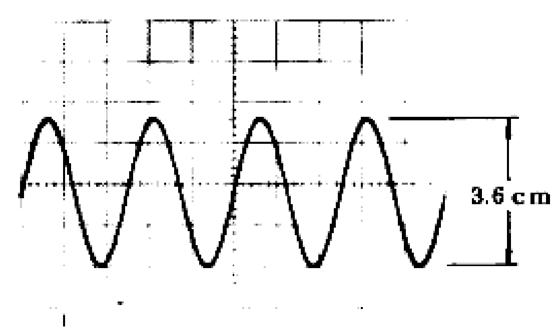
2V/cm x 4.3cm x 10 = 86V

AC Voltage Measurement

When an object AC voltage is superimposed on a DC voltage, it may be measured with the AC-GND-DC switch set to the DC position. It gives the whole view of AC and DC components. However, if the AC component is smaller than the DC component, the trace will easily move out of viewing area when the voltage is supplied after the GND level was checked within the viewing area. The trace, moved out the viewing area, may be returned into the area by adjusting the vertical POSITION control, but, it will resule in accumulation of measurement errors (guarantee for vertical axis linearity for such an extended range is somewhat rougher than the rated accuracy for VOLTS/CM attenuator). The trace may also be returned into the viewing area by reducing the setting of VOLTS/CM switch (reducing the vertical amplifier sensitivity), but it makes amplitude of AC waveform small. It is a loss in measurement accuracy. When the amplitude of superimposed DC voltage has no concern to the AC signal level to be measured, these problems are simply solved by setting the AC-GND-AC switch to the AC position. Then, a capacitor is connected in series to the input circuit to block the DC component to enter vertical axis amplifier, and only the AC component can be amplified up to an amplitude adequate for measurement.

Letting the vertical amplitude of displayed AC waveform as A (cm), equation (3-6) or (3-7) can be used for calculation of signal amplitude.

Fig. 3-19 AC voltage measurement



When the AC-GND-DC switch is set to the AC position, input signal will be attenuated 3dB at approximately 3Hz (the attenuation becomes larger in lower frequencies). When a probe is used, the 3dB attenuation point is extended to approximately 0.3Hz. For measurement of an AC voltage, excluding very low frequency signals, it is recommended to set the AC-GND-DC switch to the AC position, regardless of presence of DC component in the measured signal.

The AC voltage calculated by equation (3-6) or (3-7) gives peak value of the signal voltage. Effective value (Vrms) of a sine wave signal is given by equation (3-8).

$$\text{Voltage (Vrms)} = \frac{\text{Volt (Vp-p)}}{2\sqrt{2}} \quad \text{.............. (3-8)}$$

For example, a sine wave signal shown in Fig. 3-19 (VOLTS/CM is set to 5V position) will be;

5V/cm x 3.6 cm= 18 (V) in peak value, and from equation (3-8), rms value of this signal will be;

$18V \div 2\sqrt{2} = 7.37V$

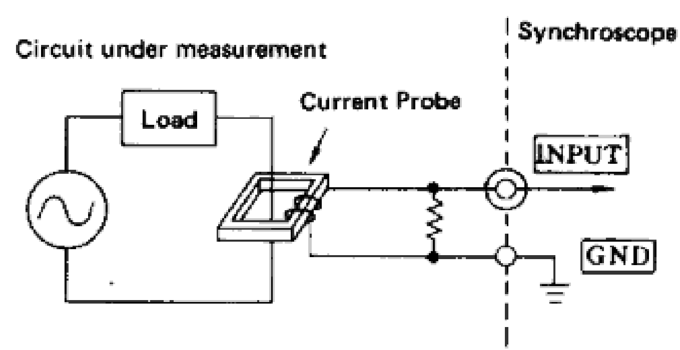
Current Waveform Measurement

Substantially, a synchroscope is an instrument to measure voltage amplitude of electrical signals. When measuring electrical phenomena other than the voltage, mechanical vibration or other physical or chemical phenomena, the object phenomenon must be converted into an electrical signal before it is supplied to the INPUT of synchroscope.

For measurement using a synchroscope, current may be converted into a voltage, by inserting a series resistor to the circuit feeding the current. Then, the current can be measured as a voltage drop across the resistor of known resistance value (V = IR, R ; value of the series resistor). Note that the resistor R must be adequately selected so that insertion of the resistor will not disturb operation of the circuit and the voltage drop will be adequate for measurement by the synchroscope.

If the circuit transferring the current does not allow the insertion of a resistor, a current probe may be used. It converts sensed current value into a voltage without opening the circuit for insertion of a resistor. As shown in Fig. 3-20, the current being measured induces a voltage across the secondary coil wound on the probe core. The voltage can be easily measured by the synchroscope. When the current level is very low, the induced voltage can be amplified before it is supplied to the vertical input of synchroscope. If the current level is very large, a current shunt must be used to avoid saturation of probe core. It should be noted, however, that the current probe has a limitation in measurable signal frequency. It is not suitable to measure a high frequency current.

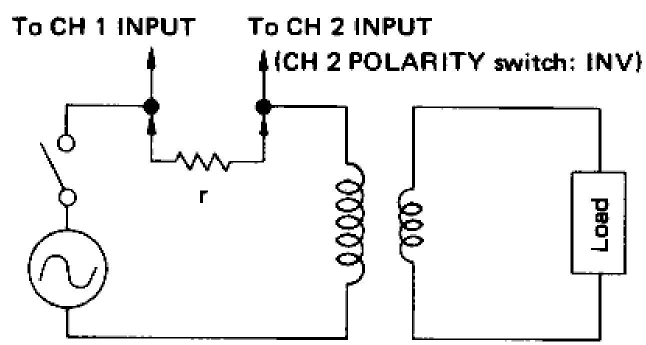
Fig. 3-20 Current waveform measurement with a Current Probe



When measuring current supplied by a circuit which is floated from the ground, as shown in Fig. 3-21, correct measurement is impossible, if the synchroscope has only one vertical axis input circuits. In this case, a differential amplifier serves to measure the current correctly, by inserting a series resistor to the circuit and connecting input connectors of differential amplifier to the ends of the resistor. This instrument can serve for differential measurement as given in Section 2, ADD operation. The following differential measurement is useful to read current amplitude transferred by a circuit floated from the ground.

Set the MODE switch to the ADD position, push the CH 2 POLARITY switch (to the INV position) and connect probes to both the CH 1 and CH 2 INPUT connectors. Connect the probe tips across the series resistor r. Voltage drop across the resistor r, i.e. waveform of the current, can be correctly measured by setting CH 1 and CH 2 to the same VOLTS/CM value.

Fig. 3-21 Current waveform measurement by a differential operation



Time Measurement

Time Interval Measurement

Time interval of two points on a signal waveform can be directly known by setting the VARIABLE control to the CALIB position from the value indicated by TIME/CM switch.

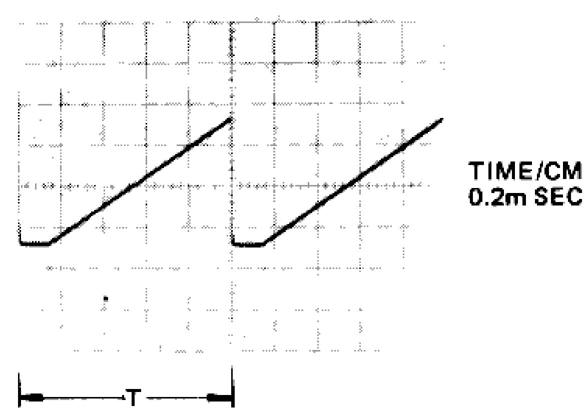
Set the HORIZONTAL DISPLAY switch to the A position, and trigger the display correctly. Read distance T by selecting the position of TIME/CM switch as shown in Fig. 3-22.

The time T can be calculated from equation (3-9).

Time T (sec) = TIME/CM value (sec/cm)
x distance read from displayed signal
x reciprocal number of sweep magnification factor.............. (3-9)

In equation (3-9), the reciprocal number of magnification factor is 1 when the sweep is not magnified, and 1/10

Fig. 3-22 Time interval measurement



when it is magnified by x10 MAG switch.

In the example, Fig. 3-22, the distance between two points is 5cm, thus, the time T is given from equation (3-9) as

0.2 msec x 5 = 1 msec

If the x10 MAG knob has been pulled;

0.2 msec x 5 x 1/10 = 0.1 msec.

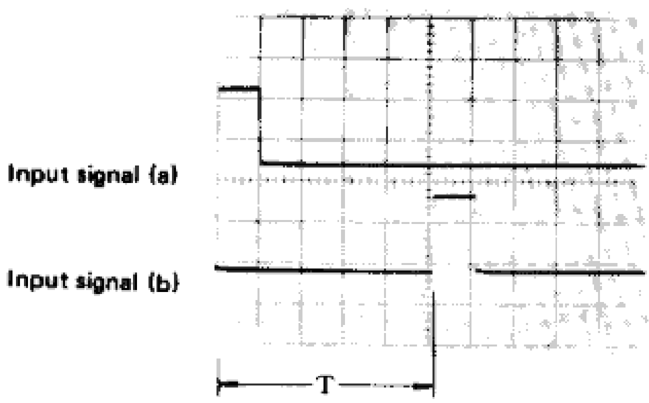
Time Difference Measurement

Time difference between two signals can be easily measured by supplying the signals to CH 1 and CH 2, and setting the MODE switch to the ALT, CHOP or ADD position. Fig. 3-23 shows an example measured by setting the MODE switch to the ALT or CHOP position.

For the time difference measurement, care must be exercised to trigger the sweep by a signal which is generated faster. Thus, the TRIGGER switch must be set to a channel which receives a signal generated faster than the other (in Fig. 3-23, to a channel receiving input signal a). Read time difference T of two signals, and calculate the time from equation (3-9).

When measuring time difference of two signals in the ALT mode, do not push two TRIGGER switches (CH 1 and CH 2) at a time. If both of these switches are pushed (though, this is illegal in ordinary dual-trace measurement), measurement of time difference is impossible.

Fig. 3-23 Time difference measurement by ALT or CHOP



Pulse Measurement

The synchroscope can be used for measuring various types of waveforms. In electronic computer or other digital circuit, pulse signals are widely used. An ideal pulse, which contains all possible harmonics above the basic pulse frequency, is indispensable for checking characteristics of circuit.

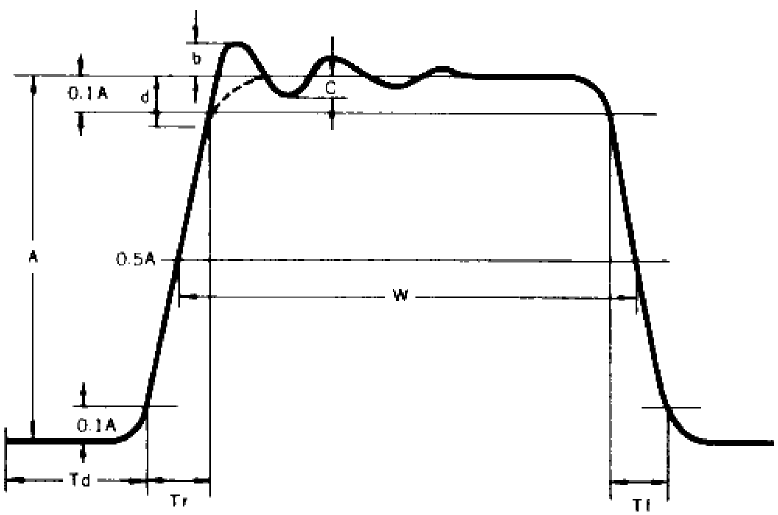
For pulse measurement, it is recommended to understand the following definitions given to pulse waveforms (see Figs. 3-24 and 3-25).

1. Overshoot
   The first pulsewise undesirable narrow waveform of superimposing on the basic pulse waveform.
2. Ringing
   Undulations produced on the top of pulse following the rising of the pulse.
3. Sag
   Pulse top which should be flat is slanted.
4. Rounding
   A pulse response characteristic in which the loss of sharp corner is excessive.
5. Rise time and fall time
   The interval between the moments at which the instantaneous pulse amplitude reaches 90% from 10% of the basic amplitude.
6. Pulsewidth
   The interval between two points at which the instan-

taneous pulse amplitude reaches 50% of the basic amplitude.

7. Signal delay time
   The time elapsed between starting of sweep in time axis and reaching the point at which instantaneous amplitude of signal reaches 10% of the basic amplitude.

Fig. 3-24 Definition of pulse terms (By MEA-27, Japanese Electronic Machinery Industry Association)



A : Basic amplitude
b/A: Overshoot
c/A: Ringing
W: Pulsewidth
T: Rise time
Tf: Fall time
d/A: Rounding
Td: Signal delay time

Measurement of Waveform Rising (Falling)

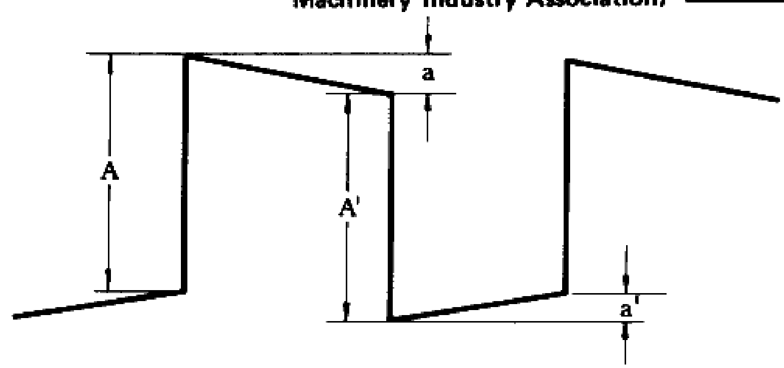
Since a signal delay circuit is built in the vertical deflection system of this instrument, rising edge (or falling edge) of input signals can be easily observed with internal triggering, provided that the rise (or fall) time of signal is faster than the signal delay time (15 nsec).

However, if the rise (or fall) time of input signal is slower then the signal delay time, for example, sonic wave or mechanical shock, can not be observed from the starting point of the phenomenon.

As given in Fig. 3-26, an waveform is displayed starting at point P' which is faster than point P, which is on the minimum triggerable level, by the signal delay time td (= 15nsec), however, the phenomenon has occured at point 0, thus, the period t minus td can not be displayed on CRT.

Use the external triggering for observing of signals which rises (or falls) very slow.

Fig. 3-25 Sag waveform (By MEA-27, Japanese Electronic Machinery Industry Association)



A : Basic amplitude Sag = a/A (or a'/A', whichever larger) x 100%

a : Sag

Pulsewidth Measurement

The basic pulsewidth measurement steps are as follows:

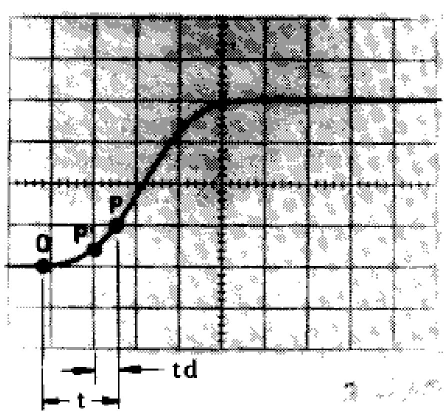
The pulse waveform is so displayed that the pulse amplitude will be equal above and below the horizontal center line of the graticule (2cm each in the example). Then the TIME/CM switch position is selected to make observation of signal easy. Distance T between the centers of rising and falling edges can be read from the display, i.e. the distance between two points of pulse edges crossing the horizontal center line of graticule is read. Then, the pulsewidth can be calculated from equation (3-9). When the pulsewidth is too narrow, use the sweep magnification function.

Rise (Fall) Time Measurement

Vertical amplitude of pulse waveform must be evenly displayed with respect to the center line, as given in the pulsewidth measurement.

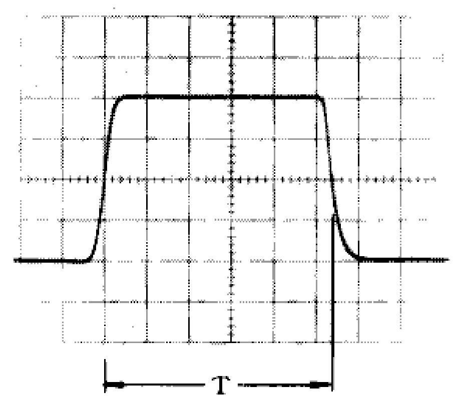
Then the rising (or falling) edge of the pulse is moved by the horizontal POSITION control so that the upper 10% point of the edge will be on the vertical center line as shown in Fig. 3-28 (the upper 10% point is 0.4cm below the top of pulse, since the displayed vertical amplitude is 4cm). Distance T_1 at which the rising (falling) edge crosses the horizontal center line is read. Then, the displayed waveform is moved so that the lower 10% point of the edge will be on the vertical center line (as shown by dotted line in the figure) and, similarly, distance T_2 is read.

Fig. 3-26 Signal rise time



When the system has no signal delay cable, sweep starts from point P. With a delay cable, it can start from point P'.
td: signal delay time

Fig. 3-27 Pulsewidth measurement



The rise (or fall) time of the pulse can be calculated by substituting the sum of T_1 and T_2 for T in equation (3-9) which gives the pulsewidth in seconds.

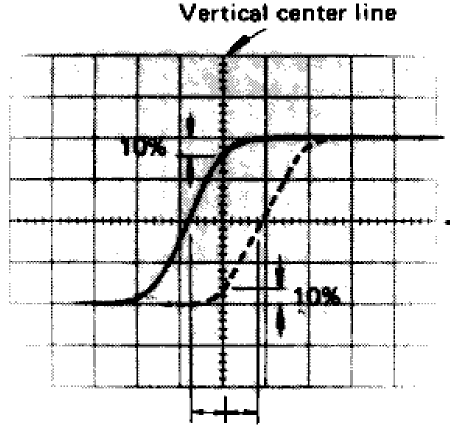
Precautions for Pulse Measurement

For rise (fall) time measurement or pulsewidth measurement, influence on rise time of the synchroscope must be considered for accurate measurements. The rise time of synchroscope is determined by two factors, the frequency bandwidth of the scope and RC values in the input circuit.

Influence on rise time given by frequency bandwidth

In this influence, such rise time is determined as 7 nsec. This is calculated from equation (3-10) which gives a rise time for a frequency bandwidth. When an ideal pulse (rise time zero) is supplied to a synchroscope, the signal will

Fig. 3-28 Rise (fall) time measurement



be displayed with a rise time given by this equation.

$$Ts = \frac{0.35}{Fs} \quad \text{.......................} (3\text{-}10)$$

where Ts : Rise time
Fs : Frequency bandwidth

If rise (fall) time of an input pulse is by far slower than the rise time of synchroscope, influence on the rise time (3.5nsec) to the displayed waveform will be negligibly small. However, some measurement errors occur when rise time of input pulse becomes close to this value.

For accurate measurement, compensate the measured value for the influence of instrument rise time, by using equation (3-3).

For example, if the rise time of an input pulse is 35 nsec, which is 5 times of the instrument rise time 7 nsec, the measured rise time will be 35.7 nsec ($Tp = \sqrt{(35 \text{ nsec})^2 + (7 \text{ nsec})^2} \doteqdot 35.7$ nsec, the rise time determined by input RC is neglected from this calculation). The measurement error in this example is approx. 2%. .For ordinary measurements, an error of this order will be permissible. In general, measurement error of this kind is neglected if the instrument rise time is 5 times faster (or more) than rise time of input pulse signal.

Influence of rise time due to input RC This rise time is determined by equation (3-2). Refer to item, Input Signal Connection, for details.

Frequency Measurement

The frequency measurement procedure is briefly classified in three methods.

First, the frequency of input signal can be obtained by measuring the one-cycle time of the signal as shown in Fig. 3-29, and calculated by using equation (3-11).

$$\text{Frequency f (Hz)} = \frac{\text{1 (cycle)}}{\text{Interval T (sec)}} \quad \text{............ (3-11)}$$

In Fig. 3-29, length of one-cycle is 8cm and A TIME/CM switch is set to 1μsec/cm. Thus, the interval T (sec) is;

T (sec) = 8cm x 1μsec/cm = 8μsec

The frequency f (Hz) can be given as;

$$\text{f (Hz)} = \frac{\text{1 (cycle)}}{8 \times 10^{-6}\ \text{(sec)}} = 125 \times 10^{3} = 125\ \text{kHz}$$

Next, the frequency of signal may be calculated by using equation (3-12), basing on number of repetitions N which is visually counted in the viewing area (10cm wide).

$$\text{Frequency of (Hz)} = \frac{\text{N (cycle)}}{\text{TIME/CM value (sec)} \times 10} \quad \text{............ (3-12)}$$

When N is large (30 to 50), the second method can assure higher accuracy than by the first method; the accuracy can be approximately equal to the rated accuracy of sweep time. However, when N is small, the count below decimal becomes very ambiguous resulting in considerable error. In the example, Fig. 3-30, N counts 34.5 and A TIME/CM is set to 1 msec. Thus;

$$\text{Frequency f (Hz)} = \frac{34.5}{1 \times 10^{-3} \times 10} = 3.45 \times 10^{3} = 3.45\text{kHz}$$

Fig. 3-29 Frequency measurement (1)

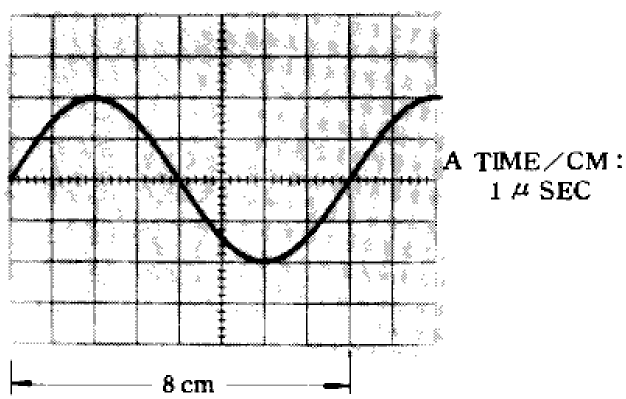
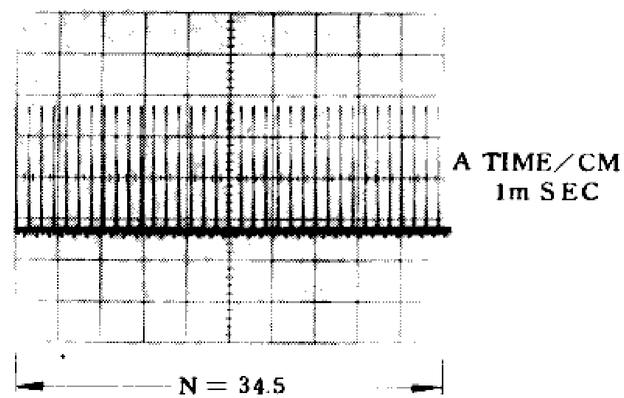


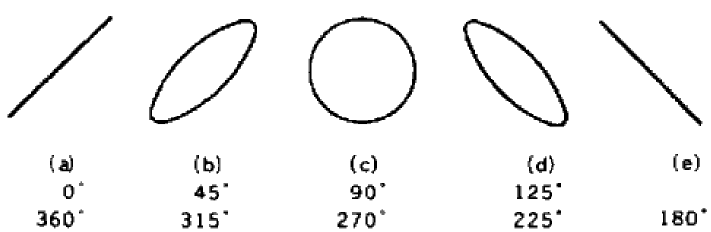
Fig. 3-30 Frequency measurement (2)



Different from the frequency measurement used in the first and second methods, the Lissajou's pattern can also be used to measure comparatively low frequencies (below 100kHz). For the Lissajou's pattern measurement, input signal waveform must be simple, i.e. sine wave, square wave, triangle wave or sawtooth wave. In this measurement, the synchroscope is operated as an X-Y scope.

The HORIZONTAL DISPLAY switch must be set to the CH 1-Y CH 2-X position, and a spot must be displayed on the CRT. Then, the signal of unknown frequency (assumed to be a sine wave signal) is applied to the CH 1 INPUT, and the other signal of known frequency (from a calibrated signal generator) is supplied to CH 2 INPUT. The synchroscope must be adjusted to set vertical and horizontal amplitudes of displayed pattern to 4cm.

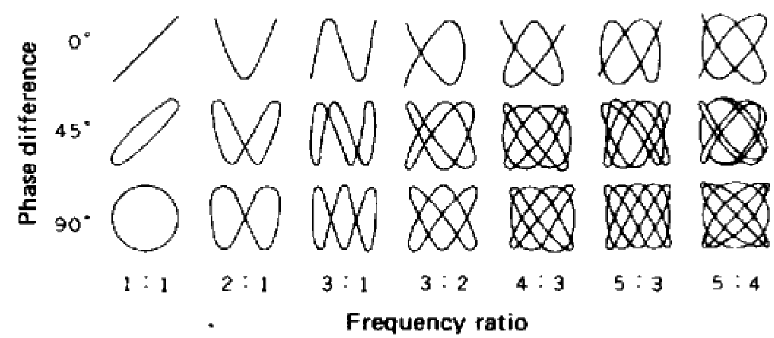
Fig. 3-31 Lissajou's patterns for sine wave signals



Then, frequency of signal from generator is changed until either one of the 1:1 Lisajou's pattern, shown in Fig. 31, is displayed. The Lissajou's pattern for frequency ratio 1:1 is either one of circle, ellipse of straight line. With the frequency ratio approaches 1:1, displayed pattern continuously repeats cycling, a→b→c→d→e→d→c→b→a .... The cycling becomes very slow when the frequency ratio approaches very close to 1:1, and the pattern stops cycling (either one of shown pattern is displayed) when it reached exactly 1:1.

When the frequency ratio reached very close to 1:1, the cycling of pattern (for example, from a to a) is repeated at a constant speed. The error frequency at the time can be known by counting the number of cycling in one second. Relative positioning of two frequencies (the unknown fre-

Fig. 3-32 Lissajou's patterns for various frequency ratios



quency is higher or lower than the SG frequency) can be known by slightly changing the SG frequency. It implies the fact that the pattern must be stopped stably, monitoring the pattern long time, when measuring a low frequency, say in the order of cvcles per second.

Fig. 3-32 shows examples of Lissajou's pattern for various ratios of sine wave frequencies. For a fractional frequency ratio, the obtainable pattern may be plotted by using the descriptive geometry technic. In general, however, it will be the easiest and the most accurate method to obtain a 1:1 pattern by using a signal generator which can continuously vary output frequency.

Fig. 3-33 shows example of Lissajou's pattern obtainable by supplying different waveforms to vertical and horizontal inputs.

Phase Measurement

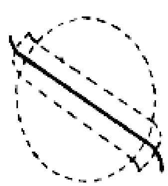
Phase difference between two signals is measured, in general, by either of the following to methods.

The first one is the Lissajou's pattern method by using the synchroscope as an X-Y scope as given in "Frequency Measurement". Phase difference of signals is calculated from amplitudes A and B of the pattern (see Fig. 3-34) by using equation (3-13).

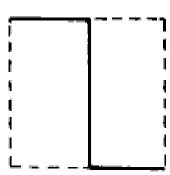
$$\text{Phase difference} = \sin^{-1}\frac{A}{B} \quad \text{.............} \quad (3\text{-}13)$$

Note that phase distortion of synchroscope will cause measurement error when input signal frequency is considerably high. This measurement is, thus, limited to signals lower than 100 kHz.

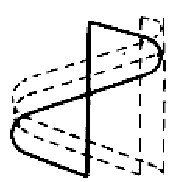
Fig. 3-33 Lissajou's patterns (1:1) for combination of different waveforms



(a) Sine wave and triangle wave

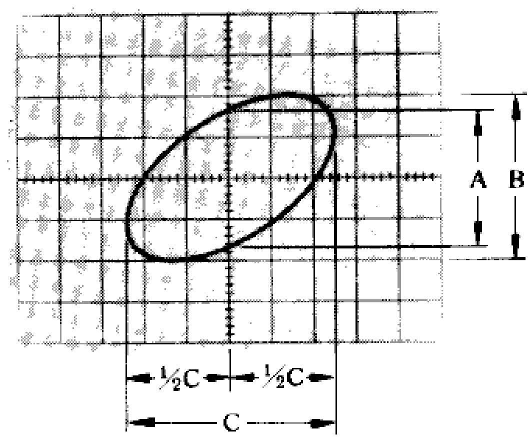


(b) Sine wave and square wave



(c) Sine wave and sawtooth wave

Fig. 3-34 Phase difference measurement using Lissajou's pattern



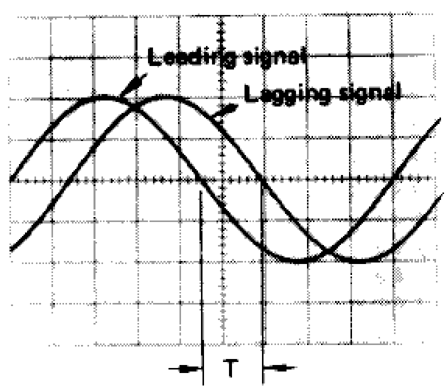
The second method is an application of dual-trace function. Fig. 3-35 shows an example of dual-trace display to leading and lagging sine wave signals of the same frequency. When the sweep is internally triggered, the TRIGGER switch must be set to a channel which is connected to the leading signal.

The keypoint of this method is to set the length of displayed 1-cycle waveform to 9cm. Then, 1cm of graticule represents a 40° of waveform phase (1 cycle = 2π = 360°). Therefore, the phase difference between signals can be easily calculated by using equation (3-14).

Phase difference = T x 40° ....(3-14)

where T: distance between crosspoints of leading and lagging signals to the horizontal center graticule

Fig. 3-35 Phase difference measurement by dual-trace display



In the example in Fig. 3-35, the distance T is 1.4cm, thus, the phase distance is given from equation (3-14) as;

40° x 1.4 = 56°

It is a typical procedure to measure the phase of signals of equal frequency, however, this method shown in Fig. 3-35 can be adoptes to measurement of signals having different frequencies (with integer frequency ratio). In this case, the triggering source must be the channel connected to the lower frequency source. (The triggering procedure is detailed in Section 2, Triggering.)

Photo-taking of Waveform

When recording displayed waveform, photo-taking is used most popularly. Photo-taking operation will be described in this part.

Removing the filter

A blue filter is used to protect the viewing area from reflection of external light and to improve contrast of trace. However, the filter should be removed before photo -taking the displayed waveform so that sensitivity of film will be raised.

To remove the filter, push the bottom of filter downward, and the top of filter slips out. Pull the top edge of filter forward. Rough handling of filter will result in breaking it. Be careful when removing it.

Camera Mounting Device and Trace Recording Camera

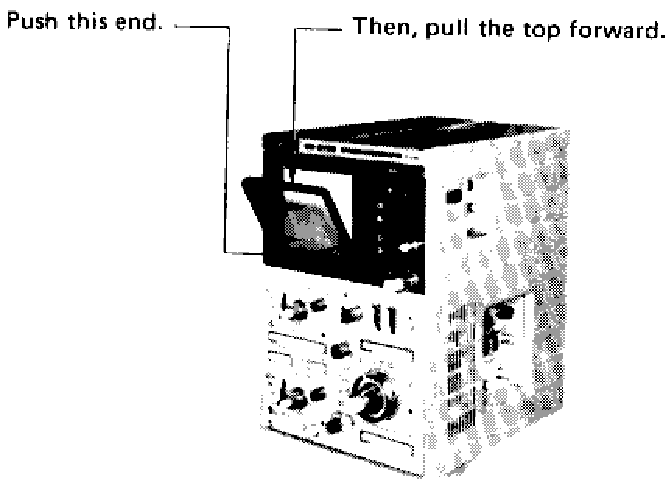
Camera mounting device and trace recording camera photo-taking of waveform are available from IWATSU. Two types, UP-8 and UP-11 are suitable for this instrument. These devices are composed of a camera mounting hood and adapter. These devices use the type B camera mounting adapter. Refer to Instruction Manual for relevant camera mounting device, for mantling and operation. Fig. 3-37 shows this instrument with UP-11 device mounted.

Photo-taking Procedure

In order to expect a qualified photos using the camera mounting device, it is essential to select a film and to set controls of camera and synchroscope as given below.

Selection of film Though the type of film will differ with type of camera to be sued, it is better to use an ASA 200 (SSS) film when using a 35mm camera or its equivalent with UP-8. For a Polaroid 180, type 107 film (equivalent to ASA 3000) is recommended. Type 42 film (equivalent to ASA 200) will be suitable for Polaroid 120.

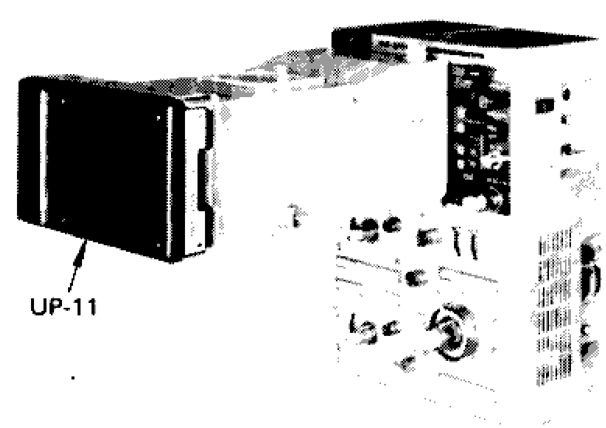
Fig. 3-36 Removing the filter



When using the UP-11 with Polaroid camera, type 107 film must be used.

Shutter speed, exprosure and focusing Setting of shutter speed and exposing time is dependent on many variables, such as phosphorescence wavelength of CRT, sensitivity of film, type of displayed waveform (sine wave, pulse, or square wave) and sweep time. Tables 3-1 and 3-2 will give a guide to exposure time for XXX and polaroid films. Focus the camera to infinite (∞) when using the UP-8. For UP-11, the camera may be set any focusing, because the camera mounting device automatically makes correct focusing.

Fig. 3-37 UP-11 mounted on this instrument



Trace intensity and scale illumination Exposing time and shuuter speed can be set as shown in Table 3-1 or 3-2, but trace intensity and scale illumination also affect quality of photos, if they are exceesively intensified or too poor.

Before taking the photograph observe the waveform from the camera finder and adjust the SCALE ILLUM and INTENSITY control to obtain an adequate intensity of trace brightness.

The scale illumination should rather be brighter than the trace intensity.

Before taking a photo of the single sweep display, change the sweep to ordinary mode and supply a test signal (for example, CAL OUT signal) to adjust trace intensity, focusing and triggering.

Table 3-1 Exposing time for SSS film

Sweep mode	Sweep time	Aperture stop	Shutter speed
Ordinary sweep	0.1μs ~ 1μs	2	1/8 ~ 1/15
(repetitive	1μs ~ 10μs	2 ~ 2.8	1/15 ~ 1/30
waveform)	10μs ~ 0.1ms	2.8 ~ 3.5	1/30
	0.1ms ~ 1ms	3.5 ~ 4	1/30
	1ms ~ 10ms	4 ~ 4.7	1/30
Single sweep	0.05μs ~ 0.1μs	1.2 ~ 1.8	T or B
(single	0.1μs ~ 1μs	1.8 ~ 2.8	T or B
waveform)	0.1s ~ 10s	8 ~ 11	T or B

NOTE: Use the ilis value given to an ordinary sweep mode, for a single sweep photography with sweep time of 1μs to 0.1sec.

Table 3-2 Exposing time for polaroid film

Sweep mode	Sweep time	Aperture stop	Shutter speed
Ordinary sweep	0.1μs ~ 1μs	4.5 ~ 5.6	1/15
(repetitive	1μs ~ 10μs	5.6	1/15 ~ 1/30
waveform)	10μs ~ 0.1ms	5.6 ~ 8	1/30
	0.1ms ~ 1ms	8 ~ 11	1/30
	1ms ~ 10ms	11 ~ 16	1/30
Single sweep	0.05μs ~ 0.1μs	3.5	B
	0.1μs ~ 1μs	4.5	B
	0.1s ~ 10s	16 ~ 22	B

NOTE: These values are for an ASA 300 Polaroid film. Use the aperture stop value given to an ordinary sweep mode, for a single sweep photography with sweep time of 0.1μsec. to 0.1 sec.

Measurement of Non-electric Phenomena

Though the direct measurement by using a synchroscope is limited to voltage measurements, recent development of transducers, which convert many other phenomenon into voltage variation, extended application of a synchroscope to wide range of phenomena. The measurement by synchroscope is now applicable to measurement of variation in kinetic system, optical event, temperature and chemistry.

Typical transducers available at present will be briefly described in this part.

Measurement of Kinetic Variations

The following behavior of substances against external force is utilized to convert kinetic variations of a thing, i.e. displacement, distortion, pressure or vibration, into electrical variation.

(1) Variation in electric resistance of resistive wire or semiconductor against external force;
This transducer is known as the strain gauge.

(2) Electric polarization of quartz or Barium Titanate against pressure;
Amount of the electric polarization, i.e. the Piezo Effect, is proportional to given pressure. The transducer of this type is known as a Piezo Element.

(3) Moving electrodes which vary the electrode distance with given external force;
The variation in electrode distance changes internal capacitance of electrodes. The variable capacitance element.

(4) Ferro-magnetic substance whose magnetic property changes with given distortion;
The magnetostriction element.

(5) Electromagnetic variation with given displacement;
The electromagnetic transducer.

Many other kinetic-electric transducers will be available. All of these transducers are used bonded, directly to measured object or to an interim medium, or making a contact to the object.

These transducers are selectively used, by their particular behavior, for distortion measurement, pressure measurement, vibration measurement and so on. Further they can be also classified, with measurement condition, as shown below;

Operable in very high tempearture ambient or in high humidity, suitable for high frequency operation, safe against large input amplitude, or very sensitive against small input.

Many other transducers are under development. They will extend the application of synchroscope measurement technic much further.

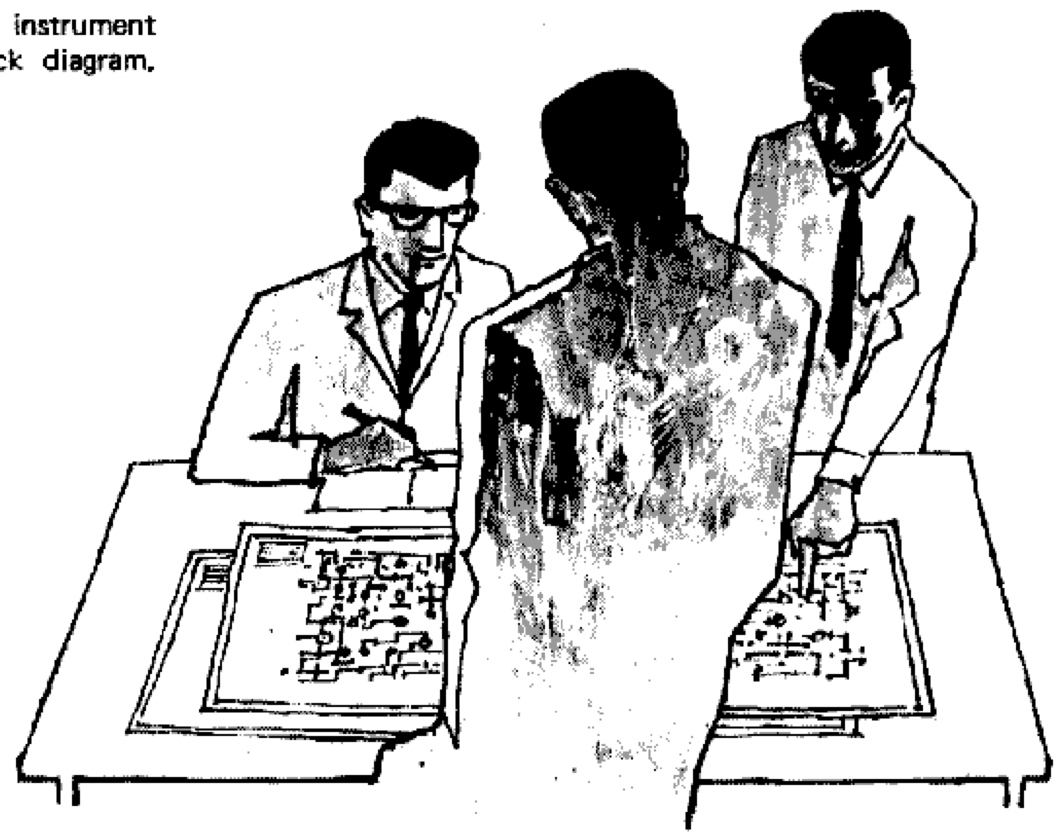
Optical or Temperature Measurement

The light can be converted into electric signal by using a photo-electric tube or a photo-transistor. The photomultiplier tube is suitable for sensing of very low light intensity.

For temperature measurement, available transducers include the thermistor which utilizes thermal variation of electric resistivity of semiconductor, and the thermo-couple in which two types of metallicleads (copper and constantan wires) are coupled to output an electromotive force against temperature given to the coupling point.

SECTION 4 OPERATING PRINCIPLE

In this section, operating principle of this instrument will be briefly described referring to a block diagram.



Operating Principle

The circuit configuration of this instrument is shown in Fig. 4-1. Each block of circuit is designed to deflect electron beam of CRT, consequently.

CH1, CH2 Preamplifiers

Two preamplifiers operate independently in the vertical deflection system. The input signal is supplied to the INPUT connector of these preamplifiers. The preamplifier converts the unbalanced input signal into a balanced signal before the signal is amplified and supplied to the switching circuit.

Switching Circuit

When the diode gate turns ON/OFF, the switching circuit supplies input signal given from CH 1 or CH 2 preamplifier, or signals from both preamplifiers, to the vertical main amplifier.

In other words, the MODE switch controls selective display of CH 1 or CH 2 signal, electronically switched dual-trace display (ALT or CHOP) or sum or difference measurement of two signals (ADD). In the ALT mode, diode gates are alternately opened or closed at the end of each sweep (supplied from A or B Sweep Generator), thus, CH 1 and CH 2 signals are alternately displayed at each sweep. In the CHOP mode, the channel signals are chopped and alternately displayed at a repetition rate approx. 1 MHz irrespective the sweep rate. In this mode, the 1 MHz switching signal (chop blanking pulse) is supplied to the Z-axis amplifier to blank transient of switching from display.

Vertical Main Amplifier

The vertical main amplifier amplifies given balanced signal to a sufficient level required for vertical deflection of electron beam of CRT.

Trigger and CH 2 OUT Amplifier

A portion of signal supplied to the INPUT connector (the trigger signal) is branched from preamplifiers to the trigger amplifier. This signal is amplified before supplied to the A and B trigger generators. A portion of input signal to the CH 2 INPUT is amplified 5 times and led to the CH 2 OUT connector.

A and B Trigger Generators

The A and B trigger generators convert given trigger signal into trigger pulses of a fixed rise time and amplitude. The trigger pulses are generated for external trigger signals from TRIG INPUT connector or for line frequency signal supplied from power transformer.

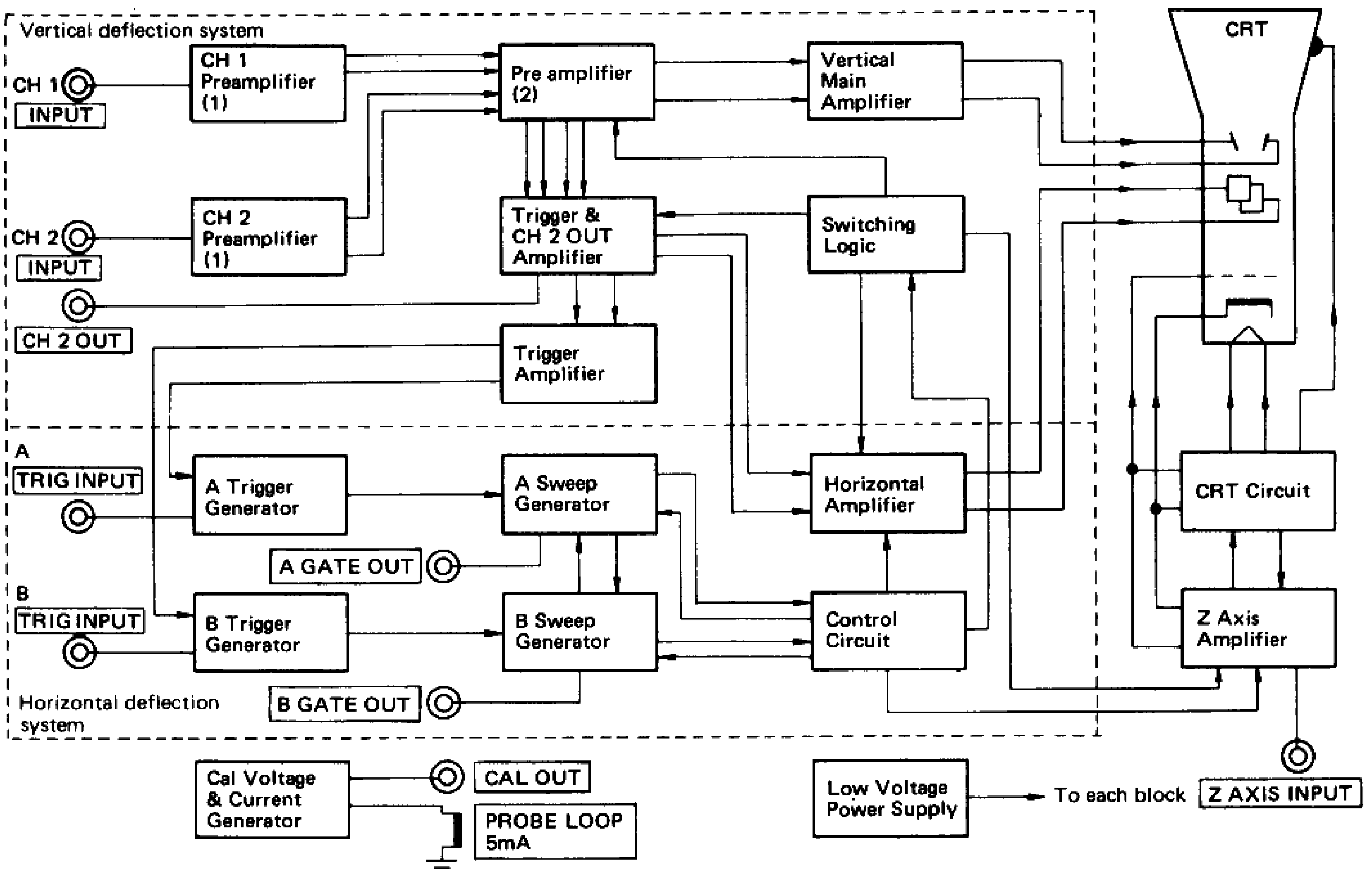
A and B Sweep Generators

The A sweep generator outputs A sawtooth signals triggered by the A trigger pulses. Similarly, the B sweep generator outputs B sawtooth signal triggered by the B trigger pulses. Normally, these sweep generators operate independently, but coupled when delayed sweep is required. Unblanking signals are supplied from these sweep generators to the Z axis amplifier. In the A INTEN BY B operation, these blanking signals are superimposed to make a part of displayed waveform, which is common to the A and B blanking signals, much more intensified. A and B gate signals are extracted to the A GATE OUT and B GATE OUT connectors, respectively.

Horizontal Amplifier

The horizontal amplifier amplifies sawtooth wave signals supplied from A and B sweep generators to a sufficient level required for horizontal deflection of CRT electron beam.

Fig. 4-1 Basic block diagram



This synchroscope functions as an X-Y scope by setting the HORIZONTAL DISPLAY switch to the CH 1-Y CH 2-X position. In this case, the input signal supplied to the CH-1-INPUT is finally led to vertical deflection plates of CRT, as the Y signal. Similarly, the input signal to CH 2 INPUT is led to horizontal deflection plates through the CH 2 preamplifier, trigger amplifier and horizontal amplifier, as the X signal.

Z Axis Amplifier

The Z axis amplifier amplifies the unblanking signals from A and B sweep generators, chop blanking pulse from the switching circuit and intensity modulation signal supplied from the Z AXIS INPUT connector. This amplifier also outputs a voltage in proportion to a control given to the INTENSITY control.

These signals and voltage are supplied to the control grid of CRT to control intensity of trace.

CRT Circuit

The CRT circuit produces high voltages required to radiate and accelerate the CRT electron beam and a 6.3V AC required to heat the CRT filament.

Low Voltage Power Supply Circuit

The low voltage power supply circuit outputs a 6.3V AC to illuminate scale lamps and various regulated DC voltages requied for other circuits.

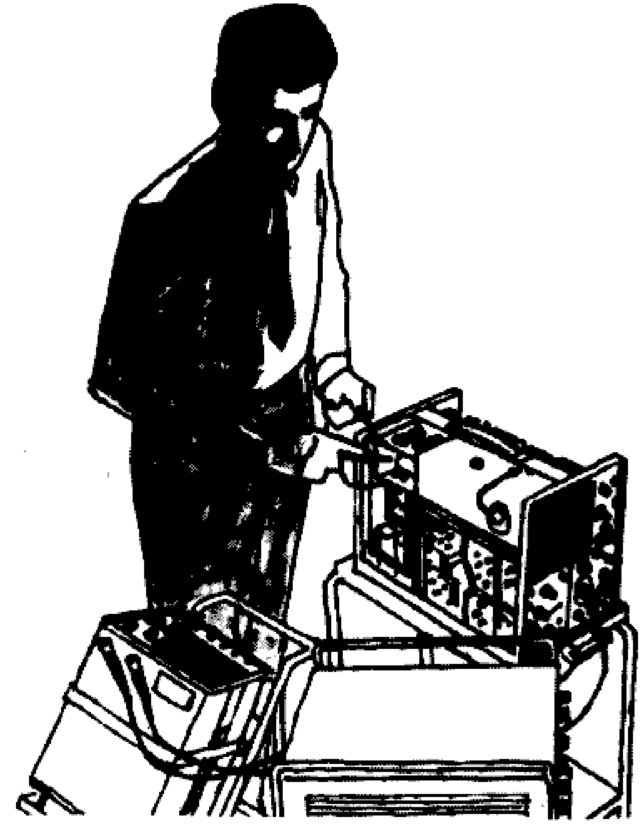
Calibration Voltage and Current Generator

The calibrator circuit outputs a voltage signal required to calibrate sensitivity of amplifier system and the voltage probe, and a current waveform required to calibrate the current probe.

SECTION 5 MAINTENANCE

Maintenance steps which will ensure correct operation of this instrument for a long period of time are described in this section. Refer to the Circuit Layout in Section 8 for locating a part or unit for which inspection or replacement is required.

In order to expect correct operation of this synchroscope over a long period of time, correct operation as given in Section 2 is essential, as well as proper maintenance given in this section.



PREVENTIVE MAINTENANCE

These are the precautions on preventive maintenance which will protect the instrument from trouble and keep it clean over a long period of time.

Cleaning

Since extent of smearing of instrument depends on ambient condition in which the synchroscope is used, number of time of cleaning can not be defined initially. Clean it any time required. Dust deposited inside the instrument affects normal flow of cooling air and easily invites local overheating of parts or trouble. Smeared switch contacts or connector pins can be the cause of defective contact, and smearing of circuit can cause arcing between circuits, particularly in moist season.

Cleaning agents recommended or must not be used are listed in Table 5-1.

Table 5-1

Recommended agent	Alcohol, gasoline or kerosene
Unsuited agent	Acetone, tri-ethyl-ketone, ether, lacquer thinner or agent containing ketone series solvent.

Cleaning the Cover

Normal smearing of cover can be cleaned by waching the cover with a neutral chemical cleaner. For greasy smearing, use a recommended agent in Table 5-1 with a soft cloth.

Front and Other Panels

Clean smeared panel with a soft cloth moisted with a recommended agent. Note that cleaning with alcohol may leave slight blotting. Neutral chemical cleaner may be used but the cleaner left on the panel or knob must be removed with a cloth soaked in water.

Dust in Instrument

The best way to remove dust inside the instrument is the blowing of compressed air. Remove persistent dust with a soft painting brush and blow the air again.

CRT

The CRT screen will be smeared if it is used long without the filter. Ordinary dust or fingerprint laft on the CRT can be cleaned by a soft cloth. Use a soft cloth moisted with alcohol to remove persistent smearing.

Filter

The filter may be clogged when used long time. Dust or fingerprint can be cleaned with a dry, soft cloth. Use a soft cloth moisted with alcohol to remove persistent smearing.

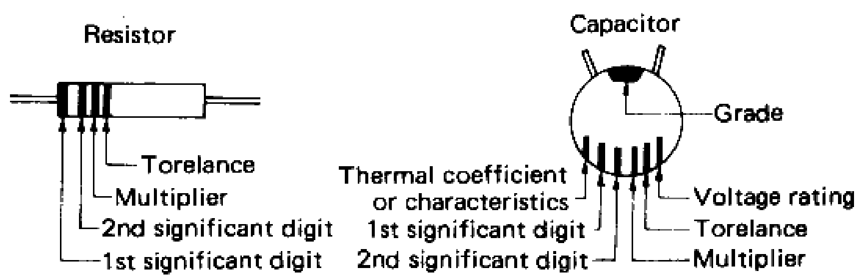
Before Preserving the Synchroscope

Before preserving the synchroscope, remove probe and adapter from panel, and store these accessories in provided accessory case. Cover the synchroscope, and store it in a dry place. It prevents deposition of dust.

Visual Inspection

Periodically inspect condition of internal circuit. Burnt resistor, defective contact of connection, broken printed circuit board and many other defects can be easily

Fig. 5-1 Color coding of resistor and capacitor



Color	Resistance or capacitance value		Torelance for resistor	Torelance for capacitor		Voltage rating for capacitor
	1st or 2nd significant digit	Multiplier		Above 10pF	Below 10pF	
BLK	0	1	–	±20.0	±2.0	–
BRN	1	10	±1	±1.0	–	–
RED	2	10^2	±2	±2.0	–	250V
ORG	3	10^3	–	±2.5	–	300V
YEL	4	10^4	–	–	–	–
GRN	5	10^5	–	±5.0	±0.5	500V
BLU	6	10^6	–	±100	–	–
VLT	7	10^7	–	–	–	–
GRY	8	10^8	–	±10.0	±0.25	–
WHT	9	10^9	–	–	±1.0	1000V
GOLD	–	10^{-1}	±5	–	–	–
SILVER	–	10^{-2}	±10	–	–	–
No color	–	–	±20	–	–	–

checked. Prompt repair of these minor defects can prevent troubles, or limit the defect within the minor level.

Periodical Calibration

In order to use the synchroscope accurately, periodical calibration of circuits is essential. When this instrument is used, frequently a calibration will be required at every 1000 hours of operation. The frequency of calibration may be extended to 6 months, if the synchroscope is used not frequently.

TROUBLESHOOTING

Troubleshooting steps to be taken when a trouble occured are given in this part. Correct understanding on overall operation system and operation of circuits greatly aids effective troubleshooting. Read Section 4 to understand the basic functioning of circuits.

Guides to shoot Troubles

Schematic Diagrams

In this manual, schematic diagrams are grouped, in general, with circuit blocks classified in Fig. 4-1. Refer to Section 8 for circuit symbols, markings and special codes.

Circuit Layout

Location of circuits within the cabinet is shown in Circuit Layout of Section 8. Use the photographs to locate circuits for inspection.

Parts Layout

Refer to part No. printed on the printed circuit board to identify parts mounted on the board.

Color Code of Wire Leads

Wires with mixed color code are used for wiring of low voltage lines. The coding is shown in Table 5-2.

Color Code of Resistors and Capacitors

Most of resistors and capacitors in the circuit are color coded by resistance value or capacitance. See Fig. 5-1 for the color code.

Polarity Marking of Transistors and Diodes

Tables 5-3 and 5-4 show marking of polarity or electrode of semiconductors, by type.

Table 5-2 Color coding of power supply wiring

Low voltage supply	Main color	Auxiliary color
+240 V	WHT	BLU
+ 60 V	WHT	YEL
+ 40 V	WHT	BLN
+ 12 V	WHT	RED
– 12 V	WHT	BLK
ground	BLK	–

Table 5-3 Marking for transistor electrode

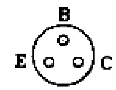
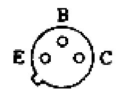
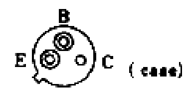
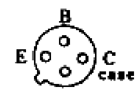
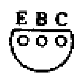
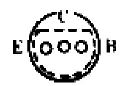
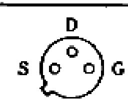
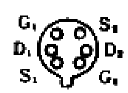
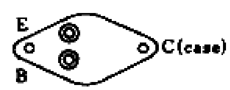
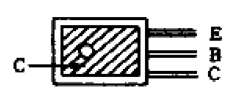
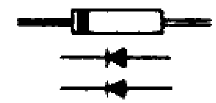
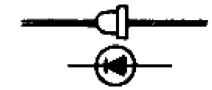
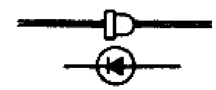
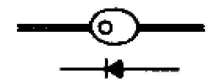
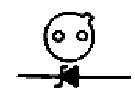
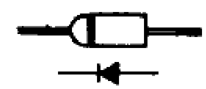
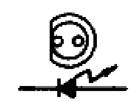
Type of transistor	Electrode marking
2SC857 (K)	
2SA578, 2SA711, 2SC154C 2SC1216, 2SC1412 2SC907HC, 2N4034, BFW30	
2SA606, 2SC995 2SD221, 2N3119	
2SC1254 2SC1275	
2N5771 2N3905 | 2SC373 2SA495 O/Y	 | 
30088C 2SK12 5007-2	
KH5199	
Power transistor 2SD93	
Power transistor MJE1102, MJE3055	

Table 5-4 Marking for diode electrode

Type of diode	Electrode marking
1S953, 1S955 , 1S1924 1S1554A, 1SS16, NDP127 RD type, HW type	
1S1760	
1S2200	
1S1458	
V03C	
1S2191	
HVT30S	
SL103	

Instruments Required for Troubleshooting

At least, the following instruments are required for troubleshooting of this instrument.

(1) Multimeter

Input resistance	:	10MΩ
Voltage range	:	0 to 300V, and special position for 2kV
Ohm range	:	0 to 20MΩ

(2) Transistor curve tracer
IWATSU model TT505, or TT506 (or its equivalent)

(3) Synchroscope

Frequency bandwidth	:	DC to 10MHz
Sensitivity	:	5mV/cm

Troubleshooting Steps

The first thing in troubleshooting is to examine if the irregular event like "a circuit trouble" is really due to a trouble within circuit, or caused by an external event. For example, certain irregular operation will occur, in a normal synchroscope, if the line voltage is out of the rated voltage range, or an INPUT is affected by induction of external signal.

Then, repeatability of the trouble must be checked. For example, when sweep is normal but irregular signal is displayed with a signal supplied to the INPUT connector, the other signal must be supplied to the input to check if the same irregular display occurs (if it occurs, the synchroscope is responsible for the trouble).

When the trouble persists against these preparatory checks, the following actual steps must be performed.

(1) Do not open covers to inspect inner circuits, before the basic operation tests given in Section 2 and a circuit suspicous for the cause of trouble becomes clear.

(2) Then, open covers and visually examine parts, wirings and copper foils of a circuit board, which is supicious for the cause of trouble, for burnt resistor, opened wiring connection or soldering. Most of the cause of troubles will be readily checked out by the visual inspection of circuit.

(3) When parts and wirings look normal, check low and high voltage power supplies. Particularly, the low voltage power supply gives considerable influence on operation of main circuits. If a DC line voltage is found excessively high, check and the cause first.

(4) Electrical check of circuit takes place when the trouble still persists. Use the multi-meter or synchroscope making close reference to relevant schematic diagram listed in Section 8, to isolate the cause of trouble.

(5) Finally, electric characteristics of active elements (transistor, diode or IC) suspicious defective, by using the Curve Tracer. Also check passive elements (resistor, capacitor, etc.) and replace suspicious parts. In many cases, a number of parts can be defective.

DISMANTLING

In this part, steps to dismantle parts or units of the synchroscope required for inspection of circuit or replacement of defective part.

Be sure to disconnect the power plug from the line receptacle.

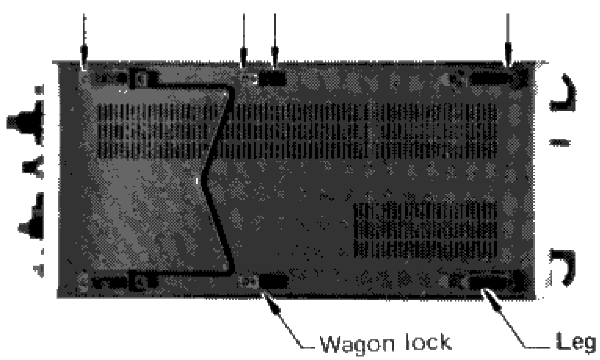
Cover

The left and right side covers can be dismantled by sliding two stoppers on the panel as indicated by an arrow marked on the panel, and lifting the cover upward.

Remove four screws located outside the legs, to dismantle the bottom cover. These legs are secured to the bottom cover by screws inside the leg.

The rear cover can be dismantled by removing two mounting screws. Two cord hooks will come out with the rear cover. When mounting the rear cover, tighten the screws with stopper of cord hooks lined with a hole bored on the cover.

Fig. 5-2 Dismantling of bottom cover

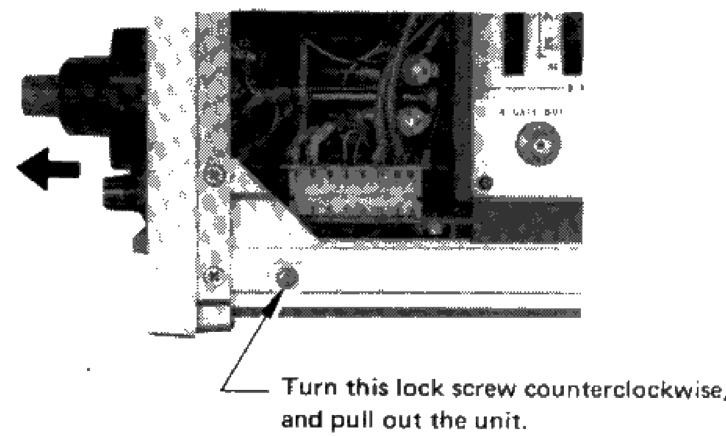


Plug-in Unit

By opening the left and right covers, a locking screw for plug-in unit is visible in lower front of each side, as shown in Fig.5-3. Unlock the unit by turning the lock screw counterclockwise, and pull out the plug-in unit.

Be careful not to supply the power to this instrument with the plug-in unit removed.

Fig. 5-3 Dismantling the plug-in unit



Power Supply Unit

Open the side and rear covers and remove four mounting screws as shown in Fig. 5-4 and disconnect the two pin connectors wired from the power supply unit to the main frame. The unit can be pulled rearward.

Panel

To dismantle panels, remove all knobs from panel by loosening setscrew with provided hex wrench.

Loosen and remove nuts from rotary switches, variable resistors and connectors (these nuts secure the control to front panel and sub panel). In vertical and horizontal plug-in units, front panel is bonded to sub panel. Pry the bonded part with a knife, as shown in Fig. 5-5, to separate the panels.

Printed Circuit Board

Printed circuit boards can be dismantled by pulling out pin-connector and multi-connector from each board, and loosening mounting screws.

Be sure to return the connectors to correct printed circuit board, when assembling the circuits. Otherwise, burning off of parts will result.

Fig. 5-4 Dismantling the power supply unit

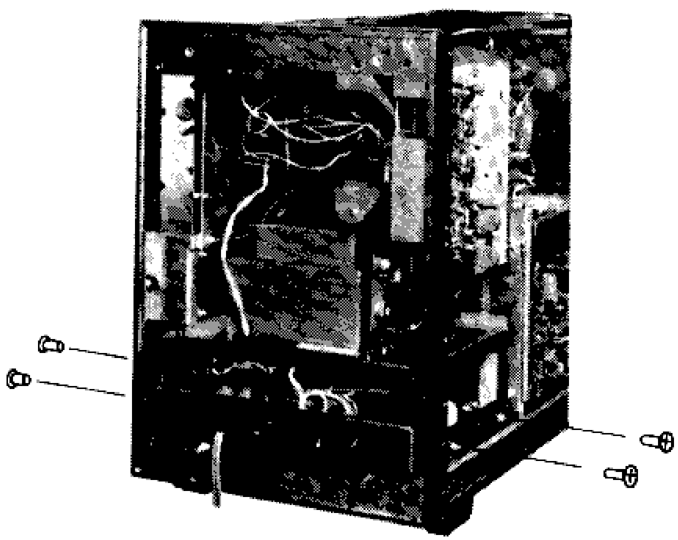
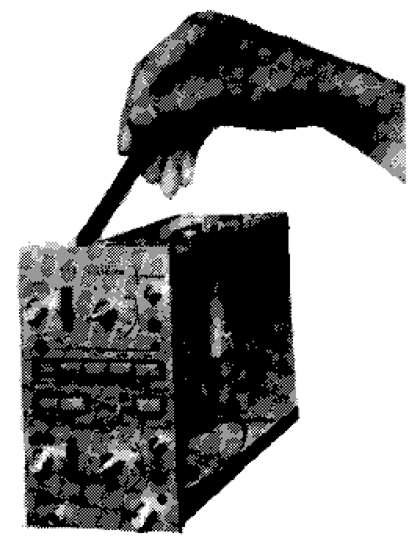


Fig. 5-5 Dismantling the panel



PARTS REPLACEMENT

Observe the following precautions when replacing parts. When replacing parts in the high voltage power supply circuit, pay special caution to hold correct insulation of parts, and avoid electrical shock to your body when supplying the power to the unit.

IC and Transistor

In order to facilitate replacement, IC's and transistors are mounted on a socket, except those in the vertical plug-in unit, power transistors and some exceptions. Observe correct polarity of electrodes when replacing the socket-mounted transistors or IC's.

As shown in Fig. 5-6 IC's must be inserted in the socket with the slotted side lined with the slot on socket. Pins are numbered as marked on the socket (pin 1 is below the slot when setting the slot leftward).

In special IC's made by IWATSU, pin No. 1 is positioned at the deeply chamfered corner. Because of special designs, IWATSU IC's are not interchangeable with other make.

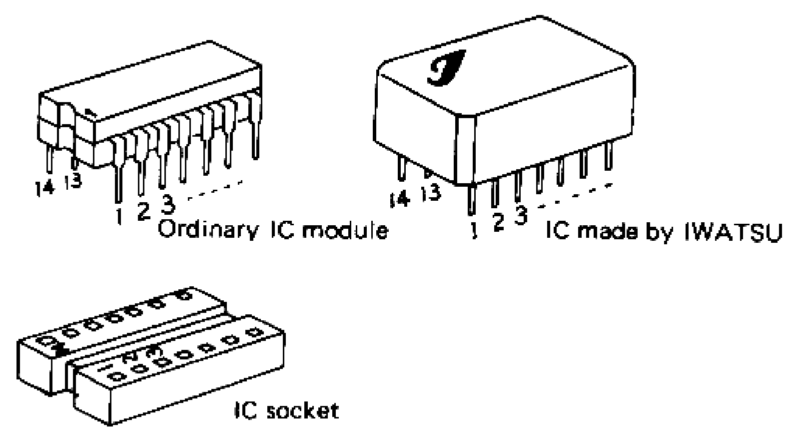
Transistors must be replaced with qualified ones. Some of transistors are specially selected to ensure the performance of this instrument rated in Section 1.

The selected type of transistors are given in Table 5-5. Refer to Table 5-3 for identification of electrodes.

Table 5-5 List of specially selected transistors

Circuit	Designation of specially selected transistor
CH 1 PREAMPLIFIER (1)	Q102 (DN 1025) Q141- Q145 (2SC1254) Q178- Q180 (2SA711)
CH 2 PREAMPLIFIER (2)	Q202 (DN 1025) Q241-Q245-Q287 -Q290 (2SC1254) Q278-Q280-Q295 -Q296 (2SA711)
TRIGGER AMPLIFIER	Q412-Q413-Q432 -Q433 (2SC1254) Q442-Q443 (2SA711)

Fig. 5-6 Pin No. of IC



Parts on Printed Circuit Board

When replacing diodes, resistors or capacitors mounted on the printed circuit board, particular care must be exercised on handling of soldering iron so as not to peel the copper foil off or break the parts.
Diodes and other semiconductors are delicate to heat. When unsoldering or soldering, hold the diode side of wire lead being heated with pliers or tweezers to absorb the soldering heat. Complete soldering or unsoldering quickly. Replacement diodes must be qualified ones similar to transistors.

Resistors, capacitors and other passive parts are also specially selected for high performance. All of these parts require replacement with qualified ones. Burning out of resistor(s) or short-circuitting of capacitor(s) can occur incidentally with short-circuitting of transistor or other excessive variation in performance. Check and remove the cause of these defects before replacing the passive parts.

Power Transistor

The power transistor of this synchroscope are located on the rear heat sink. To remove the transistors, remove the rear cover and then four screws which are located inside the cover and used to fix the heat sink. After removing the heat sink, the transistors are easily removed. The insulation mica used between the transistors and the heat sink to improve the thermal conduction must be coated with silicon grease on the both side.

Fuse

In addition to the power protection fuse located on the rear panel, low voltage protection fuses are on the printed circuit board in the rear of chassis and a CRT protection fuse is on printed circuit board in the upper right of chassis.

Ratings for these fuses are shown in Table 5-6.

Table 5-6 Fuses

Citcuit No.	Type of fuse	Function	Location
F1901	2A slow-blow	Use this fuse when power voltage switch is set to A or B.	Rear panel
	1A slow-blow	When the switch is set to C or D.	
F1912	0.25A	+240 V supply	
F1913	0.25A	+150 V supply	
F1914	0.5A	+ 65 V supply	
F1701	0.5A slow-blow	CRT circuit	Upper right PCB

CRT

Dropping of or excessive shock to CRT is very hazardous. Handle the CRT with special care. Do not apply excessive force to deflection pin. It can crack glass wall around the pin.

Dismantle the CRT, when required, in the sequence given below;

(1) Open the side and rear covers.
(2) Pull off the CRT socket.
(3) Remove the anode cap. Discharge the cap before

making access to the cap, as it may be charged with high voltage.
(4) Remove deflection pins.
(5) Unsolder wiring to beam rotation coil.
(6) Remove the title frame by loosening two mounting screws. Then, remove two mounting screws from the bezel. Remove the bezel, filter and mask.
(7) Remove two mounting screws of scale lamp mount upward.
(8) Loosen three mounting screws (in the front end) and a CRT holder screw (at the neck of CRT), and gradually pull out the CRT forward.

The CRT can be mounted in the reversed manner. Be sure to insert the deflection pins in correct position. When the CRT is replaced, the entire circuit must be calibrated.

High Voltage Oscillator Transformer

Before replacing the high voltage oscillator transformer, which supplies high voltages to the CRT, be sure to turn the POWER switch off and disconnect the power plug from the line. The high voltage circuit may be charged by very high voltage. Be sure to discharge the anode cap by shorting it to the chassis. Dismantling sequense is as follows:
(1) Open the right side cover.
(2) Open the high voltage protection cover by removing four mounting screws (this cover is in the right side of chassis).
(3) Pull out the printed circuit board which holds the transformer, forward , by remorving five screws.
(4) Unlap vinyl tape.
(5) Remove the transformer band (insulated with a vinyl tube) by loosening the mounting nut.
(6) Unsolder wiring to the transformer.

The transformer can be assembled in reversed manner.

After the replacement, high voltages must be calibrated.

Variable Resistor

In addition to variable resistors mounted on the main chassis, some are mounted on the plug-in units. The latter must be replaced after the unit is pulled out the chassis.

Dismantling sequence is as follows;
(1) Remove knob from shaft.
(2) Remove panels from the unit. (See procedures in page 5-8 Dismantling of Panels. The dismantling of panels is not required when the front panel and sub panel are secured by the mounting nut of control, or the mounting nut can be loosened without removing the panels.)
(3) Loosen the mounting nut.
(4) Unsolder wiring to the variable resistor and pull the resistor out.

Variable resistors can be assembled to the unit or chassis in the reversed sequence.

The vertical VARIABLE and horizontal A VARIABLE controls can be dismantled without remorving knob and panels, by loosening the coupling screws.

Roraty Switch

The VOLTS/CM and A and B TIME/CM switches are the rotary switches. These switches must be dismantled from the panel together with wired printed circuit board.

Dismantling VOLTS/CM Switch

(1) Remove nut and indicator plate, and loosen nut.
(2) Open the shield cover.
(3) Loosen the coupling with VARIABLE control.
(4) Unsolder wirings between the printed circuit board mounted on the switch and the printed circuit mounted on the unit.

Loosen mounting screws, and pull out the switch with the printed circuit.

Dismantling A and B TIME/CM Switch

(1) Remove the knob.
(2) Remove the mounting screw of switch (located in the rear of plug-in unit).
(3) Remove two mounting screws and open the right side cover.
(4) Disconnect the wires from the switch and pull out the switch to the right side.

The switch can be mounted on the chassis in the reversed sequence.

Lever Switch

Lever switches can be dismantled in the following sequence;

(1) Remove panels. (See Dismantling the Panels in page 5-8).
(2) Remove two mounting screws from switch.
(3) Unsolder wirings and pull out the switch.

Reverse the sequence to mount the switch.

Push Switch

Remove two mounting screws from push switch, unsolder wiring or disconnect connector to printed circuit board of the switch. Pull out the switch with the printed circuit board.

The MODE, TRIGGER and CH 2 POLARITY switches in vertical plug-in unit are soldered to a printed board, respectively. Remove four mounting screws from switch, and pull the switch out with the printed circuit board.

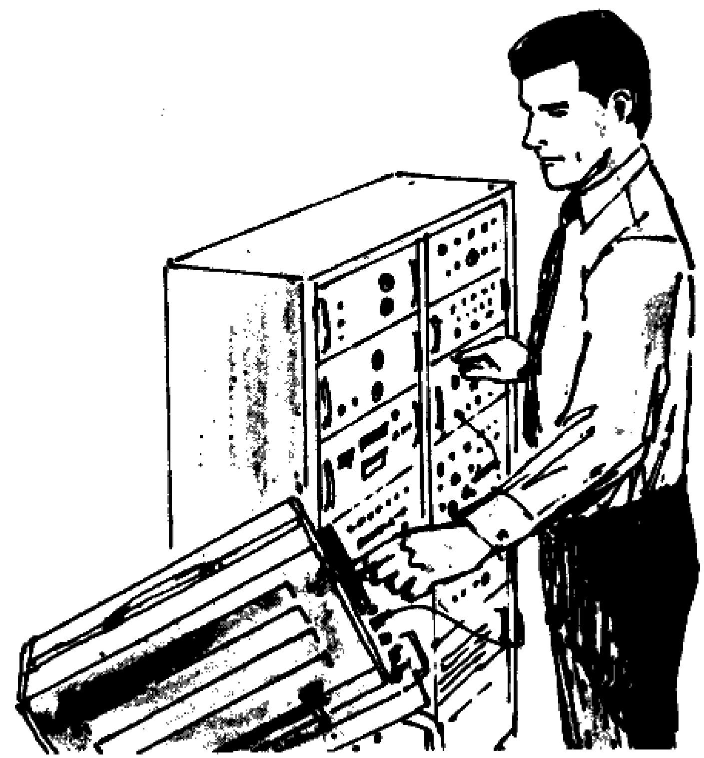
The front sub panel must be removed before removing the CALIBRATOR switch from chassis.

SECTION 6 PERFORMANCE CHECK AND CALIBRATION

In order to ensure the rated accuracy for any measurement, it is essential to retain circuits of this instrument in normal operating condition so that the rated performance of this instrument will be expected.

Reliability of performance can be expected for a long period of time by providing periodical check and calibration of performance for this instrument.

This section describes the steps required for check and calibration in detail.



FREQUENCY OF PERFORMANCE CHECK AND CALIBRATION

Since performance of this measuring instrument is subjected to aging variation, periodical checks and calibrations of the performance is required.

If the synchroscope is used very frequently, a check and calibration will be required after each 1000 hours, but the interval after the last check and calibration may be prolonged to 6 months, if it not used so frequently.

INSTRUMENT REQUIRED FOR CHECK AND CALIBRATION

The following mesuring instruments and accessories are required to provide performance check and calibration for this synchroscope.

1. Digital Voltmeter
   Voltage range — 0 to 500V DC (direct)
   0 to 2 kV DC (with high-voltage probe)
   0 to 300V AC (frequency bandwidth: 50 Hz to 100 kHz)
   Example: IWATSU VOAC707
2. Synchroscope
   Sensitivity — 5 mV/cm
   Frequency bandwidth — DC 50 20 MHz
   Cascade connection — Possible
   Example: IWATSU SS-5157
3. Sine wave generator
   Frequency range — 1 to 20 kHz
   Output voltage — 40 mVp-p or more
4. Standard signal generator
   Frequency range — 50 kHz to 50 MHz
   Output voltage — 60 mVp-p or more
   Frequency characteristics — Within ±1 dB (calibration of output voltage must be possible at any frequency)
   Example: GR model 1026
5. Square wave generator
   Repetition frequency — 1 kHz
   Rise time — 0.02 μsec or less
   Waveform distortion — As small as possible
   Output voltage — 60 mVp-p or more
6. Pulse generator
   Repetition frequency — 50 to 100 kHz
   Rise time — 1.5 nsec or less
   Waveform distortion — As small as possible
   Output voltage — 60 mVp-p or more
   Example: HP model 213B
7. Time marker generator
   Repetition period — 5 sec to 0.1 μsec
   Period accuracy — 1×10^{-5}
   Output voltage — 10 mVp-p or more
8. Universal counter
   Frequency measurement range — 500 Hz to 1.5 MHz

	Time interval measurement range	400 to 600 μsec
	Time base	1 sec to 0.1 μsec Example: IWATSU UC-6141
9.	1:1 passive probe	Example: IWATSU 116/117
10.	Voltage regulator	
11.	Cable	Example: Provided cable BB-300
12.	BNC T connector	
13.	10:1 passive probe	Example: Provided probe 1030
14.	Extension connector	Example: IWATSU optional accessory
15.	6 dB divider	Example: IWATSU B-50D3
16.	Cables of the same length	2 cables
17.	50Ω Terminator	Example: IWATSU BB-50M1
18.	Non-inductive screwdriver	Example: Probe adjustment screwdriver, an accessory

NOTES:

(1) The performance requirements shown above are the least requirements for test instruments concerned.

(2) Signal input connector of this synchroscope is the BNC type. If the output connector of a terminator or another test instrument is not the BNC type, a conversion connector must be prepared to connect the instrument directly to this synchroscope.

Performance Check and Calibration

Precautions

The following precautions must be observed before checking and calibrating the performance of this synchroscope.

(1) It is assumed, in this section, that setting of controls is made in the position described in the section of "Preparation". Therefore, the controls must be set to positions given in "Preparation", prior to starting check and calibration of all items or of limited to partial ones.

(2) Signal outputs of signal generators must be terminated by the rated output impedance (terminator).

(3) Since the low power supply voltages are commonly supplied to all circuits, excessive increase in the ripples and voltage will affect performance of the circuits. Be sure to check ripple voltages of the power supplies before starting check and calibration of the circuit performance.

(4) There are two kinds among the check and calibration items of trigger and sweep circuits; one requires an extension connector for connecting the unit and the other does not require such a connector. If there is no instruction to use such a connector, check and calibration shall be made by mounting the unit into the main frame.

(5) If a circuit does not operate as described, or it does not satisfy the rated performance, troubleshooting is required. Repeat calibration of the circuit, after the trouble is shot and repaired as given in Section 5 "Troubleshooting".

Preparation

Be sure to complete the preparation given below before starting check and calibration of performance.

(1) Adjust ambient temperature at within 10 to 35°C.

(2) Set controls as given below before supplying the power to the synchroscope.

– Front Panel –

POWER	OFF
INTENSITY	Fully counterclockwise
FOCUS	Mid-position
CALIBRATOR	20 mV
SCALE ILLUM	At any position
MODE	ALT
TRIGGER	CH1
CH2 POLARITY	NORM
AC-GND-DC	DC
VOLTS/CM	5 mV
VARIABLE	CALIB
POSITION	Mid-position
HORIZONTAL DISPLAY	A
MAIN (A) SWEEP MODE	FULL AUTO
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC
A VARIABLE	CALIB
A SWEEP LENGTH	FULL
DLY'D (B) MODE	AUTO
DELAY TIME MULTI	0
POSITION	1 o'clock position
FINE (PULL x10 MAG)	Mid-position, pushed
SOURCE	INT
COUPLING	AC
LEVEL (SLOPE)	Fully clockwise, pushed

– Right Side Panel –

SOURCE	INT
COUPLING	AC
SLOPE	+
LEVEL	Approximately mid-position
B TIME/CM VARIABLE	CALIB

(3) Set the voltage selecting plug located on the rear panel to a connection matched to your line voltage. Connect the power cord to line receptacle. If the line voltage is out of the voltage range to be covered by the selecting plug, use the voltage regulator to adjust the power supply voltage.

(4) Push the POWER switch ON, adjust intensity of trace and allow the synchroscope to be warmed up for about 1 hour.

(5) Set the MODE switch to the CH1 position.

– Power Supply and CRT Circuits –

Low Voltage Power Supply

Rating

Output DC voltages and ripple component must be within the range shown in Table 6-1.

Check and calibration

(1) Connect the digital voltmeter across a test point given in Fig. 6-1 and the ground, and check if the output voltage is within the given range in Table 6-1.

(2) If the supply voltages are out of the limit, calibrate −12V, +12V and +65V circuits in order, and check other output voltages (the power supply circuit is

designed so that other voltage outputs are automatically in the rated range when the calibration of these three circuits is completed).
See Table 6-1 and Fig. 6-1 for the sequence of calibration and the location of adjustment potentiometers.

(3) Set the MAIN (A) SWEEP MODE switch to the SINGLE position to stop sweep.

(4) Check the amplitude of the ripple component of each DC line by using a test synchroscope. Connect the vertical amplifiers of the test synchroscope in cascade to increase the sensitivity to 1 mV/cm, and use a 1:1 passive probe.

Fig. 6-1 Test points and calibration controls for low voltage power supply

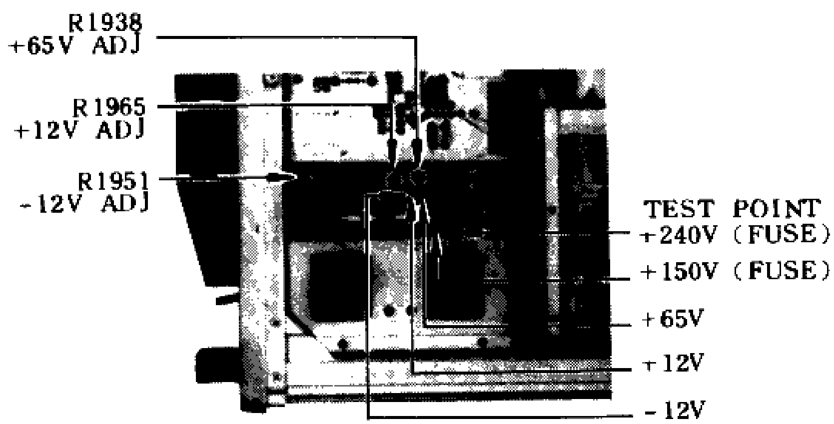


Table 6-1

Nominal voltage	Output voltage Accuracy	Ripple voltage	Check sequence	Calibration control
− 12V	Within ±0.5%	0.3 mVp-p or less	1	R1951 −12V ADJ
+ 12V	Within ±0.5%	0.5 mVp-p or less	3	R1965 +12V ADJ
+ 65V	Within ±0.5%	1.0 mVp-p or less	2	R1938 +65V ADJ
+ 30V	27 ∼ 36V	1.5 Vp-p or less	−	−
+150V	128 ∼ 172V	2.0 Vp-p or less	−	−
+240V	216 ∼ 264V	4.0 Vp-p or less	−	−

Operating Voltage Range

Rating

The display of a signal waveform must be sufficiently stable against variation in the operating voltages given in Table 6-2.

Table 6-2

Voltage selecting plug connection	Center voltage	Voltage range	Fuse
A	100V AC	90 ∼ 110V	2 A Slow
B	117V AC	106 ∼ 128V	
C	217V AC	196 ∼ 238V	1 A Slow
D	234V AC	211 ∼ 257V	

Check

(1) Turn the POWER OFF and disconnect the power cord from the line receptacle. Connect the power cord to the line through a voltage regulator (slide autotransformer), and set the regulator output voltage to the rated center voltage (see Table 6-2).

(2) Turn the POWER switch ON and connect the INPUT and CAL OUT connectors with a provided cable BB-300. The vertical amplitude of the displayed CAL signal should be 4 cm.
(3) Set the A TIME/CM switch to the 10 mSEC position.
(4) Vary the regulator output voltage continuously within the rated voltage range. Neither ripple nor intensity modulation should appear in the displayed CAL waveform.

CRT Cathode Voltage

Rating

The CRT cathode voltage, with regard to the ground potential, must be within −1550V ±10V.

NOTE: If the CRT cathode voltage is not exactly −1550V, but within the limit (±10V), calibration of this voltage is not required except in the following cases.

(1) Overall calibration of all items.
(2) Calibration of sensitivity and sweep time.

CAUTION: Be careful to protect your body from electric shock when checking or calibrating the CRT cathode voltage. Also, be sure to turn off the trace at this check and calibration, by turning the INTENSITY control fully counterclockwise.

Check and calibration

(1) Check that the CRT cathode to ground voltage is within −1550V ±10V, by connecting the digital voltmeter (with a high voltage probe) across the CRT cathode test point (see Fig. 6-2) and chassis.
(2) If the voltage is out of the limit, calibrate at −1550V with R1708 HV ADJ (see Fig. 6-2).

Intensity

Rating

A spot must appear when the INTENSITY control is turned fully clockwise, and the trace must disappear when the control is turned fully counterclockwise.

Check and calibration

(1) Set the MAIN (A) SWEEP MODE switch to the SINGLE position to stop the sweep.
(2) Turn the INTENSITY control fully clockwise and check that a spot is visible on CRT.
(3) Start the sweep by setting the MAIN (A) SWEEP MODE switch to the FULL AUTO position.
(4) Turn the INTENSITY control and check that the trace disappears.
(5) If above checks reveal unsatisfactory points, set the MAIN (A) SWEEP MODE switch to SINGLE and turn the INTENSITY control fully clockwise and adjust the voltage across the terminal B (see Fig. 6-3) of the Z axis amplifier and the ground to +30V with R1670 (see Fig. 6-3). Then, set the MAIN (A) SWEEP MODE switch to FULL AUTO and set the INTENSITY control to the position of approximately 90° left from mid-position set the R1731 INTEN ADJ (see Fig. 6-3) to the position where a trace being displayed disappears.

Fig. 6-2 Test points and calibration controls in top

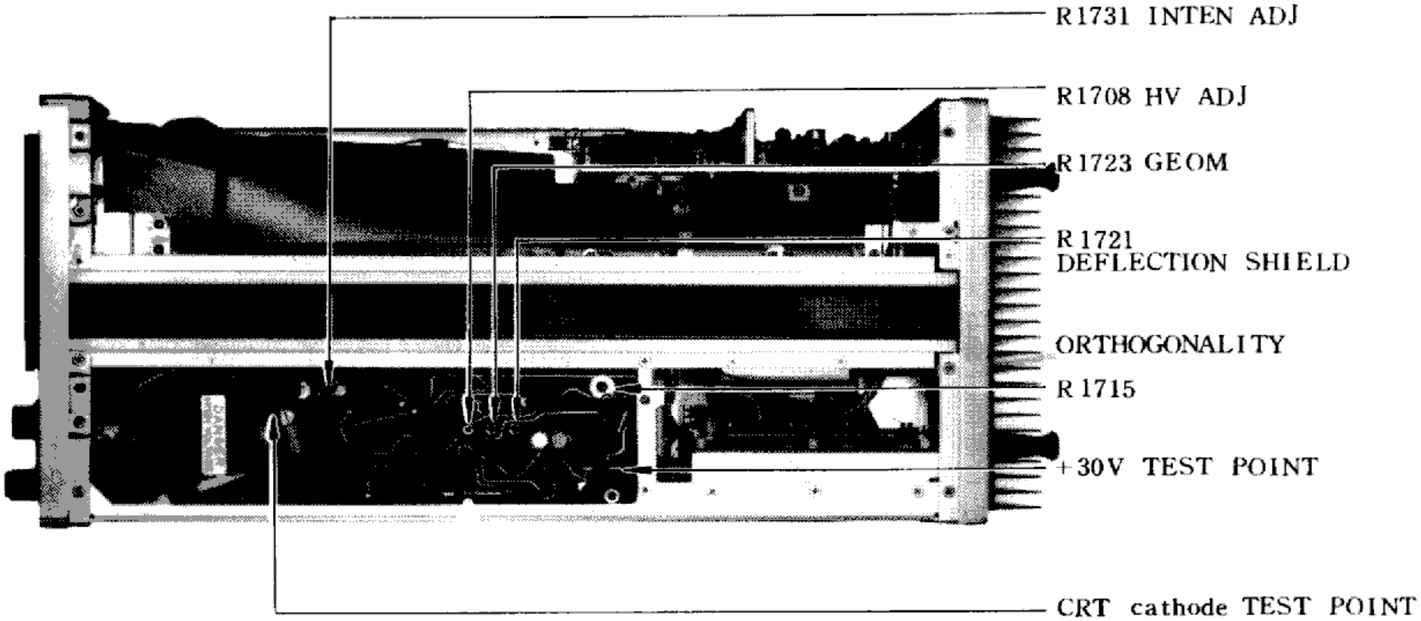
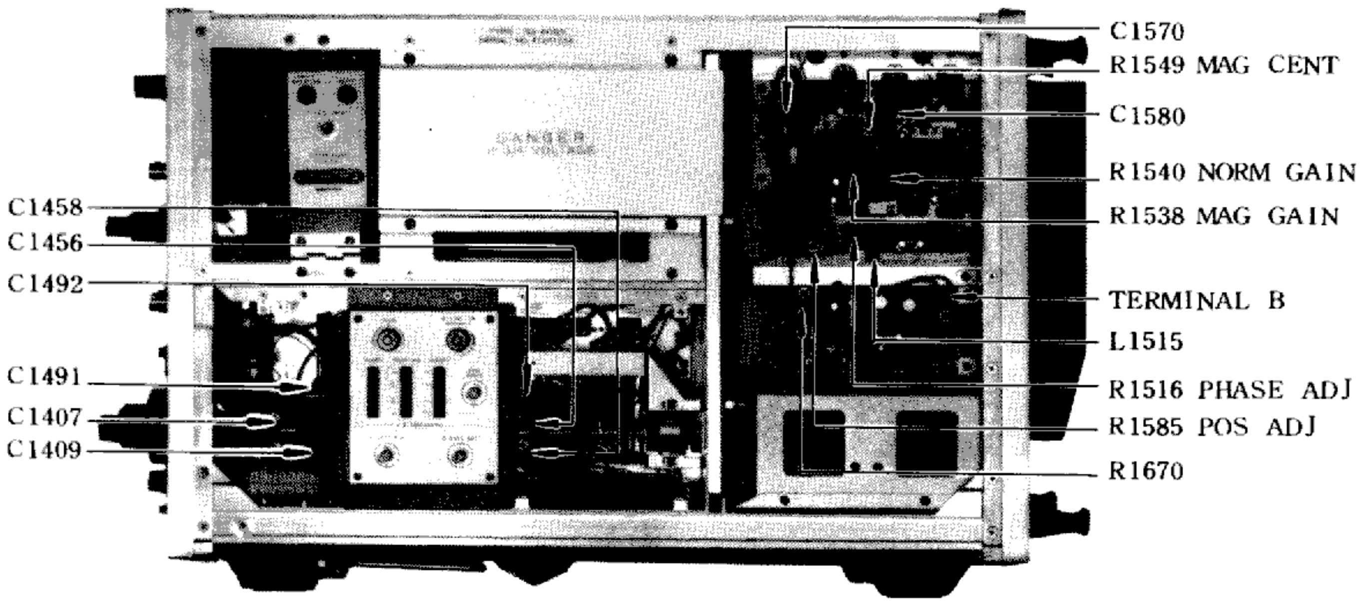


Fig. 6-3 Calibration controls and test point in right side



Pattern Distortion

Rating

When a raster is fully displayed in the 80 mm(V) x 100 mm(H) area, the sides of the raster must be straight not exceeding the limit 1.4 mm (vertical) and 1.0 mm (horizontal) as shown in Fig. 6-4.

Check and calibration

(1) Apply the signal of a sine wave generator, and adjust the output level of the generator to set the vertical amplitude of a displayed signal to 8 cm.

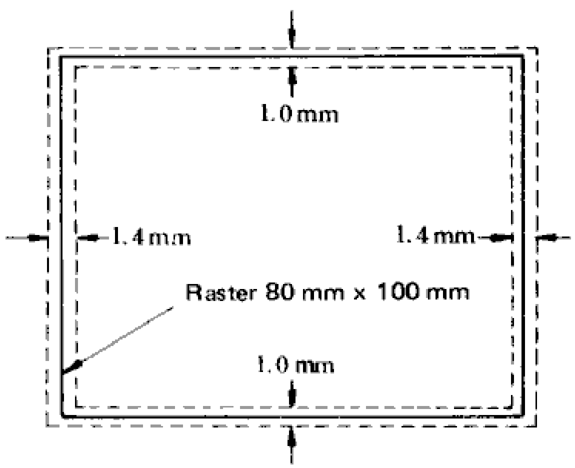
(2) Set the signal frequency to approximately 20 kHz and the A TIME/CM switch to 1 mSEC so that a raster may be displayed.

(3) Check the deviation of upper and lower ends of the raster from the horizontal scale.

(4) Adjust the horizontal POSITION control to line the vertical ends of the raster on the left or the right end of the vertical scale, and check deviation of raster from the scale line.

(5) If the deviation of the raster from the scale lines exceeds the limit, readjust R1723 GEOM and R1721 DEFLECTION SHIELD (see Fig. 6-2) to make the pattern distortion to minimum.

Fig. 6-4 Ratings for pattern distortion



Parallelness of Vertical and Horizontal Traces to Scale Lines

Rating

Vertical and horizontal traces must be parallel to vertical and horizontal scale lines.

NOTE: Since parallelness of a trace to a scale line is somewhat affected by the ground magnetism, check and calibrate the synchroscope in the accually used position are necessary.

Check and calibration

(1) Adjust the vertical POSITION control to set a trace on the horizontal center line of the CRT scale, and check the parallelness of the trace to the scale line.

(2) If the trace is not exactly parallel to the center scale

line, calibrate the TRACE ROTATION control located on the left side panel.
(3) Apply the signal of a sine wave generator to the CH1 INPUT connector, and set the vertical amplitude of a displayed signal larger than 8 cm.
(4) Set the MAIN (A) SWEEP MODE SWITCH to the SINGLE position to stop the sweep, and adjust the INTENSITY control until a vertical trace appears.
(5) Adjust the horizontal POSITION control to set a trace on the vertical center line of the CRT scale, and check the parallelness of the trace to the scale line.
(6) If the trace is not parallel to the vertical center line, adjust R1715 ORTHOGONALITY (see Fig. 6-2).
(7) Since adjustments (2) and (6) have some correlation, repeat these adjustments until correct parallelness is obtained in both vertical and horizontal directions.

– Calibration Voltage Output –

Repetition Frequency

Rating
1 kHz ±1%

Check
(1) Connect the CAL OUT connector to the frequency measurement input connector of a universal counter.
(2) Set the FUNCTION and the TIME BASE controls of the counter to FREQ. and 1 sec respectively.
(3) Check that the counter readout is in the range from 990 to 1010 Hz.
(4) If the accuracy is poor, calibrate the error with R1816 FREQ (see Fig. 6-5).

Duty Ratio

Rating
48:52 or better

Check and calibration
(1) Connect the CAL OUT to the time interval measurement input of the counter.
(2) Set the FUNCTION and the TIME BASE controls of the counter to TIME INT and 0.1 μsec respectively. Set the COM-SEP switch of the counter to the COM (common input) position, and the SLOPE (START) and the SLOPE (STOP) switches to "+" and "−" respectively so that the counter circuit will be triggered firmly by the CAL signal.
(3) Check that the readout of the counter is in the range from 480 to 520 μsec.

Output Voltage

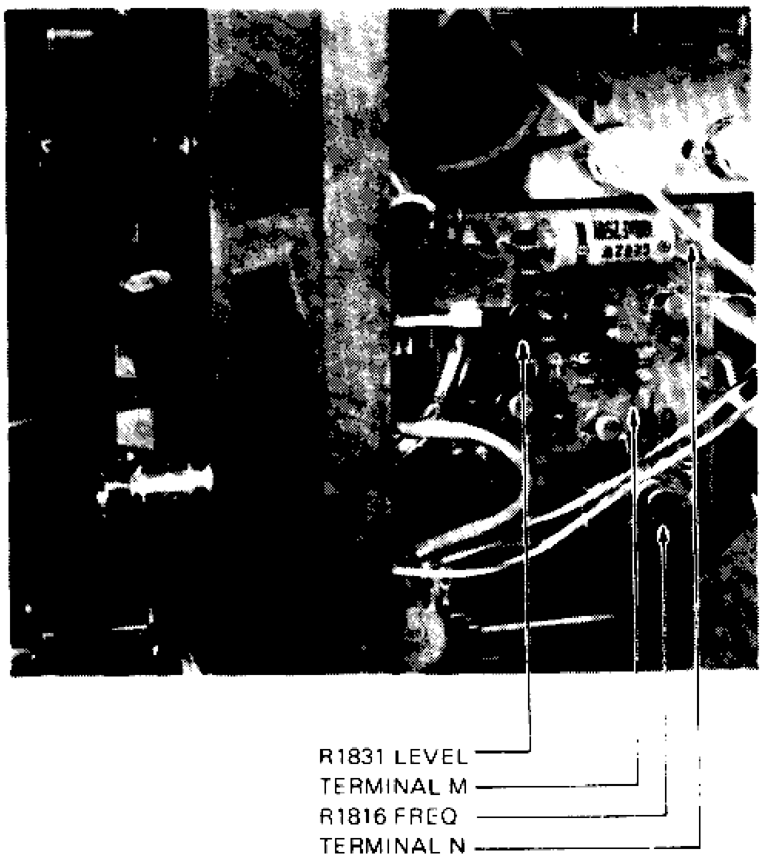
Rating
Within ±1% of a value indicated by the CALIBRATOR switch.

NOTE: Prior to checking the accuracy of the output voltage, the duty ratio must have been calibrated to 50:50.

Check and calibration
(1) Connect the COM and the V terminals of a digital voltmeter to GND and CAL OUT of the synchroscope, and set the FUNCTION switch of the voltmeter to AC.

(2) Set the CALIBRATOR switch to 2 V.
(3) Short-circuit the terminals M and N of the calibrator

Fig. 6-5 Calibration controls for calibration output voltage



circuit to stop the oscillation of the circuit.
(4) Check that the readout of the digital voltmeter is within 2 V ±1%.
(5) If the readout of the digital voltmeter exceeds the limit, calibrate the error with R1831 LEVEL (see Fig. 6-5).

– Vertical Deflection System –

Gain Switch Balance

Check and calibration
(1) Set the MODE switch to the ALT position.
(2) Change the CH1 and the CH2 VOLTS/CM switches from the 10 mV position to the 5 mV position, and check the vertical shift of the trace.
(3) If it shifts vertically, the STEP ATT BAL control located on the front panel must be adjusted until the trace stays still against switching the VOLTS/CM control.

Variable Balance

Check and calibration
(1) Set the MODE switch to the ALT position.
(2) Set the CH1 and the CH2 VOLTS/CM switches to the 10 mV position, and set the CH1 and the CH2 traces to the center of the viewing area.
(3) Check that the traces stay still against the adjustment of the VARIABLE controls of CH1 and CH2.

(4) If the traces are shifted, repeat adjustments of R148 (for CH1) VAR BAL and R248 (for CH2) VAR BAL (see Fig. 6-6) until the traces stay still against the adjustment of the CH1 and the CH2 VARIABLE controls.

Position Centering

Check and calibration

(1) Set the MODE switch to the ALT position.
(2) Set the CH1 and the CH2 POSITION controls to the mid-position, and check if the traces are positioned correctly on the horizontal center line of the viewing area.
(3) If the traces are not positioned on the center line, adjust R179 POS CENT (for CH1) and R279 POS CENT (for CH2); see Fig. 6-6.

DC Level of Vertical Main Amplifier

Check and calibration

(1) Set the trace position to the center of viewing area.
(2) Check that the terminal C or F voltage to ground is approximately +35V with a digital voltmeter (see Fig. 6-6).
(3) If the error is beyond the limit, calibrate to +35V with R615 (see Fig. 6-6).

Polarity Balance

NOTE: Check and calibration of CH2 Position Centering must have been completed before checking the Polarity Balance.

Check and calibration

(1) Set the MODE switch to the CH2 position and the CH2 VOLTS/CM switch to the 10 mV position.
(2) Repeat switching of CH2 POLARITY, and check if the trace is shifted to vertical direction.
(3) If it shifts, adjust R315 CH2 POLARITY BAL (see Fig. 6-6).

ADD Trace Position

Check and calibration

(1) Set the MODE switch to the ALT position.
(2) Set the CH1 and the CH2 traces to the center of viewing area.
(3) Set the MODE switch to the ADD position and check that the trace is shifted from the center.
(4) If the trace is shifted, adjust R364 ADD CENT (see Fig. 6-6) so that the trace stays at the center of the viewing area against changing of the MODE switch.

Sensitivity

NOTE: The calibration voltage output must be accurately calibrated before starting the calibration of amplifier sensitivity, because the sensitivity is calibrated using the calibration voltage output as the test signal.

Rating

Within ±2% of the value indicated by the VOLTS/CM switch.

Fig. 6-6 Calibration controls and test points in left side

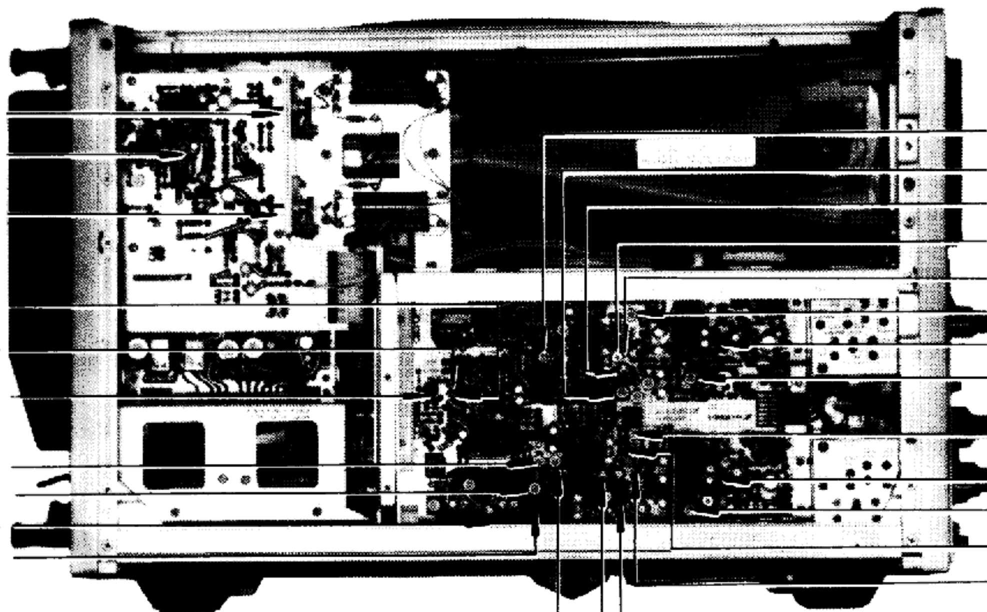
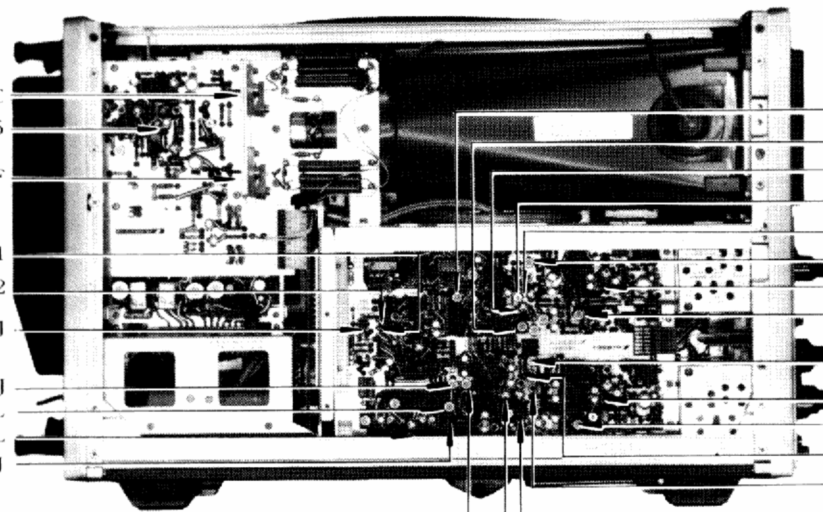


Fig. 6-6 Calibration controls and test points in left side



Check and calibration

(1) Set the CH1 and CH2 VOLTS/CM switches to the 10mV position and the VARIABLE controls to the CALIB position.
(2) Connect the CAL OUT and the CH1 INPUT connectors with the provided cable, and set the CALBRATOR switch to the 20 mV position.
(3) Set the CAL signal waveform to the center of the viewing area, and calibrate the amplitude of the displayed signal to exactly 20 mm with the GAIN (a semi-fixed control) located on the front panel.
(4) Set the MODE switch to the CH2 position and connect the CH2 INPUT and the CAL OUT connectors with a cable, and calibrate the 10 mV sensitivity of CH2 as given in item (3) above.
(5) Set the CH2 VOLTS/CM switch to the 5 mV position, and calibrate the amplitude of the displayed signal to exactly 40 mm with R236 5 mV GAIN (see Fig. 6-6).
(6) Similarly calibrate the CH1 sensitivity at 5 mV with R136 5 mV GAIN (see Fig. 6-6).
(7) Switching the VOLTS/CM and CALIBRATOR controls, check that the sensitivity at each VOLTS/CM position is accurately within ±2% of the value indicated by the switch.

Square Wave Characteristic

Rating

When a pulse having the rise time of 1.5 nsec or less and little overshoot and ringing, or a square wave with little sag is applied to the INPUT, the distortion of the waveform displayed at the center of the CRT with the amplitude of 6 cm shall satisfy the following ratings. (However, the sensitivity is 10 mV/cm and the distortion of the input waveform is omitted.)

For calculation of distortion, see Figs. 3-24 and 3-25.

Overshoot:	3% or less
Ringing:	3% or less
Matching distortion:	1% or less
Sag (at 1 kHz):	1% or less

Check and calibration

(1) Set the CH1 and the CH2 VOLTS/CM switches to 10 mV, the CH1 and the CH2 VARIABLE controls to CALIB and the CH1 and the CH2 AC-GND-DC switches to DC.
(2) Apply the signal of a squarewave generator to the CH1 INPUT connector, and set the generator frequency to 1 kHz and adjust the output level as to set the amplitude of a displayed square wave to 6 cm. Check the sag of the displayed square wave.
(3) Apply the signal of a pulse generator to the CH2 INPUT connector adjust the output level to set the amplitude of a displayed waveform to 6 cm, and check the overshoot, the ringing and the matching distortion.
(4) If the distortion of a signal waveform exceeds the value in the rating, adjustment of the following calibration controls is required. (See Fig. 6-6) Note that these calibration controls must be adjusted so that leading edge of signal may rise as sharp as possible while minimizing total distortion, otherwise, overall frequency characteristics will be affected.

For CH1	C171, C177, R177
For CH2	C271, C207, R207

(5) After the calibration of square wave characteristics is completed, the frequency bandwidth must be checked as given in next item.

Fig. 6-6

CH1 INPUT connector with the provided probe.

(3) Set the frequency of a square wave signal to 1 kHz, adjust the output level to set the amplitude of a displayed waveform to 6 cm, and adjust the phase calibration capacitor of the probe so that the "Correct Phasing" is given as shown in Fig. 6-7.

(4) Set the CH1 VOLTS/CM switch to the 20 mV position, and adjust the output level to set the amplitude of a displayed signal to 6 cm. Check that the "through" and "probe" phases are adequately obtained.

(5) Check the phases at each position of the CH1 VOLTS/CM switch as in the item (4).

(6) Set the MODE switch to the CH2 position, and apply the generator signal to the CH2 INPUT connector with the probe used at the check of CH1.

(7) Adjust the output level to set the amplitude of a displayed signal to 6 cm, and check if the displayed waveform has "Correct Phasing" as shown in Fig. 6-7. If the phasing of waveform is incorrect, readjust C43 located on attenuator of left side.

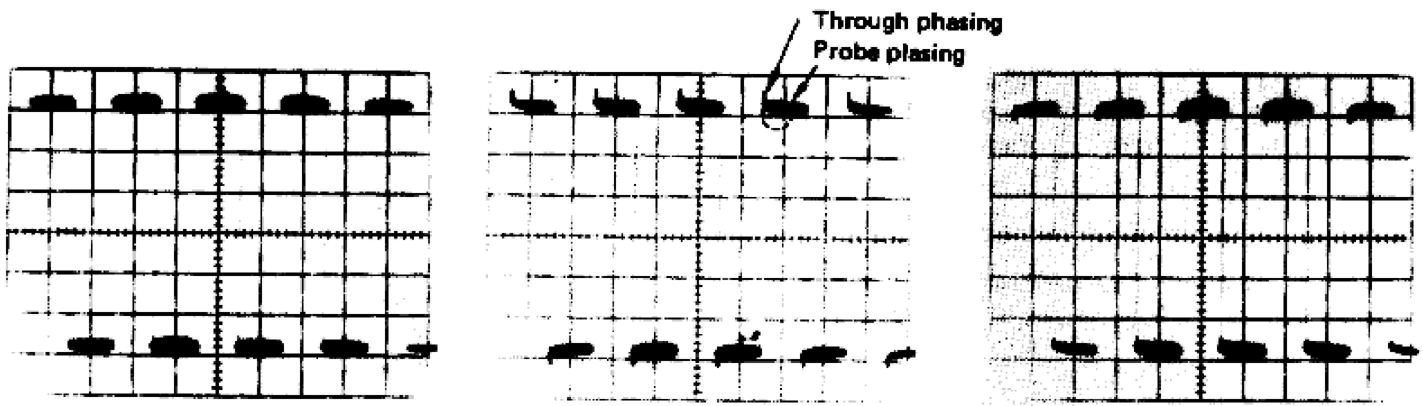
(8) Check the phase at each position of the CH2 VOLTS/CM switch as in the items (4) and (5).

NOTE: If correct phasing is not obtained in step (7) against full adjustment of C43, restart the adjustment for CH2 from step (3), and repeat the same check and adjustment for CH1.

Calibration

(1) Complete phase compensation for the 10 mV position

Fig. 6-7 Displayed waveform of attenuator phase



(a) Correct phasing (b) Incorrect (over-compensation) (c) Incorrect (poor compensation) of CH1 and CH2 as given in "Check".

(2) Set the VOLTS/CM switch to 20 mV, and set the amplitude of a signal display to 6 cm. Calibrate C30 (for CH1) and C70 (for CH2) for "through" phasing and calibrate C5 (for CH1) and C45 (for CH2) for "probe" phasing as shown in Fig. 6-7.

(3) Repeat the same calibration referring to Table 6-3 for each position of CH1 and CH2 VOLTS/CM switches.

Table 6-3

VOLTS/CM	Phase calibration capacitors			
	For CH1		For CH2	
	For "Through"	For "Probe"	For "Through"	For "Probe"
5 mV	–	C3	–	C43
10 mV	–	C3	–	C43
20 mV	C30	C5	C70	C45
50 mV	C33	C6	C73	C46
0.1V	C35	C8	C75	C48
0.2V	C20	C22	C60	C62
0.5V	C14	–	C54	–
1 V	C12	–	C52	–
2 V	C25	C28	C65	C68
5 V	–	–	–	–
10 V	–	–	–	–

NOTE:
–: No adjustment is required. The calibration is complated spontaneously through the adjustment of the others.

Common Rejection Ratio

Rating

The common mode rejection ratio must be less than 50:1 at 1 kHz and less than 20:1 at 10 MHz.

Check

(1) Set the MODE switch to ALT, the CH1 and the CH2 VOLTS/CM switches to 10 mV and the CH2 POLALITY switch to INV.

(2) Branch the signal of a sine wave generator to the CH1 and the CH1 INPUT connectors through a 6 dB divider and cables of the same length. Terminate the signals by a 50Ω terminator at the input side of the cable.

(3) Set the signal frequency to 1 kHz and adjust the signal output level to set the amplitude of a signal waveform to 8 cm.

(4) Set the MODE switch to the ADD position, and check if the displayed trace amplitude has been reduced to smaller than 1.6 mm.

(5) Connect the output of a standard signal generator as in the case of step (2), set the generator frequency to 10 MHz and check the displayed trace amplitude as in the steps (3) and (4). The trace amplitude at 10 MHz must be smaller than 4.0 mm.

Cascade Connection

1. Output potential

Check and calibration

(1) Set the CH1 and the CH2 VOLTS/CM switches to 5 mV, the CH1 and the CH2 AC-GND-DC switches to

GND and the CH2 POSITION control to mid-position.
(2) Adjust the CH1 POSITION control to shift the trace to the center of viewing area.
(3) Connect the CH1 INPUT and the CH2 OUT connector with the provided cable, and change the CH1 AC-GND-DC switch to DC. Check if the trace shifts in vertical direction.
(4) If the trace shifts excessively, fine adjust R299 0 ADJ (see Fig. 6-6).

2. Sensitivity

Rating

1 mV/cm ±3% or less

Check and calibration

(1) After the check and calibration of Output Potential is completed, set the CH1 AC-GND-DC switch to AC, and the CH2 AC-GND-DC switch to DC.
(2) Apply the signal of a sine wave generator to the CH2 INPUT connector, set the signal frequency to 1 kHz and the signal output level to 6 mVp-p.
At this setting, the amplitude of the displayed signal must be within 6 cm ±1.8 mm.
(3) If the amplitude limit is exceeded, adjust R289 1 mV GAIN (see Fig. 6-6).

3. Frequency bandwidth

Rating

DC to 20 MHz −3 dB (at full bandwidth)

Check

(1) After the calibration of sensitivity in item 2 is completed, set the CH1 AC-GND-DC switch to the DC position, and apply the signal of a standard signal generator to CH2 INPUT.
(2) Set the signal frequency to 50 kHz, and adjust the signal output level to set the amplitude of a displayed signal to 6 cm. Read and record the indication of the output level meter at this setting.
(3) Change the signal frequency to 20 MHz, and adjust the signal output to the reading of the level meter which is the same to that at 50 kHz. Check that the amplitude of the displayed signal waveform is larger than 4.25 cm (amplitude of −3 dB for 6 cm).

4. Noise

Rating

3 mmp-p or less (with the synchroscope left stationary).

Check

Set the CH2 AC-GND-DC switch to GND and operate the synchroscope in free-run sweep. Amplitude of noise component of a trace must be smaller than 5 mmp-p.

— Trigger System —

Trigger Amplifier Output Level (CH2)

Calibration

(1) Set the MODE switch to CH2 and the CH2 AC-GND-DC switch to GND.
(2) Connect a digital voltmeter across test points TP401

and TP402 (see Fig. 6-6), and calibrate the potential across these test points to 0V with R434 CH2 DC BAL (see Fig. 6-6).

(3) Next, measure the potential across TP401 and chassis, and calibrate the potential to 0V with R447 0 ADJ (see Fig. 6-6).

Trigger Amplifier Output Level (CH1)

NOTE: The Trigger Amplifier Output Level (CH2) must be calibrated before calibrating the Trigger Amplifier Output Level (CH1).

Calibration

(1) Set the MODE switch to CH1 and the CH1 AC-GND-DC switch to GND.

(2) Connect a digital voltmeter across test points TP401 and TP402 (see Fig. 6-6), and calibrate the potential across these test points to 0V with R414 CH1 DC BAL (see Fig. 6-6).

(3) Next, measure the potential across TP401 and chassis, and calibrate the potential to 0V with R418 0 ADJ (see Fig. 6-6).

Trigger Main Amplifier Output Level

Calibration

(1) Set the MODE switch to CH1 and the CH1 AC-GND-DC switch to GND.

(2) Check that the DC level of test points TP703 and TP704 (see Fig. 6-8) are respectively 0V.

(3) Measure the DC level of test point TP718 (see Fig. 6-8) and calibrate the DC level to 0V with R714 A TRIG SIG 0V ADJ (see Fig. 6-8).

(4) Measure the DC level of test point TP726 (see Fig. 6-8) and calibrate the DC level to 0V with R725 B TRIG SIG 0V ADJ (see Fig. 6-8).

NOTE: If the DC level shown in item (2) is fluctuated, a further calibration of Trigger Amplifier Output Level is required.

Level Centering (A Triggering)

Check and calibration

(1) Apply the signal of a sine wave generator to CH1 INPUT connector, set the signal frequency to 1 kHz and adjust the signal output level to set the amplitude of a displayed signal to 6 cm.

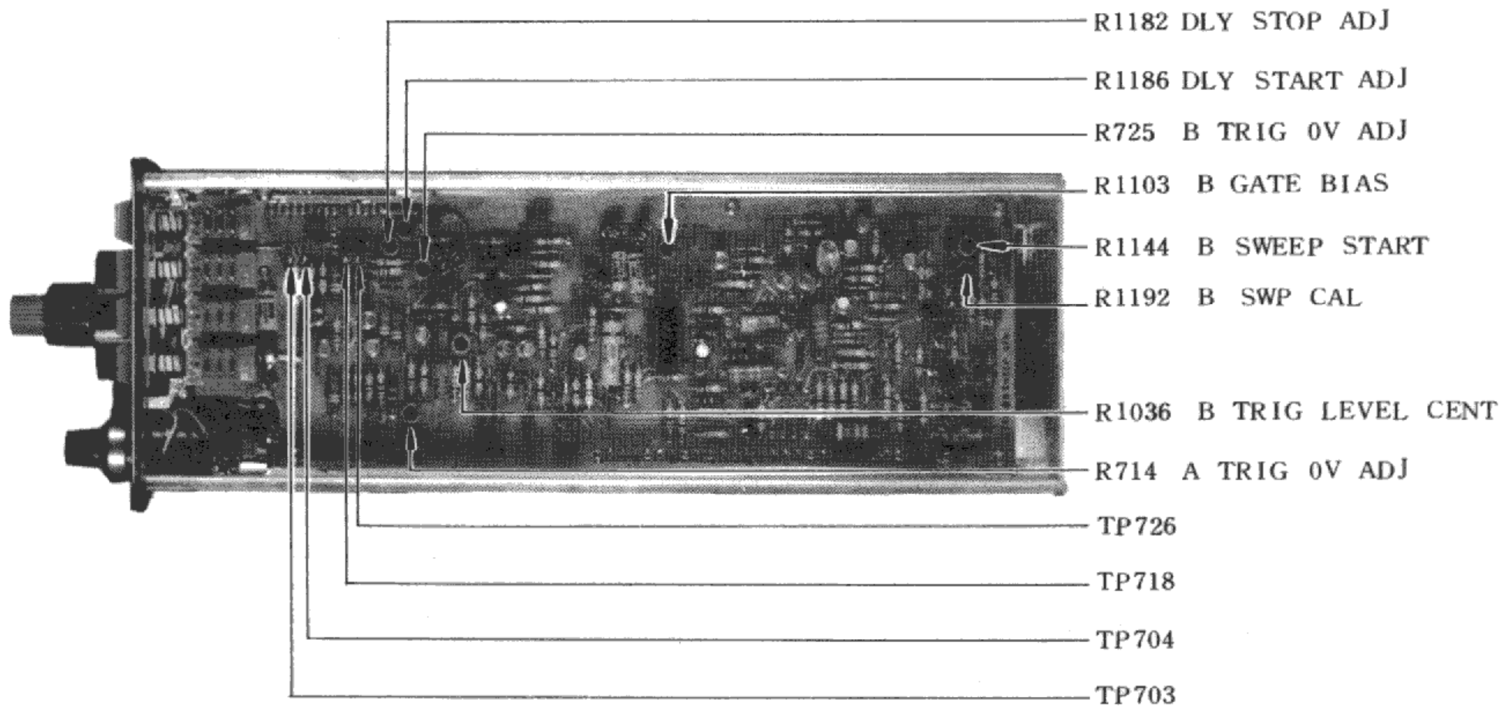
(2) Position the signal waveform equally above and below the horizontal center line of the scale.

(3) Set the COUPLING switch to the AC position and provide triggering for a signal display by setting the LEVEL control to the mid-position.
Repeat switching of the SLOPE switch to + and −, and check that a positive going slope and a negative going slope of signals start from the horizontal center line of the scale.

(4) If the signal waveform fails to start from the horizontal center line, disconnect the horizontal unit from the main frame and connect it through an extension connector to the main frame, and adjust R861 A TRIG LEVEL CENT (see Fig. 6-9).

(5) Leaving the setting of the LEVEL control unchanged, set the COUPLING switch to the DC position, and

Fig. 6-8 Calibration controls and test points in bottom of horizontal unit



repeat the check in the same way.

NOTE: If signals fail to start from the horizontal center line in the DC coupling, a further calibration of Trigger Main Amplifier Output Level (R714) is required.

Full Auto Trigger

Check and calibration

(1) Set the controls as shown below.

MAIN (A) SWEEP MODE	FULL AUTO
A TIME/CM	0.1 μSEC
(PULL x10 MAG)	Pulled

(2) Apply the signal of a standard signal generator to the CH1 INPUT connector, set the signal frequency to 30 MHz and adjust the signal output level to set the amplitude of the displayed signal to 2 cm.

(3) Check that the displayed signal can be triggered firmly over the entire LEVEL setting range and for SLOPE + and SLOPE −.

(4) If triggering of display becomes unstable at any position of the LEVEL control, dismantle the horizontal unit from the main frame, and connect them with an extension connector.

(5) Change the signal frequency to 50 kHz.

(6) Set FULL AUTO ADJ + R836 and − R837 (see Fig. 6-9) fully clockwise and the LEVEL control fully clockwise.

(7) Turn R836 gradually counterclockwise to find a position at which the display can be triggered firmly for SLOPE + and −, and set R836 the position.

(8) Set the LEVEL control fully counterclockwise, and turn R837 gradually counterclockwise to find a position at which the display can be triggered firmly to SLOPE + and SLOPE −, and set R837 at the position.

Level Centering (B Triggering)

Check and calibration

(1) Apply the signal of a sine wave generator to the CH1 INPUT connector, set the signal frequency to 1 kHz and adjust the signal output level to set the amplitude of the displayed signal to 6 cm.

(2) Position the signal waveform equally above and below the horizontal center line of the graduations.

(3) Set the controls as shown below.

HORIZONTAL DISPLAY	DLY'D (B)
DLY'D (B) MODE	TRIG'ABLE
MAIN (A) SWEEP MODE	FULL AUTO
A TIME/CM	0.5 mSEC
B TIME/CM	0.2 mSEC
COUPLING (B triggering)	AC

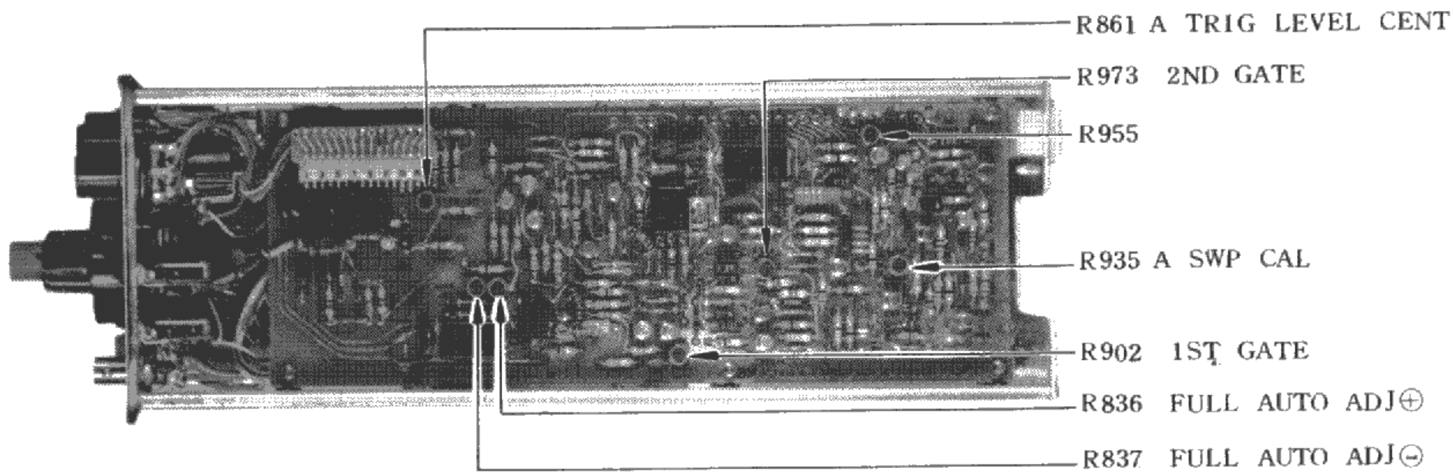
(4) Provide triggering for a signal display by setting the LEVEL control of B triggering to the mid-position. Repeat switching of the SLOPE switch of B triggering to + and −, and check that a positive going slope and a negative going slope of the signal start from the horizontal center line of the scale.

(5) If the signal waveform fails to start from the horizontal center line, adjust R1036 B TRIG LEVEL CENT (see Fig. 6-8).

(6) Leaving the setting of the LEVEL control unchanged, set the CQUPLING switch of B triggering to the DC position, and repeat the check in the same way.

NOTE: If signals fail to start from the horizontal

Fig. 6-9 Calibration controls in top of horizontal unit



center line in the DC coupling, a further calibration of Trigger Main Amplifier Output Level (R725) is required.

– Sweep System –

A Sweep Operation

Calibration

(1) Dismantle the horizontal unit from the main frame and connect them with an extension connector.

(2) Set the controls as shown below.

HORIZONTAL DISPLAY	A
MAIN (A) SWEEP MODE	NORM
SOURCE	INT
A TIME/CM	1 mSEC

(3) Apply the calibration voltage output to the CH1 INPUT connector and set the amplitude of the displayed signal to 6 cm.

(4) Setting the LEVEL control to the mid-position, provide triggering of display, and turn R902 1ST GATE (see Fig. 6-10) gradually to identify three ranges; "no sweep", "triggered sweep" and "free-run sweep". Set R902 to the center of the "triggered sweep" range.

Jitterless

Check and calibration

(1) Apply the signal of a standard signal generator to the CH1 INPUT connector, set the signal frequency to 30 MHz and adjust the signal output level to set the amplitude of the displayed signal to 6 cm.

(2) Set the A TIME/CM switch to the 0.1 μSEC position, pull the (PULL x10 MAG) switch, and check jittering of a displayed signal by continuously varying signal frequency.

(3) If jittering appears, connect the horizontal unit to the main frame with an extension connector, and adjust (see Fig. 6-9).

B Sweep Operation

Calibration

(1) Set the controls as shown below.

HORIZONTAL DISPLAY	A INTEN BY B
DLY'D (B) MODE	TRIG'ABLE
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC
DELAY TIME MULTI	5.00
SOURCE (B triggering)	INT
COUPLING (B triggering)	AC
SLOPE (B triggering	+
LEVEL (B triggering)	Mid-position

(2) Apply the calibration voltage output to the CH1 INPUT connector. Provide triggering for a displayed signal by adjusting the LEVEL control of A triggering and reduce the intensity of the display.

(3) Set R1103 B GATE BIAS (see Fig. 6-8) fully counterclockwise, then return it clockwise until approximately 1 cm (B sweep) of the display is intensified and record the position of R1103.

(4) Turn the LEVEL control of B triggering fully counterclockwise to check that the intensified part of display disappears.

(5) Turn R1103 clockwise from the setting made at step (3)

until the display is partially intensified. Record this setting position.

(6) Turn R1103 to the center of the positions recorded in steps (3) and (5).

Start Point of B Sweep

Calibration

(1) Following the calibrating of above B Sweep Operation, pull the (PULL x10 MAG) switch, and set the starting point of A sweep to the center of the viewing area.

(2) Change the HORIZONTAL DISPLAY switch to the DLY'D (B) position and adjust R1144 B SWEEP START (see Fig. 6-8) so that the B sweep may start from the same point to that of the A sweep.

Sweep Time and Linearity (A Sweep)

Rating

Sweep time:	Within ±2% of the values indicated by the A TIME/CM switch
Linearity:	Within 3%

Check

(1) Apply the signal of a time marker generator to the CH1 INPUT connector and set the repetition frequency to 1 mSEC.

(2) Set the A TIME/CM switch to 1 mSEC and the A VARIABLE control to the CALIB position.

(3) Provide triggering for a displayed signal and line the start pulse to a position 1 cm right of the end of the left end of the scale lines.

(4) Check the linearity of a display at 1 mSEC position. (See Fig. 6-10)

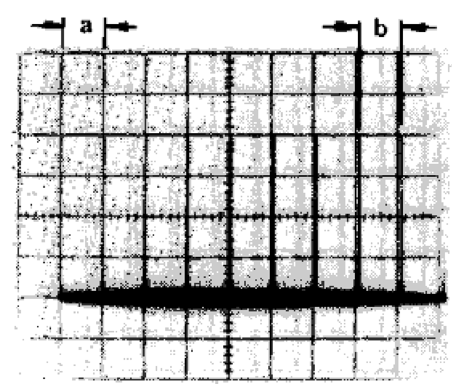
(5) Check the error of sweep time at the 1 mSEC and the 2 mSEC positions, then set the repetition frequency of the time marker to 5 mSEC and check the sweep time error at 5 mSEC position. (See Fig. 6-11)

(6) Repeat the same check of the sweep time error for different combinations of the time marker repetition frequency and setting of the A TIME/CM switch.

(7) Check the linearity of the sweep at 5 SEC to 1 SEC ranges.

NOTE: No calibration control is provided for the

Fig. 6-10 Sweep linearity



$$\text{Linearity} = \frac{2(a-b)}{a+b} \times 100\ (\%)$$

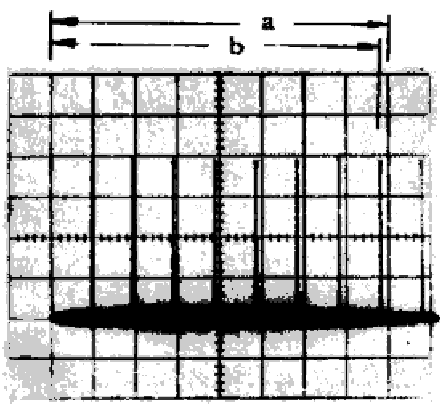
where a: maximum interval
b: minimum interval

linearity. If the linearity of display is poor, troubleshooting must be conducted to find and replace defective parts.

Calibration I [When the sweep time error in each steps has the same tendency]

(1) Check B sweep time. [See "Sweep Time and Linearity (B sweep)".]
(2) When both sweep time errors of A and B sweeps have the same tendency, adjust R1540 NORM GAIN (see Fig. 6-3).
(3) When the error in each step of the A TIME/CM switch have the same tendency, connect the horizontal unit to the main frame with an extension connector, and adjust R935 A SWP CAL (see Fig. 6-9).

Fig. 6-11 Sweep time error



$$\text{Error rate of sweep time} = \frac{a-b}{a} \times 100\ (\%)$$

where a: horizontal effective scale (80 mm)
b: measured value of time marker corresponding to a

Calibration II [When the error in a particular step is large]

(1) Adjust C1407 (see Fig. 6-3) for calibrating the error in the range from 5 μSEC to 1 μSEC.
(2) Use C1409 (see Fig. 6-3) in the range from 0.5 μSEC to 0.1 μSEC.
(3) In the steps from 5 SEC to 0.1 mSEC, replace the timing capacitor, C1401 to C1405 (see the schematic diagram) when the errors in a group of 1-2-5 steps have the same tendency, and replace the timing resistor, R1402 to R1411 (see the schematic diagram) when there is an error in a particular step.

Sweep Time and Linearity (B Sweep)

Rating

Sweep time:	Within ±2% of the value indicated by the A TIME/CM switch
Linearity:	Within 3%

Check

(1) Set the controls as shown below.

HORIZONTAL DISPLAY	A INTEN BY B
DLY'D (B) MODE	TRIG'ABLE
A TIME/CM	2 mSEC
B TIME/CM	1 mSEC

(2) Apply the time marker signal of 1 mSEC repetition period to the CH1 INPUT connector, and trigger the displayed signal with the LEVEL control of A triggering.
(3) Trigger the B sweep with the LEVEL control of B triggering.

(4) Set the HORIZONTAL DISPLAY switch to the DLY'D (B) position, and line the start pulse with the vertical scale line next to the left end of the scale.
(5) Check the linearity at the 1 mSEC position of the B TIME/CM switch. (See Fig. 6-10)
(6) Check the sweep time error at 1 mSEC and 2 mSEC of the B TIME/CM switch first, and check the error at the 5 mSEC position by setting the time marker repetition frequency to 5 mSEC (the A TIME/CM switch must be set to a position 1 step slower than the setting of the B TIME/CM switch).
(7) Repeat checks of the sweep time errors for different combinations of time marker repetition frequencies and setting of the B TIME/CM switch.

Calibration I [When the sweep time error in each step has the same tendency]
(1) Check the A sweep time. [See "Sweep Time and Linearity (A sweep)".]
(2) When both sweep time errors of A and B sweeps have the same tendency, adjust R1540 NORM GAIN (see Fig. 6-3).
(3) When the errors in each step of B TIME/CM switch have the same tendency, adjust R1192 B SWEEP CAL (see Fig. 6-8).

Calibration II [When the error in a particular step is large]
(1) Adjust C1456 (see Fig. 6-3) for calibrating the error in the range from 5 μSEC to 1 μSEC.
(2) Use C1458 (see Fig. 6-3) in the range from 0.5 μSEC to 0.1 μSEC.
(3) In the steps from 0.5 SEC to 10 μSEC, replace the timing capacitor, C1451 to C1454 (see the schematic diagram) when the errors in a group of 1-2-5 steps have the same tendency, and replace the timing resistor, R1452 to R1461 (see the schematic diagram) when there is an error in a particular step.

Magnifier Centering

Check and calibration
(1) Apply the calibration voltage output to the CH1 INPUT connector.
(2) Set the A TIME/CM switch to the 1 mSEC position.
(3) Shift the displayed signal until the starting point of the sweep (rising of cal. waveform) is set to the vertical center line of the scale.
(4) Check that the starting point of a sweep is not shifted by pulling the (PULL x10 MAG) knob.
(5) If the start point is shifted excessively, set the starting point of magnified sweep correctly to the vertical center line of the scale, and push the (PULL x10 MAG) knob. The start point of the normal sweep must be set to the vertical center line by fine adjusting R1549 MAG CENT (see Fig. 6-3).

Sweep Time and Linearity at Magnified Sweep

Ratings
Given in Table 6-4.

Table 6-4

TIME/CM	Sweep time	Linearity
5 to 0.5 SEC	Within ±3%	Within 5.5%
0.2 SEC to 0.5 μSEC	Within ±3%	Within 4.0%
0.2 and 0.1 μSEC	Within ±4%	Within 5.5%

Check

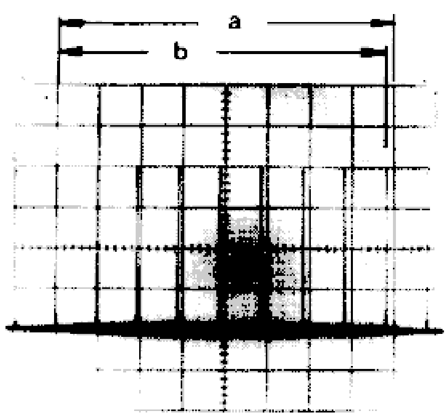
(1) Set the A TIME/CM switch to the 0.1 mSEC position, and apply the time marker signal of the 0.1 mSEC repetition frequency to the CH1 INPUT connector.

(2) Trigger the displayed signal, and line the start pulse to the left end of the scale.

(3) Set the A TIME/CM switch to the 1 mSEC position and pull the (PULL x10 MAG) knob, and check the sweep time of a magnified sweep in an area 4 cm left and right from center of the scale. (See Fig. 6-12)

(4) If the error in the item (3) is large, adjust R1538 MAG GAIN (see Fig. 6-3).

Fig. 6-12 Sweep time error at magnified sweep



Error rate of sweep time = $\frac{a - b}{a} \times 100$ (%)

where a: horizontal effective scale (80 mm)
b: measured value of time marker corresponding to a

(5) Check that the linearity of a magnified sweep is better than 4% by reading the maximum and the minimum widths of time marker intervals which correspond to 2 cm on the viewing area (3 pulses in this case) at the starting, the center and the end of the sweep, in an area 4 cm left and right from the center of the scale. (See Fig. 6-13)

(6) Set the A TIME/CM switch to the 5 SEC position and the time marker repetition frequency to 0.5 mSEC, and check that the linearity is better than 5.5% as the item (5).

(7) Disconnect the time marker signal, and apply the signal of a standard signal generator to the CH1 INPUT connector, instead.

(8) Set the A TIME/CM switch to the 0.1 μSEC position and the signal frequency to 50 MHz, and check the sweep time and the linearity. The part for 2 cycles (40 mSEC) from the start point and 4 cycles from the end of sweep must be excluded from the readings.

(9) If the error in the item (8) is large, adjust C1570 and C1580 (see Fig. 6-3).

Delay Time

Rating

Within ±3%.

Check and calibration

(1) Set the controls as shown below.

HORIZONTAL DISPLAY	A INTEN BY B
DLY'D (B) MODE	AUTO
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC

(2) Apply the time marker of the 1 mSEC repetition frequency to the CH1 INPUT connector, trigger the displayed signal by adjusting the LEVEL control of A triggering, and line the start pulse to the left end of the scale.

(3) Turn the DELAY TIME MULTI dial fully counterclockwise, and check that the multi-dial is set to 0.50.

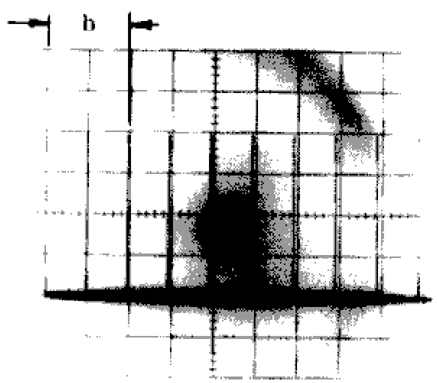
(4) Turn the dial clockwise until the intensified portion of displayed signal starts from the 2nd pulse from left, and check that the dial indicate is between 0.97 and 1.03.

(5) Turn the dial further clockwise until the intensified portion starts from the 10th pulse, and check that the dial indicate is between 8.97 and 9.03.

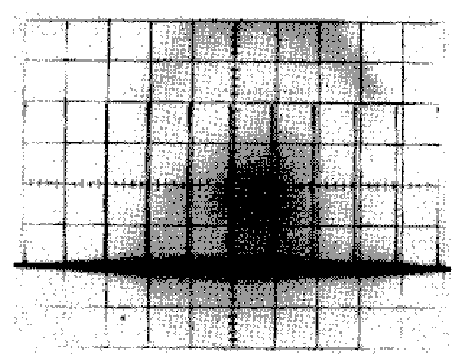
(6) If the errors are large, set the dial to the 1.00 position and adjust R1186 DLY START ADJ (see Fig. 6-8) so that the intensified portion may start from the 2nd pulse.

(7) Set the dial to 9.00 and adjust R1182 DLY STOP ADJ (see Fig. 6-8) so that the intensified portion may start

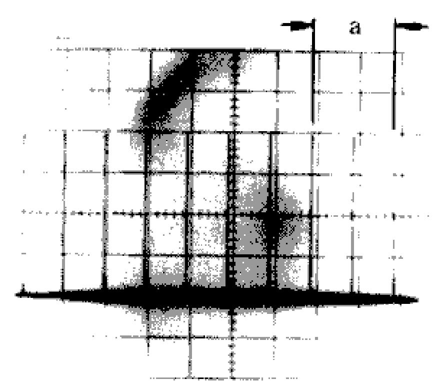
Fig. 6-13 Linearity at magnified sweep



Starting of sweep



Center of sweep



End of sweep

$$\text{Linearity} = \frac{2\,(a-b)}{a+b} \times 100\ (\%)$$

where a: maximum interval
b: minimum interval

Frequency Bandwidth

Rating

DC to 1 MHz −3 dB

Check

(1) Set the controls as given in the item (1) of the sensitivity check and calibration.

(2) Apply the signal of a standard signal generator to the CH1 INPUT connector, and set the signal frequency to 50 kHz and adjust the signal output level to set the horizontal amplitude of the trace to 4 cm. Read and record the indication of output level meter at this setting.

(3) Set the signal frequency to 1 MHz, and set the signal output level so that the same meter reading to that at 50 kHz will be obtained. Check that the horizontal amplitude of signal is larger than 2.83 cm (−3 dB referred to 4 cm).

Phase Difference

Rating

Within 3° (for DC to 1 MHz sine wave)

Check and calibration

(1) Set the controls as given in the item (1) of the sensitivity check and calibration.

(2) Apply the signal of a standard signal generator to the CH1 and the CH2 INPUT connectors by using a BNC T connector.

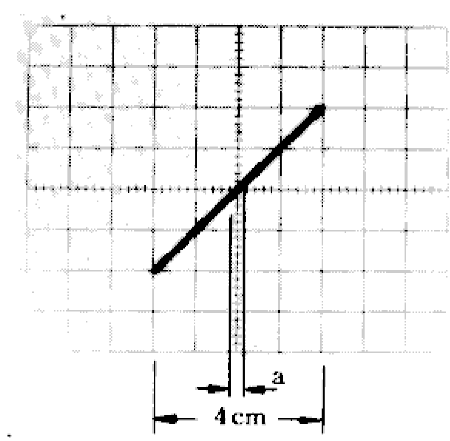
(3) Set the signal frequency to 1 MHz, and adjust the signal output level to set the horizontal amplitude of the Lissajou's pattern to 4 cm. Check the width "a" in Fig. 7-14 which must be smaller than 2 mm.

(4) Continuously vary the signal frequency, and check that the width "a" does not exceed 2 mm at any frequency.

(5) If the "a" exceeds the limit, set the signal frequency for maximum width of "a", and adjust R1516 PHASE ADJ and L1515 (see Fig. 6-3). Repeat checking by varying the signal frequency.

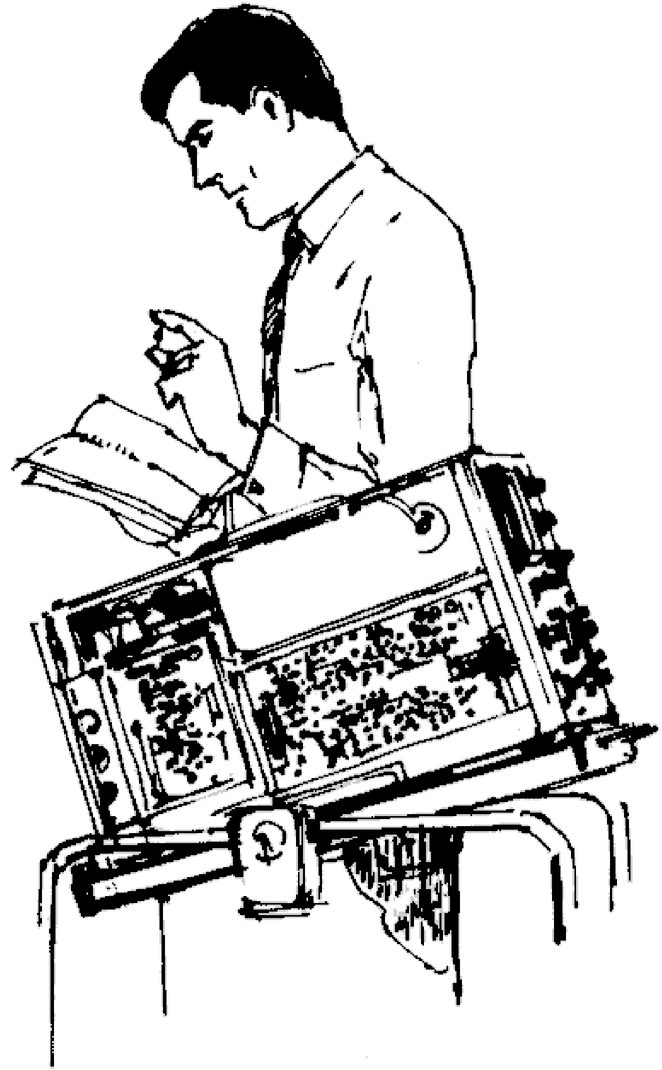
NOTE: Since the adjustment of R1516 varies the sensitivity of X axis, recalibration of the X-Y sensitivity is required when R1516 is adjusted in the item (5).

Fig. 6-14 X-Y phase difference



SECTION 7 PARTS LIST

This section particularly the specification of parts, for replacement of defective parts when the instrument is troubled.



Ordering Information

Replacement parts may be ordered through an IWATSU Representative or directly from the factory. To be certain of receiving the proper parts, a ways include the following information with the order:

a. Model Number and serial number of the instrument on which the parts will be installed.
b. Circuit reference number and subassembly name, if applicable, for which the part is intended. If the part does not have a circuit reference, the description from the parts list should be used.
c. Iwatsu part number.

For factory repair, contact the IWATSU agent and include the following information.

a. Model number and serial number of the instrument on which the work is to be performed.
b. Details concerning the nature of the malfunction, or, type of repair desired.
Shipping instructions will be sent to you promptly.

How to use This Parts List

The parts list is divided into subsections corresponding to the schematic diagrams such as VERTICAL AMP, TRIG CIRCUIT, SWEEP GENERATOR, HORIZONTAL AMP, CRT CIRCUIT and POWER SUPPLY. Component locations can be determined from the schematic diagrams, each component appears only once in the parts list. At the beginning of each subsection are listed part numbers for any complete subassemblies in that category that are available as replacement parts. These subassemblies may include individually-listed components; care should be taken to locate malfunctions to the lowest possible level of replacement part and thus avoid the time and cost involved in "over-repair"

Abbreviations

Cap. .... Capacitor
  cer. .... ceramic
  Poly. .... Polyethytel film
  elect. .... aluminium electrolytic chemical
  elect. tan. . tan-talum electrolytic chemical condenser
  [The symbol of F (farad) is omitted]
Res. .... Resistor
  w.w. .... wire wound
  comp. .... composition
  [The symbol of Ω (ohm) is omitted]
FET .... Field Effect Transistor
Diode
  T. diode ... Tunnel diode
  Z. diode ... Zenner diode
  S.B.diode... Schottky barrier diode
  V.C.diode.. Variable capacitance diode
  L.E.diode.. Light emission diode
Var. .... variable

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
CH1 & CH2 ATTENUATOR		
C1	Cap., 15p, 10%, 500V, cer.	74 050 1960
C2	Cap., 0.1µ, 20%, 600V, poly.	74 130 0100
C3	Cap., 0.5-1.5p, var., 500V, poly.	74 110 1130
C5	Same as C3	
C6	Same as C3	
C8	Cap., 4-10p, var., 250V, cer.	74 110 0840
C10	Cap., 1p, 0.25p, 500V, cer.	74 050 3620
C12	Same as C3	
C14	Same as C3	
C15	Same as C10	
C16	Cap., 47p, 10%, 500V, cer.	74 050 2080
C17	Cap., 56p, 10%, 500V, cer.	74 050 3950
C19	Cap., 1.5p, 0.25%, 500V, cer.	74 050 4840
C20	Same as C3	
C21	Cap., 10p, 1p, 500V, cer.	74 050 1920
C22	Cap., 6-20p, var., 250V, cer.	74 110 0870
C25	Same as C3	
C28	Same as C22	
C29	Cap., 100p, 5%, 50V, mica	74 070 5757
C30a	Cap., 3-7p, var., 250V, poly.	74 110 0810
C30b	Cap., 7p, 0.5p, 500V, cer.	74 050 3850
C31	Cap., 2p, 0.5p, 500V, cer.	74 050 1900
C31	Same as C15	
C32	Cap., 27p, 10%, 500V, cer.	74 050 2040
C33	Same as C3	
C35	Same as C3	
C36	Same as C10	
C41	Same as C1	
C42	Same as C2	
C43	Same as C3	
C45	Same as C5	
C46	Same as C3	
C48	Same as C8	
C50	Same as C10	
C52	Same as C3	
C54	Same as C3	
C55	Same as C10	
C56	Same as C16	
C57	Same as C17	
C59	Same as C19	
C60	Same as C3	
C61	Same as C21	
C62	Same as C22	
C65	Same as C3	
C68	Same as C22	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C69	Same as C29	
C70a	Same as C30a	
C70b	Same as C30b	
C71	Same as C31	
C72	Same as C32	
C73	Same as C3	
C75	Same as C3	
C76	Same as C10	
L42	Inductor,peaking coil(a)	74 400 5650
L48	Same as L42	
L50	Inductor,peaking coil(b)	74 400 5650
L51	Inductor,peaking coil(b)	74 400 5780
L55	Same as L50	
L56	Same as L51	
R1	Res.,75,5%,1/4W,carbon	74 223 3990
R2	Res.,110,5%,1/4W,carbon	74 223 4360
R3	Res.,900k,0.5%,metal	74 221 8280
R5	Res.,100k,0.5%,1/4W,metal	74 221 8230
R6	Same as R3	
R8	Res.,111k,0.5%,1/4W,metal	74 221 8240
R9	Res.,990k,0.5%,1/4W,metal	74 221 8310
R10	Res.,10.1k,0.5%,1/4W,metal	74 221 8200

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R11	Res.,500k,0.5%,1/4W,metal	74 221 8260
R12	Res.,1M,0.5%,1/4W,metal	74 221 8340
R13	Res.,800k,0.5%,1/4W,metal	74 221 8270
R14	Res.,250k,0.5%,1/4W,metal	74 221 8250
R15	Same as R3	
R16	Same as R6	
R21	Same as R1	
R22	Same as R2	
R23	Same as R3	
R25	Same as R5	
R26	Same as R3	
R28	Same as R8	
R29	Same as R9	
R30	Same as R10	
R31	Same as R11	
R32	Same as R12	
R33	Same as R13	
R34	Same as R14	
R35	Same as R3	
R36	Same as R8	
R40	Res.,82,5%,1/4W,carbon	74 223 3370
R45	Same as R40	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
S1A	Lever switch	74 440 2050
S1B	Rotary switch	74 431 6980
S2A	Same as S1A	
S2B	Same as S1B	
TB1	Terminal	74 510 0320
J1	BNC connector	74 500 2530
J2	Same as J1	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
CH1 & CH2 PREAMPLIFIER(1)		
C101	Cap.,2200p,+100%-0%,500V,cer.	74 060 0840
C102	Cap.,0.01μ,+80%-20%,25V,cer.	74 060 0560
C103	Same as C102	
C105	Cap.,0.5-1.5p,var.,250V,cer.	74 110 1130
C107	Same as C102	
C110	Cap.,3.3μ,20%,16V,elect.tan.	74 120 5070
C112	Same as C102	
C115	Same as C102	
C117	Same as C102	
C118	Same as C102	
C124	Same as C102	
C125	Cap.,0.1μ,+80%-20%,25V,cer.	74 060 2330
C126	Same as C125	
C128	Same as C125	
C129	Cap.,0.1μ,+80%-20%,25V,cer.	74 060 2330
C131	Cap.,4-10p,var.,250V,cer.	74 110 1210
C138	Cap.,3-7p,var.,250V,cer.	74 110 0600
C140	Cap.,0.001μ,10%,50V,poly.	74 130 1310
C147	Same as C140	
C150	Cap.,22p,10%,50V,cer.	74 050 3050
C152	Same as C150	
C156	Cap.,5p,0.5p,50V,cer.	74 050 2620

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C161	Same as C156	
C162	Same as C140	
C163	Same as C140	
C171	Cap.,6–20p,var.,250V,cer.	74 110 0870
C172	Same as C171	
C176	Cap.,0.0022u,10%,50V,poly.	74 130 1960
C177	Cap.,20p,5%,50V,cer.	74 050 5280
C180	Cap.,100p,10%,50V,cer.	74 050 1710
C181	Same as C176	
C201	Same as C101	
C202	Same as C102	
C203	Same as C102	
C205	Same as C105	
C207	Same as C177	
C210	Same as C110	
C212	Same as C102	
C215	Same as C102	
C218	Same as C102	
C224	Same as C102	
C225	Same as C125	
C226	Same as C125	
C227	Same as C102	
C228	Same as C125	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C231	Same as C131	
C238	Same as C138	
C240	Same as C140	
C247	Same as C140	
C250	Same as C150	
C252	Same as C150	
C256	Same as C156	
C257	Cap.,4.7µ,+100%-10%,25V,elect.	74 120 6160
C261	Same as C156	
C262	Same as C140	
C263	Same as C140	
C271	Same as C171	
C272	Same as C171	
C274	Cap.,150p,10%,5V,cer.	74 050 3010
C276	Same as C176	
C280	Same as C180	
C281	Same as C176	
C286	Same as C140	
C291	Same as C140	
C292	Cap.,180p,10%,50V,cer.	74 050 5950
C295	Same as C140	
C296	Same as C140	
C299	Same as C102	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
L141	Inductor,ferrite bead core	74 560 1240
L145	Same as L141	
L241	Same as L141	
L245	Same as L141	
R101	Res.,510k,5%,1/4W,cabon	74 223 4300
R102	Res.,100.1%,1/4W,metal	74 221 4290
R103	Same as R102	
R104	Res.,1k,var.,0.167W,cabon	74 321 0040
R105	Res.,430,5%,1/4W,cabon	74 223 2510
R106	Res.,3.3k,2%,1/4W,metal	74 221 4470
R108	Same as R106	
R110	Res.,5.6k,2%,1/4W,metal	74 221 3970
R112	Same as R105	
R113	Res.,390,2%,1/4W,metal	74 221 3790
R115	Thermistor,TD5-A115	74 470 3480
R116	Res.,130,2%,1/4W,metal	74 221 6480
R118	Res.,510,2%,1/4W,metal	74 221 3810
R120	Res.,100,2%,1/4W,metal	74 221 3730
R122	Res.,4.3k,2%,1/4W,metal	74 221 4390
R123	Same as R122	
R124	Res.,10,5%,1/4W,cabon	74 223 3210
R125	Res.,10,2%,1/4W,metal	74 221 5740
R126	Same as R125	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R128	Same as R124	
R130	Res.,43,2%,1/4W,metal	74 221 5860
R131	Res.,500,var.,0.5W,metal	74 349 2450
R132	Same as R130	
R133	Res.,1.1k,5%,1/4W,cabon	74 223 1910
R135	Res.,150,2%,1/4W,metal	74 221 5670
R136	Res.,100,var.,0.5W,metal	74 349 2520
R138	Same as R131	
R140	Res.,300,5%,1/4W,carbon	74 223 4340
R141	Res.,1k,2%,1/4W,metal	74 221 2860
R142	Res.,180,2%,1/4W,metal	74 221 6400
R143	Res.,100,30%,0.3W,metal	74 349 3020
R145	Same as R141	
R147	Same as R140	
R148	Res.,100,var.,0.5W,cermet	74 349 2840
R150	Res.,22,5%,1/4W,cabon	74 223 4200
R151	Res.,1k,var.,0.1W,carbon	74 322 2800
R152	Same as R150	
R153	Same as R113	
R155	Same as R113	
R156	Res.,51,5%,1/4W,cabon	74 223 4010
R158	Res.,1.8k,2%,1/4W,metal	74 221 3900
R160	Res.,620,2%,1/4W,metal	74 221 4410

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R161	Same as R156	
R162	Res.,75,2%,1/4W,metal	74 221 2980
R163	Same as R162	
R165	Res.,2.2k,2%,1/4W,metal	74 221 4380
R166	Res.,330,2%,1/4W,metal	74 221 3770
R168	Res.,220,2%,1/4W,metal	74 221 5830
R170	Same as R168	
R171	Res.,51,2%,1/4W,metal	74 5610
R172	Res.,1k,var.,0.5W,metal	74 349 2460
R173	Same as R171	
R175	Res.,120,2%,1/4W,metal	74 221 6080
R177	Res.,5k,var.,0.5W,metal	74 349 2440
R178	Res.,910,2%,1/4,metal	74 221 3850
R179	Res.,200,var.,0.5W,cermet	74 349 2870
R180	Same as R178	
R182	Same as R122	
R183	Thermistor,TD5-C250	74 470 3490
R185	Res.,470,2%,1/4W,metal	74 221 4500
R201	Same as R101	
R202	Same as R102	
R203	Same as R102	
R204	Same as R104	
R205	Same as R105	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R206	Same as R106	
R207	Same as R177	
R208	Same as R106	
R209	Res.,75k,5%,1/4W,carbon	74 223 2280
R210	Same as R110	
R212	Same as R105	
R213	Same as R113	
R215	Same as R115	
R216	Same as R116	
R218	Same as R118	
R220	Same as R120	
R222	Same as R122	
R223	Same as R122	
R224	Same as R124	
R225	Same as R125	
R226	Same as R125	
R228	Same as R124	
R230	Same as R130	
R231	Same as R131	
R232	Same as R130	
R233	Same as R133	
R234	Same as R113	
R235	Same as R135	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R236	Same as R136	
R238	Same as R131	
R239	Thermistor, TD5-C150	74 470 3720
R240	Same as R140	
R241	Same as R141	
R242	Same as R142	
R243	Same as R143	
R244	Same as R113	
R245	Same as R141	
R247	Same as R140	
R248	Same as R148	
R250	Same as R150	
R251	Same as R151	
R252	Same as R150	
R253	Same as R113	
R254	Res.,360,2%,1/4W,metal	74 221 3780
R255	Same as R113	
R256	Same as R156	
R257	Res.,390,2%,1/4W,metal	74 221 3790
R258	Same as R158	
R260	Same as R160	
R261	Same as R156	
R262	Same as R162	
R263	Same as R162	
R265	Same as R165	
R266	Same as R166	
R267	Res.,300,2%,1/4W,metal	74 221 5580
R268	Same as R168	
R270	Same as R168	
R271	Same as R171	
R272	Same as R172	
R273	Same as R171	
R274	Res.,10k,var.,0.5W,cermet	74 349 2470
R275	Same as R175	
R277	Same as R185	
R278	Same as R178	
R279	Same as R179	
R280	Same as R178	
R282	Same as R122	
R283	Same as R183	
R284	Res.,30,2%,1/4W,metal	74 221 5760
R285	Same as R284	
R286	Res.,430,5%,1/4W,carbon	74 223 2510
R287	Res.,820,2%,1/4W,metal	74 221 3840

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R288	Same as R284	
R289	Same as R136	
R290	Same as R287	
R291	Same as R286	
R292	Same as R177	
R293	Res.,430,2%,1/4W,metal	74 221 3800
R294	Same as R293	
R295	Res.,200,2%,1/4W,metal	74 221 3760
R296	Same as R295	
R297	Res.,240,2%,1/4W,metal	74 221 4550
R298	Same as R297	
R299	Same as R148	
D101	Z.diode,RD6A	74 040 0790
D102	Same as D101	
D103	Diode,1S1690N	74 040 4100
D133	L.E.diode,SR103D	74 040 4740
D176	Diode,1S953	74 040 1720
D177	Same as D176	
D178	V.C.diode,1S1924	74 040 5000
D181	Same as D176	
D182	Same as D176	
D201	Same as D101	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D202	Same as D101	
D203	Same as D103	
D233	Same as D133	
D276	Same as D176	
D277	Same as D176	
D278	Same as D178	
D281	Same as D176	
D282	Same as D176	
Q102	FET,KH5199	74 036 1120
Q122	Transistor,2SC1254	74 036 1450
Q123	Same as Q122	
Q141	Same as Q122	
Q145	Same as Q122	
Q156	Transistor,2N3905 S	74 036 1528
Q161	Same as Q156	
Q168	Transistor,2N3905	74 030 8325
Q170	Same as Q168	
Q178	Transistor,2SA711	74 036 1310
Q180	Same as Q178	
Q202	Same as Q102	
Q222	Same as Q122	
Q223	Same as Q122	
Q241	Same as Q122	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
Q245	Same as Q122	
Q256	Same as Q156	
Q261	Same as Q156	
Q268	Same as Q168	
Q270	Same as Q168	
Q278	Same as Q178	
Q280	Same as Q178	
Q287	Same as Q122	
Q290	Same as Q122	
Q295	Same as Q178	
Q296	Same as Q178	
J201	BNC connector	74 500 2530

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
	PREAMPLIFIER(2)	
C301	Cap.,0.01µ,+80%-20%,25V,cer.	74 060 0560
C302	Same as C301	
C303	Cap.,51p,5%,50V,cer.	74 050 5520
C304	Same as C303	
C305	Cap.,39p,10%,50V,cer.	74 050 3380
C306	Cap.,200p,5%,50V,cer.	74 050 1750
C310	Same as C301	
C311	Same as C301	
C312	Same as C301	
C321	Same as C301	
C323	Same as C301	
C326	Cap.,6-20p,var.,250V,cer.	74 110 0870
C328	Cap.,0.22µ,10%,50V,poly.	74 130 1960
C355	Cap.,0.001µ,10%,50V,poly.	74 130 1310
C358	Same as C355	
C361	Cap.,5p,0.5p,50V,cer.	74 050 2620
C362	Same as C361	
C370	Cap.,4.7µ,+100%-10%,25V,elect.	74 120 6160
C372	Same as C370	
C381	Cap.,47p,5%,50V,cer.	74 050 2730
L310	Inductor,ferrite bead	74 560 1240

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
L321	Same as L310	
L370	Inductor, coil	74 400 5350
L372	Same as L370	
R301	Res.,7.5k,5%,1/4W,carbon	74 223 2100
R302	Same as R301	
R303	Res.,470,2%,1/2W,carbon	74 241 0360
R304	Res.,10k,var.,0.1W,carbon	74 322 0580
R306	Same as R303	
R308	Res.,1.8k,2%,1/4W,metal	74 221 3940
R310	Res.,200,2%,1/4W,metal	74 221 3760
R311	Same as R301	
R312	Same as R301	
R313	Same as R303	
R314	Same as R304	
R315	Res.,200,var.,0.1W,metal	74 349 2870
R316	Same as R303	
R318	Res.,270,2%,1/4,metal	74 221 5620
R320	Same as R318	
R321	Same as R310	
R322	Res.,1k,2%,1/4W,metal	74 221 3860
R331	Res.,50,10%,0.5W,cermet	74 349 2920
R332	Same as R331	
R333	Same as R331	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R340	Same as R310	
R341	Same as R310	
R342	Same as R310	
R343	Same as R310	
R345	Res.,300,5%,1/4W,carbon	74 223 4340
R348	Same as R345	
R350	Res.,01k,5%,1/4W,carbon	74 223 2130
R351	Res.,75,2%,1/4W,metal	74 221 5980
R352	Res.,150,2%,1/4W,metal	74 221 5980
R353	Res.,150,2%,1/4W,metal	74 221 5670
R355	Res.,220,2%,1/4W,metal	74 221 5830
R356	Same as R303	
R358	Same as R355	
R360	Same as R353	
R361	Res.,62,2%,1/4W,metal	74 221 5640
R362	Same as R361	
R363	Res.,12k,2%,1/4W,metal	74 221 4240
R364	Res.,100,var.,0.1W,metal	74 349 2840
R365	Same as R363	
R366	Res.,1.5k,5%,1/4W,carbon	74 223 1930
R368	Same as R366	
R370	Res.,1k,5%,1/4,carbon	74 223 1900
R371	Res.,9.1k,5%,1/4W,metal	74 221 5400

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R372	Res.,110,5%,1/4W,metal	74 221 3740
R373	Res.,910,5%,1/4W,carbon	74 223 3360
R375	Same as R345	
R376	Res.,750,2%,1/4W,metal	74 221 3830
R378	Res.,620,5%,1/4W,carbon	74 223 2540
R380	Res.,270,2%,1/2W,carbon	74 241 0300
R381	Res.,47k,2%,1/4W,metal	74 221 6550
D303	Diode,1S953	74 040 1720
D306	Same as D303	
D313	Same as D303	
D316	Same as D303	
D318	Same as D303	
D320	Same as D303	
D322	Same as D303	
D341	Same as D303	
D342	Same as D303	
D343	Same as D303	
Q303	Transistor,2SC1216 H	74 030 6220
Q306	Same as Q303	
Q313	Same as Q303	
Q316	Same as Q303	
Q355	Transistor,2SC1275	74 030 6890
Q358	Same as Q355	
Q372	Transistor,2N3905	74 030 8325
IC301	Integrated circuit,FT5714M-GB	74 030 7330
IC302	Integrated circuit,BY-1 B2	74 570 0720
J301	Connector	74 500 5380
J302	Connector	74 500 5780
P302	Connector	
	Right angle header (7P)	74 500 6170
	Right angle header (7P)	74 500 6180

TRIGGER AMPLIFIER

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C401	Cap.,0.01µ,+80%-20%,25V,cer.	74 0600560
C408	Cap.,100p,+80%-20%,50V,cer.	74 060 1750
C410	Cap.,56p,10%,50V,cer	74 050 2720
C415	Same as C408	
C421	Same as C401	
C428	Same as C408	
C430	Same as C410	
C431	Cap.,6-20p,var.,250V,cer.	74 110 0870
C435	Same as C408	
C491	Cap.,0.01µ,+80%-20%,25W,cer.	74 060 0560
C492	Same as C491	
R401	Res.,43,2%,1/4W,metal	74 221 3800
R402	Res.,91,2%,1/4W,metal	74 221 5870
R403	Same as R402	
R405	Res.,47,2%,1/4W,metal	74 221 5680
R406	Same as R405	
R408	Res.,560,2%,1/4W,metal	74 221 2530
R410	Res.,30,2%,1/4W,metal	74 221 5760
R411	Res.,50,1%,0.5W,metal	74 349 2920
R412	Res.,750,2%,1/4W,metal	74 221 3830
R413	Same as R412	
R414	Res.,500,10%,0.5W,metal	74 349 2850
R415	Same as R408	
R416	Same as R401	
R417	Same as R401	
R418	Res.,200,10%,0.5W,metal	74 349 2870
R421	Res.,300,2%,1/4W,metal	74 221 5580
R422	Same as R402	
R423	Same as R402	
R425	Same as R405	
R426	Same as R405	
R428	Same as R408	
R430	Res.,43,2%,1/4W,metal	74 221 5860
R431	Same as R411	
R432	Same as R412	
R433	Same as R412	
R434	Same as R414	
R435	Same as R408	
R436	Same as R401	
R437	Same as R401	
R440	Res.,390,2%,1/4W,metal	74 221 3790
R441	Same as R440	
R442	Res.,160,2%,1/4W,metal	74 221 2440
R443	Same as R442	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R444	Res.,51,2%,1/4W,metal	74 221 4010
R445	Res.,240,2%,1/2W,carbon	74 241 0290
R446	Res.,240,2%,1/4W,metal	74 221 3970
R447	Same as R418	
R448	Res.,2.2k,2%,1/4W,metal	74 221 4380
R450	Res.,500,2%,0.5W,metal	74 349 2740
R451	Res.,3k,2%,1/4W,metal	74 221 4450
R452	Res.,12k,2 1/4	74 221 4240
R453	Same as R451	
R455	Res.,2.4k,2%,1/4W,metal	74 221 4230
R456	Res.,2k.2%,1/4W.metal	74 221 3910
R458	Res.,110,5%,1/4W,carbon	74 223 4360
R460	Res.,5%,1/4W,carbon	74 223 2530
R461	Same as R460	
R462	Res.,1.1k,2%,1/4W,metal	74 221 3870
R463	Res.,1k,5%,1/4W,carbon	74 223 1900
R465	Same as R445	
R468	Res.,1.6k,2%,1/4W,metal	74 221 3890
R469	Res.,1.6,2%,1/4W,metal	74 221 3890
R470	Res.,820,5%,1/4W,metal	74 223 2640
R491	Res.,100,5%,1/4W,metal	74 221 3730
R492	Same as R491	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D448	Diode,1S953	74 040 1720
D450	Same as D448	
D452	Same as D448	
D453	Same as D448	
Q412	Transistor,2SC1254	74 036 1450
Q413	Same as Q412	
Q432	Same as Q412	
Q433	Same as Q412	
Q442	Transistor,2N5771 S	74 036 1320
Q443	Same as Q442	
Q446	Transisotr,2N3905	74 030 8325
IC402	Integrated circuit,BY-2	74 570 0730

CIRCUIT REFERNCE	DESCRIPTION	IWATSU PART NO.
SWITCHING LOGIC		
C501	Cap.,0.01μ,5%,25V,cer.	74 060 0560
C502	Same as C501	
C503	Cap.,200p,10%,50V,cer.	74 050 1750
C504	Same as C50	
C505	Same as C503	
C506	Same as C501	
C507	Cap.,180p,10%,50V,cer.	74 050 5950
C508	Same as C501	
C511	Cap.,1000p.+80%-20%,50V,cer.	74 060 1750
C520	Cap., 4.7μ,+100%-10%,25V,elect.	74 120 6160
C521	Same as C501	
C522	Same as C501	
L520	Inductor,coil	74 400 5350
R503	Res.,560,2%,1/4W,metal	74 221 5690
R505	Same as R503	
R506	Res.,360,2%,1/4W,metal	74 221 3780
R508	Res.,3.6k,2%,1/4W,metal	74 221 3930
R510	Res.,680,2%,1/4W,metal	74 221 3820
R511	Res.,330,2%,1/4W,metal	74 221 3770
R512	Res.,620,2%,1/4W,metal	74 221 4410

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R513	Res.,2.7k,2%,1/4W,metal	74 221 3920
R515	Res.,5.1k,2%,1/4W,metal	74 221 3960
R516	Same as R515	
R518	Same as R515	
R519	Same as R515	
R520	Res.,51,2%,2W,carbon	74 243 0120
R521	Res.,1.5k,5%,1/4W,carbon	74 223 1930
R522	Res.,1k,5%,1/4W,carbon	74 223 1900
R503	Diode,1S953	74 040 1720
R504	Same as D503	
D505	Same as D503	
D520	Diode,RD5A	74 040 0770
IC501	Integrated circuit,M53274	74 030 7760
IC502	Integrated circuit,M53203P	74 030 7580
IC503	Integrated circuit,M53200	74 030 6530
IC504	Integrated circuit,M53204	74 030 6540
IC505	Integrated circuit,BY52 B1	74 570 0560
S501	Push switch	74 430 1553
S502	Push switch	74 430 1549
P501	Connector	74 500 5370
P502	Connector	74 500 6170

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
VERTICAL MAIN AMPLIFIER		
C601	Cap.,0.01μ,+100%-0%,500V,cer.	74 060 0730
C602	Same as C601	
C603	Cap.,0.01μ,+80%-20%,50V,cer.	74 060 0580
C618	Cap.,6-20p,var.,250V,cer.	74 110 0630
C619	Cao.,18p,10%,50V,cer.	74 050 3060
C623	Same as C603	
C627	Same as C603	
C633	Cap.,220,10%,50V,cer.	74 050 2750
C635	Same as C618	
C636	Same as C618	
C637	Cap.,2p,2%,50V,cer.	74 050 1690
C647	Same as C603	
C648	Same as C603	
C649	Same as C603	
C650	Same as C603	
C653	Cap.,1000p,+80%-70%,500V,cer.	74 060 0700
C654	Same as C653	
C661	Same as C603	
C663	Same as C601	
C664	Same as C601	
C680	Cap.,0.001μ,10%,50V,poly.	74 130 1310

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C681	Same as C680	
C685	Same as C618	
C692	Same as C618	
C693	Same as C619	
C694	Same as C619	
L647	Inductor,ferrite bead	74 560 1240
L648	Same as L647	
L655	Inductor,peaking coil(d)	74 400 5650
L656	Same as L655	
L680	Same as L647	
L681	Same as L647	
R601	Res.,50,var.,0.5W,metal	74 349 2920
R602	Res.,150,2%,1/4W,metal	74 221 5670
R604	Res.,74,5%,1/4W,carbon	74 223 3990
R605	Same as R604	
R606	Res.,200,2%,1/4W,metal	74 221 3760
R608	Same as R601	
R611	Res.,100,2%,1/4W,metal	74 221 3730
R613	Res.,82,5%,1/4W,carbon	74 223 3370
R614	Same as R606	
R615	Res.,200,var.,0.5W,cermet	74 349 2870
R617	Res.,200,var.,0.5W,cermet	74 349 2230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R618	Res.,2,5%,1/4W,carbon	74 223 1950
R619	Thermistor,TD5-C250	74 470 3490
R621	Same as R618	
R622	Res.,430,2%,1/4W,metal	74 221 3800
R623	Same as R622	
R625	Thermistor,TD5-C150	74 470 3720
R626	Res.,2k,5%,1/4W,carbon	74 223 1950
R631	Res.,56,5%,1/4W,carbon	74 223 4380
R632	Same as R631	
R633	Res.,2k,var.,0.5W,cermet	74 349 3128
R636	Same as R617	
R637	Res.,20k,var. 0.5W,cermet	74 349 2500
R638	Res.,47,2%,1/4W,metal	74 221 5680
R641	Res.,75,2%,1/2W,carbon	74 241 0170
R642	Same as R641	
R643	Same as R641	
R644	Same as R643	
R649	Res.,2.4k,5%,1/4W,carbon	74 223 1900
R650	Same as R649	
R651	Res.,820,5%,1/4W,carbon	74 223 2640
R653	Res.,1k,5%,5W,metal	74 221 8730
R654	Same as R653	
R655	Res.,20k,+5%,5W,metal	74 221 8750

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R656	Same as R655	
R657	Res.,150k,5%,1/4W,carbon	74 223 2310
R658	Res.,56k,5%,1/4W,carbon	74 223 3220
R661	Same as R658	
R662	Same as R657	
R663	Res.,160k,5%,1/4W,carbon	74 223 4250
R664	Same as R663	
R668	Res.,650,5%,1/4W,carbon	74 223 2530
R669	Same as R668	
R670	Res.,1.6k,+5%,5W,metal	74 221 8740
R671	Same as R670	
R680	Res.,150,5%,1/4W,carbon	74 223 3280
R681	Same as R680	
R682	Res.,51,5%,1/4W,carbon	74 223 4010
R683	Same as R682	
R684	Res.,100,2%,1/4W,metal	74 221 3730
R685	Res.,100,var.,0.5W,cermet	74 349 3142
R687	Res.,240,2%,1/2W,carbon	74 241 0290
R688	Same as R687	
R690	Res.,130,2%,1/4W,metal	74 221 6480
R691	Same as R690	
R692	Same as R606	
R695	Res.,3.9k,5%,1/4W,carbon	74 223 2020

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R696	Res.,1.3k,5%,1/4W,carbon	74 223 1920
R697	Same as R619	
R698	Res.,22,5%,1/4W,carbon	74 253 0690
R699	Same as R698	
D618	Diode,1S1924	74 040 5000
D651a.b.c	Diode,1S953	74 040 1720
D653	Z.diode,RD27FB	74 040 5272
D654	Same as D653	
D655	Same as D653	
D656	Same as D653	
D663	Same as D651	
D664	Same as D651	
D694	Same as D618	
Q622	Transistor,2n5771	74 030 7800
Q623	Same as Q622	
Q627	Transistor,BFW-30	74 030 4620
Q628	Same as Q627	
Q642	Transistor,2SC1068/201	74 030 8136
Q643	Same as Q642	
Q647	Transistor,2N3119	74 030 1830
Q648	Same as Q647	
Q663	Transistor,2SC1706 H	74 030 8139
Q664	Same as Q663	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
Q680	Transistor,2N3905	74 030 8325
Q681	Same as Q680	
NE2001	Neon bracket lamp,NL-2S	74 020 1780
NE2002	Same as NE2001	
DL601	Delay cable	74 160 0180
P601	Connector	74 500 5370

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
A TRIGGER GENERATOR		
C802	Cap.,12p,10%,500V,cer.	74 050 1950
C803	Cap.,2p,0.5p,500V,cer.	74 050 1900
C804	Cap.,0.047µ,600V,poly.	74 130 3820
C805	Cap.,100p,10%,500V,cer.	74 050 1710
C806	Cap.,68p,10%,500V,cer.	74 050 3390
C807	Same as C802	
C808	Cap.,1000p,+100%-10%,500V,cer.	74 060 0700
C809	Cap.,0.1µ,20%,100V,cer.	74 130 5280
C810	Same as C809	
C811	Cap.,0.01µ,+80%-20%,50V,cer.	74 060 0580
C819	Same as C809	
C820	Same as C809	
C822	Same as C811	
C829	Cap.,82p,10%,50V,cer.	74 050 4730
C830	Cap.,100p,10%,50V,cer.	74 050 1710
C831	Same as C811	
C832	Same as C811	
C834	Cap.,0.001µ,10%,50V,poly.	74 130 1310
C843	Same as C811	
C844	Same as C811	
C851	Same as C809	
C852	Same as C809	
C854	Same as C811	
C857	Same as C811	
C858	Cap.,47p,10%,500V,cer.	74 050 2080
C875	Cap.,20p,5%,50V,cer.	74 050 5280
C877	Same as C830	
C878	Cap.,1u,+150%-10%,50V,elect.	74 120 5810
C882	Cap.,10µ,+100%-10%,25V,elect.	74 120 6230
C886	Cap.,4.7µ,+100%-10%,25V,elect.	74 120 6160
C887	Cap.,200p,5%,50V,cer.	74 050 1750
C893	Same as C829	
C895	Same as C811	
C896	Same as C811	
L857	Inductor,peaking coil(B) 6T	74 400 3340
	(Res.,270,2%,1/4W,carbon)	74 244 0040
L875	Inductor,coil,10T	74 400 2880
R801	Res.,22,5%,1/4W,carbon	74 223 4200
R802	Res.,900k,1%,1/4W,carbon	74 226 0100
R803	Res.,110k,1%,1/4W,carbon	74 226 1660
R804	Res.,1k,5%,1/4W,compo.	74 253 0500
R805	Res.,100k,5%,1/4W,carbon	74 223 2290
R806	Res.,240k,5%,1/4W,carbon	74 223 3260

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R807	Res.,900k,0.5%,1/2W,metal	74 221 8280
R808	Res.,1M,2%,1/2W,carbon	74 241 1130
R809	Res.,100k,0.5%,1/4W,metal	74 221 8230
R810	Res.,47k,5%,1/4W,carbon	74 223 2240
R811	Res.,910,5%,1/4W,carbon	74 223 3360
R822	Same as R811	
R823	Res.,180,5%,1/4W,carbon	74 223 2450
R824	Res.,22,5%,1/4W,carbon	74 223 4200
R826	Res.,47,5%,1/4W,carbon	74 223 2730
R827	Res.,3k,5%,1/4W,carbon	74 223 1990
R828	Same as R826	
R829	Same as R826	
R831	Res.,240,5%,1/4W,carbon	74 223 4020
R832	Same as R824	
R833	Same as R831	
R834	Res.,91,5%,1/4W,carbon	74 223 2400
R835	Same as R827	
R836	Res.,500,var.,0.5W,cermet	74 349 3135
R837	Same as R836	
R838	Res.,1.8k,5%,1/4W,carbon	74 223 1940
R841	Res.,82,5%,1/4W,carbon	74 223 3370
R851	Res.,9.1M,5%,1/2W,compo.	74 254 0950
R852	Same as R851	
R853	Same as R826	
R854	Same as R824	
R856	Res., 62,5%,1/4W,carbon	74 223 4110
R858	Res.,360,5%,1/4W,carbon	74 223 2480
R859	Res.,3.6k,5%,1/4W,carbon	74 223 2010
R861	Res.,1k,var.,0.5W,cermet	74 349 3154
R862	Res.,820,5%,1/4W,carbon	74 223 2640
R863	Res.,1k,5%,1/4W,carbon	74 223 1900
R864	Same as R863	
R865	Same as R863	
R866	Res.,2k,var.,0.25W,carbon	74 325 3220
R867	Same as R826	
R868	Res.,18k,5%,1/4W,carbon	74 223 2690
R869	Res.,470Ω,5%,1/4W,carbon	74 223 2630
R871	Same as R823	
R872	Res.,6.2k,5%,1/4W,carbon	74 223 2080
R873	Same as R858	
R874	Res.,1.6k,2%,1/4W,metal	74 221 3890
R875	Same as R824	
R876	Res.,15k,5%,1/4W,carbon	74 223 2680
R877	Res.,27,5%,1/4W,carbon	74 223 3800
R881	Same as R856	
R883	Res.,100,5%,1/4W,carbon	74 223 3190
R884	Res.,750,5%,1/4W,carbon	74 223 2570
R885	Res.,5.1k,5%,1/4W,carbon	74 223 2060
R886	Res.,3.3k,5%,1/4W,carbon	74 223 2000

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
TRIGGER MAIN AMPLIFIER		
C702	Cap.,200p,5%,50V,cer.	74 050 1750
C705	Cap.,62p,10%,50V,cer.	74 050 6140
C722	Cap.,0.01µ,80%,-20%,50V,cer.	74 060 0580
C723	Same as C722	
C727	Same as C722	
C728	Same as C722	
C1201	Cap.,10µ,+100%-10%,25V,cer.	74 120 6230
C1203	Same as C722	
L727	Inductor,coil	74 400 5490
L728	Same as L727	
R701	Res.,51,5%,1/4W,carbon	74 223 4010
R702	Same as R701	
R703	Res.,33,5%,1/4W,carbon	74 223 4330
R704	Same as R703	
R705	Res.,24,2%,1/4W,metal	74 221 5990
R706	Res.,750,5%,1/4W,carbon	74 223 2570
R707	Same as R706	
R708	Res.,270,5%,1/4W,carbon	74 223 2700
R709	Res.,330,2%,1/2W,carbon	74 241 0320
R710	Same as R709	
R711	Same as R708	
R712	Res.,510,5%,1/4W,carbon	74 223 2520
R713	Res.,50,var.,0.5W,cermet	74 349 2920
R714	Res.,50,var.,0.5W,cermet	74 349 3155
R715	Same as R709	
R716	Same as R709	
R717	Res.,180,2%,1/2W,carbon	74 241 0260
R718	Res.,10k,5%,1/4W,carbon	74 223 2130
R719	Res.,51,5%,1/4W,carbon	74 223 4010
R721	Res.,1.5k,5%,1/4W,carbon	74 223 1930
R722	Res.,100,5%,1/4W,carbon	74 223 3190
R723	Res.,330,5%,1/4W,carbon	74 223 3230
R724	Same as R701	
R725	Res.,5k,var.,0.5W,cermet	74 349 3153
R726	Res.,3k,5%,1/4W,carbon	74 223 1990
R1201	Res.,22,5%,1/4W,carbon	74 223 4200
D718	Diode,1S953	74 040 1720
Q703	Transistor,2N3905	74 030 8325
Q704	Same as Q703	
Q715	Transistor,2SC1216	74 030 6170
Q716	Same as Q715	
Q721	Same as Q715	
S1201	Push Switch	74 430 1551

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R887	Same as R886	
R888	Res.,300,5%,1/4W,carbon	74 223 4340
R891	Same as R886	
R892	Same as R883	
R893	Res.,2.2k,5%,1/4W,carbon	74 223 1960
D811	Diode,1S1544A	74 040 4670
D822	Same as D811	
D841	Diode,1S953	
D842	Same as D841	74 040 1720
D843	Same as D841	
D844	Same as D841	
D845	L.E.diode,SR103D	74 040 4740
D846	Same as D845	
D855	Same as D811	
D857	T.diode,1S1760	74 040 2900
D867	S.B.diode,1SS16	74 040 5180
D871	Same as D867	
D872	Same as D867	
D873	Same as D867	
D874	Same as D867	
D875	Same as D841	
D883	Same as D841	
D884	Same as D845	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D885	Same as D841	
D893	Same as D841	
D894	Same as D841	
D895	Same as D841	
D896	Same as D841	
Q825	FET,30088C/5007-2	74 030 8084
Q828	Transistor,2SC1216	74 030 6170
Q841	Transistor,2SC1254	74 030 6860
Q842	Same as Q828	
Q857	Transistor,2N3905	74 030 8325
Q867	Same as Q857	
Q886	Same as Q828	
Q888	Same as Q828	
IC851	Integrated circuit,A28	74 570 0700
	Socket	74 480 2150
IC875	Integrated circuit,A4	74 570 0120
	Socket	74 480 2190
S801	Lever switch	74 440 2120
S802	Lever switch	74 440 2090
S803	Push switch	74 430 1551
T867	Pulse trans	74 472 1310

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
J801	Connector	74 500 5330
J802	Connector	74 500 5380
J803	Connector	74 500 2530
P802	Connector	74 500 5370

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
A SWEEP GENERATOR		
C908	Cap.,390,10%,50V,cer.	74 050 4460
C921	Cap.,0.01μ,20%,50V,cer.	74 060 3020
C928	Cap.,27p,10%,50V,cer.	74 050 5760
C933	Same as C921	
C942	Cap.,47p,10%,50V,cer.	74 050 2730
C943	Same as C921	
C946	Cap.,1000p,20%,50V,cer.	74 060 0600
C948	Cap.,2p,0.5%,100V,cer.	74 050 1900
C952	Cap.,22p,10%,50V,cer.	74 050 3050
C954	Same as C928	
C962	Cap.,0.022u,+80%-20%,25V,cer.	74 060 3180
C967	Same as C921	
C968	Cap.,18p,10%,50V,cer.	74 050 3060
C975	Cap.,33p,10%,50V,cer.	74 050 3910
C981	Same as C921	
C982	Same as C921	
R901	Res.,150,2%,1/4W,metal	74 221 5670
R902	Res.,3k,var.,0.5W,cermet	74 349 3144
R903	Res.,1k,2%,1/4W,metal	74 221 4230
R904	Res.,12k,2%,1/4W,metal	74 221 4240

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R906	Res.,1k,5%,1/4W,carbon	74 223 1900
R907	Res.,2.4k,5%,1/4W,carbon	74 223 1970
R908	Res.,910,5%,1/4W,carbon	74 223 3360
R910	Res.,390,2%,1/4W,metal	74 241 0340
R911	Res.,4.7k,5%,1/4W,carbon	74 223 2040
R912	Res.,7.51,5%,1/4W,carbon	74 223 2100
R914	Res.,1.3k,5%,1/4W,carbon	74 223 1920
R916	Same as R906	
R917	Same as R912	
R918	Res.,62,5%,1/4W,carbon	74 223 4110
R921	Res.,390,5%,1/4W,carbon	74 223 2500
R922	Res.,3k,5%,1/4W,carbon	74 223 1990
R923	Res.,4.3k,5%,1/4W,carbon	74 223 2030
R925	Res.,2.2k,5%,1/4W,carbon	74 223 1960
R926	Res.,24k,5%,1/4W,carbon	74 223 3400
R928	Res.,30k,5%,1/4W,carbon	74 223 2210
R929	Res.,22,5%,1/4W,carbon	74 223 4200
R932	Res.,430,5%,1/4W,carbon	74 223 2510
R933	Res.,51k,2%,1/4W,metal	74 221 8550
R934	Res.,10k,2%,1/4W,metal	74 221 4010
R935	Res.,2k,var.,0.5W,cermet	74 349 3145
R936	Res.,3.3k,2%,1/4W,metal	74 221 4470
R937	Res.,680,5%,1/4W,carbon	74 223 2550
R942	Res.,510,5%,1/4W,carbon	74 223 2520
R943	Res.,4.3k,2%,1W,carbon	74 242 0430
R945	Res.,10,5%,1/4W,carbon	74 223 3210
R946	Res.,20k,5%,1/4W,carbon	74 223 2170
R947	Res.,47,5%,1/4W,carbon	74 223 2730
R948	Res.,4.3k,2%,1/4W,metal	74 221 4390
R949	Same as R947	
R950	Same as R928	
R951	Same as R907	
R952	Res.,65k,5%,1/4W,carbon	74 223 3220
R953	Res.,2.2k,5%,1/4W,carbon	74 223 1960
R954	Same as R907	
R955	Res.,1k,var.,0.5W,cermet	74 349 3136
R956	Res.,100,5%,1/4W,carbon	74 223 3190
R957	Res.,2.4k,2%,1/4W,metal	74 221 4230
R958	Same as R957	
R959	Res.,6.2k,2%,1W,carbon	74 242 0470
R960	Same as R947	
R961	Res.,10k,5%,1/4W,carbon	74 223 2130
R962	Res.,3.3k,5%,1/4W,carbon	74 223 2000
R964	Res.,470,5%,1/4W,carbon	74 223 2630
R965	Res.,12k,5%,1/4W,carbon	74 223 2150

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R968	Same as R901	
R971	Same as R904	
R972	Res.,1.2k,5%,1/4W,carbon	74 223 2610
R973	Res.,2k,var.,0.5W,cermet	74 349 3145
R974	Same as R908	
R975	Same as R964	
R976	Res.,11k,5%,1/4W,carbon	74 223 3310
R977	Same as R906	
R978	Res.,1k,var.,carbon	74 325 3000
R982	Res.,100,5%,1/4W,carbon	74 223 3190
D901	T.diode,1S1760	74 040 2900
D905	Diode,1S953	74 040 1720
D907	Same as D905	
D908	Same as D905	
D913	Same as D905	
D914	Same as D905	
D915	Same as D905	
D916	Same as D905	
D923	Same as D905	
D924	Same as D905	
D925	S.B.diode,1SS16	74 040 5180
D927	Same as D905	
D931	Diode,1S1458	74 040 2920
D932	Same as D931	
D933	Same as D905	
D943	Z.diode,RD7AM	74 040 4500

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D946	Z.did	74 040 4910
D956	Same as D905	
D962	Same as D905	
D963	Z.diode,RD4AM	74 040 5010
D965	Same as D905	
D968	T.diode,1S1760	74 040 2900
D976	Same as D9250	
D977	Same as D905	
Q905	Transistor,2SC1216	74 030 6170
Q912	Same as Q905	
Q917	Same as Q905	
Q928	Transistor,2SC1707 H	74 030 3980
Q932	Transistor,25A578	74 030 6880
Q937	FET,2SK12(Y)	74 030 2920
Q942	Transistor,2SC1254	74 030 6860
Q950	Transistor,2SA495	
Q951	Transistor,2N3905	74 030 8325
Q952	Same as Q950	
Q956	Transistor,2SC373	74 030 2610
Q961	Same as Q950	
Q977	Same as Q951	
IC923	Integrated circuit,A29	74 570 0710
	Socket	74 480 2150
J916	Connector	74 500 2530

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
B TRIGGER GENERATOR		
C1002	Cap.,2p,0.5j,500V,cer.	74 050 1900
C1003	Cap.,24p,5%,500V,cer.	74 050 6770
C1004	Cap.,0.047μ,600V,poly.	74 130 3820
C1005	Cap.,100p,10%,500V,cer.	74 050 1930
C1006	Cap.,68p,10%,500V,cer.	74 050 4090
C1008	Cap.,1000p,+100%-0%,50V,cer.	74 060 0700
C1009	Cap.,82p,10%,500V,cer.	74 050 4730
C1011	Cap.,0.01μ,20%,50V,cer.	74 060 3020
C1012	Same as C1011	
C1015	Same as C1011	
C1024	Same as C1011	
C1025	Same as C1011	
C1027	Cap.,47p,10%,500V,cer.	74 050 2080
C1028	Same as C1011	
C1034	Same as C1011	
C1041	Cap.,4.7μ,+150%-10%,25V,elect.	74 120 6160
C1042	Same as C1011	
C1043	Same as C1041	
C1044	Same as C1011	
L1006	Inductor,ferrite bead	74 560 1240
L1026	Inductor,coil 6T	74 400 3340
L1032	Inductor,coil 10T	74 400 2880
	Inductor,ferrite bead	74 560 1040
L1041	Inductor,coil	74 400 5490
	Inductor,toroidle core	74 560 1590
L1043	Same as L1041	
R1001	Res.,22,5%,1/4W,carbon	74 223 4200
R1002	Res.,900,1%,1/4W,carbon	74 226 0100
R1003	Res.,110k,1%,1/4W,carbon	74 226 1660
R1004	Res.,100,5%,1/4W,carbon	74 223 2290
R1006	Res.,240,5%,1/4W,carbon	74 223 3260
R1007	Res.,1M,2%,1/2W,carbon	74 241 1130
R1008	Res.,900k,0.5p,1/2W,metal	74 221 8280
R1009	Res.,100k,0.5p,1/4W,metal	74 221 8230
R1011	Res.,910,5%,1/4W,carbon	74 223 3360
R1012	Same as R1011	
R1013	Res.,180,5%,1/4W,carbon	74 223 2450
R1014	Res.,22,5%,1/4W,carbon	74 223 4200
R1015	Res.,47,5%,1/4W,carbon	74 223 2730
R1016	Res.,3k,5%,1/4W,carbon	74 223 1990
R1017	Same as R1015	
R1018	Same as R1014	
R1021	Same as R1016	
R1022	Res.,1.2k,5%,1/4W,carbon	74 223 2610

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1023	Res.,82,5%,1/4W,carbon	74 223 3370
R1026	Res.,270,2%,1/4W,carbon	74 244 0040
R1027	Res.,62,5%,1/4W,carbon	74 223 4110
R1028	Res.,360,5%,1/4W,carbon	74 223 2480
R1029	Res.,7.5k,5%,1/4W,carbon	74 223 2100
R1030	Same as R1015	
R1031	Res.,18k,5%,1/4W,carbon	74 223 2690
R1032	Same as R1015	
R1033	Res.,22,5%,1/4W,carbon	74 223 4200
R1034	Res.,390,5%,1/4W,carbon	74 223 2500
R1035	Same as R1022	
R1036	Res.,10k,var.,0.5W,cermet	74 349 3148
R1037	Same as R1022	
R1038	Res.,10k,var.,0.1W,carbon	74 322 0210
R1039	Same as R1013	
R1110	Res.,1k,5%,1/4W,carbon	74 253 0500
D1011	Diode,1S1544A	74 040 4670
D1012	Same as D1011	
D1022	Diode,1S953	74 040 1720
D1023	Same as D1022	
D1024	Same as D1022	
D1025	Same as D1022	
D1027	T.diode,1S1760	74 040 2900
D1032	S.B.diode,1SS16	74 040 5180
D1033	Same as D1022	
Q1016	FET,3008C/5007-2	74 030 8084
Q1017	Transistor,2SC1216	74 030 6170
Q1022	Same as Q1017	
Q1023	Same as Q1017	
Q1032	Transistor,2N3905	74 030 8325
S1001	Lever switch	74 440 2120
S1004	Lever switch	74 440 2090
S1024	Lever switch	74 440 2110
J1001	Connector	74 500 5380
J1002	Connector	74 500 5330
J1003	Connector	74 500 2530
P1001	Connector	74 500 5350

B SWEEP GENERATOR

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1112	Cap.,390p,10%,50V,cer.	74 050 4460
C1118	Cap.,0.01μ,+80%-20%,50V,cer.	74 060 0580
C1127	Cap.,150p,10%,50V,cer.	74 050 3010
C1132	Cap.,4700p,+80%-20%,50V,cer.	74 060 1660
C1137	Cap.,22p,10%,50V,cer.	74 050 3050
C1141	Cap.,2p,0.5p,500V,cer.	74 050 1900
C1142	Cap.,33p,10%,50V,cer.	74 050 3910
C1143	Cap.,47p,10%,50V,cer.	74 050 2730
C1145	Cap.,1000p,20%,500V,cer.	74 060 0690
C1148	Same as C1118	
C1151	Same as C1137	
C1157	Cap.,4.7μ,+100%-10%,25V,elect.	
C1158	Same as C1118	
C1161	Cap.,150p,10%,50V,cer.	74 050 3010
C1166	Cap.,100p,10%,500V,cer.	74 050 1930
C1176	Cap.,8p,0.5p,50V,cer.	74 050 5600
C1177	Same as C1118	
C1178	Cap.,33μ,+100%-10%,25V,elect.	74 120 6170
C1180	Same as C1118	
C1194	Same as C1118	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1195	Same as C1118	
C1196	Same as C1157	
C1197	Same as C1118	
C1198	Same as C1157	
L1118	Inductor,ferrite bead core	74 560 1240
L1195	Inductor,coil	74 400 5490
	Inductor,toroidle core	74 560 1590
L1197	Same as L1195	
R1101	Res.,3k,5%,1/4W,carbon	74 223 1990
R1102	Res.,1.2k,2%,1/4W,metal	74 221 4400
R1103	Res.,3k,var.,0.5W,cermet	74 349 3144
R1104	Res.,150,2%,1/4W,metal	74 221 5670
R1105	Res.,12k,2%,1/4W,metal	74 221 4240
R1106	Res.,100,5%,1/4W,carbon	74 223 3190
R1107	Res.,1k,5%,1/4W,carbon	74 223 1900
R1111	Res.,2.4k,5%,1/4W,carbon	74 223 1970
R1112	Res.,910,5%,1/4W,carbon	74 223 3360
R1113	Res.,4.7k,5%,1/4W,carbon	74 223 2040
R1114	Res.,7.5k,5%,1/4W,carbon	74 223 2100
R1115	Same as R1114	
R1116	Same as R1114	
R1117	Res.,390,5%,1/4W,carbon	74 223 2500
R1118	Same as R1101	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1119	Res.,47,5%,1/4W,carbon	74 223 2730
R1121	Res.,470,2%,1/2W,carbon	74 241 0360
R1125	Res.,2.2k,5%,1/4W,carbon	74 223 1960
R1126	Res.,24k,5%,1/4W,carbon	74 223 3400
R1128	Res.,1.3k,5%,1/4W,carbon	74 223 1920
R1131	Same as R1107	
R1132	Res.,6.2k,5%,1/4W,carbon	74 223 2080
R1134	Same as R1114	
R1135	Res.,1.5k,5%,1/4W,carbon	74 223 1930
R1137	Res.,30k,5%,1/4W,carbon	74 223 2210
R1138	Same as R1119	
R1141	Res.,680,5%,1/4W,carbon	74 223 2550
R1142	Res.,510,5%,1/4W,carbon	74 223 2520
R1143	Same as R1125	
R1144	Res.,500,var.,0.5W,cermet	74 349 3152
R1145	Res.,4.3k,2%,1/4W,metal	74 221 4390
R1146	Res.,20k,5%,1/4W,carbon	74 223 2170
R1147	Res.,10,5%,1/4W,carbon	74 223 3210
R1148	Res.,4.7k,2%,1/4W,carbon	74 242 0440
R1149	Res.,510,5%,1/4W,carbon	74 230 0450
R1150	Same as R	
R1151	Res., 56k,5%,1/4W,carbon	74 223 3220
R1152	Res.,430,5%,1/4W,carbon	74 223 2510

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1154	Same as R1135	
R1155	Res.,1.6k,2%,1/4W,metal	74 221 3890
R1156	Res.,7.5k,2%,1/4W,metal	74 221 4000
R1157	Res.,1.8k,2%,1/4W,metal	74 221 3900
R1158	Res.,62,2%,1/4W,metal	74 221 5640
R1159	Res.,6.2k,2%,1W,carbon	74 242 0470
R1161	Res.,2.7k,2%,1/4W,metal	74 221 3920
R1162	Res.,10k,2%,1/4W,metal	74 221 4010
R1163	Res.,1.3k,2%,1/4W,metal	74 221 4460
R1164	Same as R1107	
R1165	Res.,390,2%,1/4W,metal	74 221 3790
R1166	Res.,2k,2%,1/4W,metal	74 221 3910
R1167	Res.,5.k,2%,1W,carbon	74 242 0450
R1168	Res.,22k,2%,1/4W,metal	74 221 4490
R1171	Res.,5.6k,2%,1/4W,metal	74 221 3970
R1172	Res.,39k,2%,1/4W,metal	74 221 5700
R1173	Res.,39k,5%,1/4W,carbon	74 223 2220
R1174	Res.,5.6k,5%,1/4W,carbon	74 223 2070
R1175	Res.,11k,5%,1/4W,carbon	74 223 3310
R1176	Res.,51,5%,1/4W,carbon	74 223 4010
R1177	Same as R1176	
R1179	Res.,9.1k,5%,1/4W,carbon	74 223 2130
R1180	Same as R1176	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1181	Same as R1176	
R1182	Same as R1144	
R1183	Res.,100,2%,1/4W,metal	74 221 3730
R1184	Res.,2k,var.,W.W.	75 341 0480
R1185	Res.,510,2%,1/4W,metal	74 221 3810
R1186	Same as R1144	
R1190	Res.,100,5%,1/4W,carbon	74 223 3190
R1191	Same as R1162	
R1192	Res.,2k,var.,0.5W,cer.	74 349 3145
P1193	Res.,3.3k,2%,1/4W,metal	74 221 4470
R1194	Res.,51k,2%,1/4W,metal	74 221 8550
D1101	Diode,1S953	74 040 1720
D1104	T.diode,1S1760	74 040 2900
D1107	Same as D1101	
D1108	Same as D1101	
D1111	Same as D1101	
D1122	Same as D1101	
D1123	Same as D1101	
D1124	Same as D1101	
D1125	S.B.diode,1SS16	74 040 5180
D1126	Same as D1125	
D1127	Same as D1101	
D1128	Same as D1101	
D1131	Same as D1101	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D1133	Same as D1101	
D1134	Same as D1101	
D1136	Same as D1101	
D1138	Diode,1S1458	74 040 2920
D1145	Z.diode,RD9AM	74 040 4910
D1148	Z.diode,RD7AM	74 040 4500
D1154	Same as D1101	
D1161	Z.diode,RD6AM	74 040 0800
D1180	Same as D1101	
D1192	Same as D1101	
Q1107	Transistor,2SC1216	74 030 6170
Q1115	Same as Q1107	
Q1116	Same as Q1107	
Q1137	Transistor,2SC1707H	74 030 8168
Q1138	Transistor,2SA495 O/Y	74 030 6150
Q1141	Transistor,2SK12CY	74 030 2920
Q1142	Transistor,2SC1254	74 030 6860
Q1151	Same as Q1138	
Q1152	Transistor,2SA578	74 030 6880
Q1155	Transistor,2N3905	74 030 8325
Q1157	Same as Q1155	
Q1163	Same as Q1155	
Q1164	Same as Q1155	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
IC1175	Integrated circuit, CA3086	74 030 6800
	Socket	74 480 2150
S1101	Push switch	74 430 1548
J1131	Connector	74 500 2530

CONTROL CIRCUIT (1) (2)

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1203	Res., 24k, 5%, 1/4W, carbon	74 223 4300
R1206	Res., 1.6k, 5%, 1/4W, carbon	74 223 4140
R1207	Res., 2k, 5%, 1/4W, carbon	74 223 1950
R1212	Res., 100k, 5%, 1/4W, carbon	74 223 2290
R1213	Same as R1212	
R1214	Same as R1206	
R1217	Same as R1207	
R1219	Res., 12k, 5%, 1/4W, metal	74 221 4240
R1222	Same as R1212	
R1223	Same as R1206	
R1226	Same as R1203	
R1228	Same as R1207	
R1231	Same as R1203	
R1232	Same as R1212	
R1235	Res., 1.5k, 5%, 1/4W, carbon	74 223 1930
R1236	Res., 2.2k, 5%, 1/4W, carbon	74 223 1960
R1237	Res., 11k, 5%, 1/4W, metal	74 221 5380
R1238	Same as R1219	
R1241	Same as R1235	
R1242	Same as R1236	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1243	Same as R1237	
R1244	Res.,10k,5%,1/4W,carbon	74 223 2130
R1245	Res.,750,5%,1/4W,carbon	74 223 2570
D1203	Diode,1S953	74 040 1720
D1204	Same as D1203	
D1205	Same as D1203	
D1206	Same as D1203	
D1207	Same as D1203	
D1208	Same as D1203	
D1211	Same as D1203	
D1214	Same as D1203	
D1215	Same as D1203	
D1216	Same as D1203	
D1217	Same as D1203	
D1218	Same as D1203	
D1221	Same as D1203	
D1223	Same as D1203	
D1224	Same as D1203	
D1225	Same as D1203	
D1226	Same as D1203	
D1227	Same as D1203	
D1228	Same as D1203	
D1231	Same as D1203	
D1232	Same as D1203	
D1233	Same as D1203	
D1234	Same as D1203	
D1235	Same as D1203	
D1236	Same as D1203	
D1237	Same as D1203	
D1241	Same as D1203	
D1242	Same as D1203	
D1243	Same as D1203	
D1244	Same as D1203	
D1245	Same as D1203	
D1246	L.E.diode,SR103D	74 040 4740
D1247	Same as D1203	
Q1244	Transistor,2SC373	74 030 2610
J1203	Connector	74 500 5380
J1204	Same as J1203	
P1201	Connector	74 500 5320
P1202	Same as P1201	
P1203	Connector	74 500 5370
P1204	Same as P1203	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1302	Cap.,4700p,+80%-20%,50V,cer.	74 060 1660
C1304	Cap.,0.01µ,+80%-20%,50V,cer.	74 060 0580
C1306	Same as C1304	
C1307	Cap.,10µ,+150%-10%,25V,elect.	74 120 6230
C1311	Cap.,1µ,+150%-10%,50V,elect.	74 120 5810
C1313	Cap.,1000p,+100%-0%,50V,cd	74 060 0700
C1317	Cap.,4.7µ,+150%-10%,25V,elect.	74 120 6160
C1318	Same as C1317	
C1320	Cap.,270p,10%,50V,cer.	74 050 4570
C1321	Same as C1317	
C1322	Same as C1317	
C1323	Cap.,47µ,+150%-10%,35V,elect.	74 120 6280
C1324	Same as C1323	
L1317	Inductor,coil A	74 400 5490
L1318	Same as L1317	
L1321	Same as L1317	
L1322	Same as L1317	
R1301	Res.,510,5%,1/4W,carbon	74 223 2520
R1303	Res.,100k,5%,1/4W,carbon	74 223 2290
R1304	Same as R1303	
R1305	Res.,100,5%,1/4W,carbon	74 223 3190
R1308	Res.,20k,5%,1/4W,carbon	74 223 2170

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1311	Same as R1308	
R1312	Res.,1k,5%,1/4W,carbon	74 223 1900
R1313	Res.,300,5%,1/4W,carbon	74 223 4340
R1314	Same as R1303	
R1315	Same as R1308	
R1316	Res.,750,5%,1/4W,carbon	74 223 2570
R1325	Res.,5.6k,5%,1/4W,carbon	74 223 2070
R1331	Same as R1316	
R1333	Res.,2.4k,5%,1/4W,carbon	74 223 1970
D1315	Diode,1S953	74 040 1720
D1316	L.E.diode,SR103D	74 040 4740
D1325	Same as D1315	
D1331	Same as D1315	
D1332	Same as D1315	
Q1308	Transistor,2SC373	74 030 2610
Q1313	Transistor,2SA495 0/Y	74 030 8032
Q1316	Same as Q1308	
S1301	Micro switch	74 430 1100

A & B TIMING SWITCH

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1401	Cap.,10µ,0.25%,30V,poly.	74 130 4990
C1402	Cap.,1µ,0.25%,50V,poly.	74 130 4980
C1403	Cap.,0.1µ,0.25%,50V,poly.	74 130 4970
C1404	Cap.,0.01µ,0.25%,50V,poly.	74 130 4960
C1405	Cap.,950p,0.25%50V,poly.	74 130 4940
C1406	Cap.,51p,5%,300V,mica	74 090 5750
C1407	Cap.,5.5-25p,var.,350V,cer.	74 110 0110
C1408	Same as C1406	
C1409	Same as C1407	
C1412	Cap.,0.01µ,+80%-20%,50V,cer.	74 060 0580
C1421	Cap.,10µ,+100%-10%,25V,elect.	74 120 6290
C1422	Cap.,1µ,+100%-10%,6.3V,elect.	74 120 6300
C1423	Cap.,0.1µ,20%,50V,poly.	74 130 5200
C1424	Cap.,0.047µ,20%,50V,poly.	74 130 5210
C1425	Cap.,4700p,20%,50V,poly.	74 130 5220
C1426	Cap.,1000p,20%,50V,poly.	74 130 5230
C1451	Same as C1402	
C1452	Same as C1403	
C1453	Same as C1404	
C1454	Same as C1405	
C1455	Cap.,62p,5%,300V,mica	74 090 5680
C1456	Same as C1407	
C1457	Same as C1455	
C1458	Same as C1407	
C1491	Same as C1407	
C1492	Same as C1407	
C1494	Cap.,27p,5%,300V,mica	74 090 5754
R1401	Res.,11k,0.5%,1/2W,metal	74 221 3510
R1402	Res.,8.25M,0.5%,1/2W,metal	74 221 6050
R1403	Same as R1402	
R1404	Res.,5.5M,0.5%,1/2W,metal	74 221 6040
R1405	Res.,2.75M,0.5%,1/2W,metal	74 221 4200
R1406	Res.,1.65M,0.5%,1/2W,metal	74 221 4190
R1407	Res.,550k,0.5%,1/2W,metal	74 221 4180
R1408	Res.,539k,0.5%,1/2W,metal	74 221 4170
R1409	Res.,264k,0.5%,1/2W,metal	74 221 4160
R1410	Res.,99k,0.5%,1/2W,metal	74 221 5540
R1411	Res.,44k,0.5%,1/2W,metal	74 221 5530
R1412	Res.,20k,var.,0.1W,carbon (with S1412)	74 325 1460
R1413	Res.,750,5%,1/4W,carbon	74 223 2570
R1451	Same as R1401	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1452	Same as R1402	
R1453	Same as R1402	
R1454	Same as R1404	
R1456	Same as R1406	
R1457	Same as R1407	
R1458	Same as R1408	
R1459	Same as R1409	
R1460	Same as R1410	
R1461	Same as R1411	
R1462	Res.,20k,var.,0.1W,carbon (with S1462)	74 332 2660
D1412	Z.diode,RD35AM	74 040 5020
D1413	L.E.diode,SR103D	74 040 4740
S1401	Rotary switch	74 431 6880

HORIZONTAL AMPLIFIER

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1501	Cap.,0.01μ,+100%-0%,50V,cer.	74 060 0730
C1502	Cap.,0.1μ+80%-20%,50V,cer.	74 060 0580
C1503	Same as C1502	
C1504	Same as C1502	
C1505	Same as C1502	
C1506	Cap.,4.7μ,+100%-10%,25V,elect.	74 120 6160
C1507	Same as C1506	
C1515	Cap.,220p,10%,50V,cer.	74 050 2750
C1516	Same as C1515	
C1519	Same as C1506	
C1522	Same as C1502	
C1523	Cap.,0.1μ,10%,50V,poly.	74 130 2470
C1537	Cap.,200p,10%,50V,poly.	74 130 2370
C1540	Same as C1502	
C1553	Cap.,100p,10%,50V,cer.	74 050 1710
C1554	Same as C1553	
C1563	Same as C1502	
C1565	Same as C1501	
C1570	Cap.,0.5-1.5p,var.,500V,poly	74 110 1130
C1573	Same as C1501	
C1576	Same as C1501	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1577	Same as C1502	
C1580	Same as C1570	
C1581	Same as C1502	
C1582	Same as C1502	
L1515	Inductor, coil	74 400 5660
L1559	Inductor, ferrite bead	74 560 1240
L1560	Same as L1559	
R1501	Res., 11, 5%, 1/4W, carbon	74 223 4370
R1502	Same as R1501	
R1503	Same as R1501	
R1504	Same as R1501	
R1505	Same as R1501	
R1510	Res., 51, 2%, 1/4W, metal	74 221 5610
R1511	Res., 6.2k, 2%, 1/4W, metal	74 221 4150
R1512	Res., 4.7k, 2%, 1/4W, metal	74 221 3950
R1513	Res., 12k, 2%, 1/4W, metal	74 221 4240
R1514	Res., 470, 2%, 1/4W, metal	74 221 4500
R1515	Res., 1k, 2%, 1/4W, metal	74 221 3860
R1516	Res., 500, var., 0.5W, cermet	74 349 2450
R1517	Res., 1.5k, 2%, 1/4W, metal	74 221 3880
R1518	Same as R1513	
R1519	Same as R1501	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1520	Res., 2k, 2%, 1/4W, metal	74 221 3910
R1521	Same as R1510	
R1522	Res., 150k, 5%, 1/4W, carbon	74 223 2310
R1523	Res., 9.1k, 2%, 1/4W, metal	74 221 5400
R1530	Res., 3k, 1/4W, metal	74 221 4450
R1531	Same as R1512	
R1532	Res., 2.4k, 2%, 1/4W, metal	74 221 4230
R1533	Same as R1532	
R1534	Same as R1517	
R1535	Res., 6.8k, 2%, 1W, carbon	74 242 0480
R1536	Same as R1535	
R1537	Res., 13k, 2%, 1/4W, metal	74 221 5390
R1538	Res., 100, 20%, 0.5W, metal	74 349 2520
R1539	Res., 130, 2%, 1/4W, metal	74 221 6480
R1540	Res., 500, 2%, 0.5W, metal	74 349 2620
R1541	Res., 1.8k, 2%, 1/4W, metal	74 221 3900
R1542	Res., 13k, 2%, 1W, carbon	74 242 0550
R1543	Same as R1542	
R1546	Same as R1520	
R1547	Same as R1520	
R1548	Res., 10k, 2%, 1/4W, metal	74 221 4010
R1549	Res., 20k, 10%, 0.5W, cermet	74 349 2900
R1550	Same as R1548	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1551	Res.,24k,2%,1/4W,metal	74 221 4040
R1552	Same as R1551	
R1553	Res.,510,5%,1/4W,carbon	74 223 2520
R1554	Res.,5%,1/4W,carbon	74 223 2500
R1555	Res.,1.5k,5%,1/4W,carbon	74 223 1930
R1556	Same as R1555	
R1557	Res.,470,5%,1/4W,carbon	74 223 2630
R1558	Same as R1557	
R1559	Res.,24,5%,1/4W,carbon	74 223 4390
R1560	Same as R1559	
R1561	Res.,620,5%,1/4W,carbon	74 223 2540
R1562	Res.,680.5%,1/4W,carbon	74 223 2550
R1563	Res.,1.1k,2%,1/4W,metal	74 221 3870
R1564	Res.,150k,5%,1/4W,carbon	74 223 2310
R1565	Res.,300k,5%,1/4W,carbon	74 223 2880
R1566	Same as R1559	
R1567	Res.,30k,5%,metal	74 221 8610
R1568	Res.,27,5%,1/4W,carbon	74 223 3800
R1570	Res.,42k,5%,2W,metal	74 221 8570
R1571	Same as R1563	
R1572	Same as R1564	
R1573	Same as R1565	
R1574	Same as R1559	
R1575	Same as R1567	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1576	Same as R1568	
R1577	Res.,360,2%,1/4W,metal	74 221 3780
R1578	Res.,910,2%,1/4W,metal	74 221 3850
R1580	Same as R1570	
R1581(R1582)	Res.,10k,var.,0.25W,carbon	74 325 2710
R1583	Res.,15,5%,1/4W,carbon	74 223 4320
R1584	Same as R1538	
R1585	Res.,1k,10%,0.5W,cermet	74 349 2880
R1586	Res.,10k,2%,1W,carbon	74 242 0520
R1587	Same as R1586	
R1588	Res.,56,2%,1/4W,metal	74 223 5660
D1517	Diode,1S953	74 040 1720
D1518	Same as D1517	
D1519	Same as D1517	
D1520	Same as D1517	
D1550	Same as D1517	
D1551	Same as D1517	
D1552	Same as D1517	
D1553	Same as D1517	
D1563	Diode,RD9A	74 040 0840
D1577	Same as D1563	
Q1513	Transistor,2SC373	74 030 2610
Q1514	Same as Q1513	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
Q1535	Transistor,2SC1216	74 030 6170
Q1536	Same as Q1513	
Q1546	Transistor, 2N3905	74 030 8325
Q1547	Same as Q1546	
Q1555	Same as Q1546	
Q1556	Same as Q1546	
Q1559	Same as Q1535	
Q1560	Same as Q1535	
Q1561	Transistor,2SC995	74 030 6390
Q1562	Same as Q1561	
Q1563	Same as Q1561	
Q1571	Same as Q1561	
Q1577	Same as Q1546	
NE1501	Neon bracket lamp	74 020 1780
NE1502	Same as NE1501	
RL1540	Relay,NR-HD-12V	74 450 1500
P1501	Multi connector	74 500 5370

Z AXIZ AMPLIFIER

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1601	Cap.,0.01μ,20%,500V,cer.	74 060 3170
C1602	Cap.,0.01μ,+80%-20%,50V,cer.	74 060 0580
C1603	Same as C1602	
C1616	Cap.,6-20p,var.,250V,cer.	74 110 0630
C1617	Cap.,240p,5%,50V,cer.	74 050 6500
C1620	Same as C1602	
C1621	Cap.,2p,0.5p,500V,cer	74 050 1900
C1622	Cap.,0.5-1.5p,var.,500V,cer.	74 110 1130
C1623	Cap.,8p,0.5p,500V,cer.	74 050 4650
C1624	Same as C1623	
C1625	Same as C1601	
C1632	Cap.,4700p,+100%-0%,500V,cer.	74 060 0770
C1635	Cap.,1000p,+100%-0%,500V,cer.	74 060 0700
C1645	Cap.,100p,10%,500V,cer.	74 050 1930
C1601	Res.,10,5%,1/4W,carbon	74 223 3210
R1602	Same as R1601	
R1603	Same as R1601	
R1611	Res.,1.6k,5%,1/4W,carbon	74 223 4140
R1612	Res.,6.2k,5%,1/4W,carbon	74 223 2080
R1613	Res.,5k,var.,2W,cermet	74 349 2340
R1614	Res.,750,2%,1/4W,metal	74 221 3830

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1615	Res.,10k,5%,1/4W,carbon	74 223 2130
R1616	Res.,100,5%,1/4W,carbon	74 223 3190
R1617	Res.,2k,5%,1/4W,carbon	74 223 1950
R1620	Same as R1601	
R1622	Res.,9.1k,2%,1/2W,carbon	74 241 0650
R1623	Res.,20k,5%,1/2W,carbon	74 223 4280
R1624	Same as R1623	
R1625	Same as R1623	
R1626	Same as R1601	
R1627	Res.,680,5%,1/4 W,carbon	74 223 2550
R1630	Same as R1612	
R1631	Res.,100k,5%,1/4W,carbon	74 223 2290
R1632	Res.,1k,5%,1/4W,carbon	74 223 1900
R1635	Res.,30k,5%,1/2W,carbon	74 223 4400
R1640	Res.,130,5%,1/4W,carbon	74 223 3410
R1642	Res.,15k,2%,1W,carbon	74 242 0560
R1645	Res.,470,5%,1/2W,carbon	74 223 4350
R1670	Res.,500,var.,0.5W,cermet	74 349 2850
R1671	Same as R1617	
D1617	Z.diode,RD5A	74 040 0770
D1637	Z.diode,HW75A	74 040 2880

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
Q1620	Transistor,2SC154C	74 030 4000
Q1623	Transistor,2SA606	74 030 5530
Q1624	Same as Q1623	
Q1625	Same as Q1623	
Q1632	Transistor,2N3905	74 030 8325
IC1613	Integrated circuit,AY62/A39	74 570 0690
J1642	Connector	74 500 2530
P1601	Connector	74 500 5370

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
CRT CIRCUIT		
C1703	Cap.,0.047μ,10%,50V,poly.	74 130 2010
C1705	Cap.,1000p,20%,3kV,poly.	74 130 5100
C1707	Cap.,0.1μ,10%,50V,poly.	74 130 2470
C1709	Cap.,0.01μ+80%-20%,50V,cer.	74 060 0580
C1710	Cap.,0.01μ,20%,3kV,poly.	74 130 5050
C1718	Cap.,0.01μ,+100%-0%,500V,cer.	74 060 0730
C1733	Same as C1718	
L1711	Inductor,coil(ROTATION)	74 400 5630
L1713	Inductor,coil(ORTHOGONARY)	74 400 5640
R1703	Res.,130k,2%,1/4W,metal	74 221 8090
R1704	Res.,10k,5%,1/4W,carbon	74 223 2130
R1705	Res.,15M,5%,1W,metal	74 221 8500
R1706	Res.,680k,2%,1/2W,metal	74 221 8757
R1707	Res.,2.7M,5%,1/2W,metal	74 230 3630
R1708	Res.,100k,var.,0.5W,cermet	74 349 2360
R1709	Res.,10,5%,1/4W,carbon	74 223 3210
R1710	Same as R1704	
R1711	Res.,1k,var.,0.5W,cermet	74 349 2400
R1712	Res.,180,2%,1/2W,carbon	74 241 0260
R1713	Res.,500,var., 1W,cermet	74 349 2390

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1714	Same as R1712	
R1715	Same as R1713	
R1716	Res.,20k,5%,2W,carbon	74 243 0630
R1718	Res.,200k,var.,0.25W,carbone	74 321 0230
R1720	Res.,91k,5%,1/4W,carbone	74 223 3760
R1721	Res.,20k,var.,0.5W,cermet	74 349 2500
R1722	Res.,24k,5%,1/4W,carbone	74 223 3400
R1723	Res.,200k,var.,0.5W,cermet	74 349 2380
R1724	Res.,8M,5%,1W,metal	74 221 8520
R1725	Res.,5M,var.,0.1W,carbon	74 345 0590
R1726	Res.,17M,5%,W,metal	74 221 8510
R1730	Res.,1M,5%,1W,metal	74 221 8530
R1731	Same as R1708	
R1732	Same as R1705	
R1740	Same as R1716	
R1741	Res.,62k,5%,1/4W,carbon	74 223
R1742	Res.,130k,5%,1/4W,carbon	74 223 3270
R1749	Res.,2k,5%,1/4W,carbon	74 223 1950
D1716	Z.diode,RD36FB	74 040 5281
D1717	Z.diode,1N4756	74 040 5249
D1719	Same as D1717	
D1740	Diode,1S955	74 040 1840

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
Q1740	Transistor, 2SC995	74 030 6390
Q1742	Same as Q1740	
IC1704	Integrated circuit, A2	74 570 0020
F1701	Fuse, 0.5A slow blow	74 540 0310
P1701	Multiconnector	74 500 5370
C1750	Cap., 470u, +100%-10%, 50V, elect.	74 120 6390
C1751	Cap., 0.01u, 20%, 3kV, poly.	74 130 5050
C1752	Same as C1751	
C1753	Same as C1751	
C1762	Cap., 5000p, 20%, 3kV, poly.	74 130 5060
C1763	Cap., 0.01u, 20%, 3kV, poly.	74 130 5050
R1750	Res., 100k, 5%, 1/4W, carbon	74 223 3290
R1760	Res., 100k, 5%, 1/2W, carbon	74 223 3870
R1761	Res., 22k, 5%, 1/2W, carbon	74 223 3850
R1762	Res., 100, 5%, 1/2W, carbon	74 223 4290
R1763	Res., 3M, 5%, 1/2W, carbon	74 254 0640
D1750	Diode, NDP-127	74 040 5160
D1751	Hif voltage diode, HVT-30S	74 040 4930
D1753	Same as D1751	
D1761	Diode, 1S955	74 040 1840
D1762	Same as D1761	
D1763	Same as D1761	

CIRCUIT REFERENCE	DISCRIPTION	IWATSU PART NO.
Q1750	Transistor, 2SD93	74 030 3760
V1701	Cathode ray tube, 150AJB31 (with socket)	74 010 1503
NE1761	Neon bracket lamp, NE-68	74 020 1170
NE1762	Same as NE1761	
J1751	Multiconnector	74 500 5380
P1751	Connector	74 500 5370
T1751	HV OSC transformer	74 472 1510
HP1751	HV rectifier block	74 470 3797

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
CALIBRATOR		
C1801	Cap.,100µ,+100%-10%,25V.elect.	74 120 6330
C1802	Same as C1801	
C1813	Cap.,100p,+5%,100V,mica	74 090 5772
R1801	Res.,22,5%,1/4W,compo.	74 253 0010
R1802	Same as R1801	
R1811	Res.,10k,2%,1/4W,metal	74 221 4010
R1812	Res.,270,2%,1/4W,metal	74 221 5620
R1813	Res.,6.8k,2%,1/4W,metal	74 221 3990
R1814	Same as R1811	
R1815	Res.,330,2%,1/2W,metal	74 221 8968
R1816	Res.,50k,20%,0.5W,metal	74 349 3147
R1817	Same as R1811	
R1818	Same as R1811	
R1819	Same as R1811	
R1821	Res.,2.378k,0.25%,1/4W,metal	74 221 8972
R1822	Res.,510,2%,1/4W,metal	74 221 3810
R1823	Res.,1k,2%,1/4W,metal	74 221 3860
R1824	Res.,5.1k,2%,1/4W,metal	74 221 3960
R1825	Res.,20k,2%,1/4W,metal	74 221 4030
R1826	Res.,27k,2%,1/4W,metal	74 221 4560
R1827	Res.,2.4k,2%,1/4W,metal	74 221 4230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1831	Res.,500,20%,0.5W,metal	74 349 3135
R1832	Res.2.2k,2%,1/4W,metal	74 221 4380
R1841	Res.,450,0.25%,1/4W,metal	74 221 8973
R1842	Res.,55,0.25%,1/4W,metal	74 221 8974
R1843	Res.,495,0.25%,1/4W,metal	74 221 8975
R1844	Same as R1842	
R1851	Res.,51,2%,1/4W,metal	74 030 5610
Q1823	Transistor,2N3905	74 030 8325
Q1824	Same as Q1823	
Q1825	Transistor,2SC1216	74 030 6170
Q1826	Same as Q1825	
IC1813	Integrated Circuit,RC4558T	74 030 8130
S1851	Push Switch	74 430 1140

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
POWER SUPPLY		
C1911	Cap.,0.1μ,10%,50V,poly.	74 130 2470
C1921	Cap.,330μ,+100%-10%,160V,elect.	74 120 6180
C1922	Same as C1921	
C1923	Same as C1921	
C1924	Cap.,3300μ,+100%-10%,3.5V,elect.	74 120 6200
C1925	Same as C1924	
C1926	Cap.,470μ,+100%-10%,6.3V,d elect.	74 120 6190
C1930	Cap.,3.3μ,+150%-10%,160V,elect.	74 130 6210
C1931	Cap.,0.1μ,10%,50V,poly.	74 130 2470
C1932	Cap.,0.00μ,10%,50V,poly.	74 130 1310
C1933	Same as C1932	
C1934	Cap.,0.1μ,10%,100V,poly.	74 130 2730
C1940	Cap.,0.1μ,10%,50V,poly.	74 130 2470
C1950	Cap.,10u,+100%-10%,25V,elect.	74 120 6230
C1952	Same as C1931	
C1953	Same as C1940	
C1956	Cap.,33μ,+100%-10%,16,elect.	74 120 6220
C1960	Same as C1950	
C1961	Same as C1940	
C1966	Same as C1931	
R1901	Res.,10k,var.,0.5W,W.W.	74 332 0210

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1902	Res.,10k,5%,1/4W,carbon	74 223 2130
R1903	Res.,390,5%,1/4W,carbon	74 223 2500
R1904	Res.,7.5k,5%,1/4W,carbon	74 223 2100
R1905	Same as R1904	
R1911	Res.,3.9k,5%,1/4W,carbon	74 223 2020
R1912	Res.,47k,5%,1/4W,carbon	74 223 3750
R1913	Res.,1001 5%,1/4W,carbon	74 223 2290
R1921	Res.,100k,2%,1/2W,carbon	74 241 0890
R1922	Same as R1921	
R1923	Same as R1921	
R1924	Same as R1921	
R1925	Same as R1921	
R1926	Same as R1921	
R1930	Res.,3.9k,2%,1W,carbon	74 242 0420
R1931	Res.,6.8k,2%,2W,carbon	74 243 0530
R1932	Res.,6.2k,5%,1/4W,carbon	74 223 2080
R1933	Res.,3.9k,5%,1/4W,carbon	74 223 2020
R1934	Res.,330,5%,1/4W,carbon	74 223 3230
R1935	Res.,220,5%,1/4W,carbon	74 223 2470
R1936	Res.,1,5%,1W,metal	74 221 8837
R1937	Res.,33k,2%,1/4W,metal	74 221 4250
R1938	Res.,1k,var.,0.75W,W.W	74 331 0470
R1939	Res.,6.2k,2%,1/4W,metal	74 221 4150

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1940	Res.,22,5%,1/4W,carbon	74 223 4200
R1950	Res.,1.2k,2%,1/4W,metal	74 221 4400
R1951	Res.,200,var.,0.75W,W.W.	74 331 0680
R1952	Res.,390,2%,1/4W,metal	74 221 3790
R1953	Res.,100,5%,1/4W,carbon	74 223 3190
R1954	Res.,620,5%,1/4W,carbon	74 223 2540
R1955	Res.,0.3,5%,1W,metal	74 221 8560
R1960	Res.,5.6k,5%,1/4W,carbon	74 223 2070
R1961	Res.,200,5%,1/4W,carbon	74 223 3840
R1962	Same as R1954	
R1963	Same as R1955	
R1964	Res.,3k,2%,1/4W,metal	74 221 4450
R1965	Same as R1951	
R1966	Same as R1964	
R1970	Res.,1k,2%,1W,carbon	74 242 0300
R1971	Same as R1070	
D1921	Diode,M4E-1	74 040 3890
D1922	Same as D1921	
D1923	Same as D1921	
D1924a,b,c,d,	Diode,V03C	74 040 3350
D1925a,b,c,d,	Same as D1924	
D1926	Same as D1921	

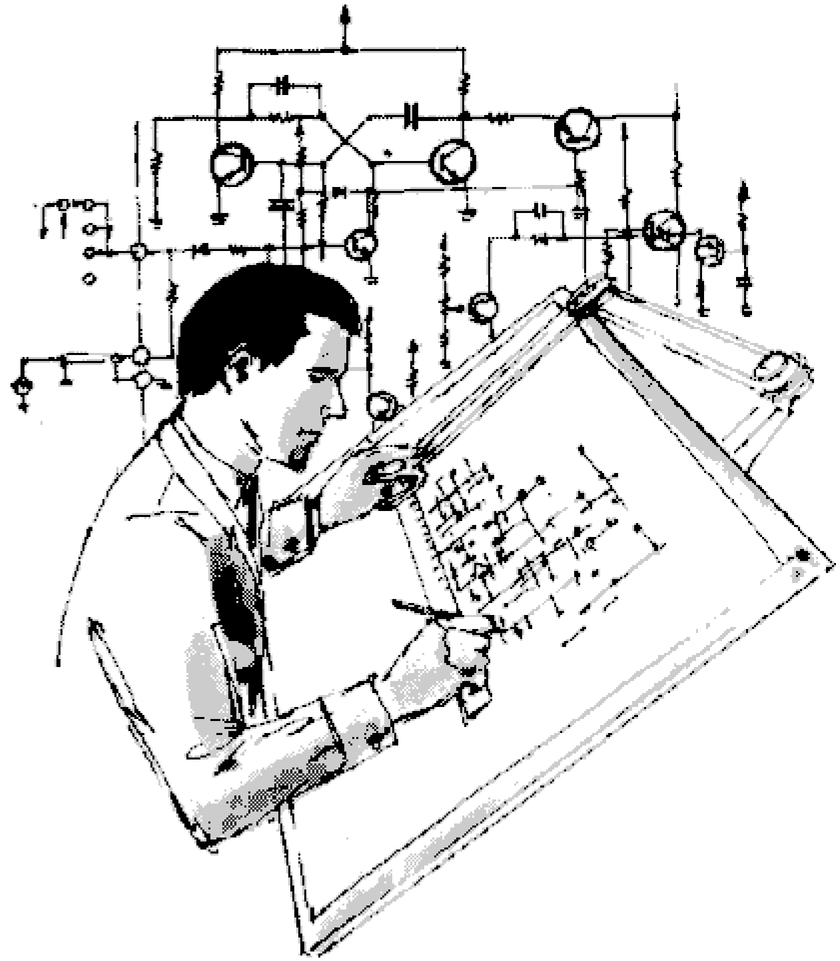
CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D1930	Diode,RD33FB	74 040 5271
D1931	Diode,RD9A	74 040 0840
D1933	Diode,RD39FB	74 040 5269
D1934	Diode,1S953	74 040 1720
D1935	Diode,V03C	74 040 3350
D1939	Same as D1934	
D1956	Diode,1S2191	
Q1901	Transistor,2SC960	74 030 8117
Q1902	Transistor,2SA708A	74 030 8118
Q1920	Transistor,MJE30555	74 030 6780
Q1933	Transistor,2SC1707 H	74 030 8168
Q1934	Transistor,2SD221	74 030 4010
Q1935	Transistor,2SD221	74 030 3350
Q1971	Same as Q1920	
Q1972	Transistor,MJE1102	74 030 6770
Q1973	Same as Q1972	
IC1950	Integrated circuit,A1	74 570 0010
IC1960	Same as IC1950	
NE1902	Neon bracket lamp	74 020 1170
PL1901	Lamp,6.3V 150mA	74 480 2465
PL1902	Same as PL1901	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
PL1903	Same as PL1901	
PL1904	Same as PL1901	
F1901	Fuse,2A slow blow	74 540 0330
F1902	Thermal fuse,	
F1912	Fuse,0.25A	74 540 0220
F1913	Same as F1912	
F1914	Fuse,0.5A	75 540 0640
FL1901	Line filter,MC-2020	74 400 5500
S1901	Push switch	74 430 1150
T1901	Transformer	74 471 2820
J1901	Voltage selecting jack (connector)	74 480 2270
J1911	Multi connector	74 500 5960
J1970	Multi connector	74 500 5380
P1901B	Voltage selecting plug	74 500 5830
P1970	Multi connector	74 500 5350
U1901	Power cord	74 470 1710

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
INTER CONNECTING		
J601	Multi connector	74 500 5380
J1501	Same as J601	
J1601	Same as J601	
J1701	Same as J601	
J2001	Same as J601	
J2002	Multi connector	74 500 5390
J2003	Same as J2002	
J2004	Connector	74 500 6140
P2001	Multi connector	74 500 6350

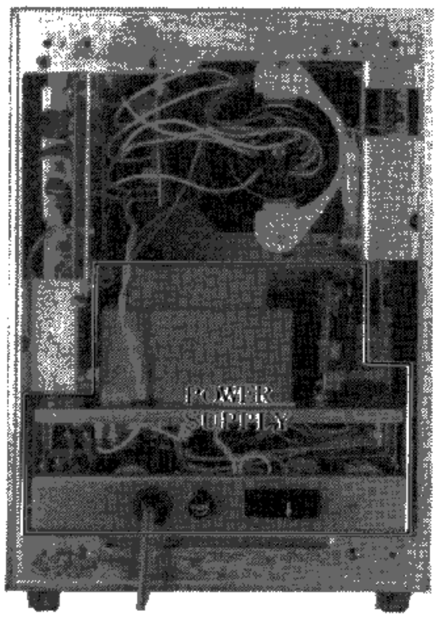
SECTION 8 DIAGRAMS

This section lists diagrams required for calibration and maintenance of this instrument and describes symbols and markings used for these diagrams.

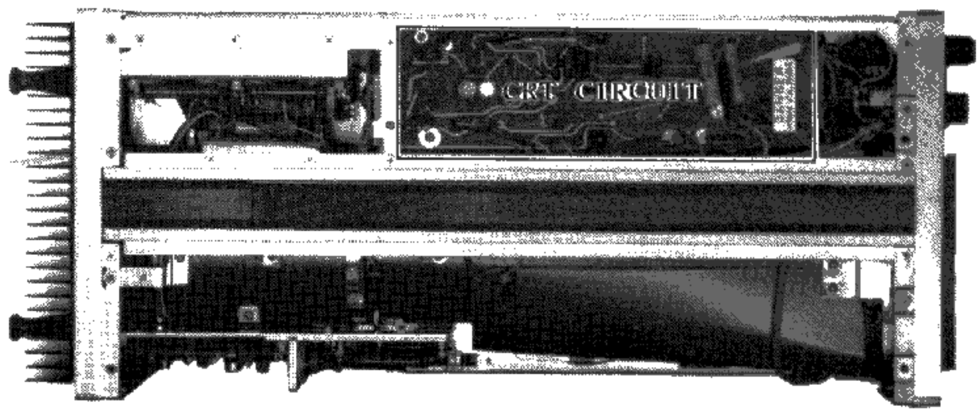


Circuit Layout

Fig. 8-1 Rear view and top view

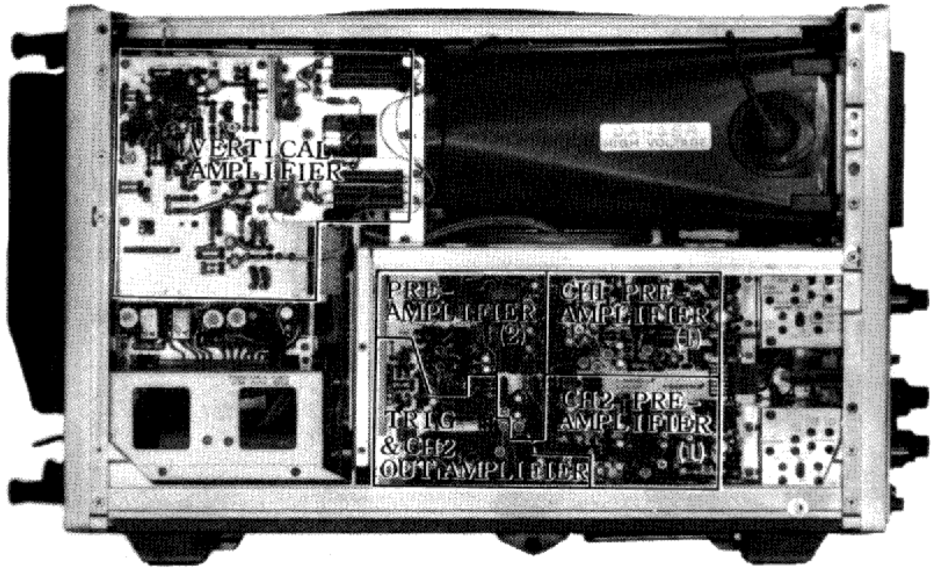


Rear view



Top view

Fig. 8-2 Left side view and vertical amplifier unit



Left side view

Vertical amplifier unit

Top view

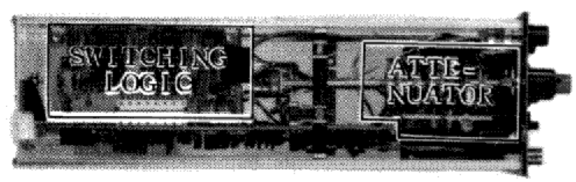
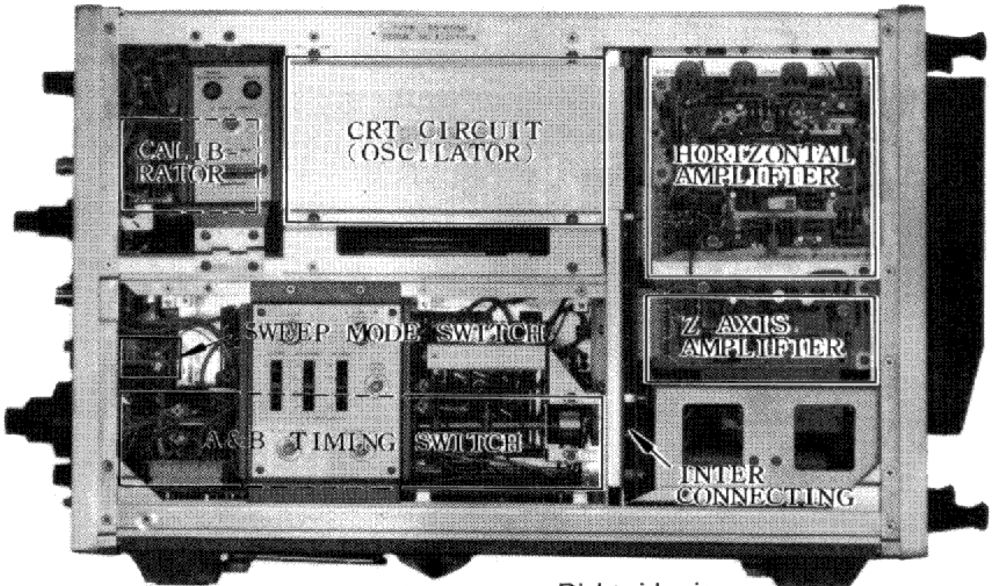
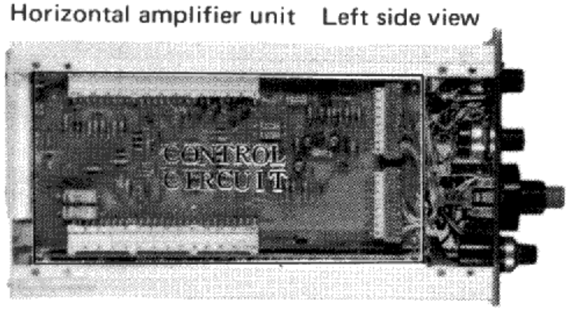


Fig. 8-3 Right side view and horizontal amplifier unit



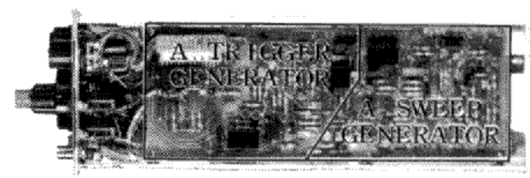
Right side view

Horizontal amplifier unit Left side view



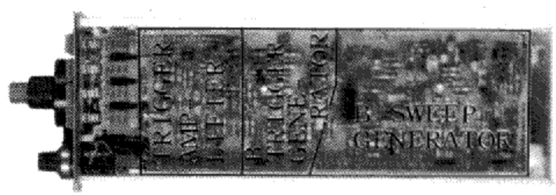
Horizontal amplifier unit

Top view



Horizontal amplifier unit

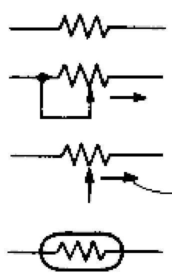
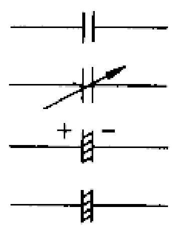
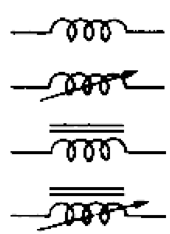
Bottom view

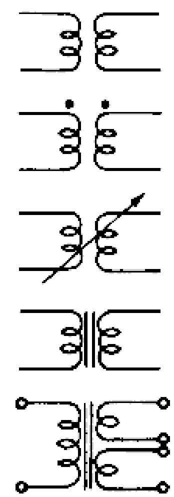
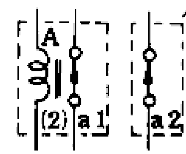
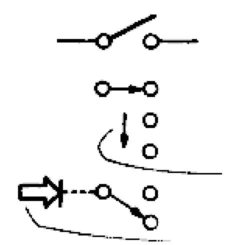
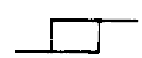


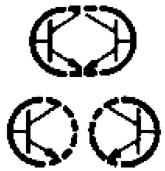
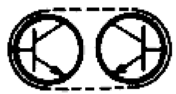
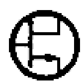
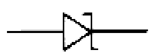
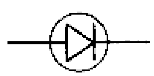
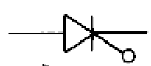
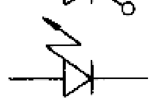
Symbols and Markings

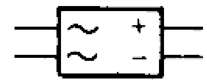
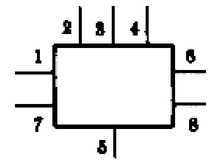
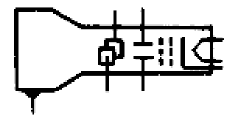
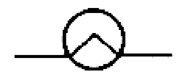
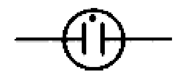
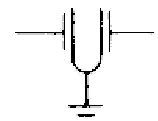
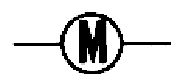
For simplified cross-reference of schematic diagrams, IWATSU employs unified circuit symbols and markings shown below.

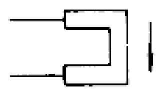
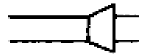
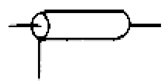
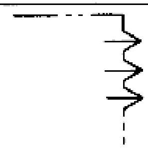
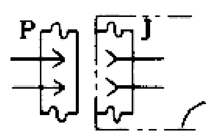
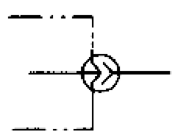
Table 8-1

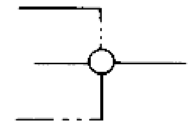
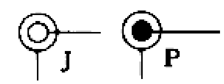
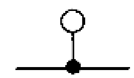
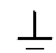
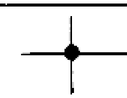
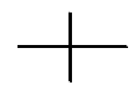
Nomenclature	Code	Symbol and marking
Resistor	R	 Fixed Variable Variable (clock wise direction) Thermistor
Capacitor	C	 Fixed Variable Electrolyte (with polarity) Electrolyte (non-polarity)
Inductance	L	 Fixed Variable with core With variable core

Nomenclature	Code	Symbol and marking
Transformer	T	 Fixed coupling Fixed coupling with inner-end-of-coil marking Variable coupling With core Power or high voltage trans-former
Relay	RL	 When a pair of contacts shown separated from coil
Switch	S	 Single throw type Rotary and Lever Clockwise direc-tion Pushbutton (pushed state)
Thermal switch	TH	

Nomenclature	Code	Symbol and marking	
Transistor	Q		Ordinary type
			Twin transistor
			With heat-sink
			With thermal couple
			MOS FET
			Junction FET
Diode	D		Ordinary type
			Zener
			Tunnel
			SCR
			LED
			Vari-cap

Nomenclature	Code	Symbol and marking	
Diode stack	D		
IC	IC		1 to 8: pin No.
CRT	V		
Lamp	PL		
Neon tube	NE		
Oscillator element	X		Piezo-fork
			Crystal
Motor	M		
Hour meter	HM		

Nomenclature	Code	Symbol and marking	
Fuse	F		R: rapid-blow S: slow-blow
Battery	B		
Probe loop			Direction of current
Power cord	U		
Coaxial cable	W		
Printed circuit board	PB		
Multi-plug on PCB	P		
Multi-connector	P, J		Plug (P) and jack (J) On PCB
Pin-connector			

Nomenclature	Code	Symbol and marking	
Terminal connection			Soldered connection to terminal
Coaxial connection	P, J		Plug (P) and jack (J)
Terminal post	TB		
Test point	TP		
Semi-fixed code			Variable resistor
Adjustment Required			
Ground code			
Connection			Connected
			Not connected
		TO FROM	Destination of wiring
Designation of panel			

Unit of resistance, capacitance or inductance (Ω, F or H) is omitted from diagram.

Description on Special Symbol Marks

Connection Symbol Marks

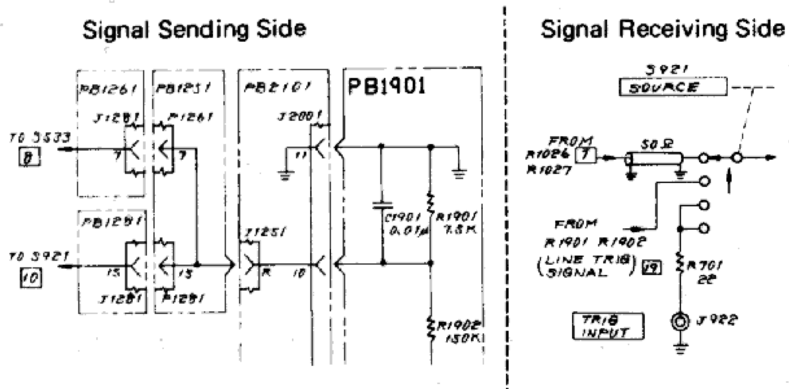
If the schematic diagram becomes complicated and it also becomes impossible to indicate the connecting lines on the same schematic diagram, these lines are expressed by the arrow marking with alphabelt indicating that the relevant line is being connected.

Sending and Receiving Signals

When the signal is fed to, for received from another schematic diagram, its indication is made clear to which circuit component or from which circuit component the signal is fed or received by indicating it with arrow marking and the relevant circuit component for the convenience of reference to the schematic diagram.

This instrument uses a large number of connectors for signal sending and receiving. In such a case, all signal routes up to the final point (circuit component) are indicated on the signal sending side. In addition, in case the signal comes from another diagram, only the circuit component from which the signal is fed is indicated on the relevant schematic diagram.

Fig. 8-4 Indication of sending and receiving signals



Switch Wafer

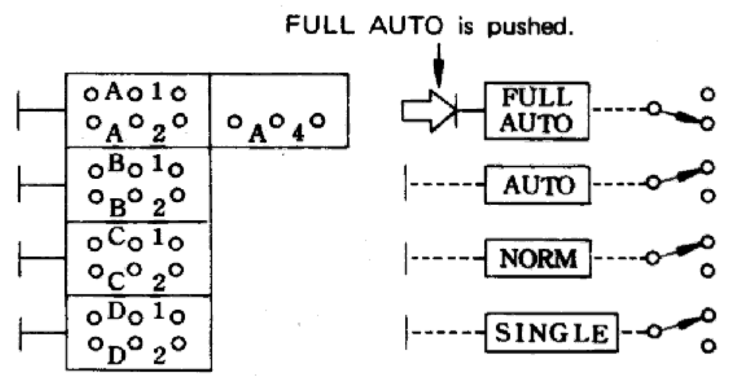
As for the rotary switches used in this synchroscope, their wafer positions are indicated on the schematic diagram. That is, front side of the first wafer which is viewed from the side of front panel is indicated as A-F and the rear side is as A-R. Sequentially, succeeding wafer positions are indicated as B-F, B-R, ...

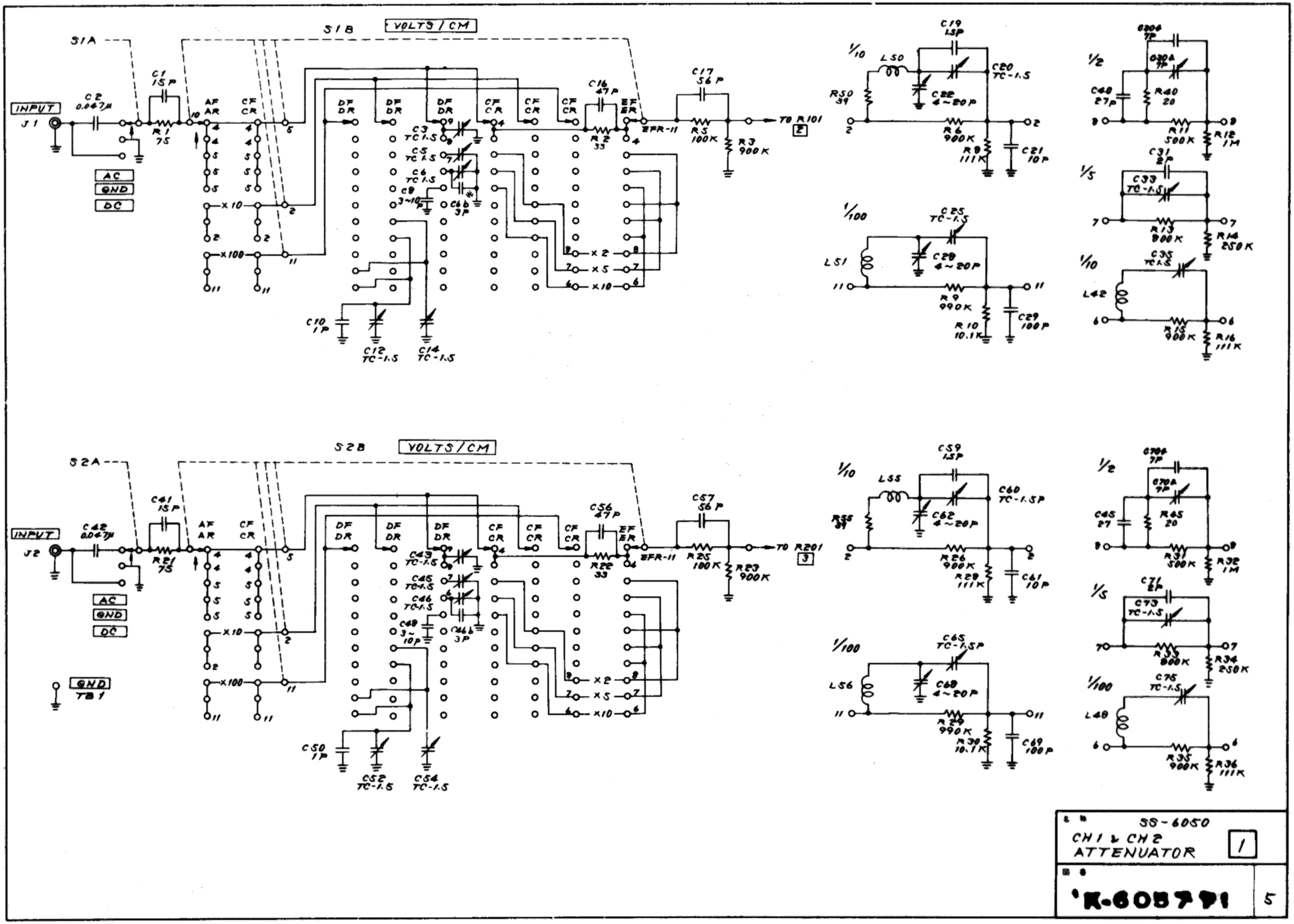
The switches with concentric axes like the A, B TIME/CM switches are indicated as aA-F, aA-R, ... when viewed from the front side and the next switch is as bA-F, bA-R, ...

Push Button Switches

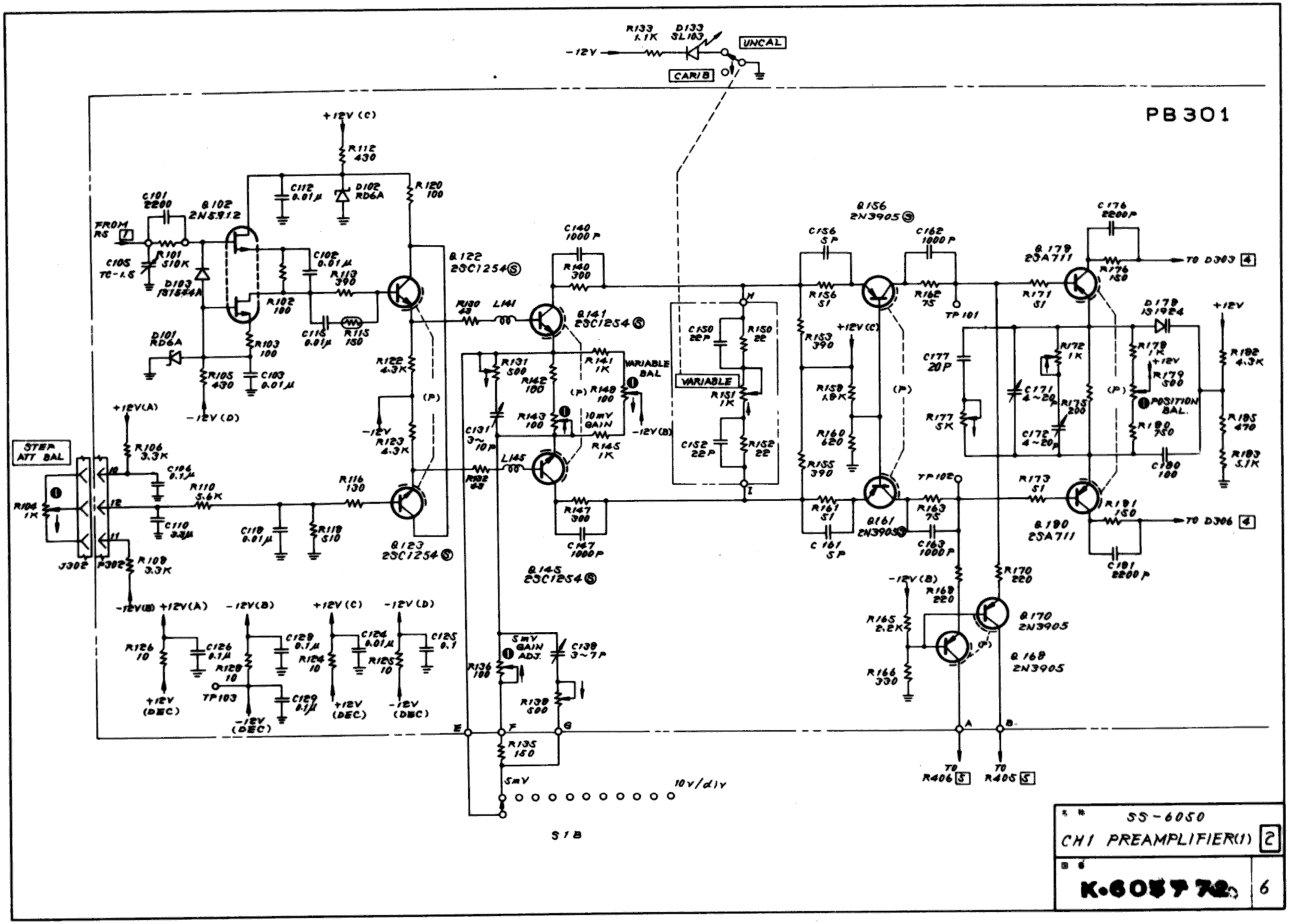
All push button switches are, in principle, indicated on the schematic diagram with the release conditions. In case of interlocking type push button switches, it is indicated under the condition that it is pushed by using typical type button as shown in Fig. 8-5. The figure in the left of Fig. 8-5 shows the terminals being used by each push button switch.

Fig. 8-5 Indication of push button switch

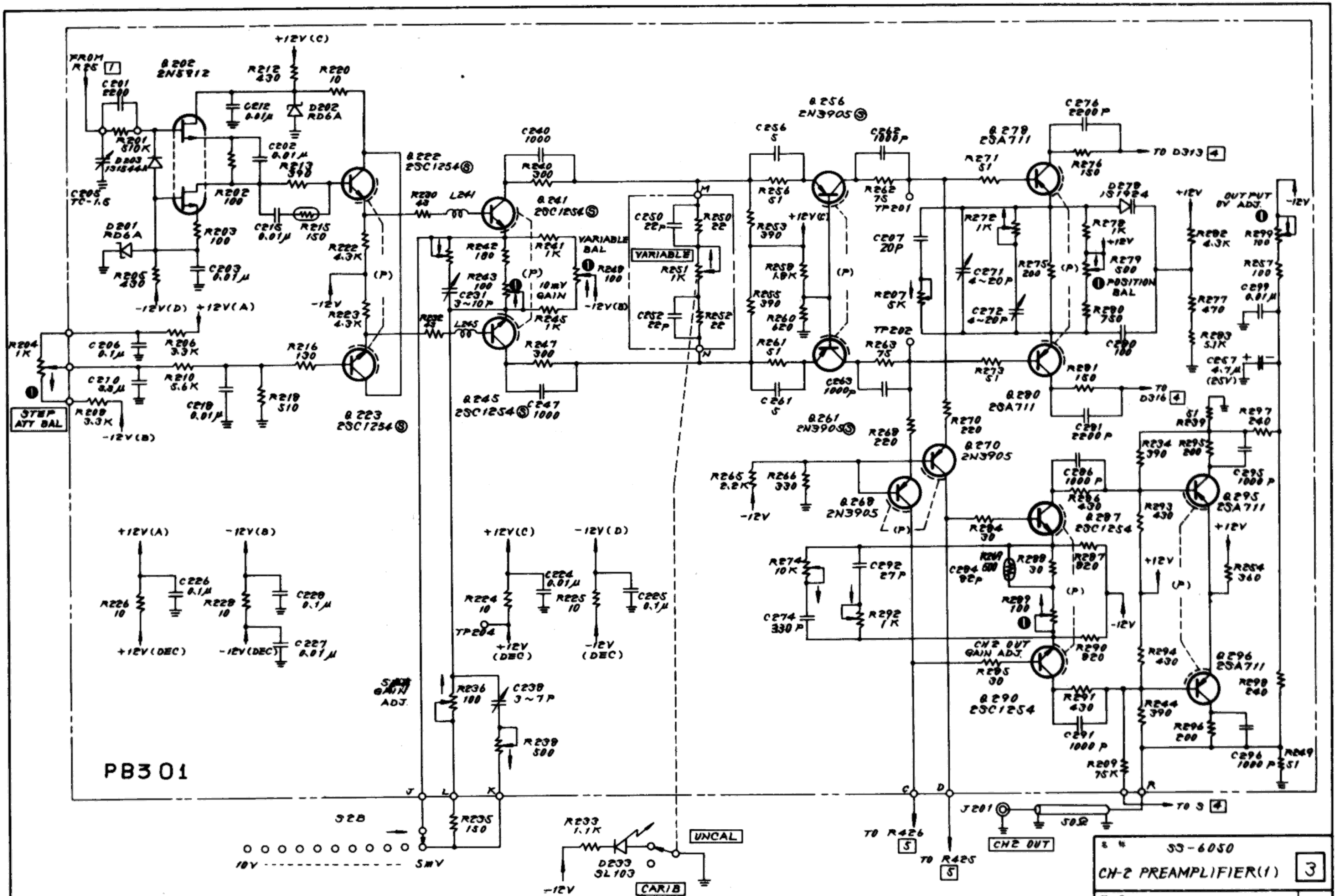




INPUT
J1
C2 0.047μ
S1A
C1 15P
R1 75
AC
GND
DC
S1B
VOLTS/CM
AF AR
CF CR
DF DR
EF ER
×10
×100
C3 TC-1.5
C5 TC-1.5
C6 TC-1.5
C8 3~10P
C6b 3P
C10 1P
C12 TC-1.5
C14 TC-1.5
C16 47P
R2 33
EFR-11
×2
×5
×10
C17 56P
R5 100K
R3 900K
TO R101
2
1/10
L50
C19 15P
C20 TC-1.5
R50 39
C22 4~20P
R6 900K
R8 111K
C21 10P
1/100
C25 TC-1.5
C28 4~20P
L51
R9 990K
R10 10.1K
C29 100P
1/2
C40 27P
R40 20
R11 500K
R12 1M
1/5
C31 2P
C33 TC-1.5
R13 900K
R14 250K
C35 TC-1.5
L42
R15 900K
R16 111K
INPUT
J2
C42 0.047μ
S2A
C41 15P
R21 75
AC
GND
DC
GND
TB1
S2B
VOLTS/CM
C43 TC-1.5
C45 TC-1.5
C46 TC-1.5
C48 3~10P
C46b 3P
C50 1P
C52 TC-1.5
C54 TC-1.5
C56 47P
R22 33
EFR-11
C57 56P
R25 100K
R23 900K
TO R201
3
1/10
L55
C59 15P
C60 TC-1.5P
R55 39
C62 4~20P
R26 900K
R28 111K
C61 10P
1/100
C65 TC-1.5P
C68 4~20P
L56
R29 990K
R30 10.1K
C69 100P
1/2
C45 27
R45 20
R31 500K
R32 1M
1/5
C71 2P
C73 TC-1.5
R33 900K
R34 250K
1/100
C75 TC-1.5
L48
R35 900K
R36 111K
SS-6050
CH1 & CH2
ATTENUATOR
1
K-605791
5



PB301
-12V
R133 1.1K
D133 SL103
UNCAL
CARIB
+12V (C)
R112 430
C112 0.01µ
D102 RD6A
R120 100
C101 2200
Q102 2N5912
FROM RS
R101 510K
C105 TC-1.5
D103 1S1544A
C102 0.01µ
R113 390
R102 100
C115 0.01µ
R115 150
D101 RD6A
R103 100
R105 430
C103 0.01µ
-12V (D)
Q122 2SC1254
R130 68
L141
Q141 2SC1254
C140 1000P
R140 300
R131 500
R141 1K
VARIABLE BAL
R142 100
R148 100
R143 100
10mV GAIN
-12V (B)
R145 1K
C131 3~10P
L145
R132 68
R147 300
C147 1000P
Q145 2SC1254
R122 4.3K
R123 4.3K
Q123 2SC1254
R116 130
+12V (A)
STEP ATT BAL
R106 3.3K
C104 0.1µ
R110 5.6K
R104 1K
C110 3.3µ
C118 0.01µ
R119 510
J302
P302
R109 3.3K
C150 22P
R150 22
VARIABLE
R151 1K
C152 22P
R152 22
Q156 2N3905
C156 5P
R156 51
C162 1000P
R162 75
TP101
R153 390
+12V (C)
R159 1.8K
R160 620
R155 390
R161 51
C161 5P
Q161 2N3905
TP102
R163 75
C163 1000P
C176 2200P
Q179 2SA711
R176 150
TO D303 4
R171 51
D179 1S1924
+12V
R192 4.3K
C177 20P
R172 1K
R178 1K
R179 500
C171 4~20P
R175 200
POSITION BAL.
R177 5K
C172 4~20P
R190 750
R195 470
C180 100
R193 5.1K
R173 51
Q190 2SA711
R191 150
TO D306 4
C191 2200P
R170 220
-12V (B)
R169 220
Q170 2N3905
R165 2.2K
Q168 2N3905
R166 330
TO R406 5
TO R405 5
-12V (B) +12V (A)
-12V (B)
+12V (C)
-12V (D)
R126 10
C126 0.1µ
R128 10
C128 0.1µ
R124 10
C124 0.01µ
R125 10
C125 0.1
+12V (DEC)
TP103
C129 0.1µ
-12V (DEC)
+12V (DEC)
-12V (DEC)
5mV GAIN ADJ.
C139 3~7P
R136 100
R139 500
R135 150
5mV
10V/div
S1B
SS-6050
CH1 PREAMPLIFIER(1) 2
K-60572
6



SS-6050

CH-2 PREAMPLIFIER(1) 3

K-605773 6

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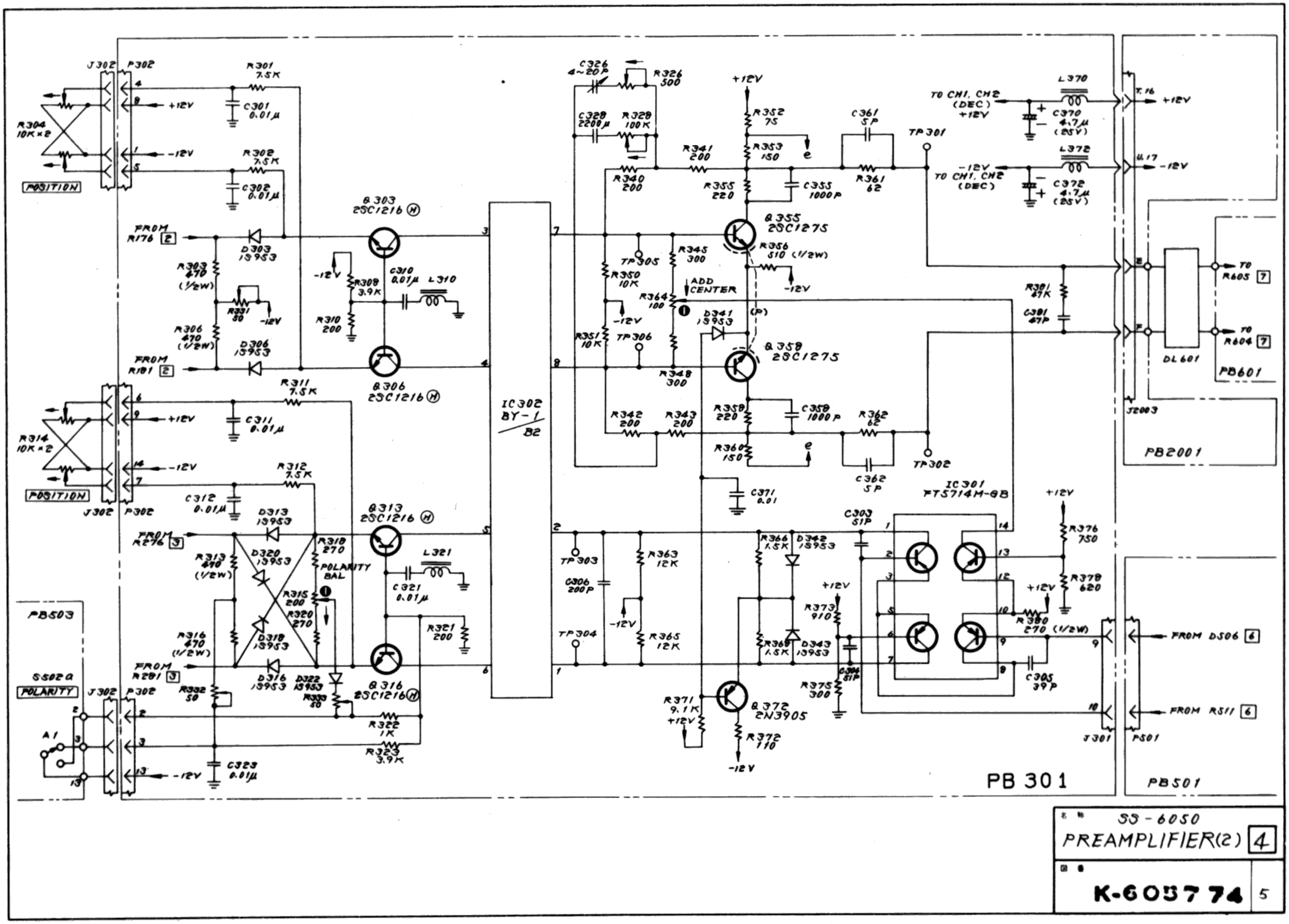
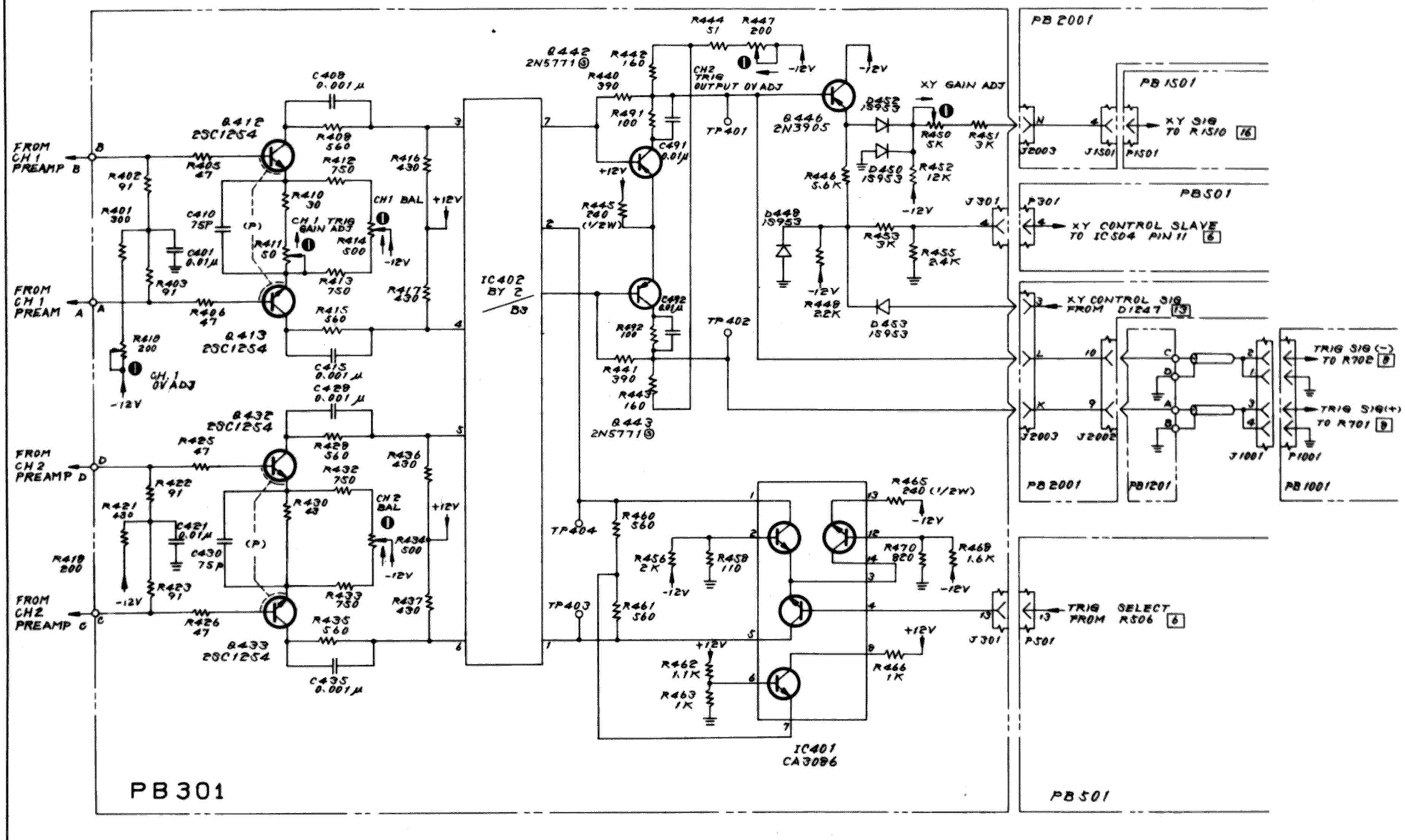
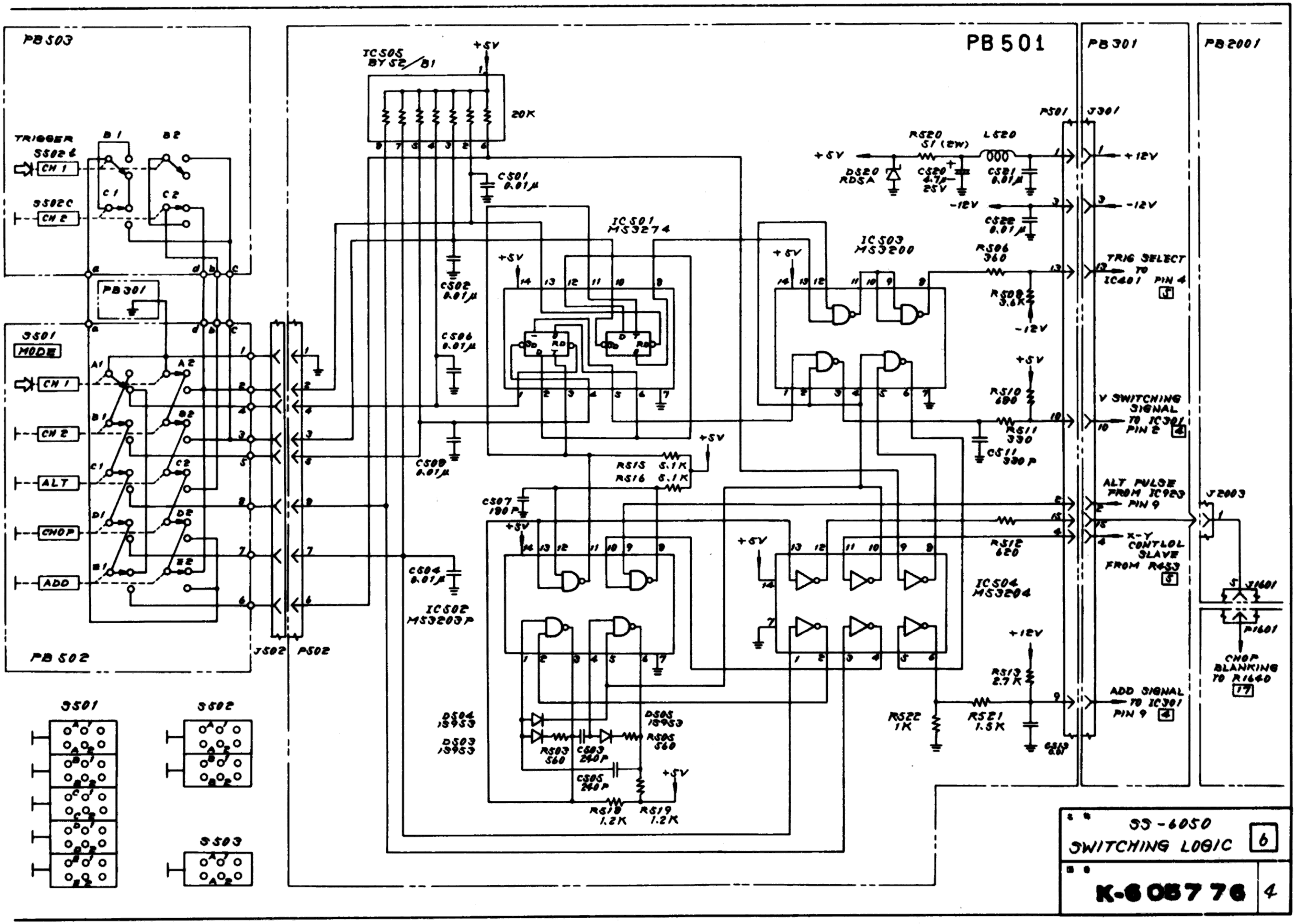


J302
P302
R304 10K×2
POSITION
R314 10K×2
R301 7.5K
C301 0.01µ
R302 7.5K
C302 0.01µ
+12V
-12V
FROM R176 2
FROM R181 2
FROM R276 3
FROM R281 3
D303 1S953
D306 1S953
R303 470 (1/2W)
R306 470 (1/2W)
R331 50
Q303 2SC1216 (H)
Q306 2SC1216 (H)
Q313 2SC1216 (H)
Q316 2SC1216 (H)
R308 3.9K
R310 200
C310 0.01µ
L310
R311 7.5K
C311 0.01µ
R312 7.5K
C312 0.01µ
D313 1S953
D320 1S953
D318 1S953
D316 1S953
D322 1S953
R313 470 (1/2W)
R316 470 (1/2W)
R318 270
R315 200
R320 270
POLARITY BAL
C321 0.01µ
L321
R321 200
R332 50
R333 50
R322 1K
R323 3.9K
C323 0.01µ
PB503
S502a
POLARITY
A1
IC302 BY-1/B2
C326 4~20P
R326 500
C328 2200µ
R328 100K
R340 200
R341 200
R342 200
R343 200
R345 300
R348 300
R350 10K
R351 10K
R364 100
ADD CENTER
TP305
TP306
+12V
R352 75
R353 150
R355 220
C355 1000P
Q355 2SC1275
R356 510 (1/2W)
D341 1S953
Q358 2SC1275
R358 220
C358 1000P
R360 150
C361 5P
R361 62
R362 62
C362 5P
TP301
TP302
C371 0.01
TP303
TP304
C306 200P
R363 12K
R365 12K
R366 1.5K
R368 1.5K
D342 1S953
D343 1S953
R371 9.1K
Q372 2N3905
R372 110
R373 910
R375 300
C304 51P
C303 51P
IC301 FT5714M-GB
R376 750
R378 620
R380 270 (1/2W)
C305 39P
FROM D506 6
FROM R511 6
J301
P501
PB501
PB 301
TO CH1, CH2 (DEC) +12V
-12V TO CH1, CH2 (DEC)
L370
C370 4.7µ (25V)
L372
C372 4.7µ (25V)
R381 47K
C381 47P
DL601
TO R605 7
TO R604 7
PB601
J2003
PB2001
SS-6050
PREAMPLIFIER(2) 4
K-605774
5



SS-6050
TRIGGER AMPLIFIER 5

K-605775



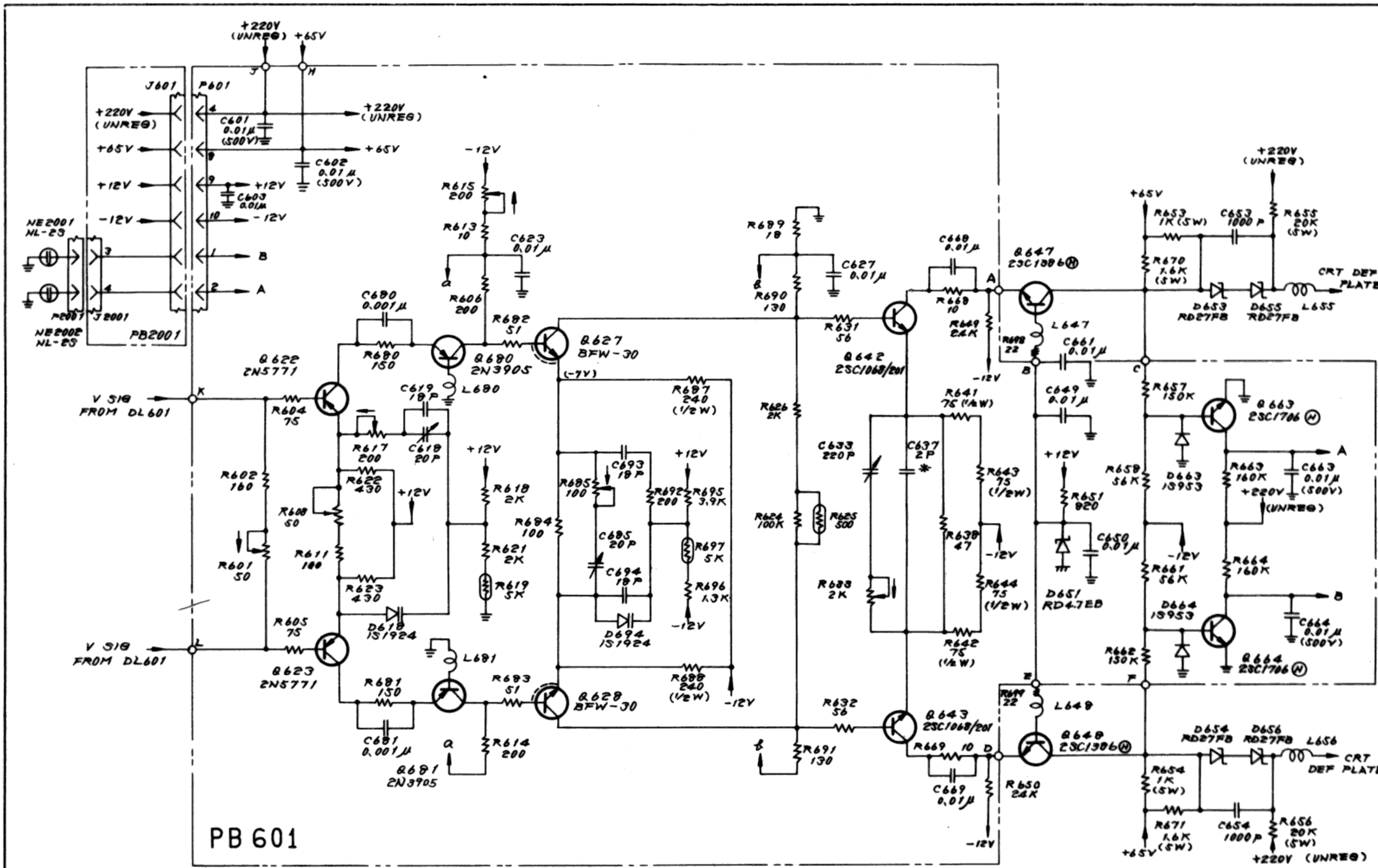
SS-6050

SWITCHING LOGIC

6

K-605776

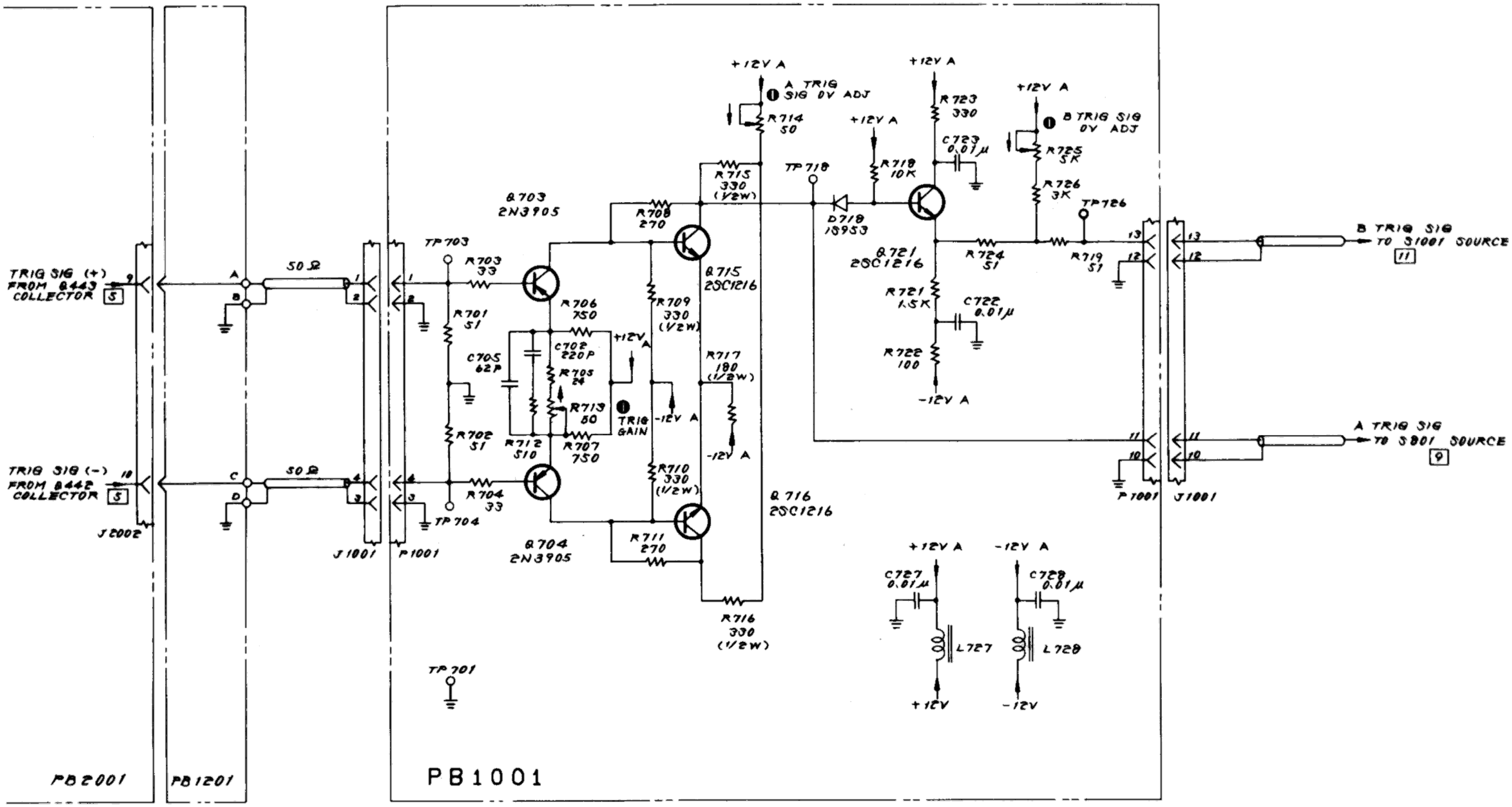
4



SS-6050

VERTICAL MAIN AMPLIFIER 7

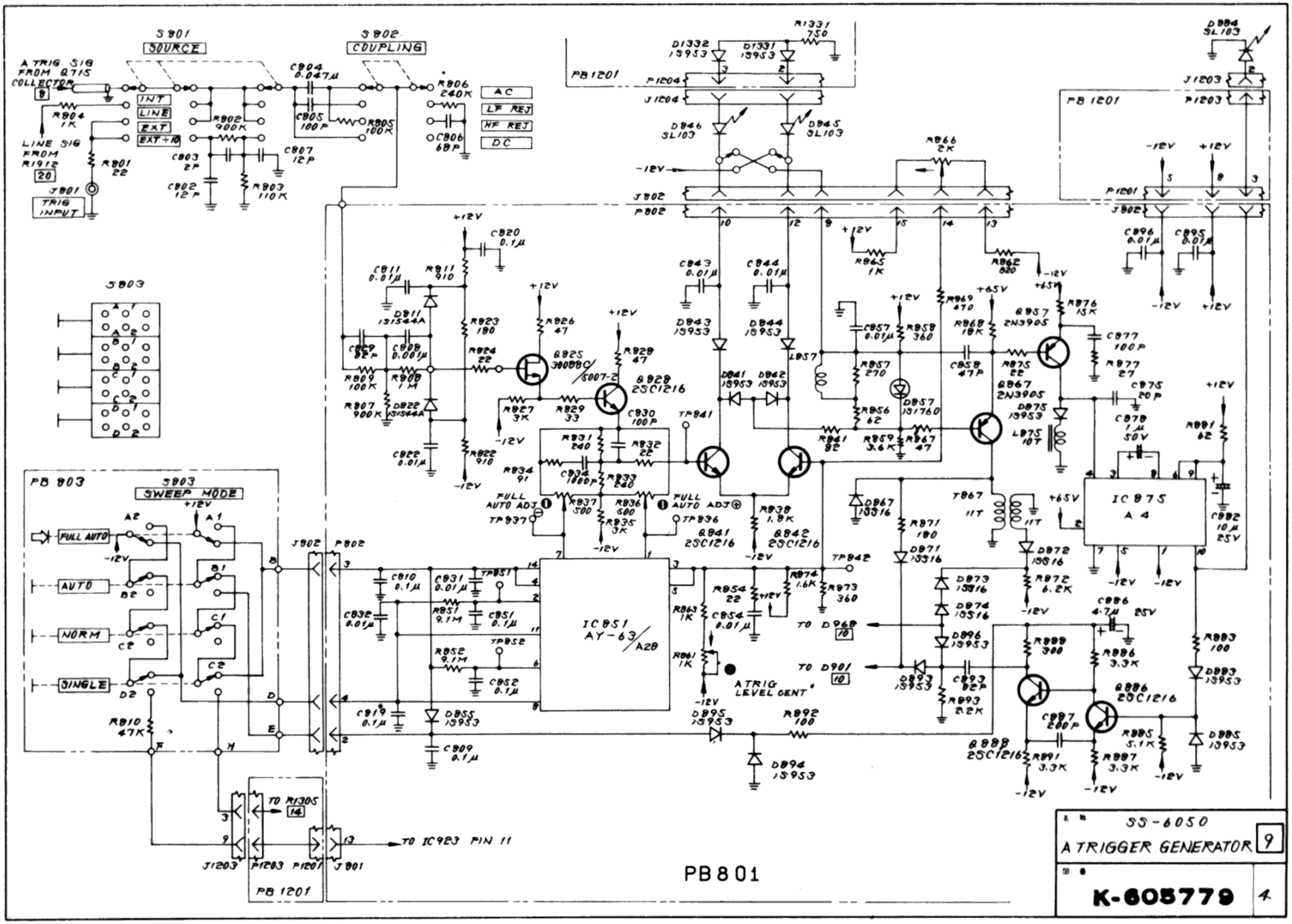
K-605777 9

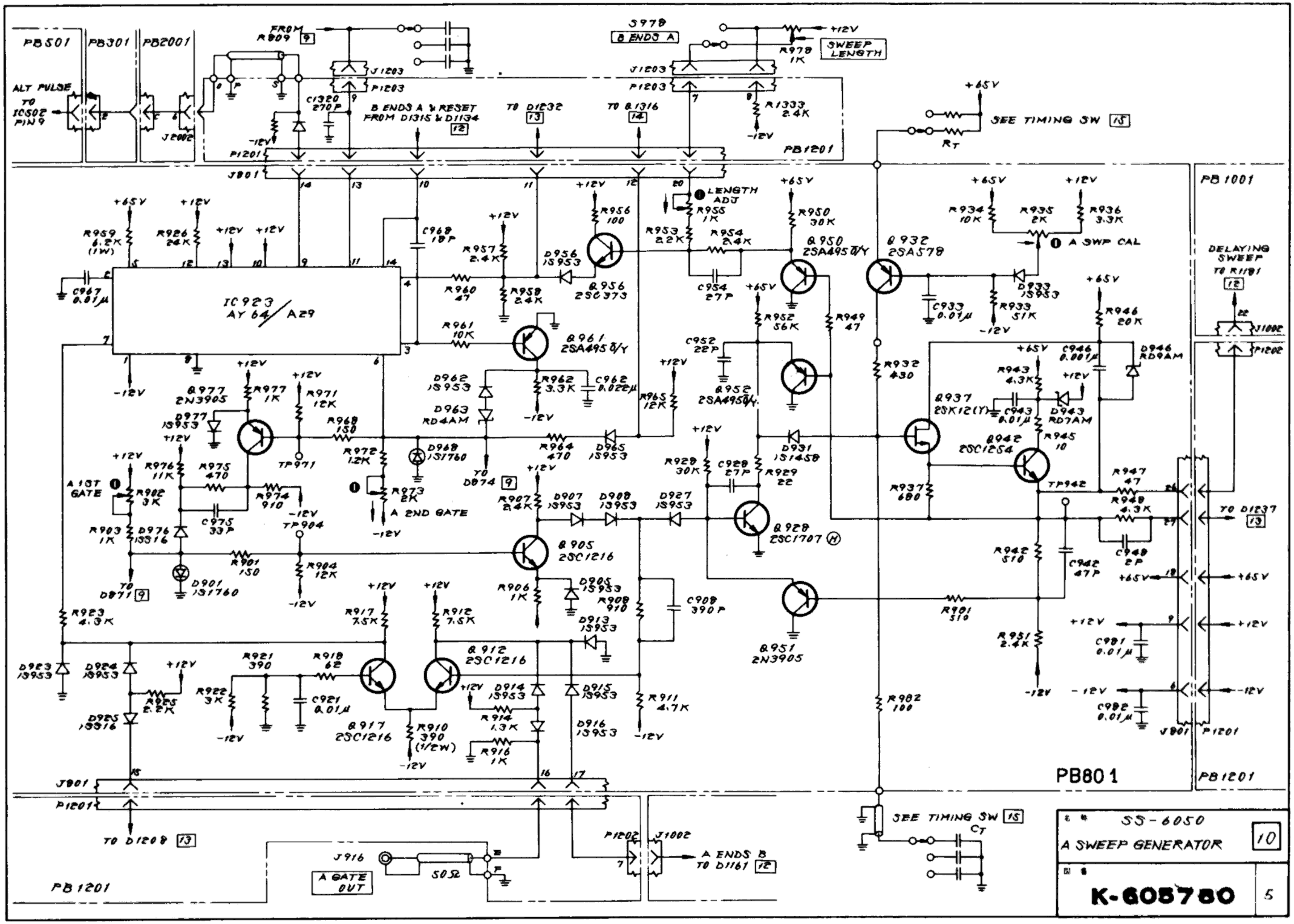


SS-6050

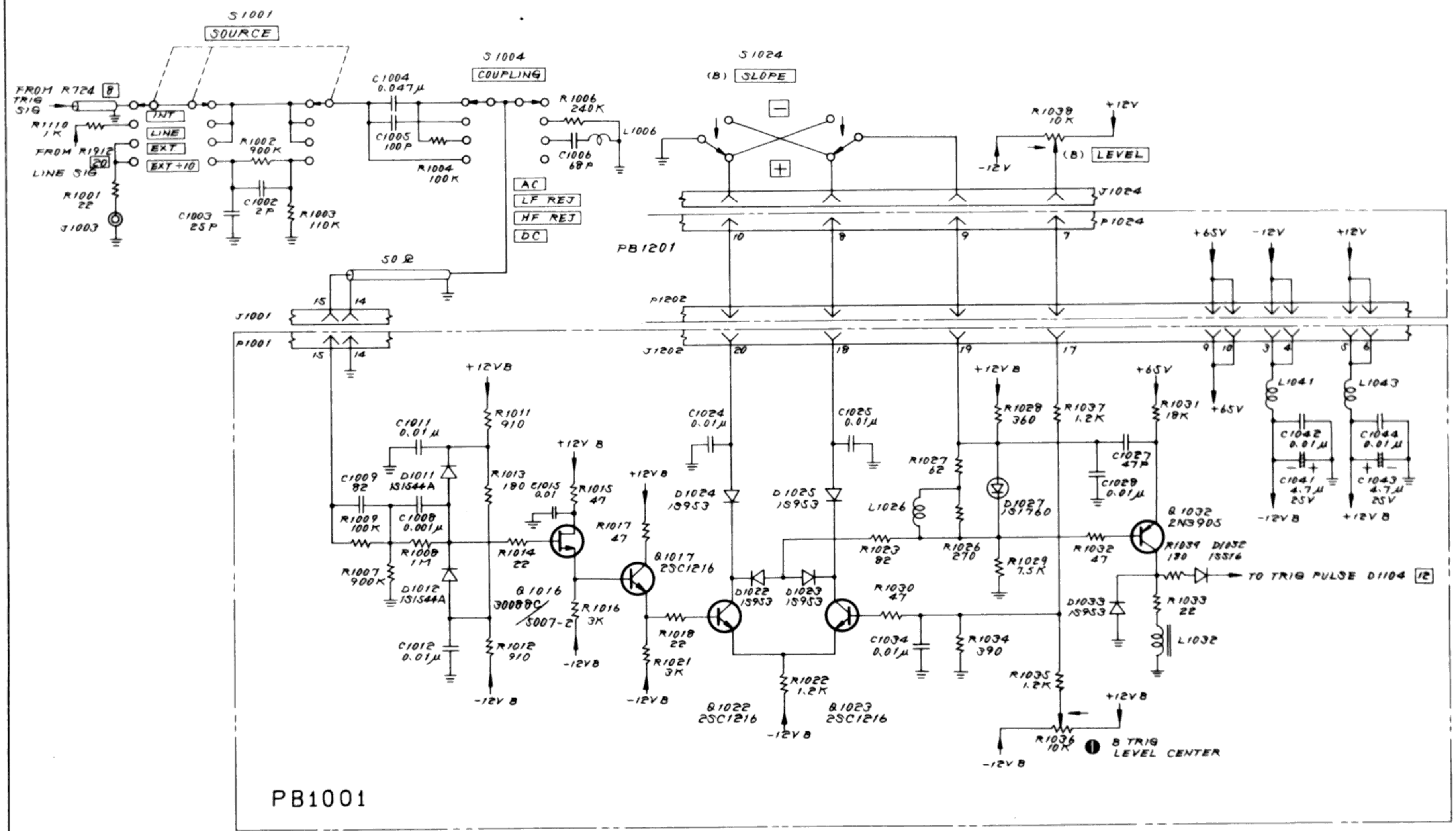
TRIGGER MAIN AMPLIFIER 8

K-605778 4


S801
SOURCE
S802
COUPLING
A TRIG SIG FROM Q715 COLLECTOR
INT
LINE
EXT
EXT÷10
AC
LF REJ
HF REJ
DC
LINE SIG FROM R1912
TRIG INPUT
J801
R801 22
R802 900K
R803 110K
R804 1K
R805 100K
R806 240K
C802 12P
C803 2P
C804 0.047μ
C805 100P
C806 68P
C807 12P
PB1201
P1204
J1204
D1332 1S953
D1331 1S953
R1331 750
D846 SL103
D845 SL103
R866 2K
J802
P802
D884 SL103
J1203
P1203
P1201
S803
PB 803
SWEEP MODE
FULL AUTO
AUTO
NORM
SINGLE
R810 47K
Q825 3008BC/5007-2
Q828 2SC1216
Q841 2SC1216
Q842 2SC1216
Q857 2N3905
Q867 2N3905
Q886 2SC1216
Q888 2SC1216
IC851 AY-63/A28
IC875 A4
FULL AUTO ADJ
TP837
TP836
TP841
TP842
TP851
TP852
ATRIG LEVEL CENT
TO D968 10
TO D901 10
TO R1305 14
TO IC923 PIN 11
T867
PB801
PB 1201
SS-6050
A TRIGGER GENERATOR 9
K-605779 4



PB501
PB301
PB2001
ALT PULSE
TO IC502 PIN 9
J2002
FROM R809 9
J1203
P1203
C1320 270P
B ENDS A & RESET FROM D1315 & D1134 12
TO D1232 13
TO Q1316 14
S978
B ENDS A
+12V
SWEEP LENGTH
R978 1K
R1333 2.4K
-12V
PB1201
P1201
J801
+65V
SEE TIMING SW 15
RT
PB1001
LENGTH ADJ
R955 1K
R953 2.2K
R954 2.4K
C954 27P
R956 100
Q956 2SC373
D956 1S953
R957 2.4K
R958 2.4K
R960 47
C968 18P
R959 6.2K (1W)
R926 24K
C967 0.01µ
IC923 AY 64/A29
R961 10K
Q961 2SA495 O/Y
R950 30K
Q950 2SA495 O/Y
Q932 2SA578
R934 10K
R935 2K
R936 3.3K
A SWP CAL
D933 1S953
R933 51K
C933 0.01µ
DELAYING SWEEP TO R1181 12
J1002
P1202
R952 56K
R949 47
C952 22P
Q952 2SA495 O/Y
R932 430
R946 20K
C946 0.001µ
D946 RD9AM
R943 4.3K
C943 0.01µ
D943 RD7AM
Q937 2SK12(Y)
Q942 2SC1254
R945 10
D931 1S1458
R965 12K
D962 1S953
D963 RD4AM
R962 3.3K
C962 0.022µ
Q977 2N3905
R977 1K
D977 1S953
R971 12K
R968 150
TP971
R972 1.2K
D969 1S1760
TO D874 9
R964 470
D965 1S953
A 1ST GATE
R982 3K
R976 11K
R975 470
R974 910
C975 33P
TP904
R973 2K
A 2ND GATE
R983 1K
D976 1S316
R901 150
R904 12K
TO D871 9
D901 1S1760
R907 2.4K
D907 1S953
D908 1S953
D927 1S953
Q905 2SC1216
R929 30K
C928 27P
R929 22
Q928 2SC1707 (H)
R937 680
TP942
R947 47
R948 4.3K
C948 2P
TO D1237 13
R942 510
C942 47P
R906 1K
D905 1S953
R908 910
C908 390P
D913 1S953
R981 510
Q951 2N3905
R951 2.4K
C981 0.01µ
C982 0.01µ
R923 4.3K
R917 7.5K
R912 7.5K
Q912 2SC1216
D923 1S953
D924 1S953
R925 2.2K
D925 1S316
R921 390
R918 62
R922 3K
C921 0.01µ
Q917 2SC1216
R910 390 (1/2W)
D914 1S953
D915 1S953
R914 1.3K
R916 1K
D916 1S953
R911 4.7K
R982 100
PB801
TO D1208 13
J916
A GATE OUT
50Ω
P1202
J1002
A ENDS B TO D1161 12
SEE TIMING SW 15
CT
SS-6050
A SWEEP GENERATOR
10
K-605780
5

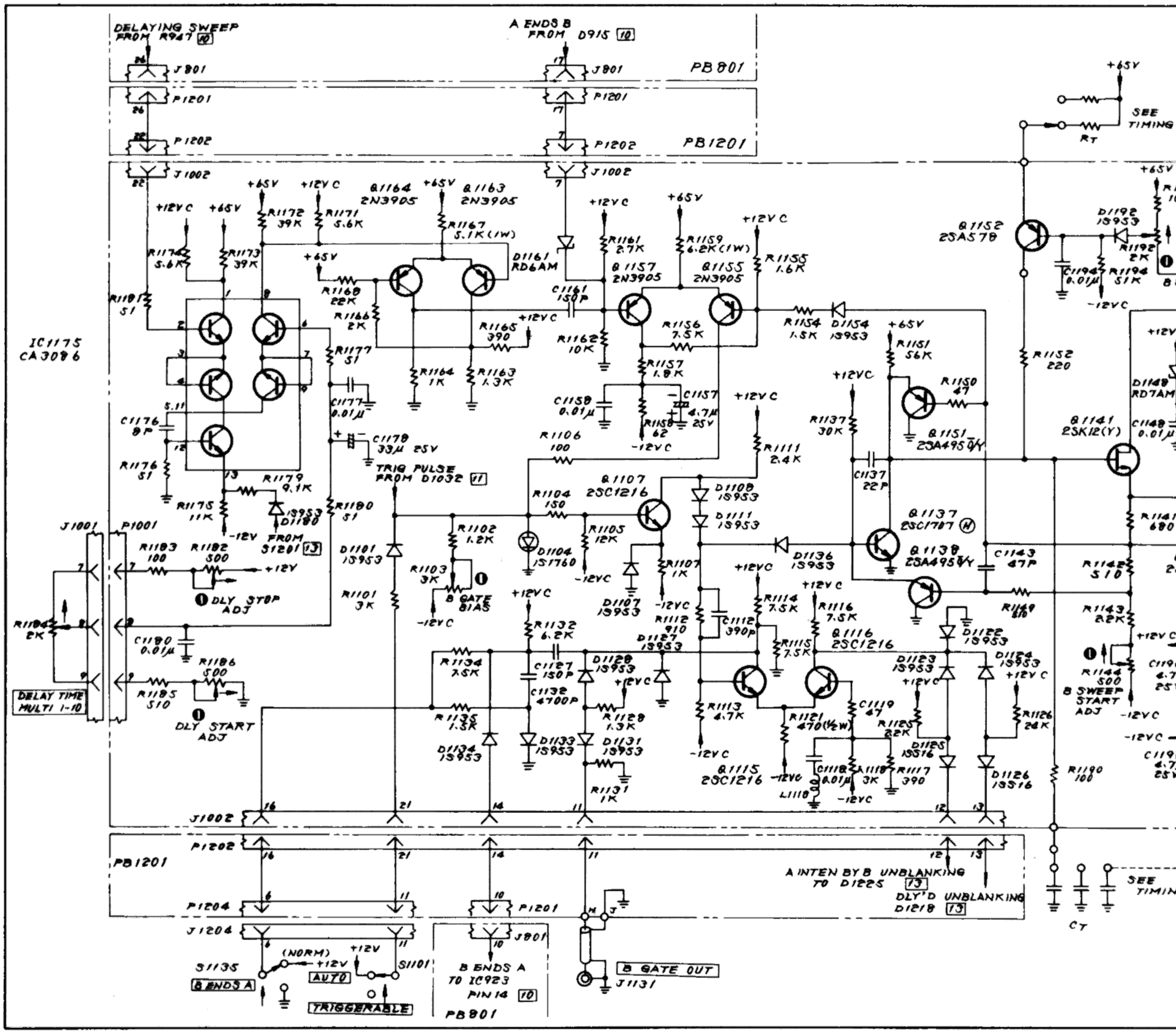


SS-6050

B TRIGGER GENERATOR 11

K-605781

5

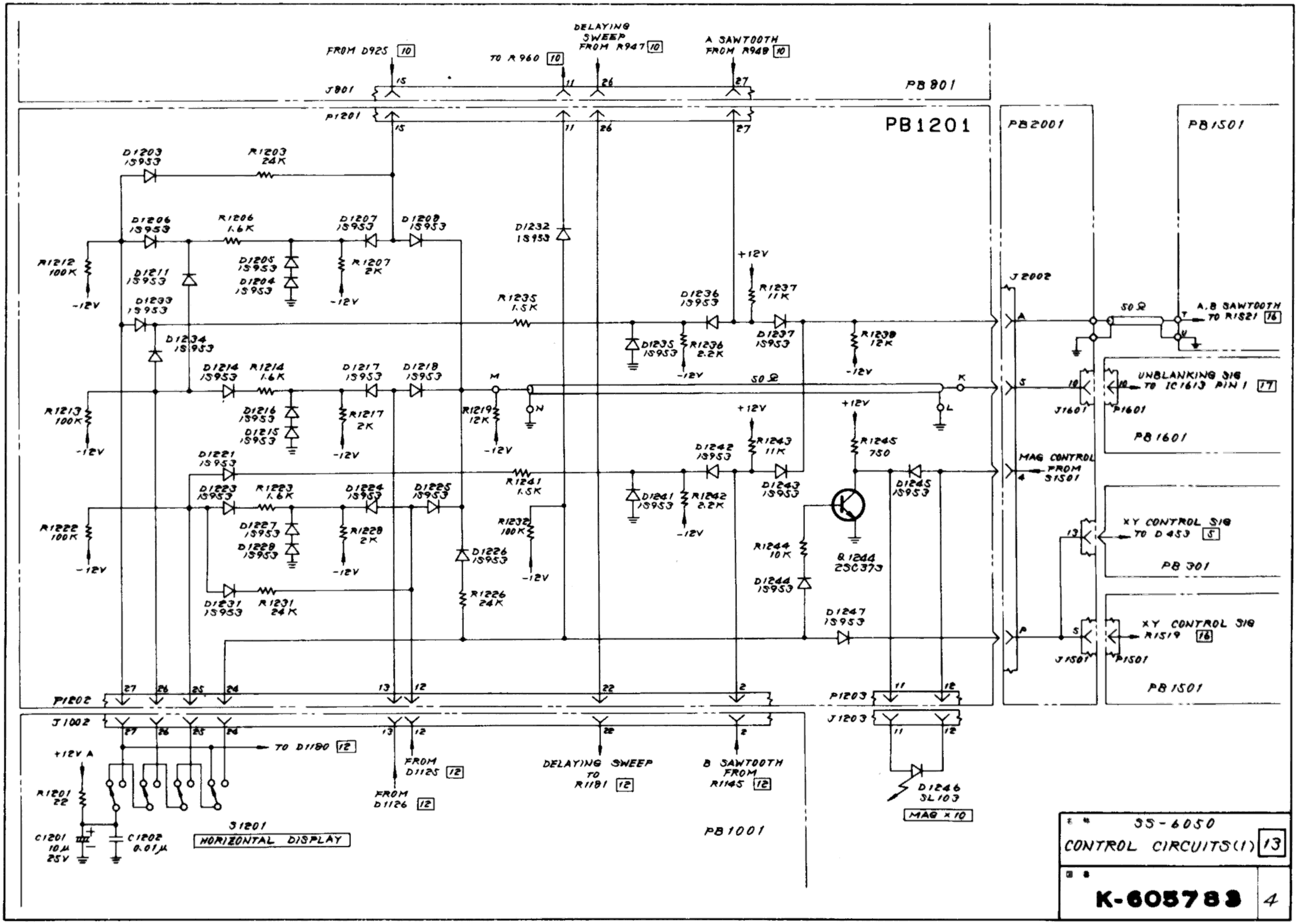


SS-6050

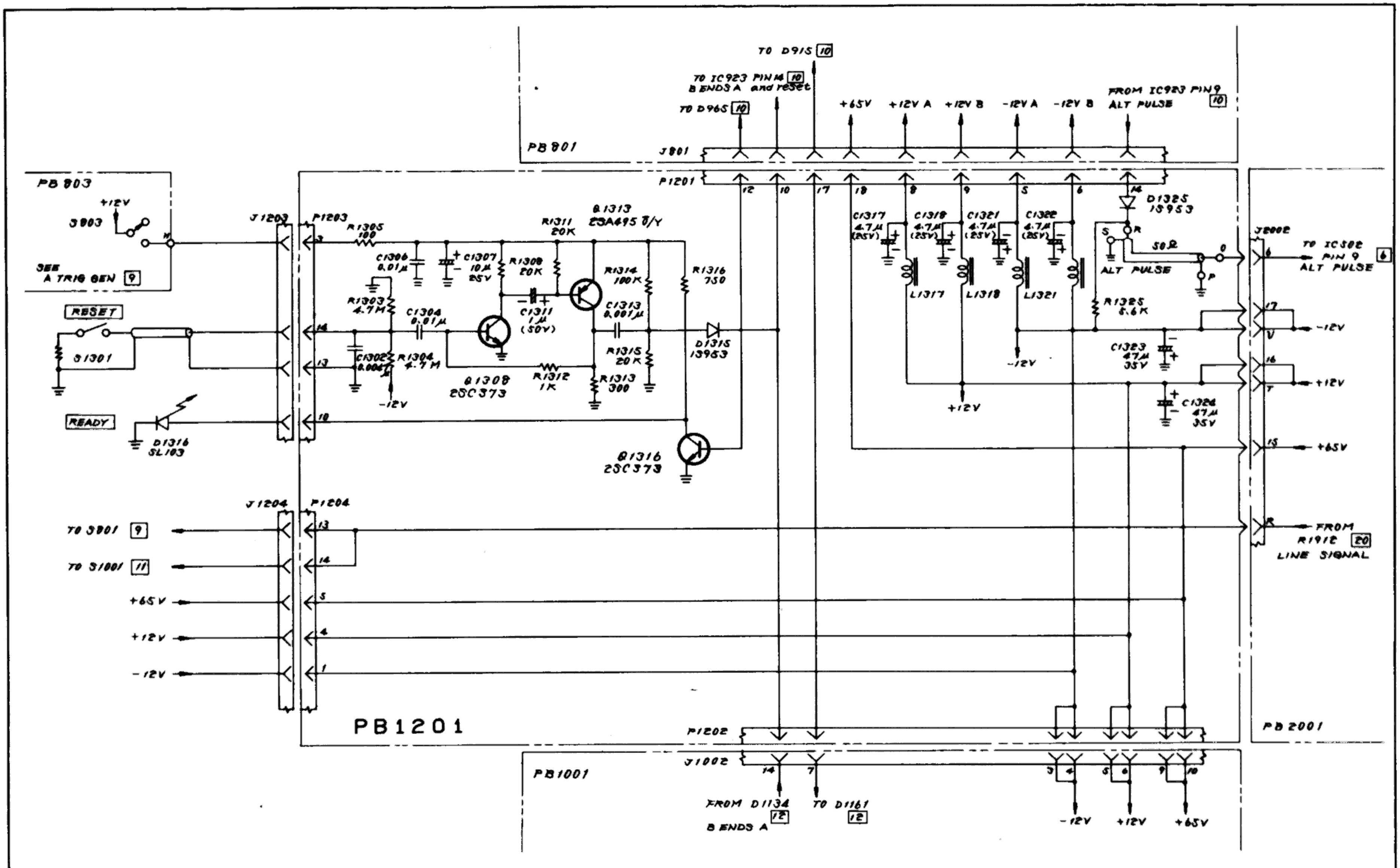
B SWEEP GENERATOR 12

K-605782

5



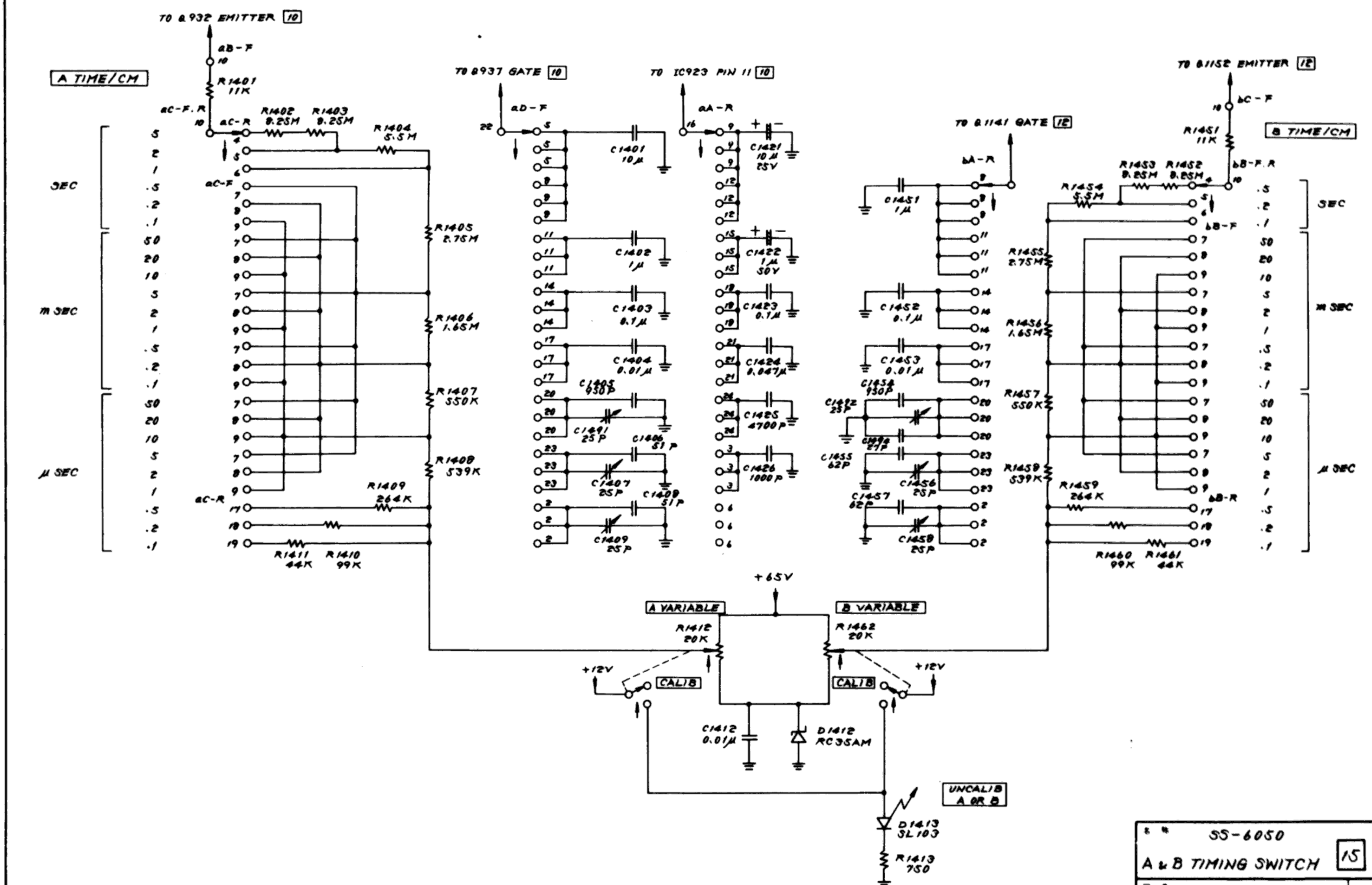
FROM D925 10
TO R960 10
DELAYING SWEEP FROM R947 10
A SAWTOOTH FROM R948 10
J801
PB801
P1201
PB1201
PB2001
PB1501
D1203 1S953
R1203 24K
D1206 1S953
R1206 1.6K
D1207 1S953
D1208 1S953
D1232 1S953
R1212 100K
D1211 1S953
D1205 1S953
D1204 1S953
R1207 2K
-12V
+12V
D1233 1S953
R1235 1.5K
D1236 1S953
R1237 11K
J2002
A.B SAWTOOTH TO R1521 16
D1234 1S953
D1235 1S953
R1236 2.2K
D1237 1S953
R1238 12K
D1214 1S953
R1214 1.6K
D1217 1S953
D1218 1S953
50Ω
UNBLANKING SIG TO IC1613 PIN 1 17
R1213 100K
D1216 1S953
D1215 1S953
R1217 2K
R1219 12K
J1601
P1601
PB1601
D1221 1S953
D1242 1S953
R1243 11K
R1245 750
MAG CONTROL FROM S1501
D1223 1S953
R1223 1.6K
D1224 1S953
D1225 1S953
R1241 1.5K
D1241 1S953
R1242 2.2K
D1243 1S953
D1245 1S953
R1222 100K
D1227 1S953
D1228 1S953
R1228 2K
D1226 1S953
R1232 100K
R1244 10K
Q1244 2SC373
XY CONTROL SIG TO D453 5
PB301
D1244 1S953
D1231 1S953
R1231 24K
R1226 24K
D1247 1S953
XY CONTROL SIG R1519 16
J1501
P1501
PB1501
P1202
P1203
J1002
J1203
+12V A
TO D1180 12
R1201 22
FROM D1125 12
FROM D1126 12
DELAYING SWEEP TO R1181 12
B SAWTOOTH FROM R1145 12
D1246 SL103
MAG ×10
S1201
HORIZONTAL DISPLAY
C1201 10μ 25V
C1202 0.01μ
PB1001
SS-6050
CONTROL CIRCUITS(1) 13
K-605783
4



SS-6050

CONTROL CIRCUIT(2) 14

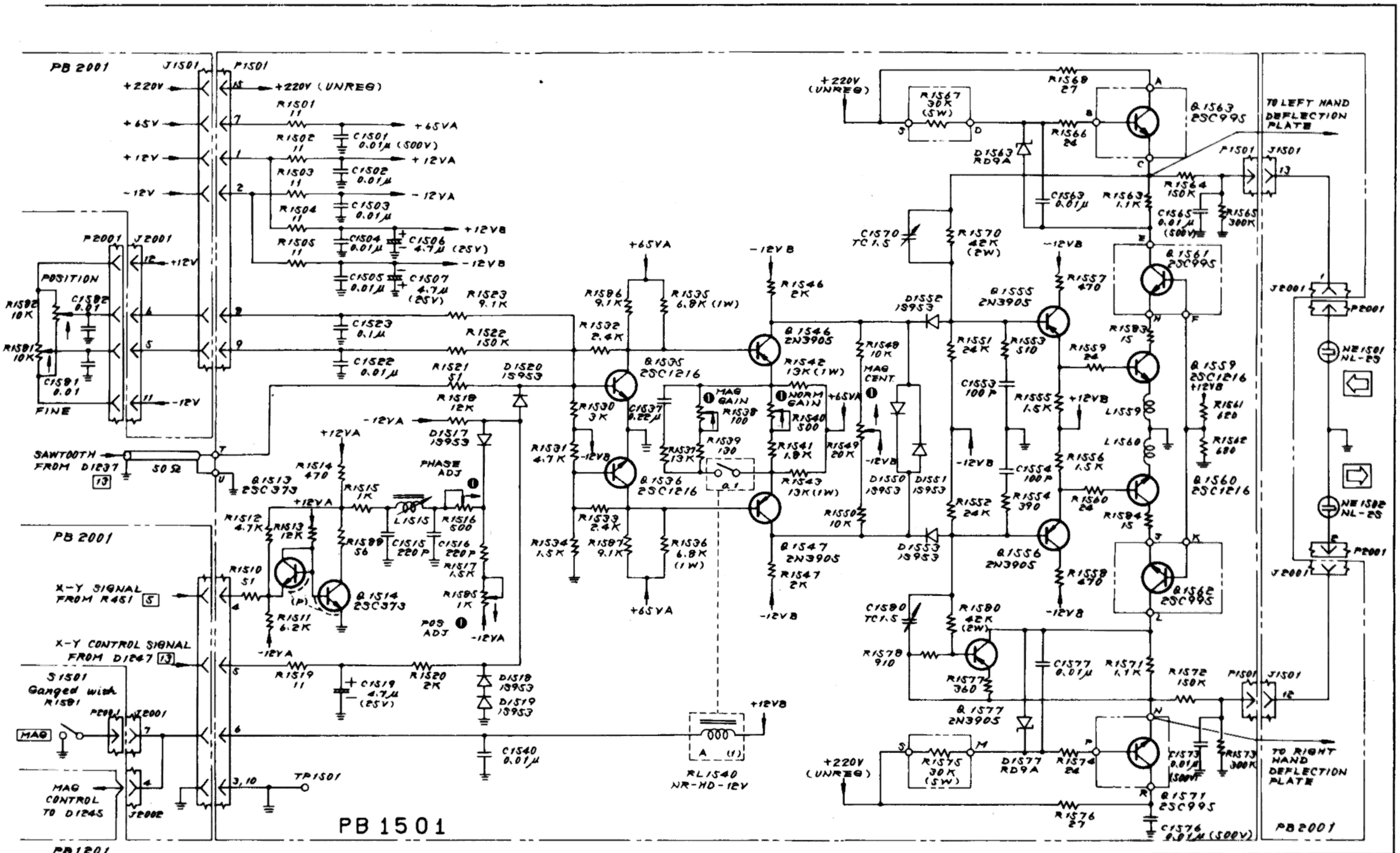
K-605784 4



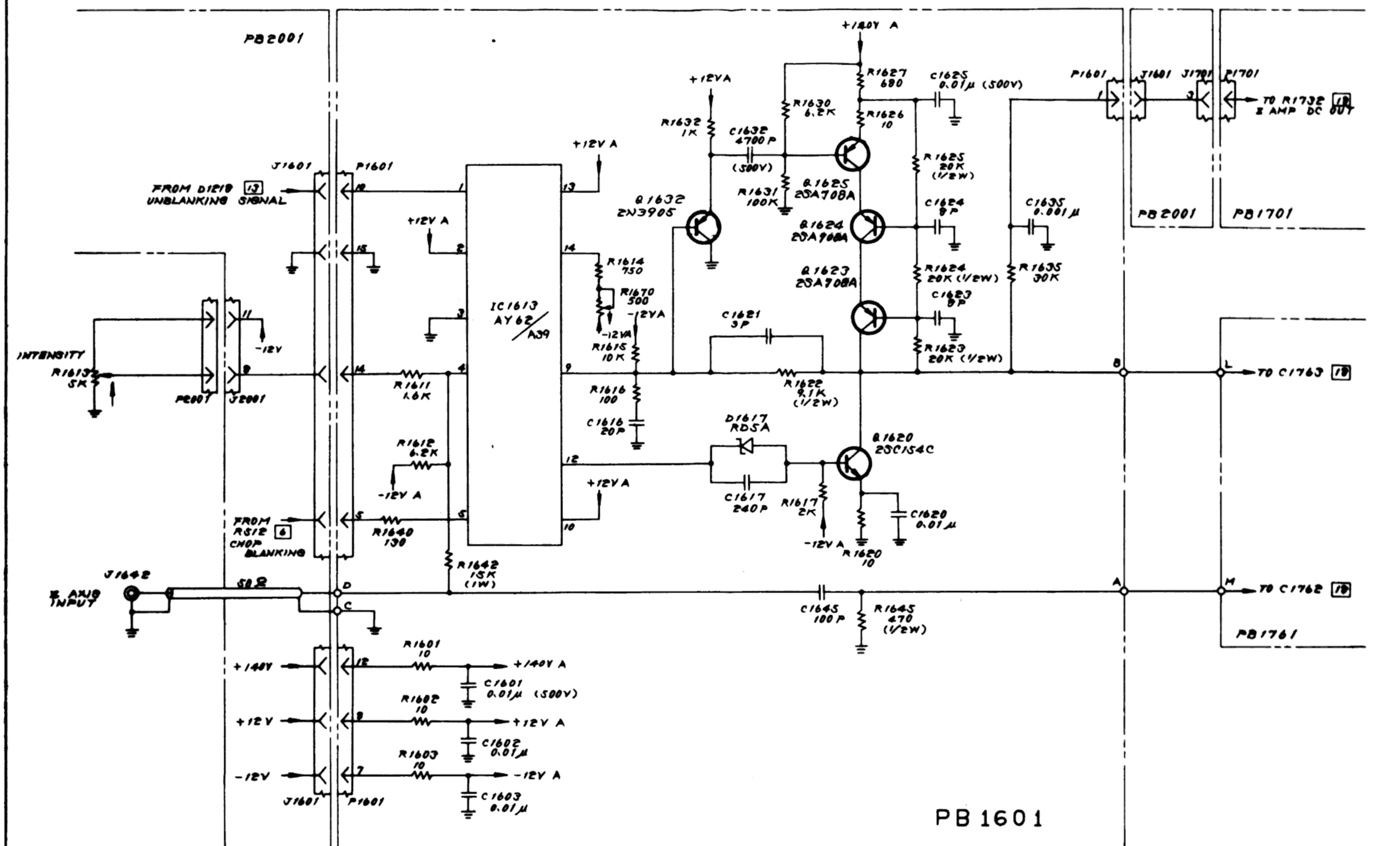
SS-6050

A & B TIMING SWITCH 15

K-605785 2



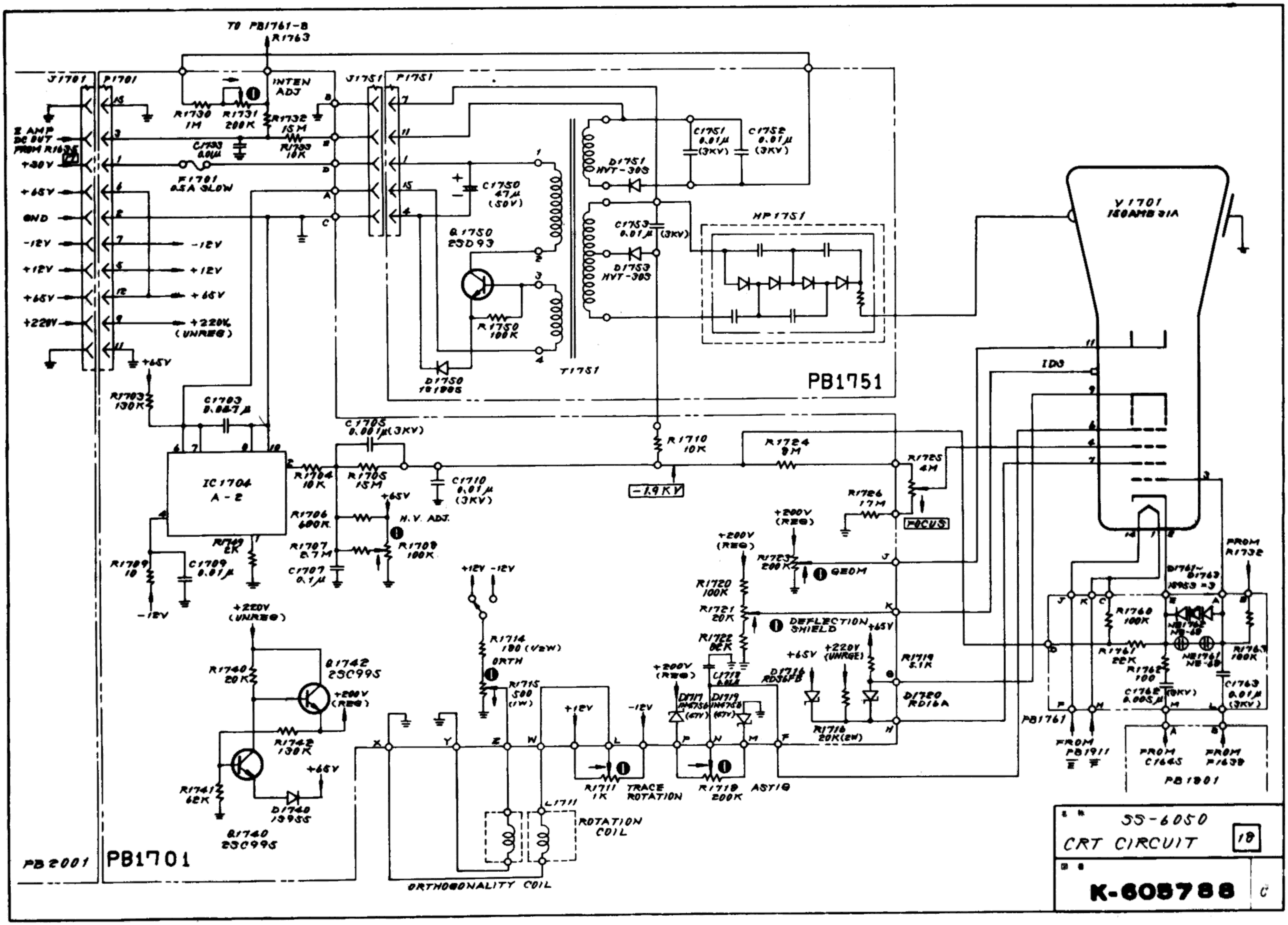
SS-6050	
HORIZONTAL AMPLIFIER	16
K-605786	7



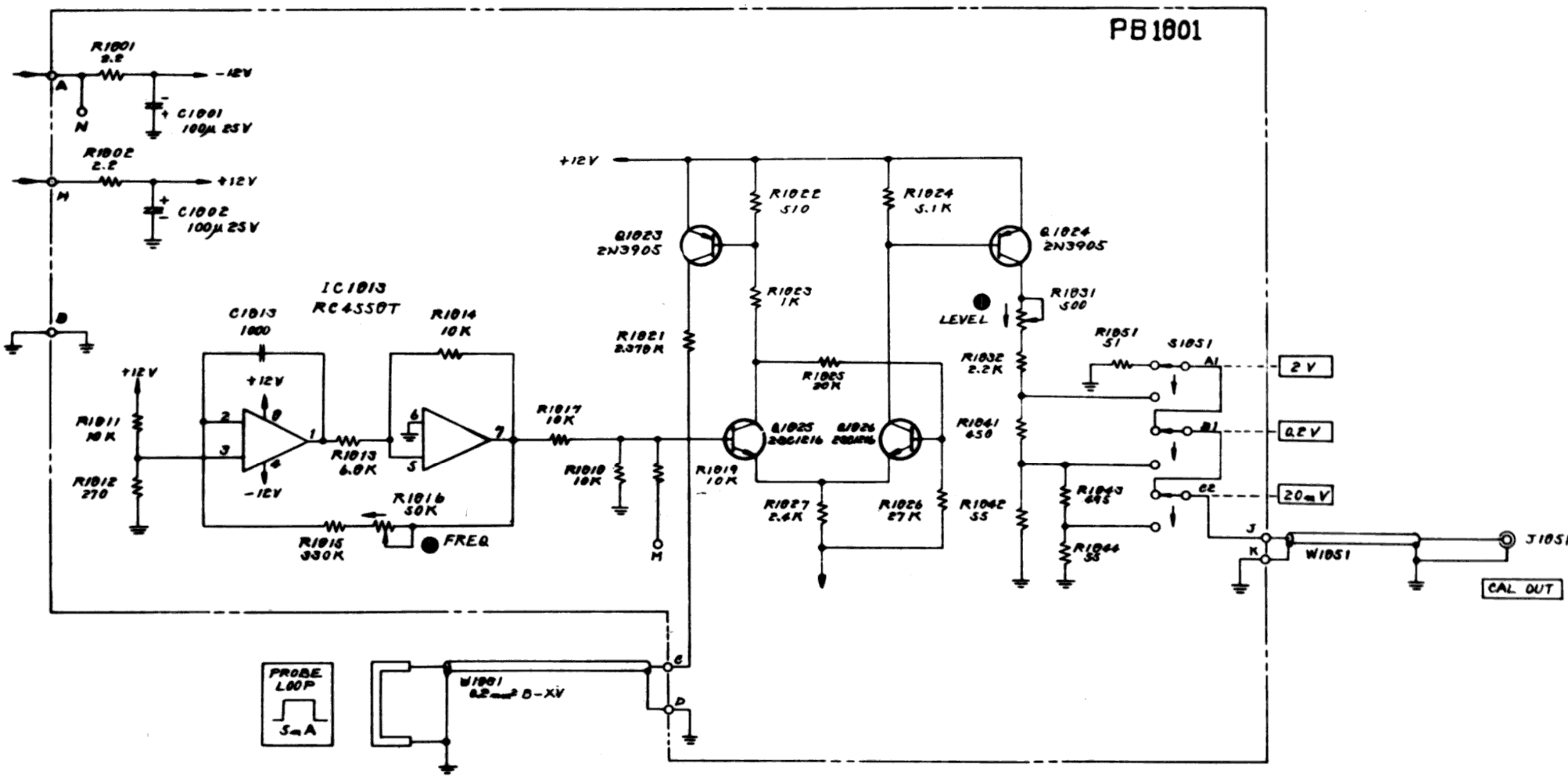
SS-6050

Z AXIS AMPLIFIER 17

K-605787 0



TO PB1761-8
R1763
J1701
P1701
INTEN ADJ
R1730 1M
R1731 200K
R1732 15M
R1733 10K
C1793
F1701 0.5A SLOW
+30V
+65V
GND
-12V
+12V
+65V
+220V
+220V (UNREG)
J1751
P1751
C1750 47μ (50V)
Q1750 2SD93
R1750 100K
D1750 1S1885
T1751
D1751 HVT-30S
D1753 HVT-30S
C1751 0.01μ (3KV)
C1752 0.01μ (3KV)
C1753 0.01μ (3KV)
HP1751
PB1751
V1701
R1703 130K
C1703
IC1704 A-2
R1704 10K
R1705 15M
C1705 0.001μ (3KV)
C1710 0.01μ (3KV)
R1706 680K
R1707 2.7M
R1708 100K
C1707 0.1μ
H.V. ADJ.
R1709 10
C1709 0.01μ
R1710 10K
-1.9KV
R1724 8M
R1725 4M
R1726 17M
FOCUS
+200V (REG)
R1723 200K
GEOM
R1720 100K
R1721 20K
DEFLECTION SHIELD
R1722 82K
R1719 5.1K
D1720 RD16A
R1716 20K (2W)
+220V (UNREG)
Q1742 2SC995
R1740 20K
R1742 130K
R1741 62K
D1740 1S955
Q1740 2SC995
+12V -12V
R1714 180 (1/2W)
ORTH
R1715 500 (1W)
R1711 1K
TRACE ROTATION
R1718 200K
ASTIG
L1711
ROTATION COIL
ORTHOGONALITY COIL
R1760 100K
R1761 22K
R1762 100
C1762 0.005μ (3KV)
R1763 100K
C1763 0.01μ (3KV)
FROM R1732
PB1761
FROM PB1911
FROM C1645
FROM F1639
PB1901
PB2001
PB1701
SS-6050
CRT CIRCUIT
18
K-605788



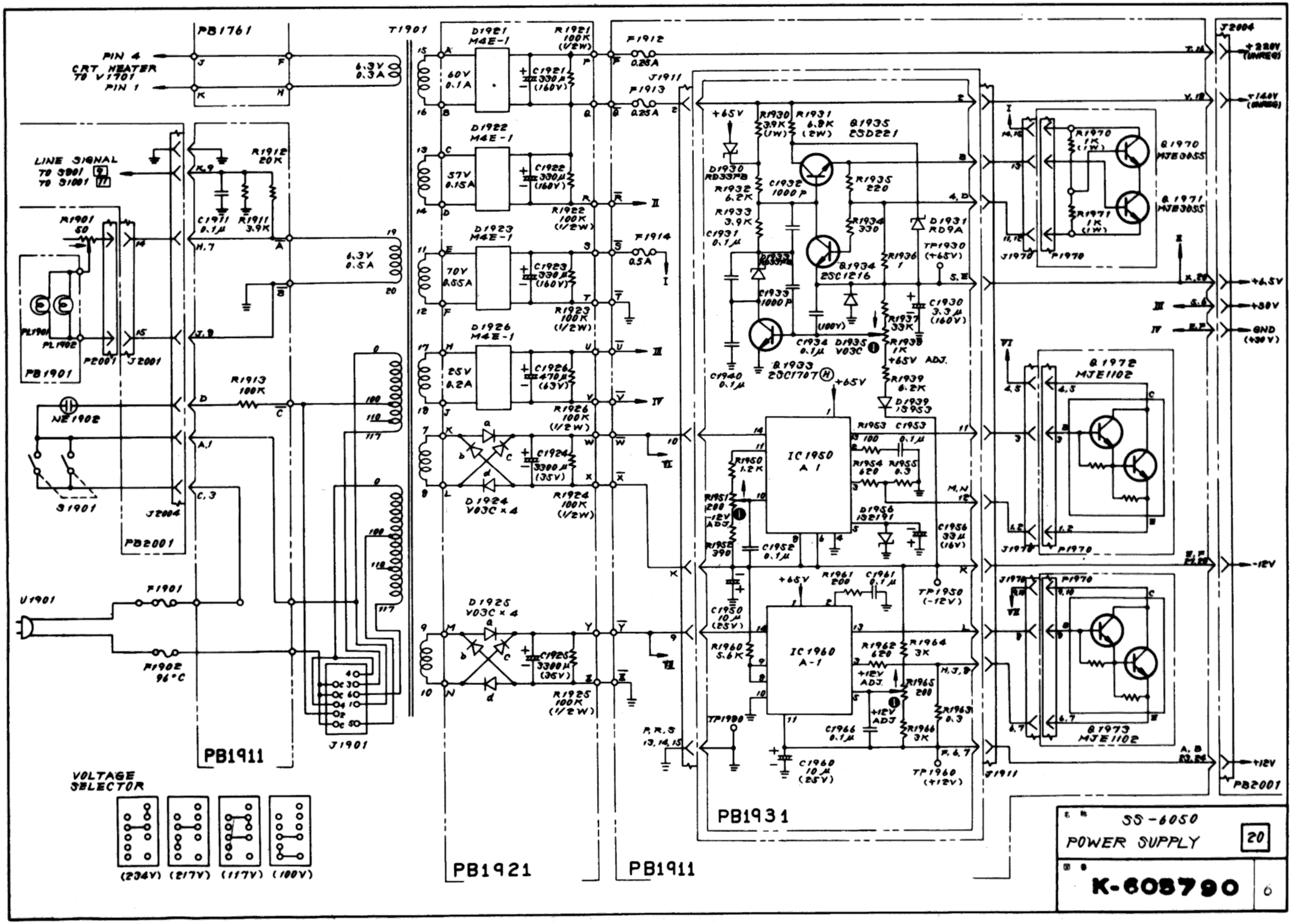
SS-6050

CALIBRATOR

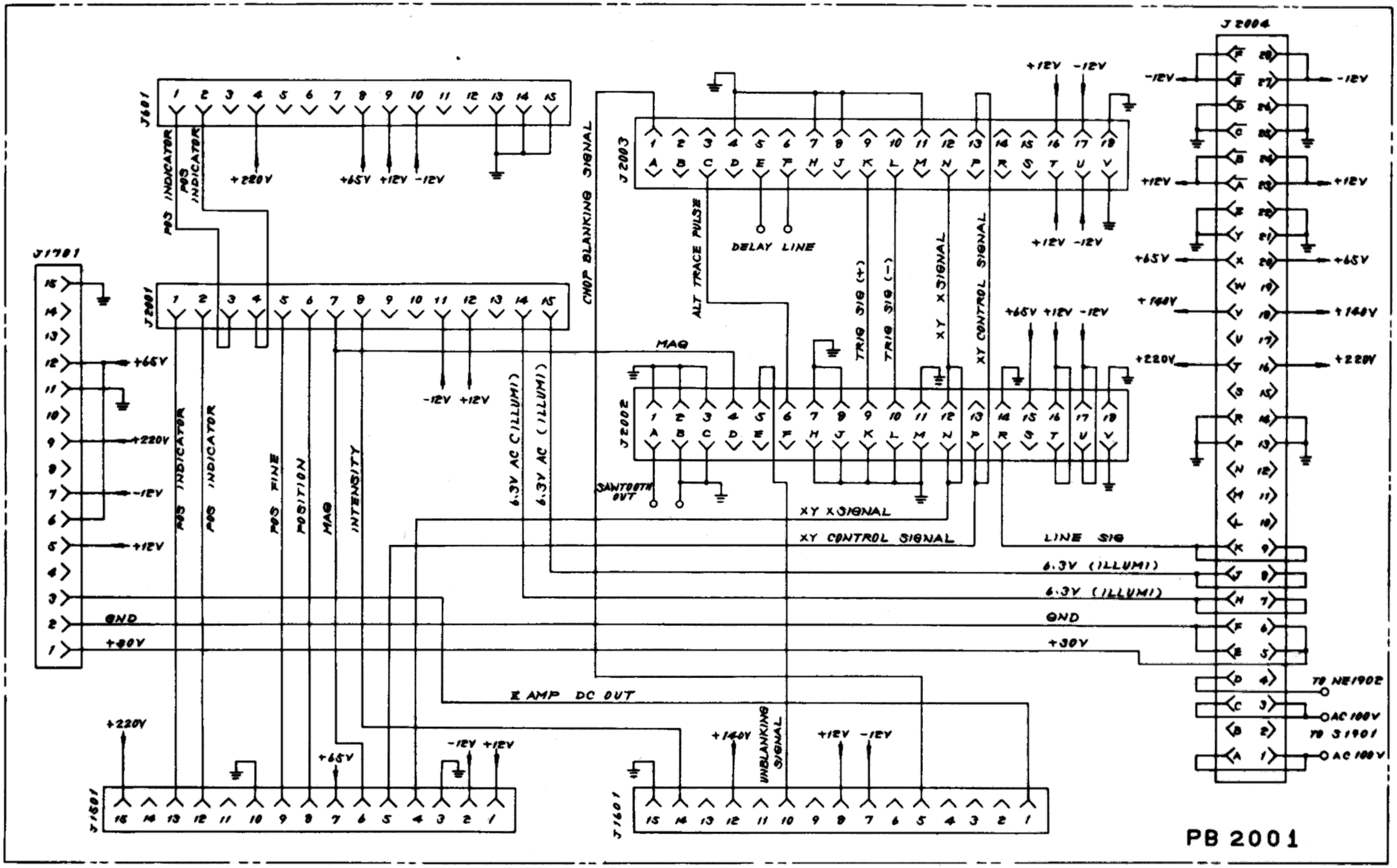
19

K-605789

3



SS-6050
POWER SUPPLY
20
K-608790
6
PB1911
PB1921
PB1931
VOLTAGE SELECTOR
(234V) (217V) (117V) (100V)



SS-6050

INTER CONNECTING

21

K-C05791

2

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