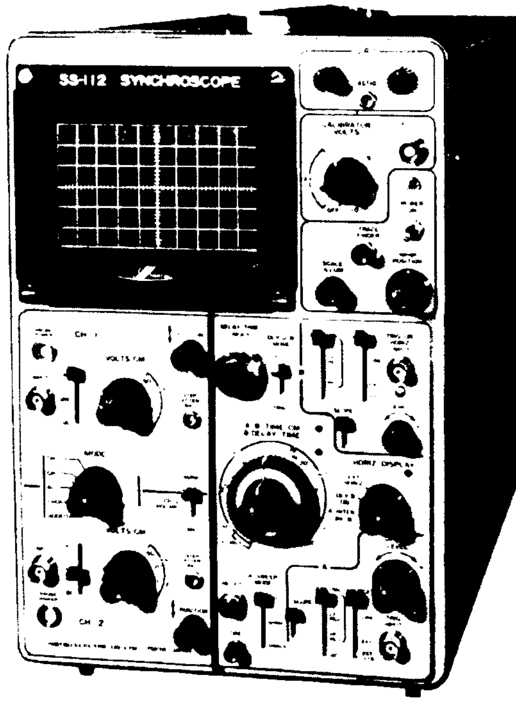
INSTRUCTION MANUAL

SYNCHROSCOPE SS-112

IWATSU ELECTRIC CO., LTD.
TOKYO JAPAN



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SYNCHROSCOP

SS-112

IWATSU ELECTRIC CO., LTD

Main office: 7-41, 1-chome Kugayama Suginami-ku, Tokyo, 167 Japan. Telephone Tokyo (334) 11

Overseas Operation Department: Asahiseimei-Building 2, 2-chome Nihonbashi-tori Chuo-ku, Tokyo, 103 Japan
Telephone Tokyo(272)0461. Telex TK4225(TELEIWA). Cable Address TELEPHIWAT

In U.S.A.: **E-H Research Laboratories, Inc.** 515-11th Street. Box 1289, Oakland, California 946
Telephone (415) 834-3030. Telex TWX 910-366-7258

NOTICE

This Instruction Manual was re-edited by Iwatsu electric co., based upon the E-H Instruction Manual for the Model SS-112 Synchroscope, November 1970.

While all procedures described herein have been verified by Iwatsu/E-H, minor errors in translation may exist. In such event, please notify Iwatsu/E-H.

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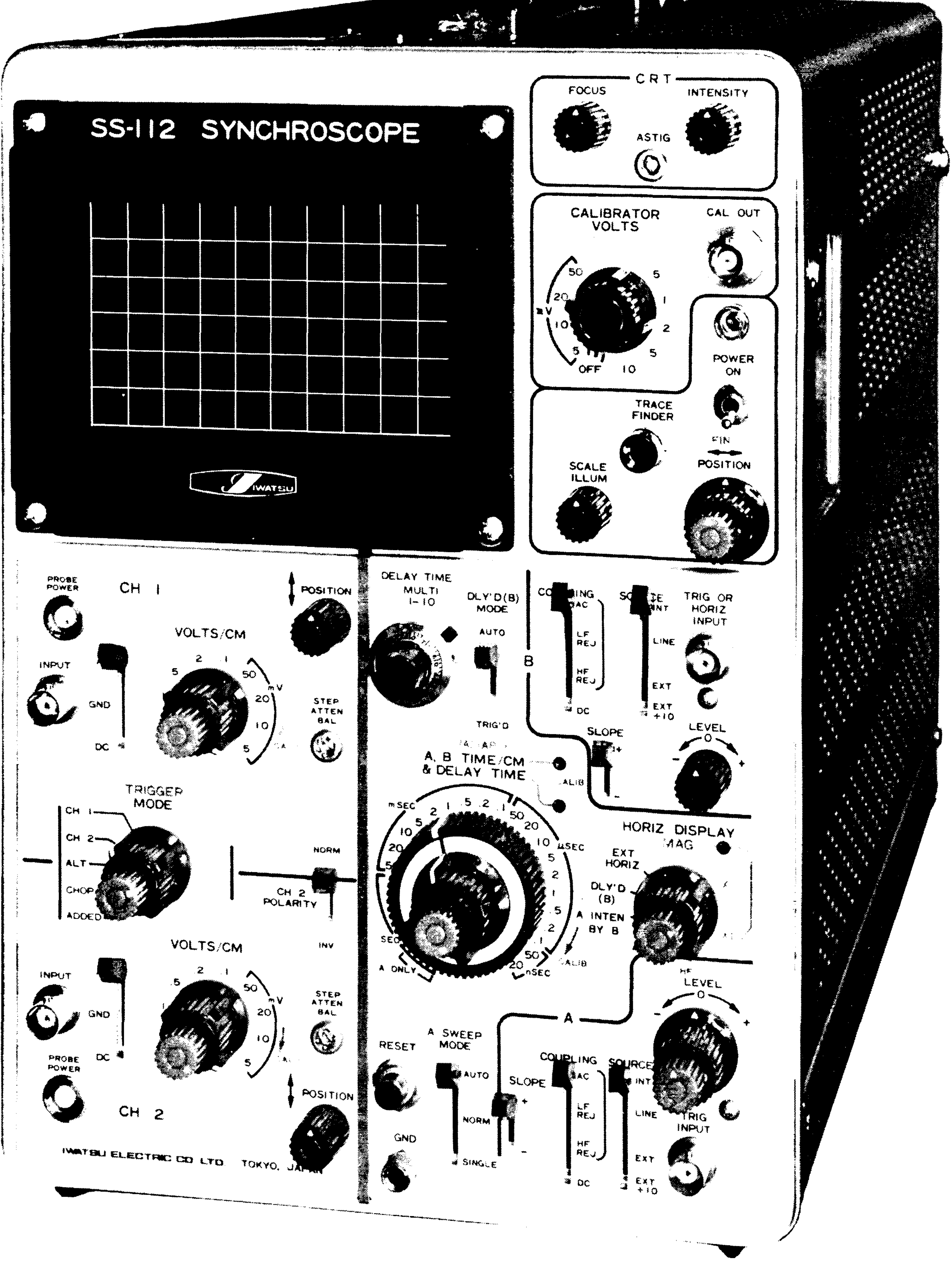


Figure 1-1 Iwatsu Model SS-112 Synchroscope

SECTION 1
SPECIFICATIONS

1-1 INTRODUCTION

This manual provides information for operation and maintenance of the Iwatsu SS-112 Synchroscope, shown in Figure 1-1. The information is divided into six sections: Section 1 gives a general description of the instrument and lists specifications; Section 2 provides a description of operator controls, operating procedures, and measurement methods; Section 3 describes the theory of operation of the instrument; Section 4 contains maintenance and calibration procedures, Section 5 contains the parts list and ordering information, and Section 6 contains component location photographs and schematic diagrams.

1-2 GENERAL INFORMATION

The SS-112 is a high-performance synchronized oscilloscope designed to provide 100 MHz bandwidth with operating features and conveniences found on oscilloscopes with lower bandwidths. Dual vertical channels give 5 mV sensitivity over the full bandwidth, with five display modes including X-Y operation. Sweep speeds are from 20 ns/cm to 5 sec/cm, with a X10 magnifier. Delayed sweep mode with intensity modulation of the trace for precise delay settings allows quick setup for delayed operation. Triggering over the full bandwidth is available from either vertical input or from separate A and B external inputs. A rectangular five-inch CRT with internal graticule and 6 x 10 cm display allows easy waveform measurement without parallax error.

Table 1-1 Step Response Characteristics

Characteristic	Performance Requirement	
	5 and 10 mV/cm	20 mV and higher
Overshoot	less than 3%	less than 5%
Undershoot	less than 2%	less than 3%
Ringing	less than 2%	less than 2%
Sag (at 1 MHz)	less than 1%	less than 1%
Sag (at 60 Hz)	less than 1%	less than 1%

NOTE: All values for input pulse with less than 1 ns risetime.

1-3 SPECIFICATIONS

a. Vertical Deflection System. Dual-trace vertical amplifiers, with specifications common to both channels, unless otherwise noted.

Sensitivity .... 5 mV/cm to 5 V/cm, in 10 calibrated ranges, with continuous variation between ranges. Sensitivity can be reduced to 1/2.3 of calibrated values up to 11.5 V/cm maximum. Accuracy 3%.

Bandwidth ....dc to 100 MHz (3 db point), dc-coupled; 3 Hz to 100 MHz, ac-coupled.

Bandwidth Switch ....dc to 100 MHz (3 db point) in full range, dc to 10 MHz in 10 MHz range.

Risetime ....3.5 ns step response characteristics listed in Table 1-1.

Signal Delay .... 90 ns

Input Impedance .... 1 megohm in parallel with 14 pF at input connector; 10 megohms in parallel with 10 pF using 1014 attenuator probe.

Maximum Input Level ....500 V dc + ac peak

Operating Modes .... Channel 1 only, Channel 2 only, alternate, chopped at 1 MHz rate, and added algebraically.

Polarity Inversion ....Channel 2 signal displayed normal or inverted, with front-panel polarity selection.

Common Mode Rejection ....20:1 at 10 MHz, in added mode.

Linearity .... less than 0.6 division compression or expansion of a 2-division signal at the center of screen when moved to either screen edge.

Vertical Drift .... less than 1 mV/hr, after stable operation

Output Signal ....Channel 2 output signal available at side panel connector. Gain X5 with respect to Channel 2 input. Characteristics for cascaded connection listed in Table 1-3.

Table 1-3 Response of Cascaded Channels

Characteristic	Performance
Sensitivity	1 mV/cm ±3%
Bandwidth	DC to 30 MHz, −0.5 dB, +1.5 dB
Offset Voltage	less than ±15 mV
Noise	less than 5 mm p-p

Internal Trigger Selection ....either Channel 1 or Channel 2 signal can be selected for trigger in alternate or chopped dual-trace modes.

b. Horizontal Deflection System.

Sweep Modes .... A Sweep, Delayed Sweep, and external sweep.

A Sweep Modes .... Auto, Normal, Single

A Sweep Range ....20 ns/cm to 5 sec/cm in 23 ranges, with continuous variation between ranges. Up to 1/2.5 times the selected value available in each range, with 12.5 sec/cm maximum. Accuracy 3%.

Sweep Magnifier ....X1 and X10, allowing effective sweep ranges to 2 ns/cm.

B Sweep Range .... same as A Sweep

Sweep Linearity ....better than 3% in each range, both A and B sweep.

Delay Time ....1 μs to 50 s, continuously variable by A TIME/CM and DELAY TIME MULTI control. Uncalibrated delay times between 20 ns and 0.5 μs are also available.

Delay Time Jitter ....less than 0.05%, determined by ratio of A and B TIME/CM settings.

Single Sweep .... normal and delayed single sweep modes available.

External Sweep ....two external modes: from TRIG OR HORIZ IN connector or using Channel 2 input signal. Characteristics listed in Tables 1-4 and 1-5.

Table 1-4 External Horizontal Input Characteristics

Characteristic	Performance
Input Impedance	1 megohm in parallel with 25 pF
Sensitivity	0.22 V/cm with SOURCE in EXT 2.2 V/cm with SOURCE in EXT ÷ 10
Bandwidth	DC to 10 MHz (−3 dB)
Phase Measurement Bandwidth	DC to 100 kHz (less than 3° internal phase shift at 100 kHz)

Table 1-5 Horizontal Characteristics Using Channel 2

Characteristic	Performance
Input Impedance	1 megohm in parallel with 14 pF
Sensitivity	within ±3% of Channel 2 VOLTS/CM setting
Bandwidth	DC to 10 MHz (−3 dB)
Phase Measurement Bandwidth	DC to 100 kHz (less than 3° internal phase shift at 100 kHz)

c. Triggering

A Triggering
- Modes ....internal, external, and line frequency
- Polarity ....+ or −
- Coupling ....AC, DC, HF REJ, and LF REJ
- External Trigger Input ....1 megohm, 25 pF in parallel
- Trigger Freq. Range .... see Table 1-6

B Triggering
- Modes ....internal, external, and line frequency
- Polarity ....+ or −
- Coupling .... AC, DC, HF REF, and LF REJ
- External Trigger Input ....1 megohm, 25 pF in parallel
- Trigger Freq. Range .... see Table 1-7

d. Output Signals

A Gate .... 5 V p-p square wave, output impedance 1.5 kilohm. Minimum load impedance, 100 kilohms.

B Gate .... 5 V p-p square wave, output impedance, 1.5 kilohm. Minimum load impedance, 100 kilohms.

Calibrator
- Output Voltage .... 5 mV to 10 V, 11 steps
- Accuracy .... ±2%
- Frequency .... 1 kHz ±1%
- Asymmetry .... less than 1%
- Risetime .... less than 200 ns
- Falltime .... less than 500 ns

e. CRT

CRT Type .... D13-45, 5 in. square, with 6 x 10 cm internal graticule.
Accelerating Voltage ....15 kV

Intensity Modulation ....5 V to 200 V p-p (maximum) to intensify trace. Input impedance 47 kilohms.

f. Power Requirements

Operating Range ....100 Vac, or 200 Vac, with selection of high (105-126 V and 207-253 V) or low (90-110 V and 180-220 V) ranges.

Frequency .... 50-400 Hz

Power Consumption ....100 W at 100 V line

Table 1-6 A Sweep Trigger Characteristics

Coupling	Freq. Range	Minimum Trigger Level Internal Trigger (amplitude)	External Trigger (signal level)
AC	30 Hz - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 75 mV
	50 - 100 MHz	less than 15 mm	less than 0.1 V
	100 - 130 MHz	less than 20 mm	less than 0.15 V
	130 - 150 MHz	—	less than 0.2 V
LF REJ	30 kHz - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 75 mV
	50 - 100 MHz	less than 15 mm	less than 0.1 V
	100 - 130 MHz	less than 20 mm	less than 0.15 V
	130 - 150 MHz	—	less than 0.2 V
HF REJ	30 Hz - 50 kHz	less than 2 mm	less than 50 mV
DC	DC - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 75 mV
	50 - 100 MHz	less than 15 mm	less than 0.1 V
	100 - 130 MHz	less than 20 mm	less than 0.15 V
	130 - 150 MHz	—	less than 0.2 V

NOTE: In the Auto sweep mode, the sweep cannot be triggered by signals with frequencies lower than 50 Hz, even if COUPLING is in the DC position.

g. Environmental Conditions

Temperature Range ....—10° C to +50° C

Relative Humidity Range .... 90% at 40° C

Vibration .... normal operation after instrument subjected to 1000 cycles/minute, 1.5 mm peak amplitude, three planes, for one hour.

Shock ....5 cm drop test, three times for each side, 30° angle.

h. Mechanical

Dimensions
.... 8-1/2 in. (215 mm) wide
.... 12 in. (305 mm) high
.... 17-3/4 in. (450 mm) long

Weight .... 35 lb (16 kg)

Table 1-7 B Sweep Trigger Characteristics

Coupling	Freq. Range	Minimum Trigger Level Internal Trigger (amplitude)	External Trigger (signal level)
AC	30 Hz - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 0.1 V
LF REJ	30 kHz - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 0.1 V
HF REJ	30 Hz - 50 MHz	less than 2 mm	less than 50 mV
DC	DC - 15 MHz	less than 2 mm	less than 50 mV
	15 - 50 MHz	less than 10 mm	less than 0.1 V

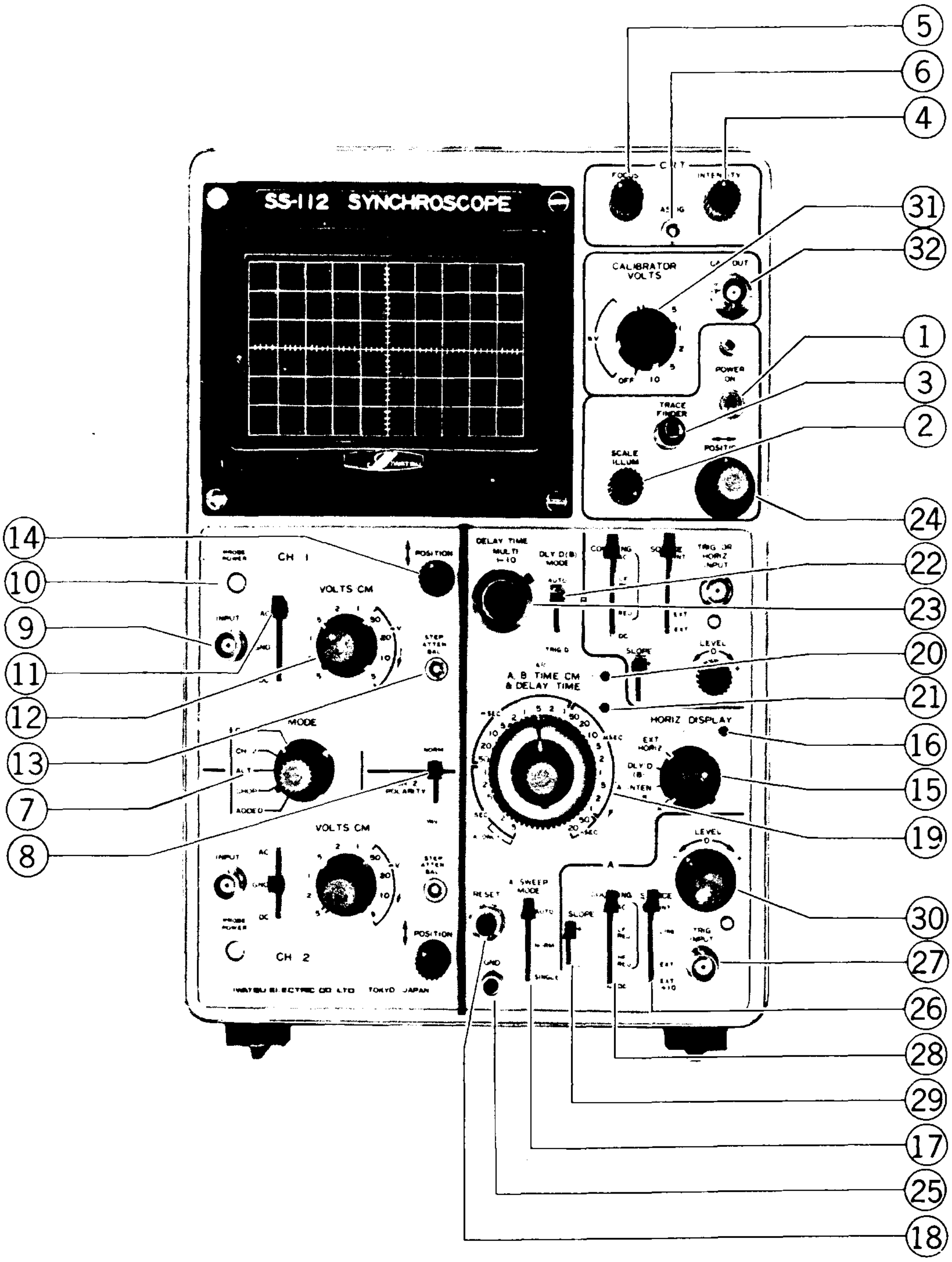
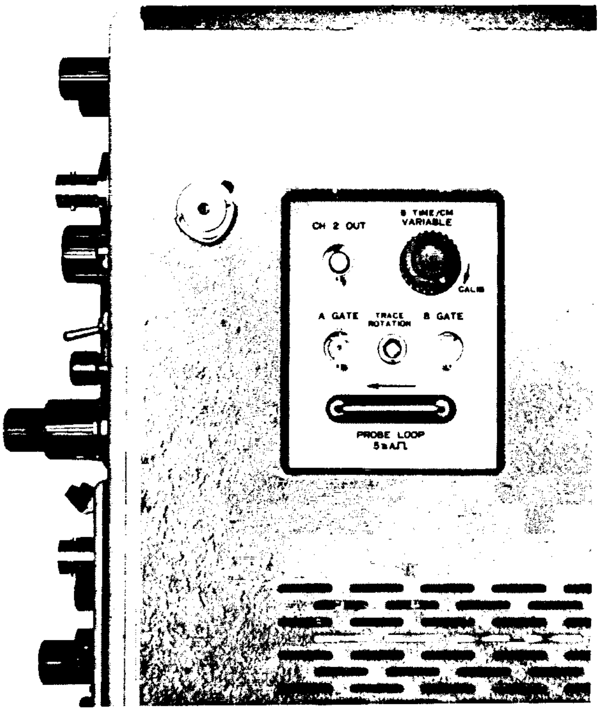
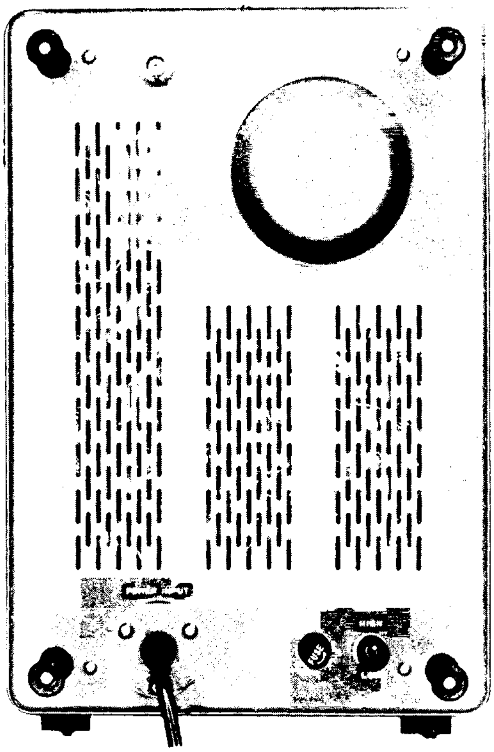
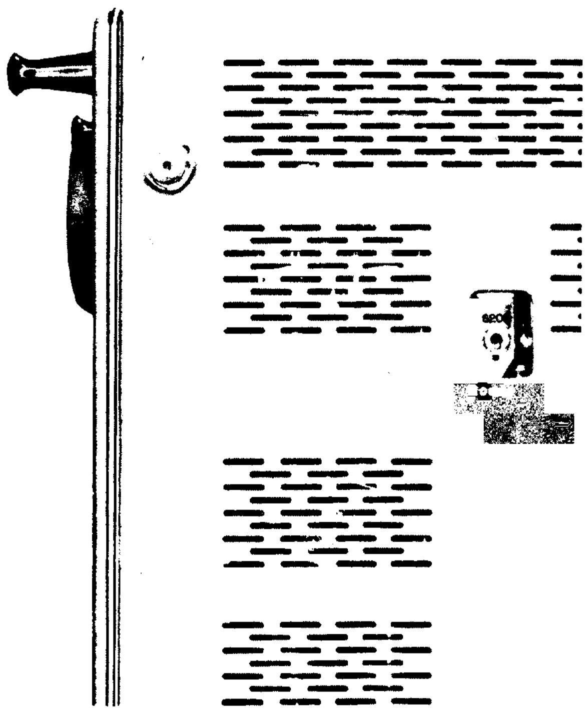


Figure 2-1 Operator Controls and Indicators







LEGEND

1. POWER ON
2. SCALE ILLUM
3. TRACE FINDER
4. INTENSITY
5. FOCUS
6. ASTIG
7. MODE, TRIGGER
8. CH 2 POLARITY
9. INPUT
10. PROBE POWER
11. AC–GND–DC
12. VOLTS/CM, VARIABLE
13. STEP ATTEN BAL
14. POSITION (vertical)
15. MAG
16. Magnified Display Indicator
17. A SWEEP MODE
18. RESET
19. A, B TIME/CM & DELAY TIME
20. UNCALIB (A, B Time/cm)
21. UNCALIB (Delay Time)
22. DLY'D (B) MODE
23. DELAY TIME MULTI
24. POSITION, FINE
25. GND
26. SOURCE
27. TRIG INPUT
28. COUPLING
29. SLOPE
30. LEVEL, HF STAB
31. CALIBRATOR VOLTS
32. CAL OUT

SECTION 2 OPERATING INFORMATION

2-1 GENERAL INFORMATION

This section of the manual describes operating controls and gives operating procedures. Typical measurements are also included.

Names of front-panel controls are shown in capital letters (e.g., DELAY TIME MULTI); the parameters controlled are shown in lower case letters (e.g., delay time).

2-2 PANEL COVER

The panel cover is used to protect the front panel during transit or storage. When in use, take the cover off. When transporting install the panel cover.

2-3 FILTER CHARACTERISTICS and REPLACEMENT

The oscilloscope is supplied with a mesh filter as standard equipment. Polarized filters are available as an accessory. Filter characteristics are listed in Table 2-1. When taking pictures of observed waveforms, remove the filter for better sensitivity. First push down on the bottom of the filter and pull the upper portion outward (See Figure 2-2). Be careful not to damage the mesh filter.

Table 2-1 Filter Characteristics

Polarized Filter	Mesh Filter
Absorbs light reflected from CRT faceplate, but light is reflected from surface of filter. Trace focus is better than mesh filter.	Reduces reflections from surface of CRT faceplate and surface of filter. Because of diffraction, trace focus not as good as polarized filter.

2-4 CONTROLS AND CONNECTORS

Controls and connectors on front panel, side panel and rear panel are described. On concentric controls, black and red knobs correspond to black and red lettering respectively. Refer to Figure 2-1 for location of controls.

a. **POWER.** Power line switch. Power is supplied to instrument when switched to ON position and pilot light glows.

b. **SCALE ILLUM.** Controls brightness of the internal graticule. Clockwise rotation increases brightness.

c. **TRACE FINDER.** This pushbutton switch is used to locate an off-screen trace. Pushing TRACE FINDER reduces the deflection and brings the trace on-screen. To locate a trace, push TRACE FINDER and note the location of the trace. Use the POSITION controls to bring the trace to the center of the screen, keeping the pushbutton depressed. When the button is released, the trace will appear normally.

NOTE

If no trace appears when TRACE FINDER is pushed, increase the setting of the INTENSITY control slightly and the trace should appear.

d. **INTENSITY.** Controls intensity of the trace or spot. Clockwise rotation brightens trace.

e. **FOCUS.** Controls focus of the trace or spot.

f. **ASTIG.** This screwdriver adjustment, together with the FOCUS control, allows adjustment of the trace for best definition. The ASTIG adjustment should be used only when FOCUS will not give required adjustment.

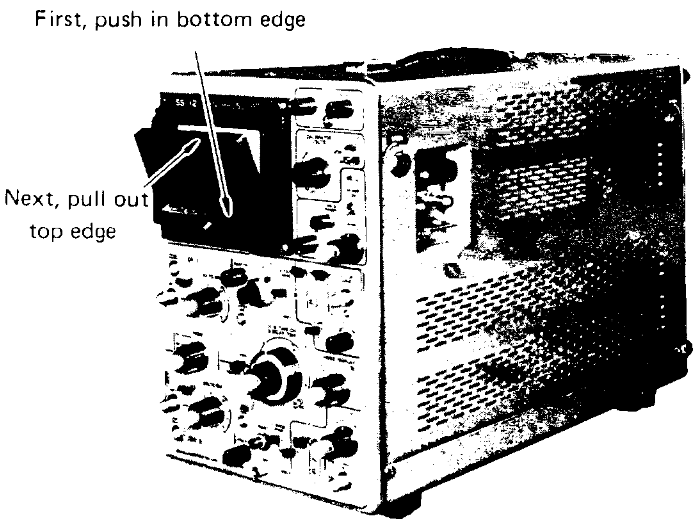


Figure 2-2 Filter Removal

NOTE

Identical controls in each channel have identical functions. Descriptions following are for both channels.

g. **MODE.** Selects the operation of the vertical signal amplifiers.

(1) CH 1: Only the Channel 1 trace appears on the screen.

(2) CH 2: Only the Channel 2 trace appears on the screen.

(3) ALT: Alternate presentation of Channel 1 and Channel 2 traces (switched alternately at end of each horizontal sweep). Simultaneous single sweeps of the two signals cannot be made.

(4) CHOP: Channel 1 and Channel 2 traces are chopped at approximately 1 MHz rate.

(5) ADDED: Simultaneous operation of both amplifiers. Channel 1 and Channel 2 signals are added algebraically.

h. **TRIGGER.** In using internal trigger, when MODE is set to ALT, CHOP or ADDED, triggering signals can be selected as follows. When TRIGGER is set to CH 1, the signal to CH 1 INPUT is used for triggering. When TRIGGER is set to CH 2, the signal to CH 2 INPUT is used for triggering.

When MODE is set to CH 1, the signal to CH 1 INPUT is used for triggering independently of TRIGGER. Similarly, when Mode is set to CH 2, CH 2 signal is used for triggering.

i. **CH 2 POLARITY.** Selects of the polarity of CH 2 signal. In NORM, normal polarity. In INV, inverted polarity.

j. **INPUT.** Input terminal for connection of signal cable or probe. Type BNC connector.

k. **PROBE POWER.** When optional source follower probe is used, this connector provides operating power.

l. **AC-GND-DC.** Selects input signal coupling:
AC:ac coupling; rejects DC component of the input.
DC: direct coupling.
GND: grounds amplifier input (does not ground signal input).
For checking ground (reference) level.

m. **VOLTS/CM.** Selects vertical deflection sensitivity in 10 ranges between 5 mV/cm and 5 V/cm. Indicated values show sensitivity when VARIABLE is set to CALIB (fully clockwise).

n. **VARIABLE.** Decreases sensitivity continuously. Reduces sensitivity to 1/2.3 when the knob is fully counterclockwise. For quantitative measurements, set VARIABLE to CALIB.

o. **STEP ATTEN BAL.** This screwdriver adjustment balances the preamplifier circuit so that no baseline shift occurs when the VOLTS/CM switch is rotated.

p. **POSITION.** Moves trace vertically. Clockwise rotation raises position of trace.

q. **HORIZ DISPLAY.** This control selects four horizontal display modes:

(1) A: For normal waveform observation. Sweep time is determined by A TIME/CM and A VARIABLE. Trigger controls for A sweep mode are located at lower right portion of front panel.

(2) A INTEN BY B: In this mode, the sweep time/cm is set by the A TIME/CM switch. The trace is intensified for the duration of the B sweep time (set by B TIME/CM). This allows precise positioning of the delay time before selecting a delayed sweep presentation (DLY'D (B)).

(3) DLY'D (B): Delayed sweep. Those portions of the trace intensified in A INTEN BY B mode are expanded to the full 10 cm trace.

(4) EXT HORIZ: External sweep (X-Y) operation. In this mode normal sweep is inoperative. Horizontal deflection done by signals connector to either TRIG OR HORIZ INPUT or CHANNEL 2 INPUT.

r. **MAG.** Controls magnification of horizontal sweep. In X1 position, sweep is unmagnified. In X10, position, sweep times are 1/10 of the indiciated value of A, B TIME/CM. When X10 is used, indicator next to MAG will be on.

s. **Expanded Display Indicator.** Shows X10 magnification is selected.

t. **A SWEEP MODE.** Selects A sweep mode:

(1) AUTO: Automatic triggering from 50 Hz to 150 MHz. When trigger signal frequency is less than 50 Hz, or when there is no trigger signal, or when LEVEL setting exceeds trigger amplitude, sweep will free-run.

(2) NORM: Normal trigger. When there is no trigger signal, or when LEVEL setting exceeds trigger amplitude, the sweep stops. Sweep triggers when trigger signal amplitude exceeds LEVEL setting.

(3) SINGLE: One sweep will occur for a trigger signal occurring after the RESET pushbutton/indicator is pushed. No further sweeps will occur until the RESET pushbutton is pushed and another trigger signal is applied.

u. **RESET.** This combined switch/indicator resets the sweep circuit after a single sweep is triggered, and lights to indicate that the sweep circuit is ready for another sweep.

v. **A TIME/CM (DELAY TIME).** Selects sweep time in 26 ranges between 20 ns/cm and 5 sec/cm. This control selects sweep rate for A sweep operation and sets basic delay time for delayed sweep operation. To read sweep time, set A VARIABLE to CALIB (UNCALIB lamp off), and read the value of A TIME/CM. To read delay time, set A VARIABLE to CALIB (UNCALIB lamp off) and read the value of (indicated value of A TIME/CM) times the indicated value of DELAY TIME MULTI. Note that the indicated value of DELAY TIME MULTI is not calibrated when A TIME/CM is between 20 ns and 0.5 μs (UNCALIB lamp on).

w. **B TIME/CM.** Selects 24 ranges between 20 ns/cm and 1 sec/cm. To read sweep time, set B TIME/CM VARIABLE to CALIB and read the value of B TIME/CM.

x. **A VARIABLE.** This control provides continuous adjustment of A sweep time. Full control range gives up to 1/2.5 of the indicated values of each range in A TIME/CM. Counterclockwise rotation gives slower sweep time or longer delay. For quantitative measurements use CALIB position.

y. UNCALIB. Display lamps indicate uncalibrated sweep. Lamp (20, Figure 2-1) is on when:

(1) HORIZ DISPLAY is A or A INTEN BY B and A VARIABLE is not in CALIB.

(2) HORIZ DISPLAY is DLY'D (B) and B TIME/CM VARIABLE is not in CALIB.

Lamp (21, Figure 2-1) is on when:

1. HORIZ DISPLAY is A INTEN BY BY or DLY'D (b) and A TIME/CM is 20 ns - 0.5 μs.

2. HORIZ DISPLAY is A INTEN BY B or DLY'D (B) and A VARIABLE is not in CALIB position.

z. DLY'D (B) MODE. When HORIZ DISPLAY is in INTEN BY B or DLY'D (B), this control selects delayed sweep mode.

(1) AUTO. Delayed sweep with free-running trace.

(2) TRIG'D. Triggered delayed sweep.

aa. DELAY TIME MULTI. Provides continuously variable delay time.

ab. POSITION. Controls horizontal position of the trace. Clockwise rotation moves the trace to the right.

ac. FINE. Provides precise horizontal position control. It is especially useful when X10 magnification is used.

ad. GND. Chassis ground connection.

ae. SOURCE. SOURCE switch in B sweep can also be used to select external sweep signals.

(1) INT. (Internal Trigger:) The signal connected to Channel 1 or Channel 2 INPUT is used for triggering.

(2) LINE: Power line frequency triggering.

(3) EXT. (External Triggering): Connect the trigger signal to TRIG INPUT (for B, TRIG OR HORIZ INPUT). For external sweep, use this position.

(4) EXT ÷ 10: Attenuates the external triggering signal or external sweep signal (gain - 1/10).

af. TRIG INPUT (Trigger Input): Connector B TRIG OR HORIZ INPUT can also be used for external sweep signal. Input impedance is 1 megohm with less than 25 pF in parallel. Maximum input signal is 100 V p-p.

ag. COUPLING. Selects coupling of trigger signal. COUPLING in B can also be used for external sweep signals, but normally LF REJ, and HF REJ are not used for this purpose.

(1) AC: Selects coupling. Blocks dc and attenuates signal components below 30 Hz.

(2) LF REJ: High-pass filter coupling. Attenuates signal components lower than 30 kHz.

(3) HF REF: Low-pass filter coupling. Attenuates signal components higher than 50 kHz.

(4) DC: Direct coupling.

ah. SLOPE. Selects positive or negative slope of signal for triggering.

ai. LEVEL. Selects signal level at which triggering occurs.

aj. HF STAB. Decreases display jitter for signals above 10 MHz.

ak. CALIBRATOR VOLTS. Selects peak-to-peak amplitude of square wave output at CAL OUT connector. Calibrated in 11 ranges from 5 mV and 10 V. No output in OFF position.

al. CAL OUT CONNECTOR. Output impedance is 50 ohms when calibrator volts is in six lowest ranges (marked in red on front panel). The output impedance in the other ranges is approximately 500 ohms.

am. BANDWIDTH. Selects full or 10 MHz range. It erase noise components and present more clear trace by switching to "10 MHz range".

an. CH 2 OUT. Amplified Channel 2 signal (X5 gain). Output impedance, 50 ohms.

ao. B TIME/CM VARIABLE. This control provides continuous adjustment of B sweep time. Full control range gives up to 1/2.5 of the indicated value of each range in B TIME/CM. Counterclockwise rotation gives slower sweep time. For quantitative measurements, use CALIB position.

ap. A GATE. Square wave (5 V p-p) output synchronized to A sweep. Output impedance 1500 ohms.

aq. TRACE ROTATION. Screwdriver adjustment rotates trace for alignment to horizontal graticule lines.

ar. B GATE. Square wave (5 V p-p) output synchronized to B sweep. Output impedance 1500 ohms.

as. PROBE LOOP. Square wave current (1 kHz, 5 mA) flows in the loop, with conventional current flow indicated by the arrow. For calibrating current probe.

at. POWER INPUT. Recessed connector for primary ac power.

au. LINE VOLTAGE RANGE. Selects line voltage range:

(1) LOW, 100 V ±10%

(2) HIGH, 115 V ± 10%

The instrument can also be converted for 200 V ±10% or 230 V ±10% use. In this case, LOW is 200 V ±10%, and HIGH is 230 ±20%.

av. 2A SLOW. Primary power fuse, 2A slow-blow for

100 V and 115 V operation.

aw. Z AXIS INPUT. Input connector for external intensity modulation. Input impedance, 47 kilohms maximum input, 200 V p-p.

2-5 OPERATING PRECAUTIONS

Before operating the SS-112, observe the following precautions:

a. Check the LINE VOLTAGE switch. Use the correct setting.

b. Check the operating temperature. The ambient temperature must be between -10°C and +50°C.

c. Check the input signal voltage. It must not exceed the limits as listed in Table 1-2. For the measurement of high voltage, resistive or capacitive voltage dividers must be used.

d. Check the trace. It must not be left as an intensified spot or off the screen.

e. Output connectors A GATE, B GATE, and CH 2 OUT must never be grounded.

2-6 PRELIMINARY PROCEDURES

The following procedure should be used when the instrument is turned on for the first time. Set controls as follows:

INTENSITY	centered
MODE	CH 1
CH 2 POLARITY	NORM
AC-GND-DC	GND
POSITION	centered
HORIZ DISPLAY	A
MAG	X1
A SWEEP MODE	NORM
HORIZONTAL POSITION	centered
POWER	ON

Wait about 15 seconds, and then rotate INTENSITY clockwise to produce a spot on the CRT. Adjustment of the horizontal position controls may also be required.

a. Focusing. Use FOCUS to produce the sharpest spot on the CRT. Use ASTIG in conjunction with FOCUS if FOCUS alone will not produce a well-defined spot.

b. Sweep Triggering. Set A SWEEP MODE to AUTO.

NOTE

When LEVEL is set near midrange, triggering may be unstable (this is not a disorder). In this case set LEVEL a little to the right or left. Reduce intensity to a moderate level. Turn horizontal POSITION counterclockwise and adjust the starting point of the sweep to the first vertical graticule line.

c. Connecting an Input. By connecting the calibrator signal, we can obtain a waveform on the screen. Set controls as follows:

VOLTS/CM (CH 1)	0.2
VARIABLE (CH 1)	CALIB position
CALIBRATOR VOLTS	0.5
AC-GND-DC	DC
A TIME/CM	2 ms

A square wave with an amplitude of 2.5 cm should appear on the screen. The amplitude of the signal on the screen can be varied using VOLTS/CM and VARIABLE.

d. Trigger Mode Selection. Before selecting a trigger mode, the following items must be considered:

(1) Trigger Source; internal trigger (INT), external trigger (EXT, EXT - 10), line trigger (LINE).

(2) Trigger signal coupling; AC, LF REJ, HF REJ or DC.

(3) Trigger slope; positive or negative.

As an example, consider the case where external trigger and AC coupling, positive slope triggering, are required. In this case, the trigger controls should be set as follows:

SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+

2-7 TRIGGER CONTROLS

Selection of trigger signal source, signal coupling, and trigger slope depends on the particular application and the trigger signal available. The following paragraphs describe typical uses of the trigger controls.

a. Trigger Source.

(1) INT: In this position, the trigger signal is taken from the waveform under observation, either channel. For most applications, this mode is suitable. The TRIGGER switch associated with the vertical input channels selects whether the trigger signal is from Channel 1 or Channel 2.

(2) LINE: In this position, the power-line frequency is used to trigger the sweep. This mode is suitable for observation of waveforms related to a harmonic or subharmonic of the line frequency (e.g., power supply ripple).

(3) EXT: This position selects an external signal for sweep triggering. The external signal must be related to the waveform under observation in such a way that the time delay between the two waveforms is within the capability of the oscilloscope. This mode is useful for observing signals within a circuit where the amplitude, polarity, and delay changes from one stage to the next. The use of an external trigger signal will produce a stable display without the need to adjust trigger controls.

(4) EXT ÷ 10: This position is the same as EXT, except that the external trigger signal is attenuated by 10:1. This mode is useful when a high-amplitude trigger signal is used.

b. Trigger Signal Coupling.

(1) AC: In this position, the dc component of the trigger signal (internal or external) is blocked, and the components of the signal below approximately 30 Hz are attenuated. This coupling mode is useful if offset voltages are superimposed on the trigger signal or if low-frequency noise is present.

(2) LF REJ: In this position, the components of the trigger signal below approximately 30 kHz are attenuated. This coupling mode is useful for observing waveforms which have low frequency modulation or noise superimposed. The signal is capacitively-coupled, and dc levels will also be blocked.

(3) HF REJ: Components of the trigger signal above 50 kHz are rejected in this position. DC levels are also rejected, and signals below 30 Hz are attenuated. This mode is useful when the trigger signal has high frequency noise superimposed.

(4) DC: This trigger coupling mode provides direct coupling of the trigger signal. Observation of low frequency signals or signals with low repetition frequencies is possible only in this mode.

c. **Trigger Level and Trigger Slope Selection.** The point at which the trigger circuits will start the sweep is selected by the combination of trigger slope and trigger level controls. When the waveform under observation is used as the trigger source (internal trigger mode) it will be a fairly simple matter to choose the trigger point by observing the waveform on the screen. When an external trigger is used, the slope and level selection must be made with the polarity and amplitude of the trigger signal kept in mind. For example, the trigger output of most pulse generators is usually fixed in polarity and amplitude and bears no relationship to the output pulse in terms of polarity, width, risetime, and amplitude. If the external trigger signal amplitude is large, it may be advantageous to use the EXT ÷ 10 position of the trigger SOURCE switch to give the trigger LEVEL control a wider range of control.

(1) Trigger Level The LEVEL control determines the trigger signal amplitude which will trigger the sweep. When the LEVEL control is set to a point in the + portion of the range, the sweep will be triggered at a more positive point on the trigger signal. When set in the - portion of the range, the sweep will trigger on a more negative point (see Figure 2-3).

(2) Trigger Slope: The SLOPE switch selects either the positive-going (+ setting) or negative-going (- setting) portion of the trigger signal for triggering the sweep. The signal polarity or dc offset level does not affect the trigger point; only the slope of the signal affects the point.

(3) HF Stability: When signals above 10 MHz are observed, the HF STAB control is used to eliminate horizontal jitter. If the display cannot be stabilized using LEVEL, adjust HF STAB for minimum jitter.

d. **Automatic Triggering.** In the automatic triggering mode, the sweep will free-run at approximately a 50 Hz rate when no trigger signal is present or the trigger input frequency is below approximately 50 Hz. This mode is useful when it is desired to check dc levels while also observing waveforms, since a baseline will appear even in the absence of a signal.

e. **Normal Triggering.** This trigger mode may be used when the trigger signal frequency is below 50 Hz. When no trigger signal is present (either external or internal), the sweep will not be triggered and no trace will be present.

f. **Single Sweep.** This mode may be used for photographing single events or events at low sweep speeds. The sweep is locked out until the RESET pushbutton/indicator is pushed and is lighted. The next trigger signal after the sweep is reset will trigger the sweep and cause a single trace. No further sweeps will occur until the sweep is again reset by the pushbutton.

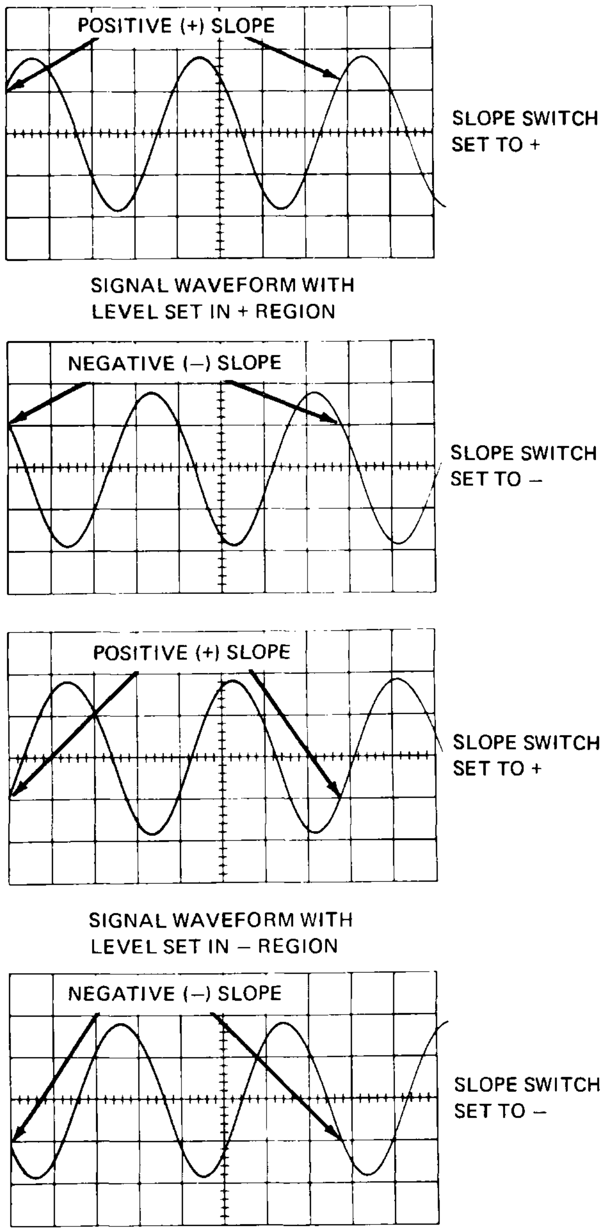


Figure 2-3 Trigger Slope and Level Selection

2-8 MEASUREMENT OF ALGEBRAIC SUM OF TWO SIGNALS

Algebraic addition of two signals can be useful for rejecting common-mode signals, or for minimizing a dc offset in one channel by applying an offset in the opposite polarity in the other channel.

Connect signals to Channel 1 and Channel 2 INPUT connectors. Set MODE to ALT or CHOP. Adjust triggering to obtain a stable display.

Adjust Channel 1 and Channel 2 POSITION controls to place each signal in the center of the screen. Set MODE to ADDED; the display will be the algebraic sum of the two waveforms. If required, set CH 2 POLARITY switch to the INV position; this will provide a display of the difference of the two waveforms.

2-9 CASCADED OPERATION

To obtain higher sensitivity than normal, the output of Channel 2 can be connected to the input of Channel 1, giving an effective gain of five and lowering the sensitivity to 1 mV/cm. In this mode of operation, normal internal or external triggering can be used. Set the VOLTS/CM switches of both channels to the 5 mV position.

2-10 SWEEP MAGNIFICATION

The sweep can be expanded using the X10 MAG position of the HORIZ DISPLAY switch. When used in this mode, the trace is effectively 100 cm long, and the sweep speed is 1/10 of the value indicated on the A,B TIME/CM switch. This mode is useful for observing portions of the waveform which are displaced from the sweep start and not visible on a faster sweep range. The magnifier may also be used to increase the 20 ns/cm sweep range to an effective 2 ns/cm sweep range.

2-11 DELAYED SWEEP

This mode of operation uses the A sweep as a delay generator to delay the start of the sweep to some desired point in time with respect to the start of the normal sweep. The B sweep then determines the sweep speed of delayed display. The following paragraphs discuss the use of two delayed sweep modes: triggered and automatic.

a. Automatic Delayed Sweep. To demonstrate the use of auto delayed sweep, set controls as follows:

MODE	CH 1
VOLTS/CM (Channel 1)	0.5
VARIABLE (Channel 1)	CALIB
CALIBRATOR VOLTS	0.5
HORIZ DISPLAY	A
A SWEEP MODE	AUTO or NORM
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC
DLY'D (B) MODE	AUTO
SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+

Connect calibrator output and Channel 1 input. Adjust LEVEL (A) to obtain a stable trace. Set HORIZ DISPLAY to A INTEN BY B. An intensified zone will appear on the trace. By rotating DELAY TIME MULTI, the intensified portion of the trace can be moved to any part of the calibrator waveform. This intensified zone represents the portion of the waveform which will be displayed in the expanded, delayed sweep. The A TIME/CM switch controls the basic delay increment. The DELAY TIME MULTI provides a multiplier for the basic delay to give the total delay. For example, in this demonstration of automatic delayed sweep, the basic delay is 1 millisecond. The multiplier allows the total delay to be varied from approximately 0.5 msec to 10 msec in this example. The position of the intensified zone is determined by the setting of the A TIME/CM control and the multiplier. The length of the intensified zone is determined by the setting of the B TIME/CM control.

Position the intensified zone so that it includes one of the waveforms near the right-hand edge of the screen. Now switch HORIZ DISPLAY to DLY'D (B). The selected waveform will appear, at a sweep speed of 0.1 msec/cm. By changing the setting of the DELAY TIME MULTI control, any portion of the waveform can be observed.

By setting B TIME/CM to a faster sweep speed, the calibrator waveform jitter can be observed (some refinement of the multiplier setting may be necessary to keep the leading or trailing edge on the screen).

b. Triggered Delayed Sweep. To demonstrate triggered sweep, set controls as follows (all controls not mentioned should be left in the positions specified in the auto trigger demonstration):

HORIZ DISPLAY	A
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC
DLY'D (B) MODE	TRIG'D
SOURCE (B)	INT
COUPLING (B)	AC
SLOPE (B)	+
DELAY TIME MULTI	5.00
LEVEL (B)	centered

Switch HORIZ DISPLAY to A INTEN BY B and adjust LEVEL (B) until the intensified zone appears on the trace. By rotating the multiplier control, the zone can be moved from the leading edge of one waveform to the leading edge of the next. Because the sweep is triggered, continuous control of delay is not possible. Switch HORIZ DISPLAY to DLY'D (B). The portion of the waveform intensified previously will now be displayed at the sweep time set by B TIME/CM. If B TIME/CM is set to faster sweep rates, it will be noted that the jitter seen in the auto delay mode is not present. Because the delayed sweep is triggered by the delayed waveform, no jitter will be seen.

2-12 SINGLE SWEEP OPERATION

To demonstrate single sweep operation, the following example uses the calibrator signal connected to the Channel 1 input. Set controls as follows:

HORIZ DISPLAY	A
A SWEEP MODE	NORM
CALIBRATOR VOLTS	0.5
VOLTS/CM (A)	0.2
A TIME/CM	1 mSEC
SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+

Adjust LEVEL (A) to obtain a stable display. Disconnect the calibrator signal from the Channel 1 input. Set A SWEEP MODE to SINGLE and push RESET. The indicator will come on. Reconnect the calibrator signal. A single sweep will occur and the RESET indicator will go out. The single sweep mode can be used with either internal or external triggers, and with all input modes. It should be noted that in alternate sweep mode, each trigger will result in one sweep for one channel, i.e., two triggers are required for a dual-trace presentation.

2-13 X-Y OPERATION

The SS-112 can be used as an X-Y oscilloscope for measuring phase shift, frequency ratio, etc. To demonstrate this capability, set controls as follows:

CALIBRATOR VOLTS 0.5
VOLTS/CM (Channel 1) 0.2
MODE .... CH 1
SOURCE (B) .... EXT
COUPLING (B) .... AC or DC

Connect calibrator output through a BNC T connector to both Channel 1 INPUT and TRIG OR HORIZ INPUT connectors. Two spots will appear on the screen (some adjustment of vertical and horizontal POSITION controls may be necessary to bring the spots into the center of the screen. In X-Y operation, the horizontal input has a sensitivity of approximately 0.2 V/cm with the SOURCE (B) switch in the EXT position and 2 V/cm in the EXT ÷ 10 position.

2-14 SIGNAL CONNECTIONS

Connections may be made to the SS-112 either directly by means of coaxial cable, or with the 10:1 attenuator probe supplied. The input of each vertical channel is 1 megohm in parallel with 13 pF, and may be increased to 10 megohms in parallel with 10 pF by using the probe. To preserve the bandwidth capability of the vertical deflection system, either high-quality coaxial cable or the probe should be used for signal connection.

Before the probe is used for waveform measurement, the compensation should be checked. Set controls as follows:

CALIBRATOR VOLTS 5
VOLTS/CM (Channel 1) 0.2
SOURCE (A) .... INT
COUPLING (A) .... DC
SLOPE (A) .... +

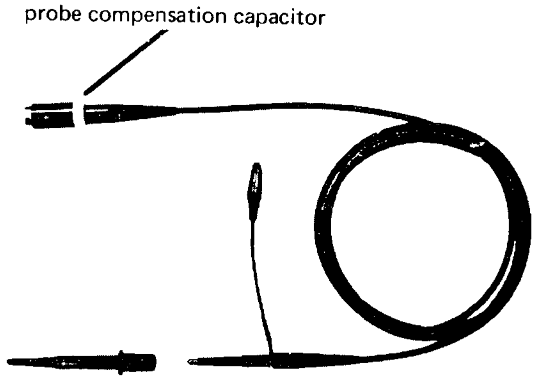


Figure 2-4 Probe Compensation Adjustment Location

Connect probe to Channel 1 input and touch probe tip to CAL OUT center conductor. Adjust LEVEL (A) for stable trace. Adjust the variable capacitor in the probe connector body (see Figure 2-4) for a correctly compensated square wave (see Figure 2-5).

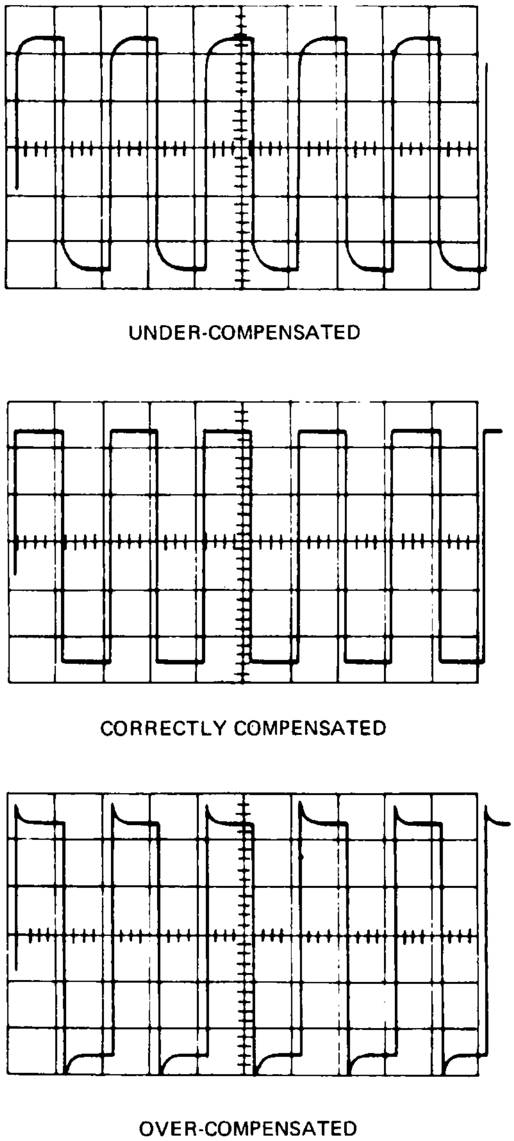


Figure 2-5 Probe Compensation Adjustment Waveforms

When fast pulses are to observed, proper grounding of the probe must be observed to avoid distortion of the displayed waveform. For best results, avoid grounding the probe with the ground lead. Instead, use the bayonet adapter, and find a ground point near the point of observation.

A 350 MHz bandwidth FET probe is available to give 1 megohm input impedance with less than 7.5 pF parallel capacitance. This unit, the SFP-1 Source Follower Probe, mounts on the side of the oscilloscope cabinet and receives operating power from the PROBE POWER connectors adjacent to each channel INPUT connector. A complete description of this unit is included in the instruction manual for the SFP-1.

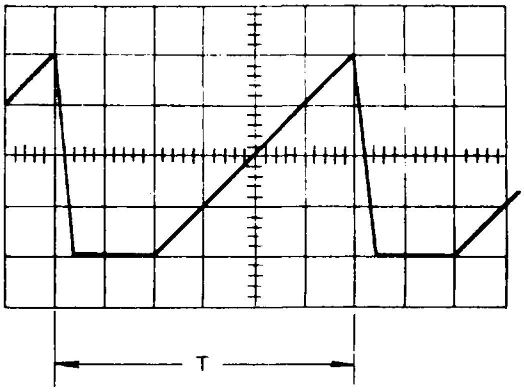


Figure 2-6 Time Interval Measurement

2-15 TYPICAL MEASUREMENTS

The following paragraphs outline typical operating procedures for making measurements with the SS-112.

a. **Voltage Measurement.** The peak-to-peak amplitude of a waveform can be determined quantitively by setting the VARIABLE control to the CALIB position and noting the amplitude of the waveform in screen divisions. The peak-to-peak amplitude is the product of the deflection in centimeters and the setting of the VOLTS/CM control.

If deflection factors not corresponding to those available with the VOLTS/CM control are required, the voltage calibrator and the VARIABLE control may be used in combination to give any required deflection factor. For example, a calibrated sensitivity of 0.25 V/cm may be obtained by setting the CALIBRATOR VOLTS control to 0.5, the VOLTS/CM control to 0.1, and using the VARIABLE control to make the deflection of the calibrator waveform exactly 2 cm.

Before any quantitative measurements are made, the accuracy of the VOLTS/CM control should be verified by connecting the calibrator output to the input of the channel to be used. Set the VOLTS/CM control to the range of interest, and check calibration with a calibrator output giving at least 2 cm deflection.

Measurements of dc levels may be made in the same way as waveform measurements. After verifying the calibration of the VOLTS/CM range, set controls as follows:

VOLTS/CM	as required
VARIABLE	CALIB
Input Coupling Switch	GND
A SWEEP MODE	AUTO

Adjust the vertical POSITION control to place the trace on a convenient graticule line. If the polarity of the dc voltage is known, the trace may be placed at the top or bottom of the screen as required. After the trace is lined with the graticule, set the Input Coupling Switch to DC and connect the signal. The dc voltage is the product of the trace deflection in centimeters and the sensitivity in volts/cm. Offset voltages or other superimposed levels may be measured in the same way by setting the input coupling to GND (the signal input is not grounded in this position, only the vertical amplifier input) and establishing a reference on the graticule. When the input coupling is set to DC, the superimposed level can be measured from the reference line to the center of the ac waveform (sine waves only; pulse waveforms may not conform to this rule).

b. **Current Measurement.** Current waveforms are most easily measured with the Iwatsu CP-502 Current Probe. This clip-on unit allows observation of current waveforms without disturbing the circuit under test. If the current probe is not available a series resistor may be substituted. For best results using a series resistor, connect the Channel 1 input to one side of the resistor, and the Channel 2 input to the other side. Set both VOLTS/CM switches to the same range, and CH 2 POLARITY to INV. With the MODE switch in ADDED, the waveform on the screen will be proportional to the net current through the resistor.

c. **Time Measurement.** Time interval, time difference, risetime, or falltime can be measured directly from the graticule calibration. The following paragraphs describe typical time measurements.

(1) Time Interval. Display the waveform on the screen with the interval to be measured within the graticule limits. With the coarse and fine horizontal position controls, place the initial point at one of the vertical graticule lines (see Figure 2-6). Measure the horizontal distance to the second point. The time interval T is the product of the horizontal distance in centimeters and the setting of the A TIME/CM switch, taking into account the effect of the sweep magnifier if used.

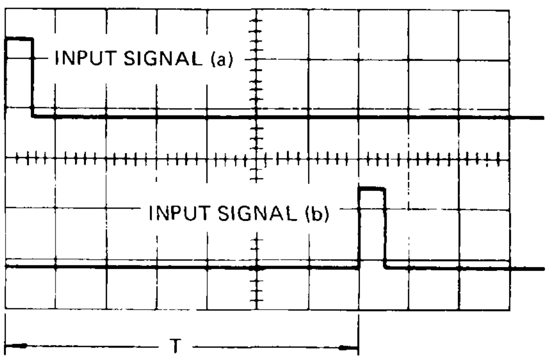


Figure 2-7 Time Difference Measurement

(2) Time Difference. The time difference between two signals may be measured in several ways. Using alternate sweep or chopped mode, and internal triggering, the TRIGGER switch should be set to the channel which has the initially occurring waveform. Use the position controls to place the first waveform at one of the vertical graticule lines (see Figure 2-7). The time difference is the product of the horizontal distance between the two points and the sweep time/cm setting. The ADDED position of the MODE switch may also be used to produce a single trace if this is advantageous.

(3) Risetime Measurement. Measurement of rise or fall times in pulse waveforms is identical to the time interval measurement previously described if the risetime is greater than five times the oscilloscope risetime (3.5 ns). For a 5:1 ratio of actual pulse risetime to oscilloscope risetime, the error is approximately 2% and generally can be neglected. For faster risetimes (smaller ratio) the error becomes large

(approximately 40% for a 1:1 ratio) and cannot be neglected. If risetimes substantially faster than 7 ns are to be measured, a sampling oscilloscope such as the Iwatsu SAS-5009B should be used. For ease in measuring 10-90% rise or fall times, the following is suggested.

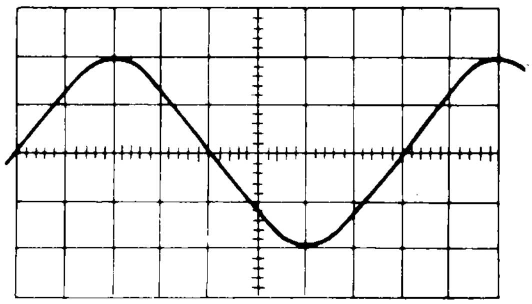
Set VOLTS/CM so that peak-to-peak pulse amplitude is greater than 5 cm. Use VARIABLE to adjust amplitude of display to exactly 5 cm. Adjust vertical POSITION controls so that top and bottom of waveform are 0.5 cm above and below the 2nd and 6th graticule lines. Set A TIME/CM to a range which displays the rise and fall time over as large a portion of the screen as possible. Use the horizontal POSITION control to place the 10% point (it occurs at the 1st horizontal graticule line for rise and 4th line for fall) at the 2nd vertical graticule line. The rise or fall time is the product of the distance between the 10% and 90% points and the sweep time (taking into account the X10 magnifier if used).

d. Frequency Measurement. The frequency of a periodic waveform can be determined with reasonable accuracy by using the following method.

(1) Display the waveform using either internal or external trigger. Adjust VOLTS/CM and VARIABLE controls to give a waveform amplitude of 4 cm.

(2) Using vertical POSITION control, center the waveform about the center horizontal graticule line.

(3) Using horizontal POSITION and FINE controls, place the point at which the waveform crosses the center horizontal graticule line on the first or second vertical graticule line (see Figure 2-8).



TIME/CM: 1 μsec/cm

VARIABLE: CALIB position

Figure 2-8 Frequency Measurement

(4) Measure the horizontal distance between the first and third crossings of the center graticule line: this represents the period of the waveform. Determine the period by multiplying the horizontal distance in centimeters by the sweep time/cm.

(5) Find the reciprocal of the period (in seconds): this is the frequency (in Hz). For example, a waveform with a period of 2.5 μs (2.5×10^{-6} seconds) has a frequency of $1/2.5 \times 10^6$ Hz (400 kHz).

The frequency ratio of two signals can be found by using a

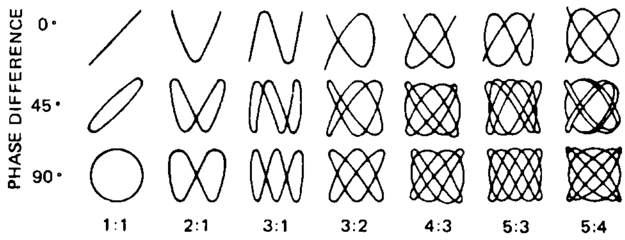


Figure 2-9 Lissajous Figures for Various Frequency Ratios

Lissajous pattern as shown in Figure 2-9. Connect input signals as described in the paragraph concerning X-Y operation. This method of ratio determination is useful for frequencies below 100 kHz.

Another method of determining frequency is to set up the waveform so that from 30 to 50 waveform cycles appear in the 10 cm graticule area. Count the number of cycles and divide by ten times the A TIME/CM setting. This figure is the repetition frequency in Hz.

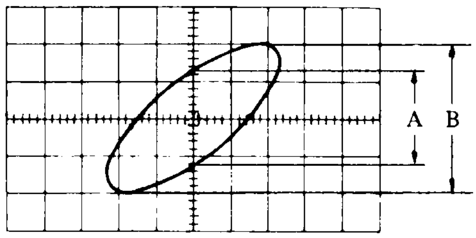


Figure 2-10 Phase Measurement With Lissajous Figures

e. Phase Measurement. For two equal-frequency signals less than 100 kHz, a Lissajous figure may be used to obtain a measurement of phase difference. Referring to Figure 2-10, measure distances "A" and "B" on the waveform. The phase difference Θ (in degrees) is given by:

$$\Theta = \arcsin A/B$$

Another method of determining phase difference is to connect signals to the Channel 1 and Channel 2 inputs and display the two signals in either chopped or alternate mode. Use the VARIABLE control on the A TIME/CM switch to make the period exactly 9 cm (see Figure 2-11). The phase difference may now be computed by finding the time difference T and multiplying the difference in cm by 40°.

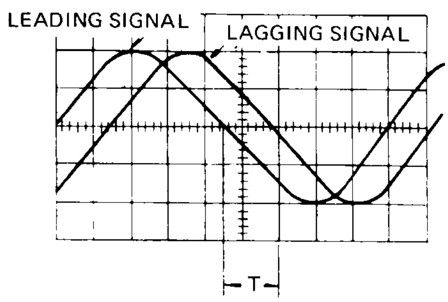


Figure 2-11 Phase Measurement, Equal-Frequency Signals

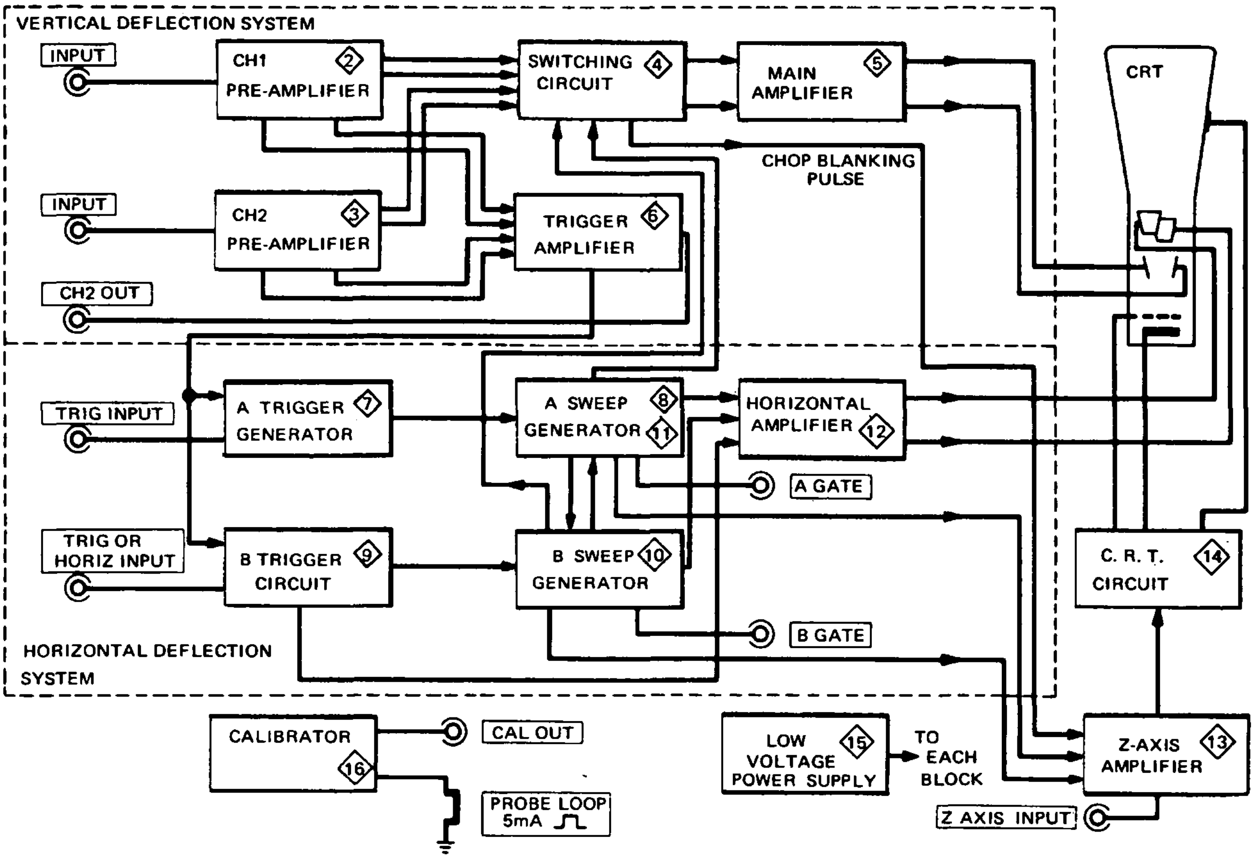


Figure 3-1 Overall Block Diagram

SECTION 3
THEORY OF OPERATION

3-1 GENERAL INFORMATION

This section describes operating principles of circuit blocks in the SS-112.

3-2 OVERALL FUNCTIONAL DESCRIPTION

The preamplifier section consists of two independent preamplifiers for Channel 1, and Channel 2, a diode gate, and a delay line driver. The input signal is connected to the INPUT connector, converted into a balanced signal and amplified and fed to the diode gate. By opening or closing this diode gate with the signal from the switching circuit, either or both balanced signals from Channel 1 and/or Channel 2 are fed to the Main Vertical Amplifier through the delay line driver. The MODE switch selects either Channel 1 or Channel 2 alone, the two signals electronically switched (ALT or CHOP), or the algebraic sum (ADDED) or difference of the two signals. In the ALT position of the MODE switch, the switching circuit is driven by a trigger signal from the Sweep Generator and the diode gate is switched by the output signal from the Switching Circuit, resulting in an alternating display of the Channel 1 and Channel 2 signals as complete sweeps. In the CHOP mode, the switching circuit oscillates on a free-running basis at a repetition rate of approximately 1 MHz which switches the diode gate (opens or closes) causing the output signals from the two channels to be alternately displayed at a repetition rate of approximately 1 MHz regardless of the sweep time. In this mode, to blank the transients of the switching action the switching waveform (chopped blanking pulse) is supplied to the blanking amplifier.

The Main Vertical Amplifier amplifies the balanced signal to a level sufficient to deflect the electron beam of the CRT.

The signal fed to the INPUT connector is also internally fed to the Trigger Amplifier where it is amplified and fed to the A and B Trigger Generators. The signal fed to the CH2 INPUT is amplified by 5 and supplied to the CH2 OUT connector.

The A and B Trigger Generators convert the trigger signal into a trigger pulse having a constant amplitude and width. The trigger pulse may also be generated by an external trigger signal or line frequency signal supplied to the TRIG INPUT (TRIG OR HORIZONTAL INPUT) connector. The A Sweep Generator is triggered by the A Trigger Generator, and the B Sweep Generator by the B Trigger Generator. The A and B Sweep Generators are interconnected for delayed sweep operation. Three types of interconnection are provided; the connection for delayed sweep, the connection to control the width of the intensified part of the display in the A INTEN BY B mode, and the connection to intensify the display in delayed sweep operation. In addition, the gate signal from the B sweep generator is fed to the unblanking mixer of the A Sweep Generator, from which either the A or B unblanking signal or the mixed unblanking signals (when the HORIZ DISPLAY switch is set at A INTEN BY B) are supplied to the unblanking amplifier. Also, gate signals are produced and fed to the A GATE and B GATE connectors, respectively.

Two methods of operation are provided for XY function. In either case, the Y axis input signal is fed to the Channel 1 input and eventually to the vertical deflection plates. The X axis signal may be fed to CH2 INPUT or to the TRIG OR HORIZ INPUT. In the first method, the input signal is fed to the horizontal deflection plates through the Channel 2 Preamplifier, Trigger Amplifier, a part of the B Trigger Generator, and the Horizontal Amplifier. In the latter method, the input signal is fed to the horizontal deflection plates through a part of the B Trigger Generator and the Horizontal Amplifier. A Lissajous pattern is then formed by the X and Y signals.

The unblanking circuit amplifies the unblanking pulses from the A and B Sweep Generators and the external intensity modulation input signal from the Z AXIS INPUT connector. The amplified signals are fed to the grid of the CRT to control the intensity.

The blanking amplifier amplifies a chopped blanking pulse and blanks the transient produced in CHOP mode operation.

The CRT Circuit produces the high voltage required to emit and accelerate the electron beam.

The 6.3 Vac used for the CRT filaments and graticule illumination lamps, and the low DC voltages required for the operation of circuits are obtained from the Low Voltage Power supply.

The Calibrator produces the calibration voltage used for the calibration of internal circuit and the voltage probe, as well as the calibration current for the current probe.

3-3 CIRCUIT DESCRIPTION

a. **General.** The following discussion makes reference to the schematic diagrams in Section 6. These diagrams are also referenced in the overall block diagram, Figure 3-1.

b. **Vertical Input and Attenuator.** (Schematic 1). The vertical signal input is connected through the INPUT connector to the input coupling switch. In AC position, the signal is coupled through C26 to the attenuator. In DC position, the signal is direct-coupled. In GND position, the attenuator input is grounded and the signal input is not connected.

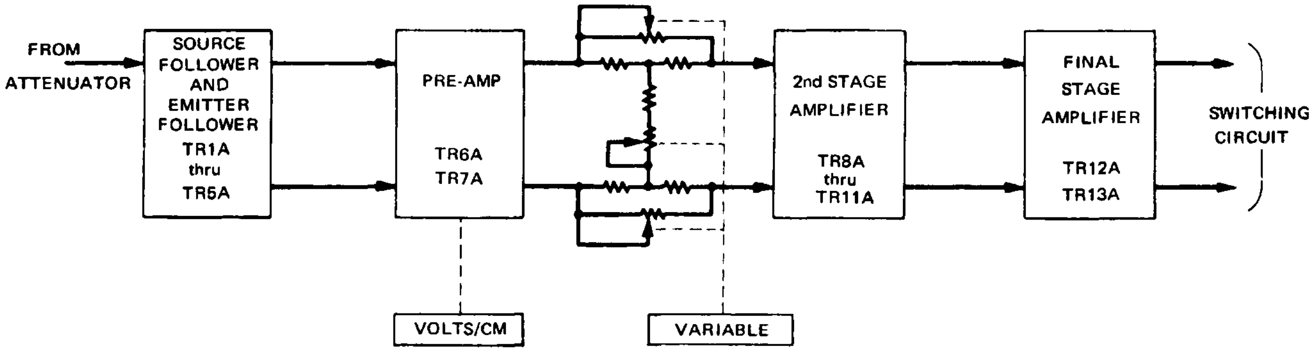


Figure 3-2 Channel 1 Preamplifier Block Diagram

The input attenuator consists of VOLTS/CM switch S2 and eight frequency-compensated attenuator networks. On the 5 mV/cm range, the signal is unattenuated, and the gain of the vertical preamplifier is increased by changing the emitter resistance of TR6/TR7 (S2 section E switches in a parallel resistance network). On the 10 mV/cm range, the input is also unattenuated, but the resistance network in the TR6/TR7 emitter circuit is switched out and the gain of the preamplifier is reduced by a factor of two. On the 20 mV/cm and higher ranges, compensated attenuator networks are switched to provide the required attenuation ratio.

c. **Channel 1 Preamplifier** (Schematic 2). The preamplifier input circuit consists of a FET source follower stage (TR1A) driving emitter follower TR3A. The input to TR1A is protected by TR2A, which is diode-connected and clamps signals which could damage the input stage. Screwdriver adjustments R39A and R42A provide dc balance control for the differential amplifier stages to avoid trace shift when the VOLTS/CM control is switched from the 5 mV/cm position to the 10 mV/cm position. Figure 3-2 is a block diagram of this circuit.

The single-ended input is converted to a balanced signal by differential amplifier stages TR6A and TR7A. The resistive network between the emitters of these stages provides gain control and gain adjustment of the 5 mV/cm range. The output from the collectors of TR6A/TR7A is connected to the second amplifier stages through VARIABLE control, R59A, which is a three-section variable resistor forming part of a bridged-T network. This network attenuates the signal and provides an impedance match for the input of the second amplifier stage.

The second amplifier stage consists of two emitter-coupled differential amplifiers. Variable resistor R81A, connected between the emitters of TR10A and TR11A, adjusts the amplifier gain on the 10 mV/cm range. A portion of the signal at the collectors of TR8A/TR9A is taken off to provide a signal to the sweep trigger circuits.

The final preamplifier stage is TR12A/TR13A, which drives the Main Vertical Amplifier through the Switching Circuit.

d. **Channel 2 Preamplifier** (Schematic 3). The Channel 2 preamplifier (See Figure 3-3) is identical to the Channel 1 preamplifier up to the output of the second amplifier stage. At this point, a diode network is inserted to provide polarity inversion capability. When CH 2 POLARITY switch is in the NORM position, D35B, D36B, D37B, and D38B are on and D33B, D34B, D39B, and D40B are all off. In this configuration the output of TR10B is connected to the base of TR12B and the output of TR11B is connected to the base of TR13B. When S31B is in the INV position, the diodes which were formerly on turn off and the off diodes turn on. The signal connection is now reversed, and signal polarity at the preamplifier output is inverted. Screwdriver adjustment R85B balances amplifier to minimize trace shift when switching from normal to inverted polarity.

e. **Switching Circuit** (Schematic 4). The output signals from both preamplifiers are connected to a diode gating network in the switching circuit (see Figure 3-4). This network controls the signal connection to the main vertical amplifier to give single or dual-trace operation, as well as signal addition.

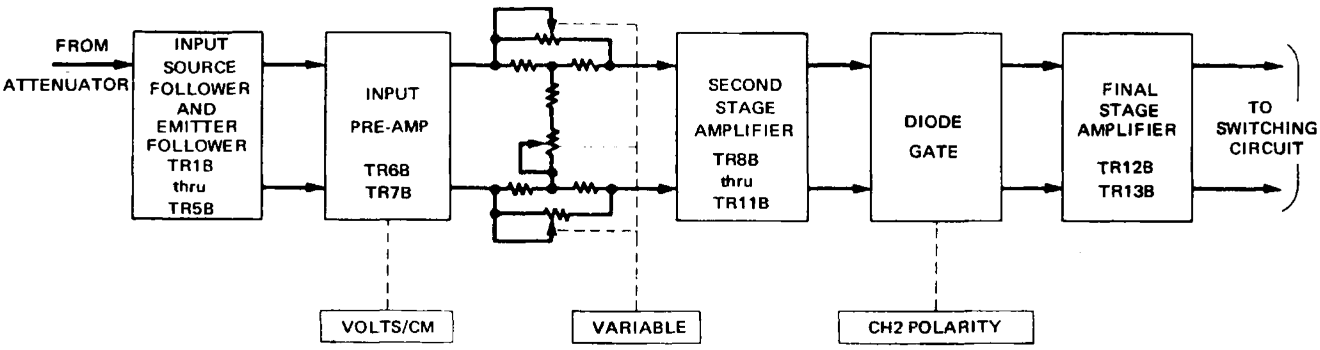


Figure 3-3 Channel 2 Preamplifier Block Diagram

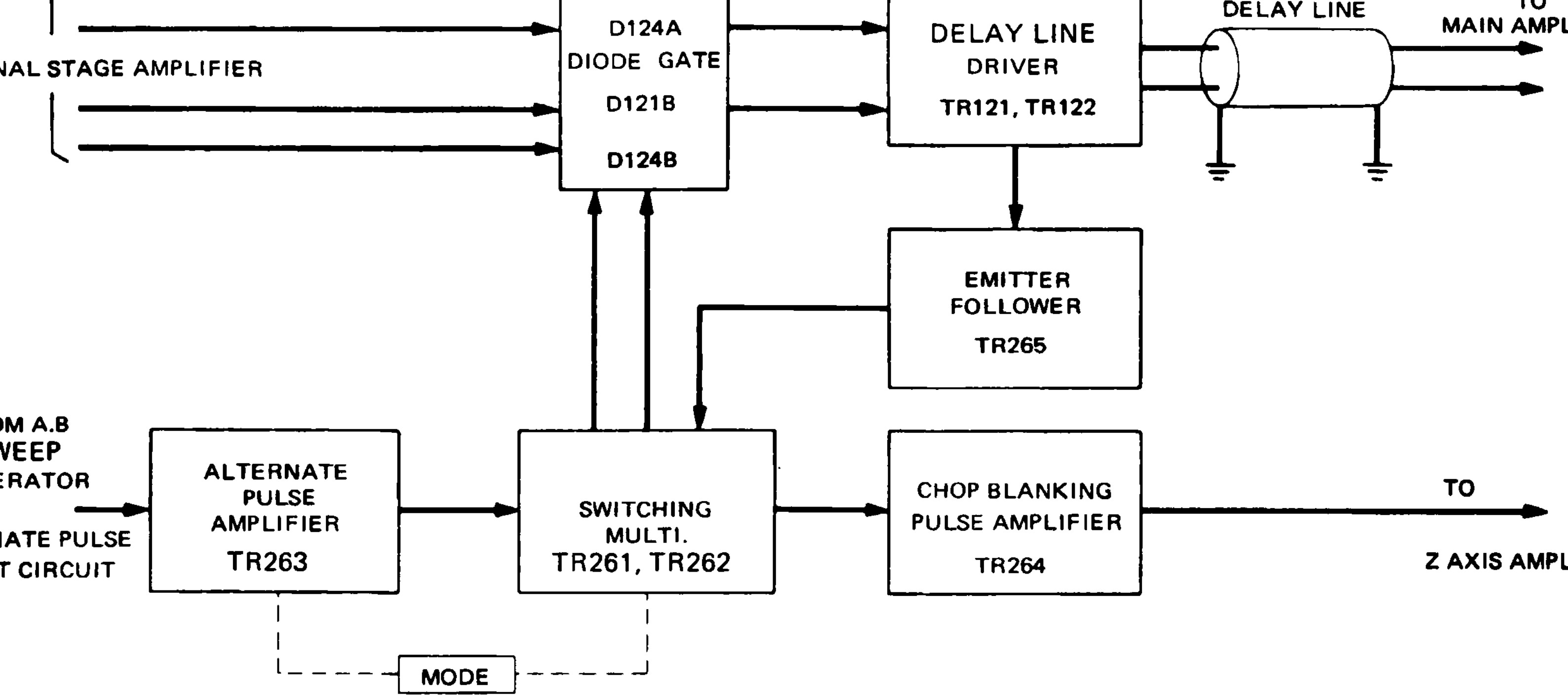


Figure 3-4 Switching Circuit Block Diagram

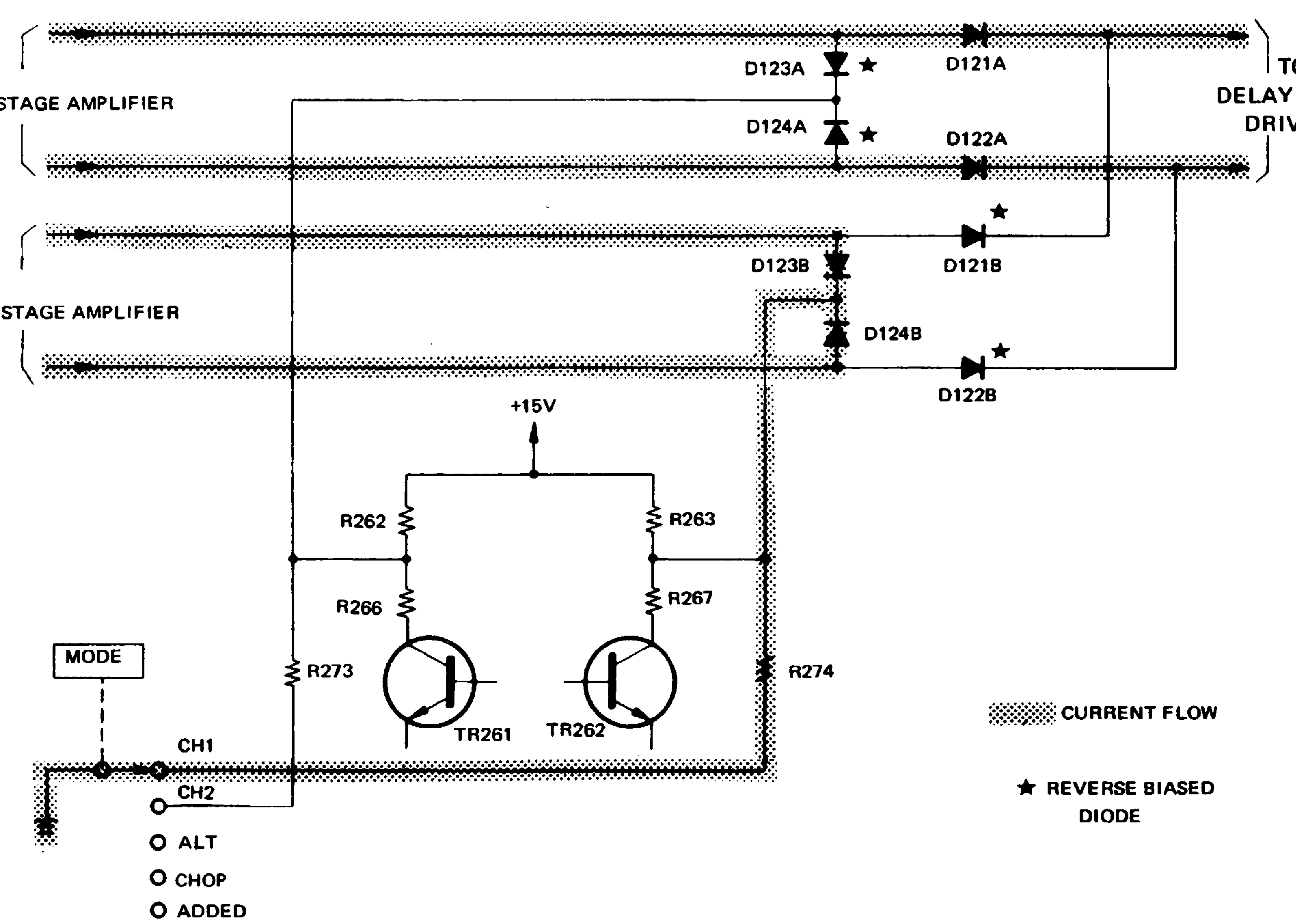


Figure 3-5 Diode Gate Circuit (CH 1 Mode)

gle trace operation, MODE switch S151 controls the ction of diodes in the gating network to connect one or ther channel. Referring to Figure 3-5, when S151 is in

and D121B, D122B, D123A, and D124A are off. D D121A and D122A are on and connect the Channel 1 to the base circuit of differential amplifier TR121/TR12

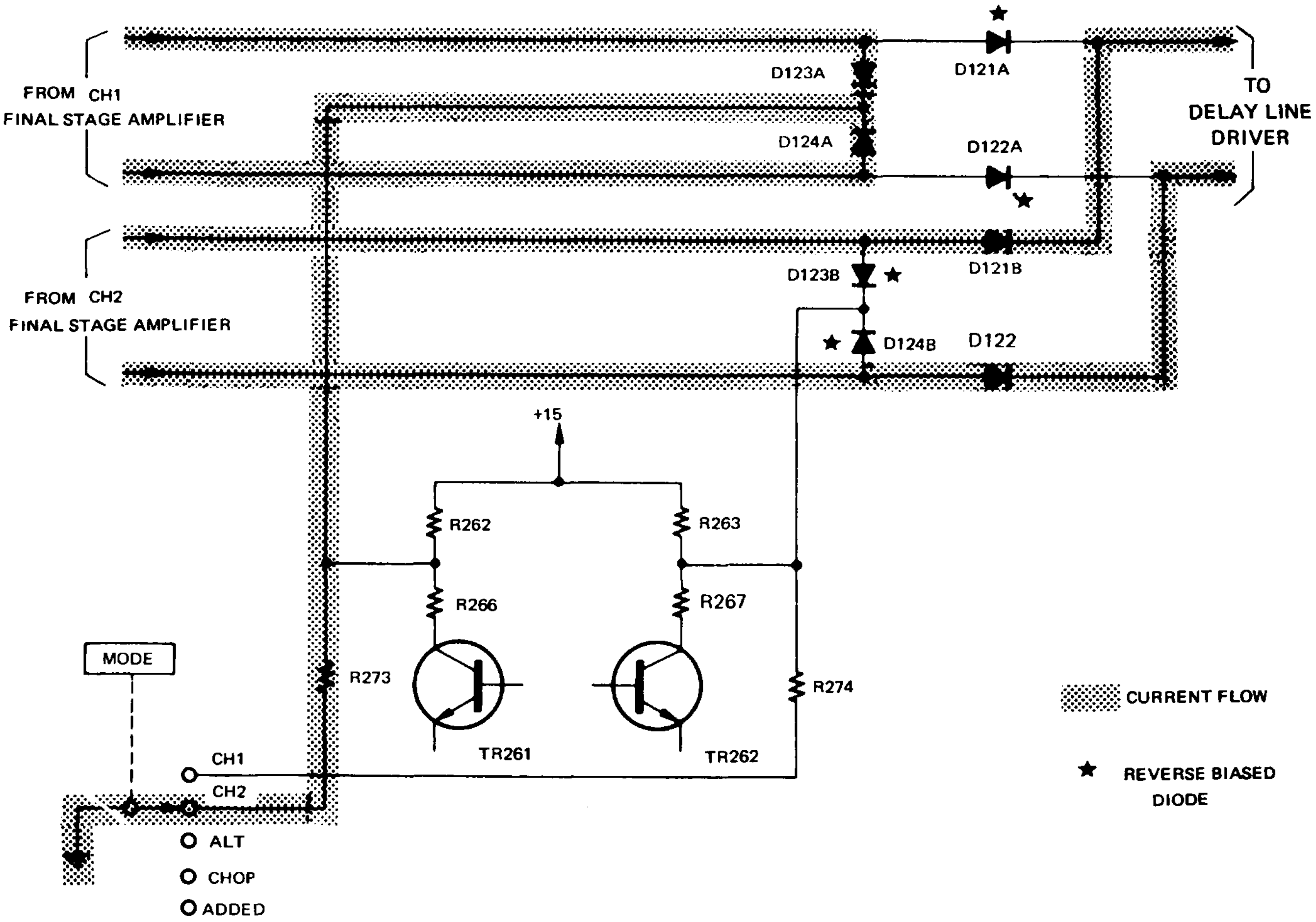


Figure 3-6 Diode Gate Circuit (CH 2 Mode)

the cathodes of D123A and D124A are grounded, and this clamps the anodes of D121A and D122A near ground and turns them off. This disconnects the Channel 1 signal from the switching circuit. Diodes D123B and D124B are off; D121B and D122B are on and connect the Channel 2 signal to driver amplifier stage TR121/TR122.

In the two dual-trace modes, a multivibrator consisting of TR261, TR262, and TR263 controls the gating operation. In the ALT position of S151, alternate pulse amplifier TR263 is activated when its emitter is grounded. Each time the sweep is triggered, a signal from the sweep circuit is amplified by TR263 and switches TR261/TR262 which operates as a bistable multivibrator in this mode. In one state, TR262 is turned on and TR261 is off. The low level at the collector of TR262 turns on D123B and D124B, which connects the Channel 1 signal as previously described. The next sweep trigger signal switches the multivibrator to the other state and the Channel 2 signal is connected to the driver amplifier. This alternating action continues as long as the sweep is triggered.

Emitter follower TR265 feeds back a signal from the emitters of TR121/TR122 to the cathodes of clamp diodes D261/D262. This feedback compensates the gate diodes in the switching circuit so that low-level signals from the vertical preamplifier stages will be switched as fast as high-amplitude signals.

When S151 is in the CHOP position, the emitters of TR261/TR262 are returned to ground through pulse transformer T261. In this condition, TR261/TR262 act as an astable multivibrator with an operating frequency of approximately 1 MHz. The diode gating network operates in the same manner as the other modes, alternately connecting

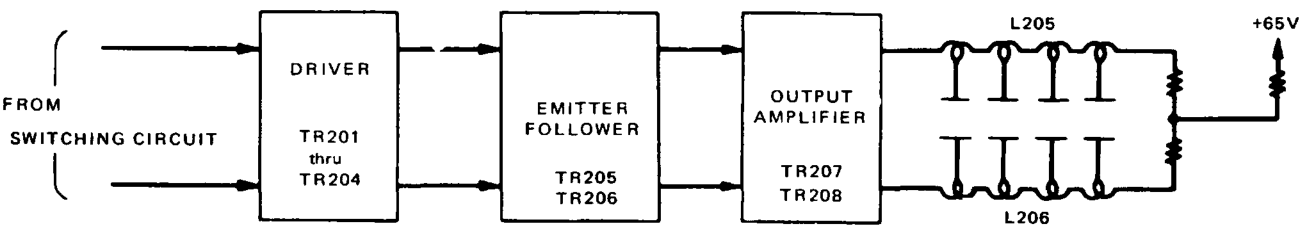


Figure 3-7 Main Vertical Amplifier Block Diagram

the signals from each channel to the driver amplifier. A blanking pulse is sent to the intensity modulation circuit of the CRT through T261 and TR264.

When S151 is in the ADDED position, the switching multivibrator is off, and both diode gate networks are on, adding the signals from both channels to the input of the driver amplifier.

The driver amplifier consists of differential amplifier pair TR121/TR122, connected as a feedback amplifier with collector-base feedback in each stage. The low-impedance output of the driver amplifier drives the 93-ohm delay line connected to the vertical amplifier input.

f. **Main Vertical Amplifier** (Schematic 5). The Main Vertical Amplifier consists of cascaded differential amplifiers which drive the distributed vertical deflection plates of the CRT. Referring to Figure 3-7, the input to the main amplifier is from the 90 ns delay line. An RCL network composed of R201, R202, R203, C201, and L201 provides a compensated termination for the delay line. The first two stages, TR201/TR202 and TR203/TR204 are differential pairs with frequency compensation networks in the emitter circuits. The signal from the collectors of TR203/TR204 drives an impedance transformation stage composed of emitter followers TR205/TR206. These stages provide a high input impedance for the amplifier stages and a low output impedance to output amplifiers TR207/TR208.

Output amplifiers TR207/TR208 are emitter-coupled amplifiers which drive the delay line/deflection plate networks. This network forms the collector load for the stages together with R238 through R244. Variable resistor R240 is an adjustment which allows proper termination of the delay line.

g. **Trigger Amplifier** (Schematic 6). The trigger amplifier provides an amplified signal from each of the vertical input preamplifiers. An additional amplifier circuit amplifies the Channel 2 signal and provides a gain of 5 to the CH2 OUT connector.

Referring to Figure 3-8, the amplifier for each channel consists of cascaded, emitter-coupled amplifier pairs. The output of each amplifier chain is connected to a diode gating matrix with series and shunt diodes controlled by the MODE (S151) and TRIGGER (S152) switches. Depending on the position of these switches, either the Channel 1 or Channel 2 signal is connected to the input of the output amplifier which drives the trigger circuits.

When the MODE switch is in the CH1 position, the cathodes of D151B and D152B are grounded through R180B and S151 (assuming that HORIZ DISPLAY switch S401 is in any position except EXT HORIZ). This turns off D153A and D154A by clamping their anodes through D151B and D152B. Since the diodes in the Channel 1 gating circuit (D151A, D152A, D153A, and D154A) are in the opposite condition, the Channel 1 signal passes through and is connected to output amplifier TR159/TR160. When the MODE switch is in the CH2 position, the cathodes of D151A and D152A are grounded and the Channel 1 signal is blocked. The Channel 2 diode gate is now opened and the Channel 2 signal is connected to the output amplifier.

In either of the dual-trace modes (alternate or chopped), or in the added mode, the TRIGGER switch controls the operation of the diode gating circuits.

The Channel 2 output is provided by differential amplifier TR161/TR162. This amplifier pair provides a 50-ohm output taken from the collector of TR162.

h. **A Trigger Generator** (Schematic 7). The trigger signal for the A sweep circuits is produced by the A Trigger Generator (see Figure 3-9). This circuit accepts trigger signals from either vertical channel, from the power line, or from an external source.

The trigger signal is selected by SOURCE switch S301. In INT position, the output of the trigger amplifier is selected; in LINE position, 1.5 Vac from the power transformer is selected; in EXT and EXT ÷ 10 positions, the signal connected to TRIG INPUT J301 is selected. The output of

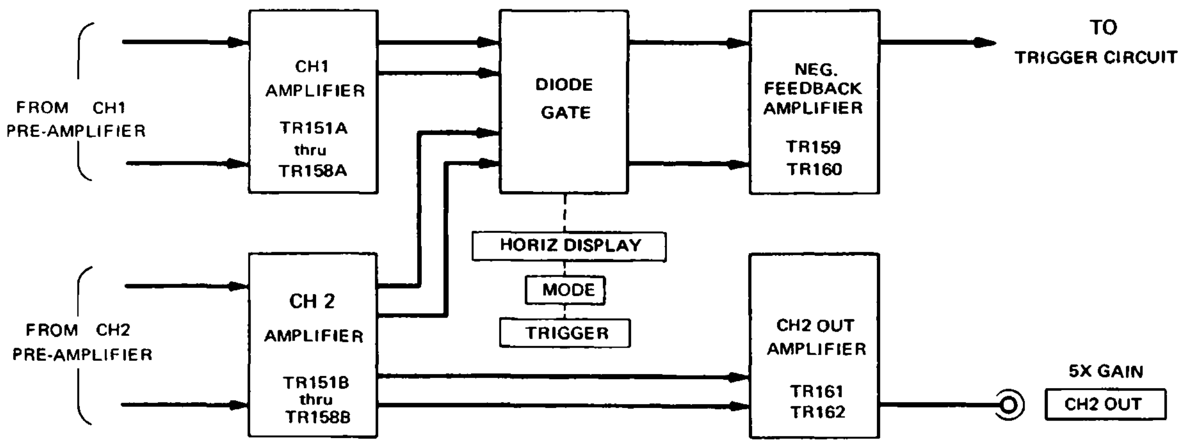


Figure 3-8 Trigger Amplifier Block Diagram

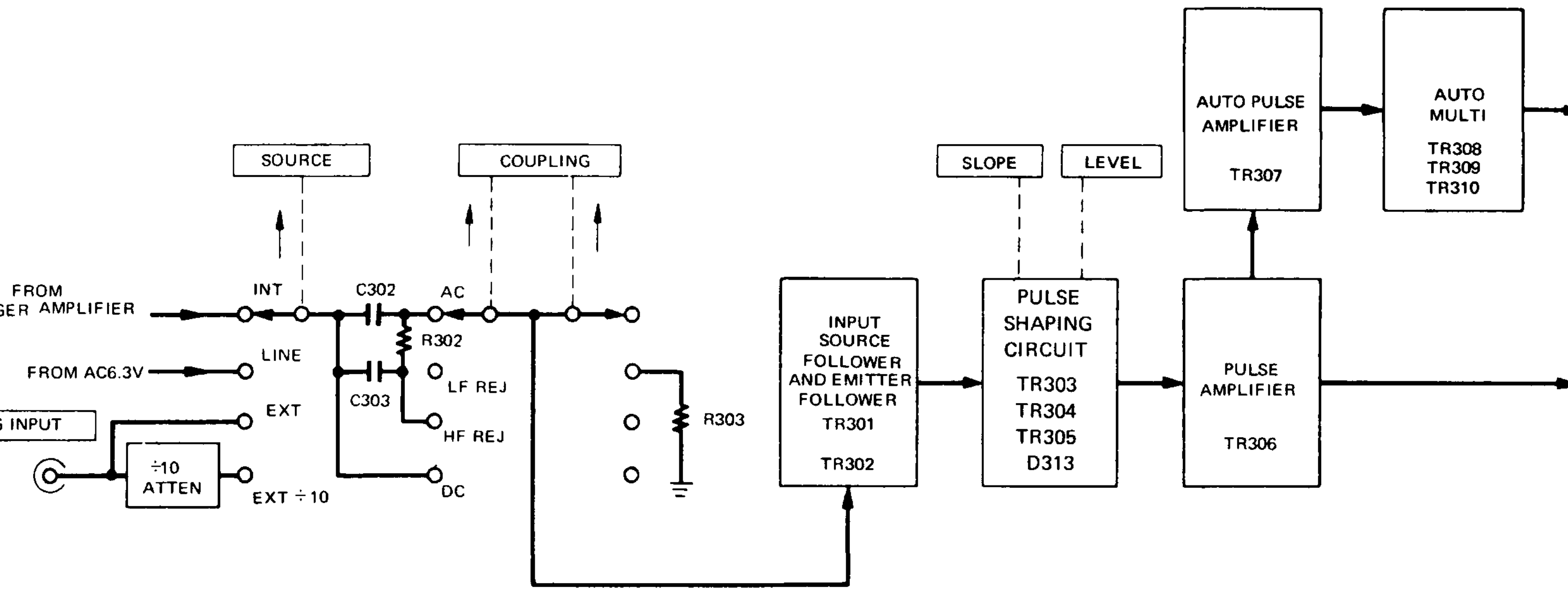


Figure 3-9 Block Diagram, A Trigger Generator

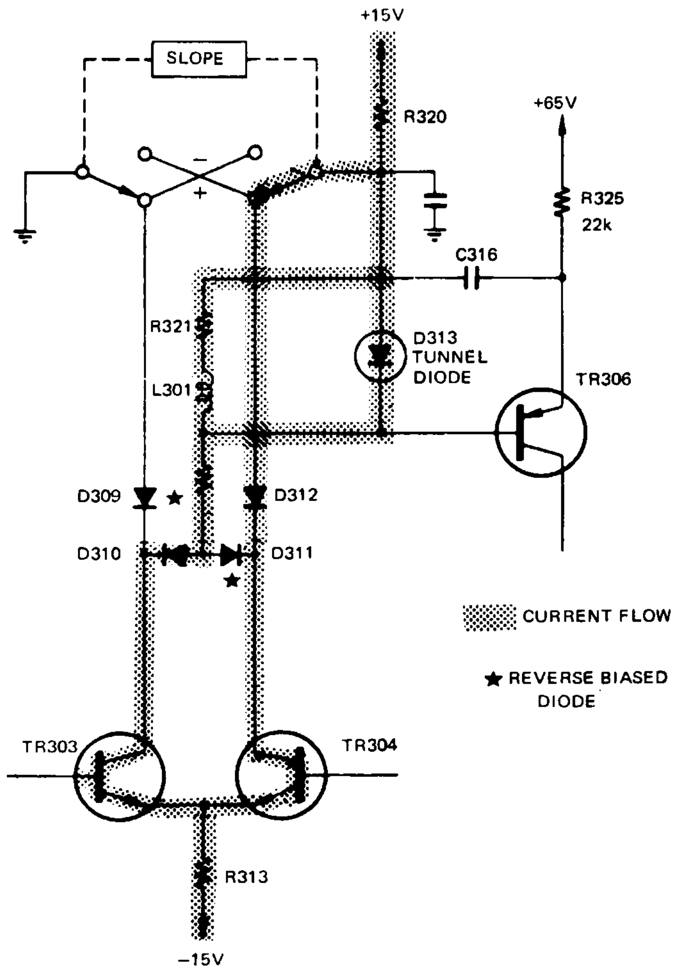


Figure 3-10 Pulse Shaping Circuit (+ Slope)

the SOURCE switch is connected to COUPLING switch S302 which allows capacitive coupling (AC position), coupling through a high-pass filter (LF REJ position), through a low-pass filter (HF REF position), or direct coupling (DC position). In the AC position, the low frequency cut-off is approximately 30 Hz; in the LF REJ position, the cut-off is approximately 30 kHz; in the HF REJ position, the bandpass is approximately 30 Hz to 50 kHz.

The output of the COUPLING switch is connected to the input stage of the trigger generator circuit. The input stage is a source follower which drives a comparator circuit consisting of TR302 through TR305. One side of the comparator (the base of TR302) is connected to the trigger signal through source follower TR301. The other side of the comparator is connected to LEVEL control R320. This control sets the dc reference level which determines the triggering point on the trigger waveform.

Referring to Figures 3-10 and 3-11, assume that a trigger signal as shown is applied to the base of TR303. Using LEVEL control R320, the trigger level is set to a voltage E_L. Initially, TR303 is off and TR304 is on. At a time T_1, the trigger signal reaches the level E_L. At this point, TR303 turns on and TR304 turns off. The current which is flowing through tunnel diode D313 increases to the point where D313 switches from a low-voltage state to a high-voltage state (see Figure 3-12). The sharp spike generated by switching is amplified and shaped by TR306 to provide a trigger pulse to the sweep circuit.

The preceding discussion assumed that SLOPE switch S303 was in the + position. When S303 is in the − position, the initial conditions of TR303 and TR304 are reversed (see

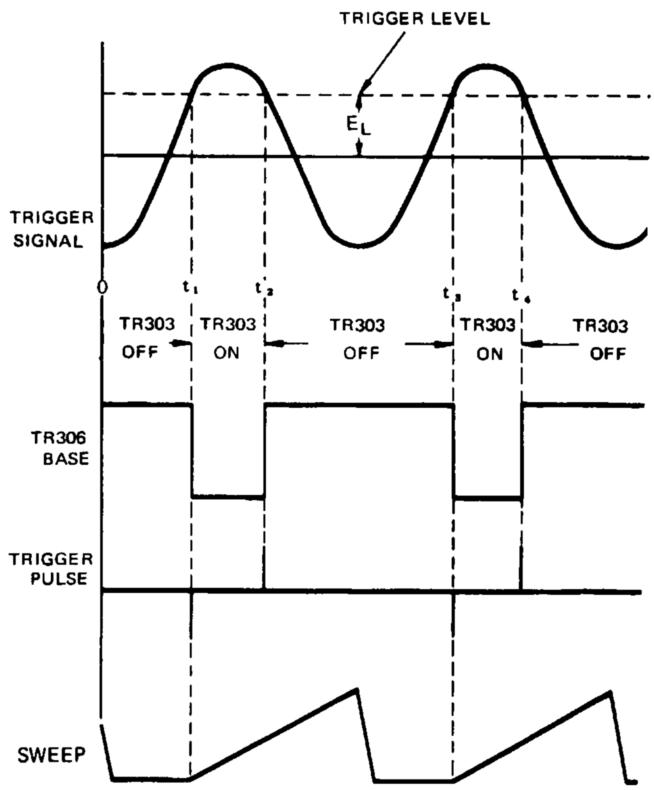


Figure 3-11 Trigger Signal and Trigger Waveforms (+ Slope)

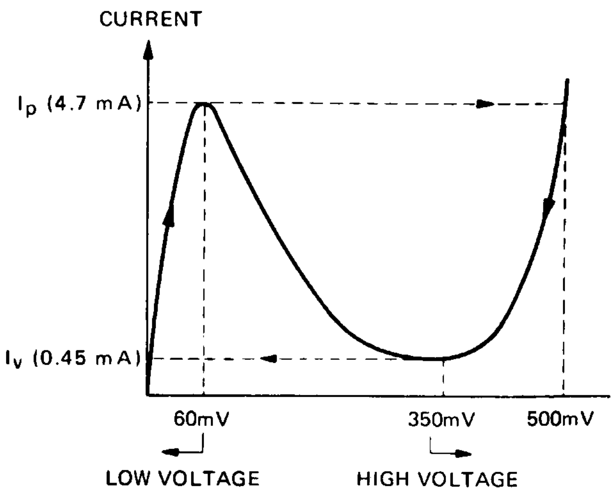


Figure 3-12 Tunnel Diode Characteristics (D313)

Figure 3-13). In this case, TR303 is on, drawing current through R323 and D313. When the trigger signal reaches the level set by the LEVEL control, TR303 turns off and TR304 turns on. The additional current now flowing through D313 is enough to switch it into the low-voltage state, generating a spike as previously discussed. Figure 3-14 shows waveforms for this condition.

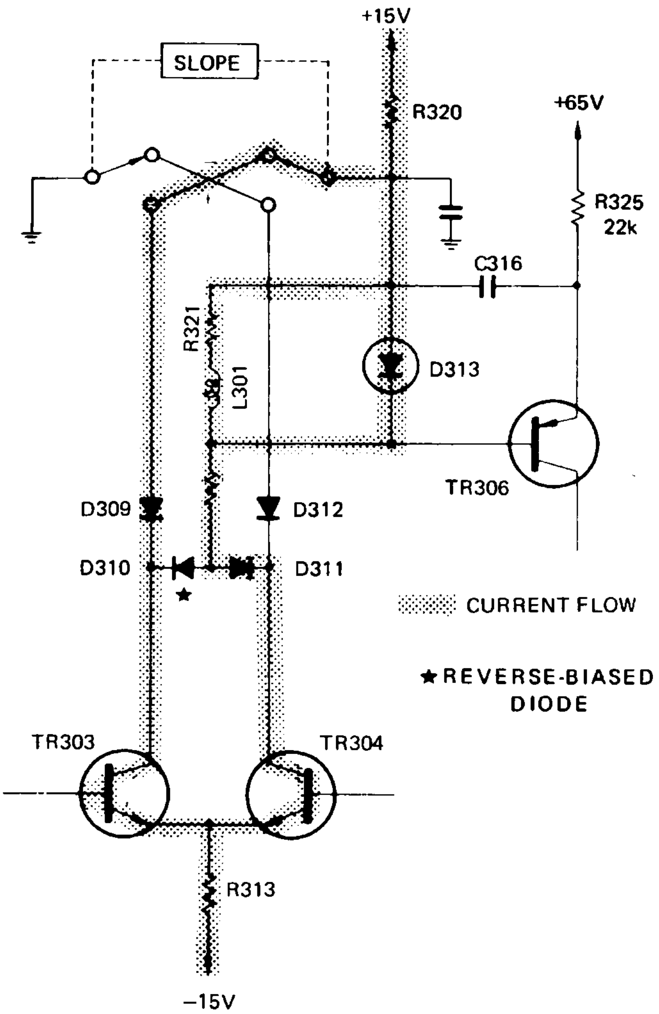


Figure 3-13 Pulse Shaping Circuit (– Slope)

When A SWEEP MODE switch S402 is in the NORM position, the sweep is triggered when the first trigger pulse occurs after the end of a sweep. If no trigger signals are present, or if the trigger signal does not reach the trigger level, the sweep is not triggered. When S402 is in the AUTO position, an automatic trigger circuit composed of TR307-TR310 generates a gate signal to allow the sweep to free run.

When the A SWEEP MODE switch is set at the AUTO position, the A sweep generator assumes a triggered state or free-run state depending on the presence or absence of trigger pulses.

The operation of the auto multivibrator is as follows: (see Figure 3-15).

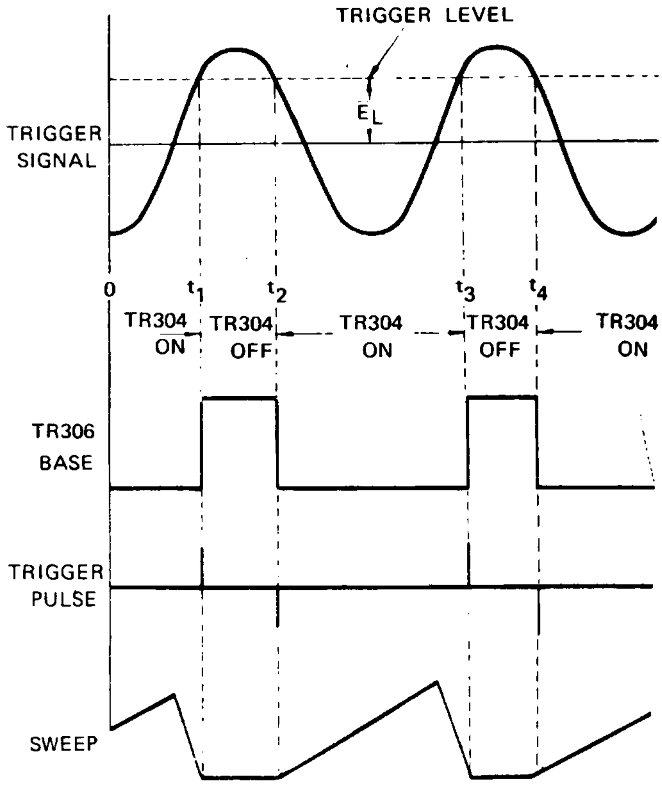


Figure 3-14 Trigger Signal and Trigger Waveforms (– Slope)

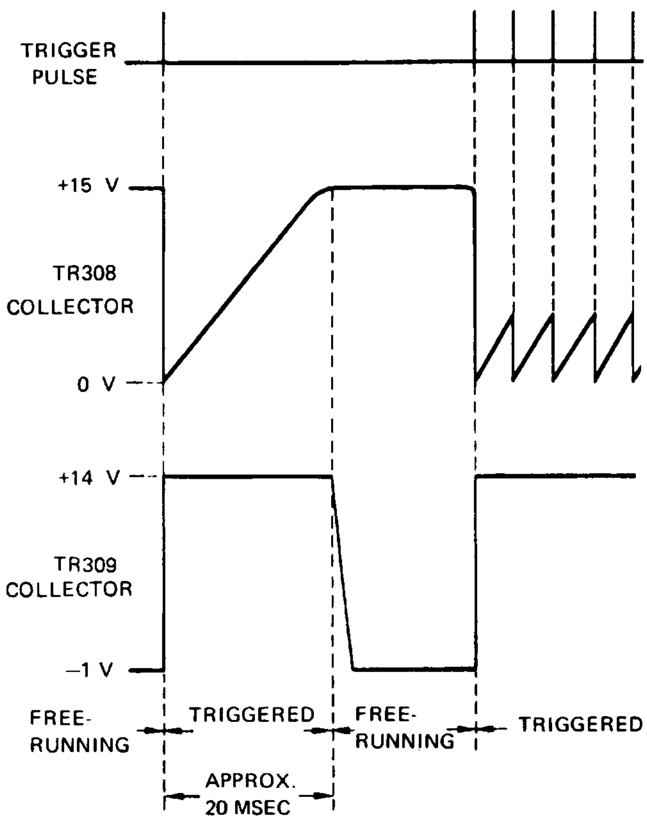


Figure 3-15 Waveforms, AUTO Trigger Mode

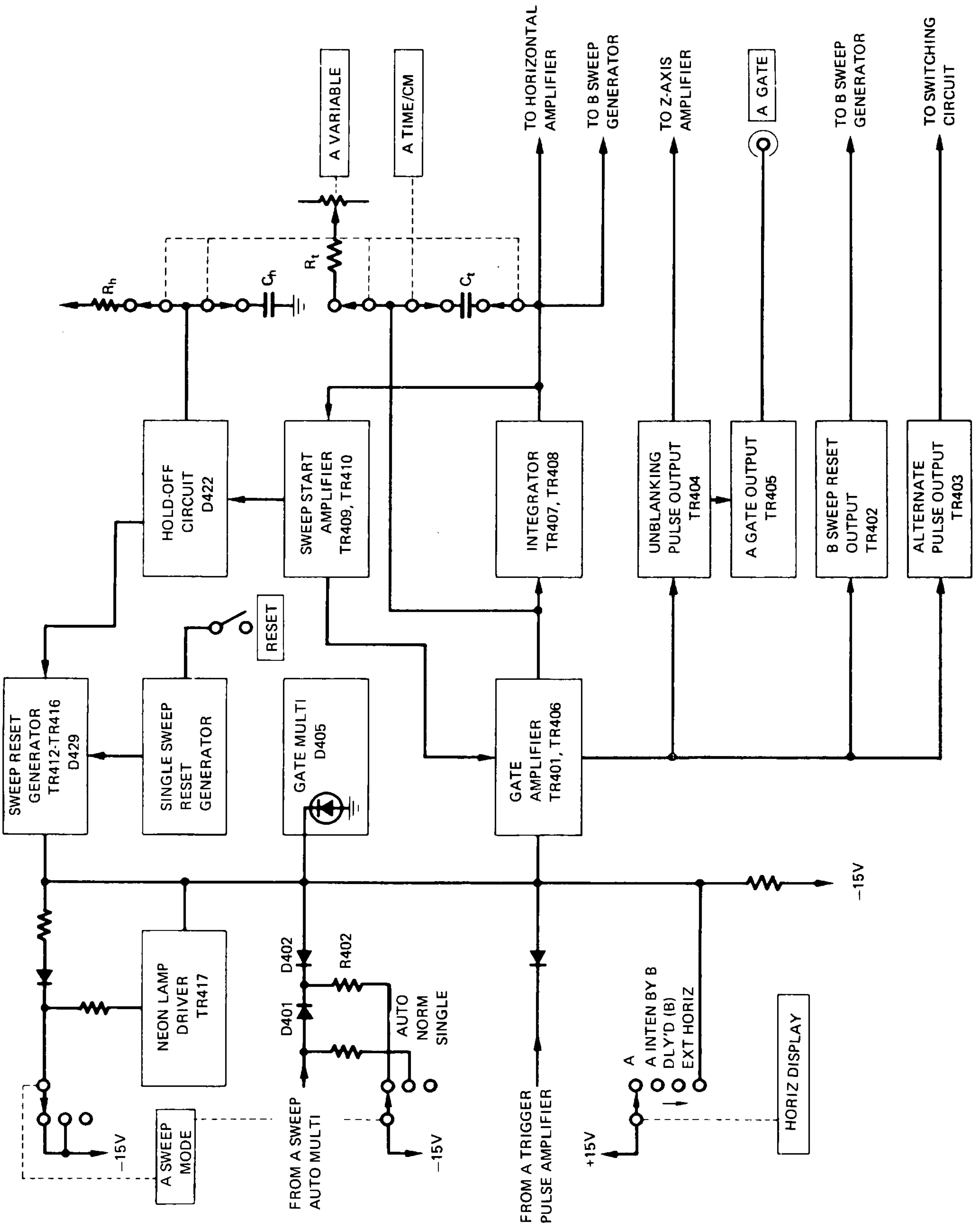


Figure 3-16 Block Diagram, A Sweep Generator

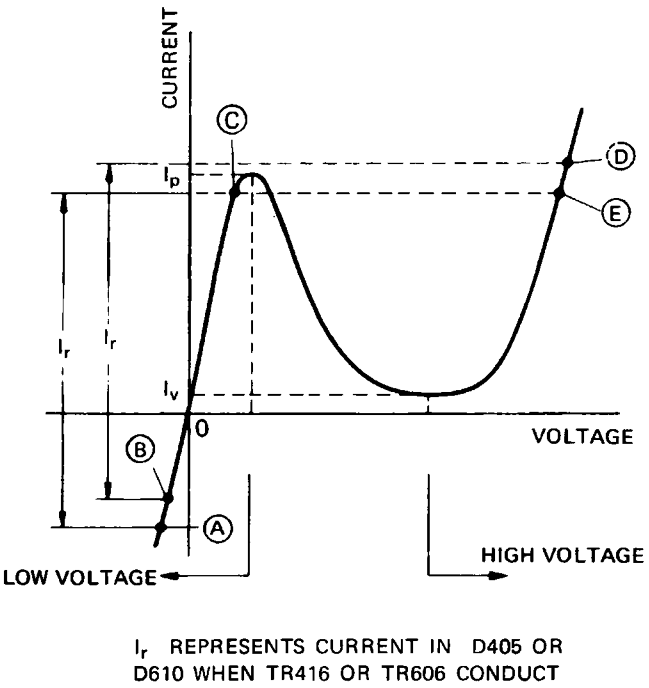


Figure 3-17 Tunnel Diode Characteristics (D405, D610)

Since current flows through L303 and R332 to D316, the base potential of TR308 is clamped at approximately −0.7 volts, and the base voltage of TR310 is divided by R337 and R338 to approximately −0.3 volts. Consequently, TR310 turns on and TR308 turns off. C320 is charged through R333 causing D317 and D318 to be turned on. Current flows through these diodes from +75 volts through R333, TR310, and R339. TR309 turns off since reverse bias is applied between the emitter and base. D401 in the A Sweep Generator also turns off, therefore current flows through R401 to D402. This current moves the operation point of the gate multivibrator, D405, in the A Sweep Generator from point A to point B in Figure 3-17. The A Sweep Generator oscillates on a free-run basis when the operating point of D405 is at point B.

The moment trigger pulses are fed from T302 of the pulse amplifier to the A Sweep Generator, the collector of TR306 produces a positive pulse. With this pulse TR308 turns on and TR310 turns off, and the collector voltage of TR308 steps into the negative region, which causes C320 to discharge rapidly. (See Figure 3-15 for the following discussion.) Consequently, D317 and D318 turn off and TR309 turns on. As a result, the collector voltage of TR309 reaches approximately +14 volts. This, in turn, causes D401 to turn on and D402 to turn off, and the operating point of D405 shifts to point A in Figure 3-18. The A Sweep Generator is then triggered.

When the trigger pulse stops, TR309 turns off and TR310 turns on again. The collector potential of TR308 increases gradually depending on the time constant of R333 and C320, and when approximately +15 volts is reached, D307 and D318 turn on, and TR309 turns off, causing its collector potential to step into the negative region (approximately -1 volt). As shown in Figure 3-15, if trigger pulses are continuously applied before the TR308 collector potential increase (until D317 and D318 turn on), TR309 is not able to turn off, and the triggered state of the A Sweep Generator is maintained. However, if the trigger pulse internal becomes longer than approximately 20 msec (approximately 50 Hz), the triggered state of the A Sweep Generator is no longer maintained since the TR309 collector voltage steps into the negative region.

i. A Sweep Generator (Schematic 8). The configuration of the A Sweep Generator is shown in Figure 3-16. When the HORIZ DISPLAY switch is set to a position other than EXT HORIZ, three operating modes, normal trigger, automatic operation and single sweep are available.

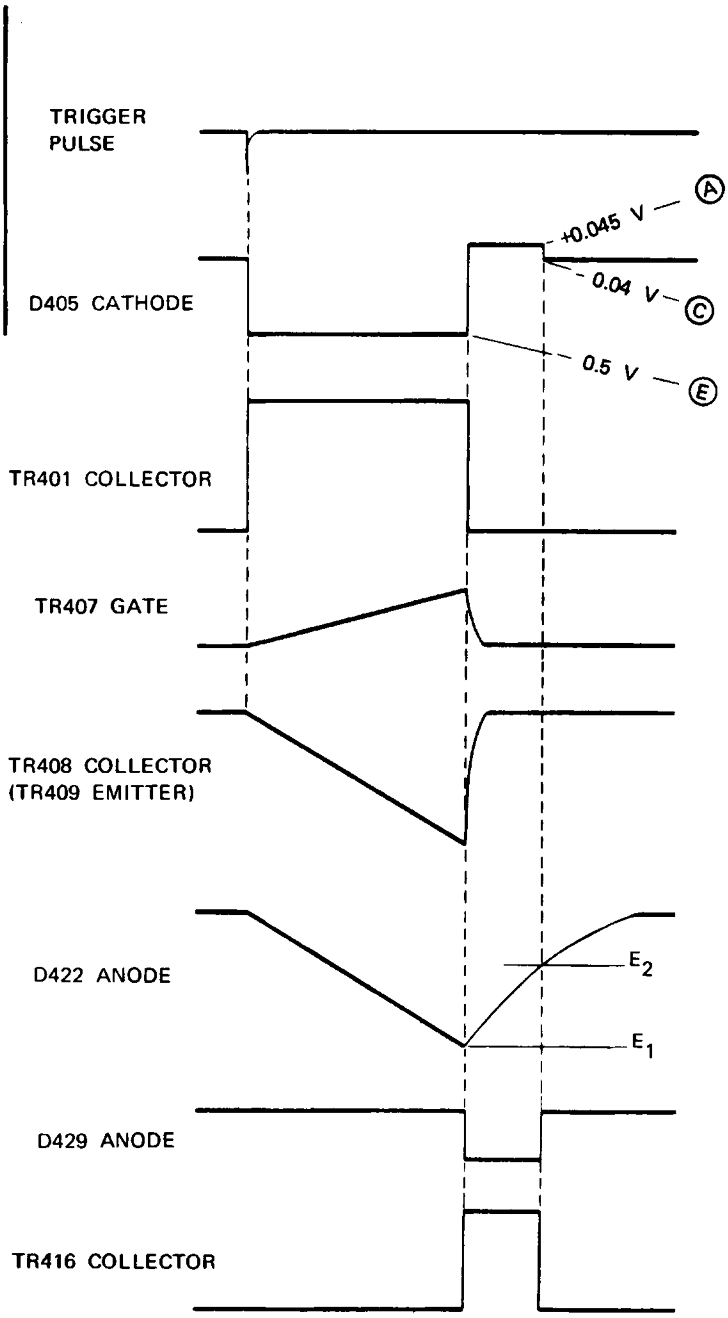


Figure 3-18 Waveforms, NORM Sweep Mode

The A Sweep Generator provides the following signals.

(1) Sawtooth. The sawtooth sweep waveform is fed through the horizontal preamplifier to the horizontal deflection plates of the CRT. The signal is also fed to the B Sweep Generator in order to produce the delay pulse.

(2) Unblanking signal to intensify trace and blank retrace: fed to the unblanking amplifier and the control grid of the CRT.

(3) Positive gate pulse provided during the positive going slope of the sweep waveform: Fed to the A GATE output connector located on the right side panel.

(4) Reset pulse to terminate the unnecessary part of the B sweep signal during the A INTEN BY B Sweep Operation: fed to the B Sweep Generator.

(5) Alternate signal to actuate the alternate sweep: fed to the alternate pulse amplifier in the vertical deflection system.

Normal trigger operation of the A Sweep Generator is performed by setting the HORIZONTAL DISPLAY switch to any position other than EXT HORIZ and the A SWEEP MODE switch to the NORM position. Strictly speaking these normal triggered operations differ to some extent with the HORIZ DISPLAY switch position. For ease of description, operation in which the HORIZ DISPLAY switch is set to the A position will be used as an example.

Assume a condition before the sweep starts with no trigger signal. TR416 in the sweep reset circuit is conducting and D402 is off, and a very small amount of current flows through gate multivibrator D405 (a tunnel diode) to place the operating point of the diode in the low voltage region, C (Figure 3-17). The cathode voltage of the diode is approximately −0.04 V (see Figure 3-18), and is higher than when the diode is in the high voltage region. (The anode of D405 is grounded, therefore, the high voltage operation of the diode means that the cathode is placed at a more negative voltage.)

The gate amplifier, TR401, is turned off in this condition, and its collector voltage is approximately −4 V. Diode D411 is connected to the emitter of TR406, and current flows through the diode through R_t.

An amplifier composed of TR407 and TR408 is connected to the anode of D411. Timing capacitor C_t forms a feedback circuit between the output and input of the amplifier and constitutes an integrator circuit. The output of the integrator is fed to the horizontal amplifier and the base of TR409. TR409 and TR410 compose a voltage comparator (sweep start control circuit) of which the output is returned, through diode D421, to the base of TR406. Diode D421 conducts before the sweep start, therefore, a DC feedback loop is formed by TR406, TR407, TR408, TR409, TR410, and D421. R_t and C_t determine the time constant of the integrator. The time constant varies with the position of the A TIME/CM switch. Switching of R_t causes a variation in the input and output voltage of the amplifier composed of TR407 and TR408, however due to the feedback loop, the output voltage is maintained at a constant level.

The cathode of diode D422 is connected to the emitter of TR409, and current flows from the diode through R_h. The anode of the diode is connected to the gate of TR412.

A tunnel diode, D429, is connected to the collector of TR413. Before the sweep starts, the gate voltage of TR412 is sufficiently higher than the base voltage of TR414, therefore, TR412 shuts off, TR414 conducts, and D429 is set in the high voltage region. The comparator output is connected to the base of TR416. Diode D429 is in the high voltage region at this time, and TR413 is conducting. The collector voltage of TR413 is approximately zero, and a very small amount of current flows through R471.

If a trigger pulse is fed from the A Trigger Generator to the cathode of D405, the diode current exceeds I_p the tunnel diode steps to the high voltage region, (point E in Figure 3-18) and the cathode voltage becomes approximately −0.5 V (refer to Figure 3-19).

The collector of TR401 becomes more positive, D411 and D421 are shut off, and the integrator starts the integration operation with the time constant determined by R_t and C_t The gate potential of TR407 starts to increase linearly and the collector voltage of TR408 also decreases linearly. This voltage variation turns on emitter follower TR409, and the emitter voltage also starts to decrease.

Since D422 is on, its anode voltage also decreases linearly. At a certain gate voltage (E_1), TR412 turns on, and TR414 turns off, causing tunnel diode D429 to step to the low voltage region. TR416 then turns off.

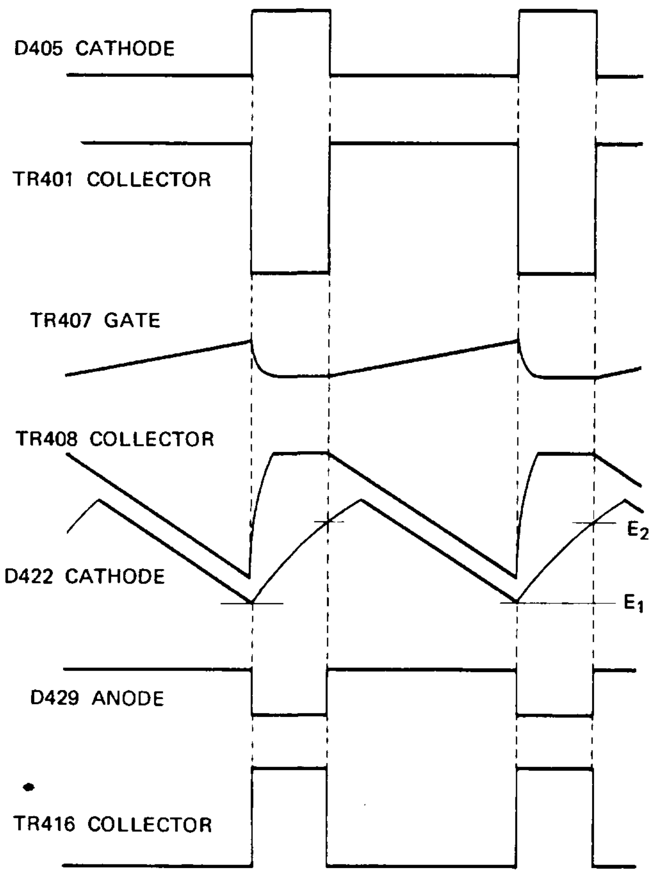


Figure 3-19 Waveforms, Auto Sweep Mode

The voltage increase at the collector of TR416 causes current to flow through R471, and the forward current of tunnel diode D405 decreases. D405 steps to its low voltage region (point A) in Figures 3-17 and 3-18, and the cathode potential becomes more positive (approx. +0.045 V ––– refer to Figure 3-14). Therefore, TR401 turns off and its collector voltage becomes more negative, causing diodes D411 and D421 to conduct.

The conduction of D411 discharges C_t, and the gate voltage of TR407 decreases rapidly while the collector voltage of TR408 rises. TR410 is still cut off, and the emitter voltage of TR409 rises to a level approximately equal to that of the collector of TR408. The anode voltage of D422 increases gradually, due to its capacitive load consisting of C_h. D422 shuts off, and the anode potential increases with a time constant determined by R_h and C_h.

When the anode of D422 reaches a certain voltage (E_2) TR412 turns off, and TR414 conducts. D429 steps to the high voltage region. TR416 conducts, and the forward current of D405 increases to change the operating point of the tunnel diode to point C as its cathode potential steps to −0.04 V. The tunnel diode returns to its initial operating point wherein an incoming trigger pulse can drive the diode toward the high voltage region.

At the same time, the rise of TR408 collector voltage returns TR409 and TR410 to their normal operating region (voltage comparator region) and these transistors operate to stabilize the collector voltage of TR408.

The time it takes the anode voltage of D422 to increase from E_1 and E_2, or the time during which the anode of D429 is negative, is called the "hold-off" time. The hold-off time must be sufficiently longer than the time it takes for the collector potential to restore to normal (retrace time). Proper hold-off time is determined by selecting the values of R_h and C_h.

One cycle of normal sweep operation ends when D405 returns to its initial operating status.

By placing the HORIZ DISPLAY switch in any position other than EXT HORIZ and A SWEEP MODE switch in the

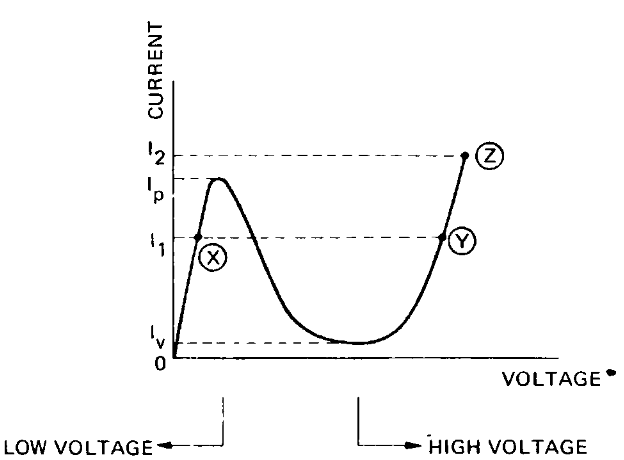


Figure 3-20 Tunnel Diode Characteristics (D429)

AUTO position, the A Sweep Generator starts auto-triggered sweep. In order to simplify the description, the auto trigger operation will be described with the MODE switch set in the A position.

As previously described, auto trigger operation is classified into two types, i.e., trigger pulse's presence and trigger pulse's absence. The triggered operation is similar to the normal trigger operation.

When the trigger pulse is not present, the auto multivibrator in the A Trigger Generator; TR309 is turned off, and a small amount of current flows through D401 to change the operating point of D405 from point A to point B as shown in Figure 3-17.

When the sweep reset transistor, TR416, conducts in this condition, current similar to that in normal trigger operations flows through R471; the operating point of D405 moves to the high voltage region (point D in Figure 3-17) even if the trigger pulse is not present, and the cathode voltage of D405 becomes negative to start the sweep operation. When the anode voltage of D422 increases to E_2 at the end of a sweeep TR416 again conducts to start another sweep. Waveforms for this operating mode are shown in Figure 3-19.

When a negative trigger pulse is fed to D405, D401 conducts and D402 is shut off since the collector of TR309 is at +14 V as previously described. As in normal trigger operation, current flows through D405 to start the sweep. If the pulse interval is longer than approximately 20 msec, TR309 shuts off before the next trigger pulse arrives and the sweep free-runs.

As previously described, auto trigger operation is classified into two types, i.e., trigger pulse's presence and trigger pulse's absence. The triggered operation is similar to the normal trigger operation.

When the trigger pulse is not present, the auto multivibrator in the A Trigger Generator; TR309 is turned off, and a small amount of current flows through D401 to change the operating point of D405 from point A to point B as shown in Figure 3-17.

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When a negative trigger pulse is fed to D405, D401 conducts and D402 is shut off since the collector of TR309 is at +14 V as previously described. As in normal trigger operation, current flows through D405 to start the sweep. If the pulse interval is longer than approximately 20 msec, TR309 shuts off before the next trigger pulse arrives and the sweep free-runs.

Single sweep operation is possible in any position of the HORIZ DISPLAY switch except the EXT HORIZ position. In this paragraph single sweep operation in which the HORIZ DISPLAY switch is set to the A position is described. In the single sweep mode, TR413, TR415 in the sweep reset circuit not related to normal trigger operation, and TR417 in the neon tube indication circuit are actuated.

Assume a condition with neither a trigger nor a reset pulse.

Gate multivibrator D405 is in the low voltage region (point A in Figure 3-17), and the cathode is approximately +0.045 V (refer to Figure 3-21). TR401 is off, and its collector is approximately −4 V. D411 and D421 are conducting, TR409 and TR410 are in the voltage comparator region, C_h is charged, and D422 is conducting.

The gate voltage of TR412 is sufficiently higher than the bases of TR413 and TR414, and TR410 is shut off. The bases of TR413 and TR414 are at approximately the same voltage, and current flowing through R458 (I_2 in Figure 3-20) is equally distributed to TR413 and TR414. The current through TR414 (D429) is I_1, and that flowing through TR413 is $I_2 - I_3$. Therefore, the operating point of tunnel diode D424 is point X in Figure 3-20. This current turns off TR416 and keeps its collector at a high level.

An amplifier, TR415, and neon indicator circuit, TR417, are connected to the collector of TR416. The high voltage on the collector of TR416 causes TR417 to conduct. Therefore, the voltage on the collector of TR417 is low, and the neon tube does not light.

Prior to generating a reset pulse, the single sweep reset pulse generator is in the following condition. TR414 is shut off and its base voltage is approximately −3.4 V, and collector voltage is approximately +8 V, and tunnel diode D432 is in the high voltage region. TR418 is off since its base voltage is approximately −0.45 V. Then, the collector voltage becomes approximately −15 V.

When a reset pulse is produced by depressing the RESET switch, the base voltage of TR419 becomes positive to allow TR419 to conduct. D432 steps to the low voltage region causing the base of TR418 to become negative and allowing TR418 to conduct. The positive transition of the collector of TR418 is differentiated by R480 and C422, and a positive pulse (single sweep reset pulse, or simply the reset pulse) is generated and fed to the anode of D429.

The reset pulse drives D429 to its high voltage region (point Y in Figure 3-20) and its anode voltage becomes more positive (refer to Figure 3-21). TR416 conducts, causing its collector voltage to become more negative. TR415, which is a phase inverter, increases the base voltage of TR413 to a point sufficiently higher than that of TR414. TR413 then turns off and TR414 conducts. The collector current of TR414 increases; the operating point of D429 moves to point Z in Figure 3-20, and the diode operation is stabilized. The decreased collector voltage of TR416 increases the forward current of gate multivibrator D405 to move its operating point to point C in Figure 3-17, and the cathode of D405 becomes negative (to −0.04 V, refer to Figure 3-18). At this time, the circuit is in a ready condition and a trigger pulse can drive D405 to its high voltage region and start the sweep. The decrease in collector voltage of TR416 also decreases the base voltage of TR417 which is then turned off. Neon lamp NE401 lights to indicate the ready condition of the single sweep circuit.

When a trigger pulse is applied, D405 steps to its high voltage region (point E in Figure 3-18), its cathode voltage is reduced, and the sweep starts. The anode voltage of D422 decreases, along with the linear voltage decrease of the collector of TR408, until the anode voltage reaches E_1 and

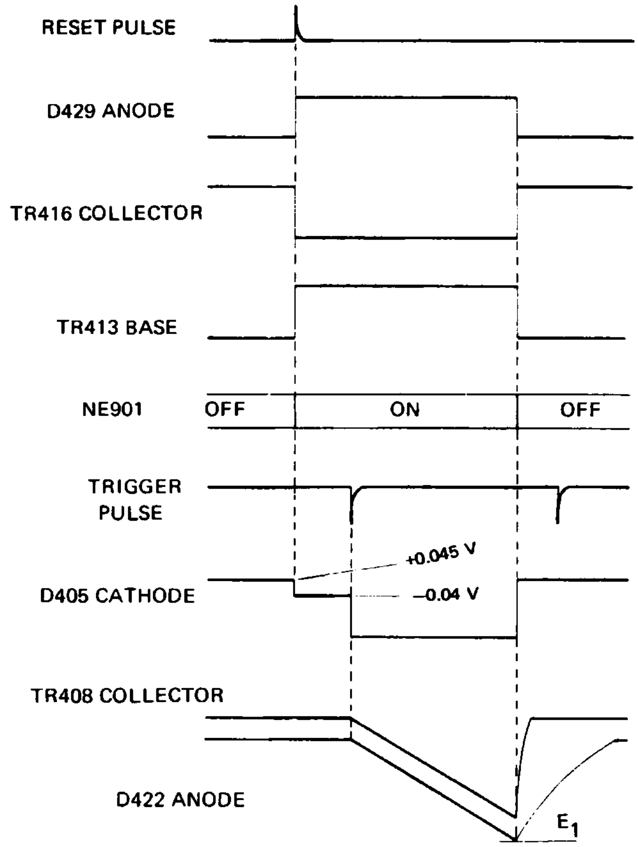


Figure 3-21 Waveforms, SINGLE Sweep Mode

TR412 conducts and TR414 is shut off (TR413 has been shut off). D429 steps to its low voltage region (approximately 0 in Figure 3-21), and its anode voltage becomes negative. This negative transition causes the collector of TR416 and the cathode of D405 to become positive. The sweep ends and the voltages at the collector of TR408 and the cathode of D422 start to increase. Simultaneously, TR417 conducts, NE401 goes off, and the base of TR413 becomes more negative and approximately equal to the base voltage of TR414.

Because of its capacitive load, the anode voltage of D422 cannot follow the rapid rise in cathode voltage, and the anode voltage gradually increases with a time constant determined by R_h and C_h, until it reaches the point indicated by E_2 at which time TR412 turns off (similar to normal trigger operation). The base of TR413 is at the same voltage as that of TR412, therefore the current flowing through R445 is equally distributed to these two transistors, and the operating point of D421 is set to point X in Figure 3-20. An incoming trigger pulse cannot actuate the sweep unless the anode of D424 is driven by a reset pulse to drive the diode positive.

j. **B TRIGGER GENERATOR** (Schematic 9). The configuration of the B Trigger Circuit is shown in Figure 3-22. The purpose of this circuit is to produce trigger pulses to drive the B Sweep Generator. The circuit from the TRIG OR HORIZ INPUT connector to the input source follower also functions as an input circuit for horizontal input signals when the instrument is used as an X-Y oscilloscope. The B Trigger Generator consists of a HORIZ DISPLAY switch,

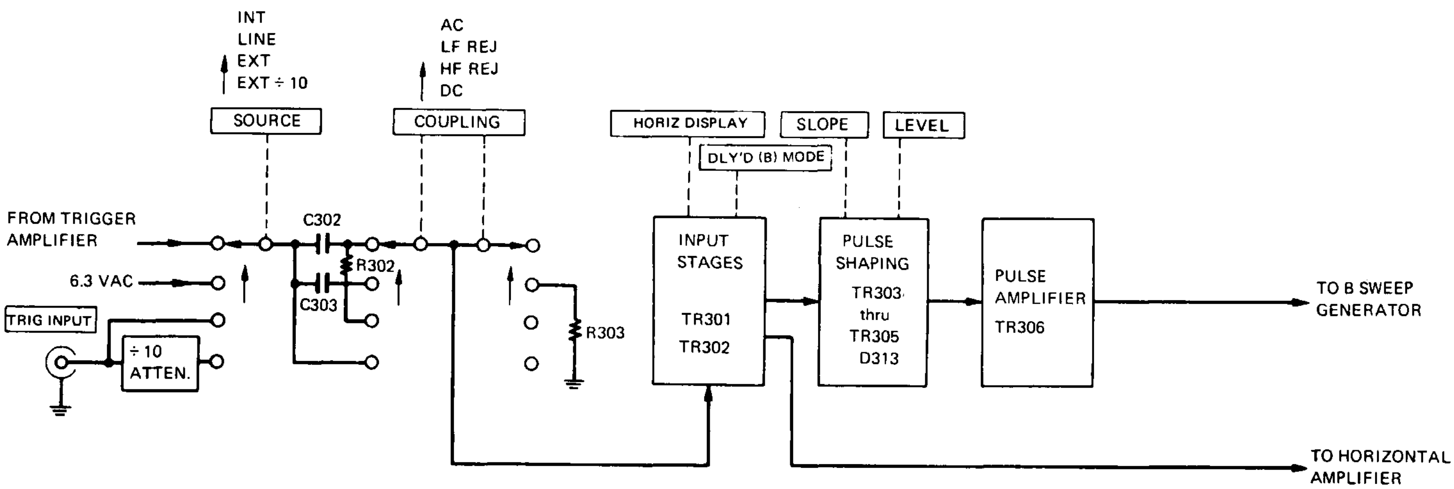


Figure 3-22 Block Diagram B Trigger Generator

which switches the associated circuits from one circuit to another, as mentioned above, and a horizontal signal amplifier. It also contains a DLY'D (B) MODE switch which is used to switch the associated circuits from triggered delay sweep to non-triggered delay sweep, or vice versa. Since the circuit up to the input source follower is identical to that of the A Trigger Circuit, further discussion of these components is omitted.

The pulse shaper circuit is composed of transistors TR501, TR502, TR503, TR504, TR505, and tunnel diode D513. The emitters of TR503 and TR504 are connected to the −15 V line through the common emitter resistor R522 which provides current switching of the transistors (when one transistor turns on, the other shuts off). For example, when the base potential of TR503 is higher than that of TR504; TR503 conducts and TR504 cuts off. This current switching also switches the operating point of the tunnel diode, and converts the trigger signal into a trigger pulse with a very fast risetime.

Assuming that the SLOPE switch is set to the + position, +15 V is connected to the anode of D512 which then conducts, and D510 turns off. Current flows through D511. When a trigger signal (sine wave) is fed to the base of TR503, and the triggering level, set by the LEVEL control, is E_L TR503 is cut off and TR504 conducts at time t_0. When the trigger signal level increases and exceeds the trigger point E_L at time t_1 TR503 conducts, causing TR504 to cut off. When the trigger signal level again becomes more negative than the triggering level E_L, TR503 turns off and TR504 conducts. When TR503 is cut off, tunnel diode D513, which is connected in series with TR503, is placed in its low voltage region. Only a small amount of current flows through TR506 as its emitter is connected to a high resistance, R534 (22 kilohms), and it is isolated from other circuits by C518. When TR503 switches from off to on, a current larger than I_p of D513 (4.7 mA) flows through the tunnel diode to drive it into its high voltage region. Since the cathode of D513 is kept more negative than the power supply and the voltage across the tunnel diode increases rapidly when it goes into the high voltage region, the transition causes a rapidly changing current flow through C518 and TR506 and drives the pulse transformer. A positive pulse, the width of which is determined by C518, is obtained from the collector of TR506.

When TR503 turns off, the current flowing through D513 becomes smaller than I_p and the operating point of the tunnel diode steps to the low voltage region causing a negative pulse output at the collector of TR506. The polarity of the positive and negative pulses are inverted by pulse transformer L502. The negative pulse (trigger pulse) from the transformer is used to drive the B Sweep Generator.

By adjusting the LEVEL control, the trigger pulse can be generated at any point on the positive going slope of the trigger signal. Since the input trigger signal fed to the base of

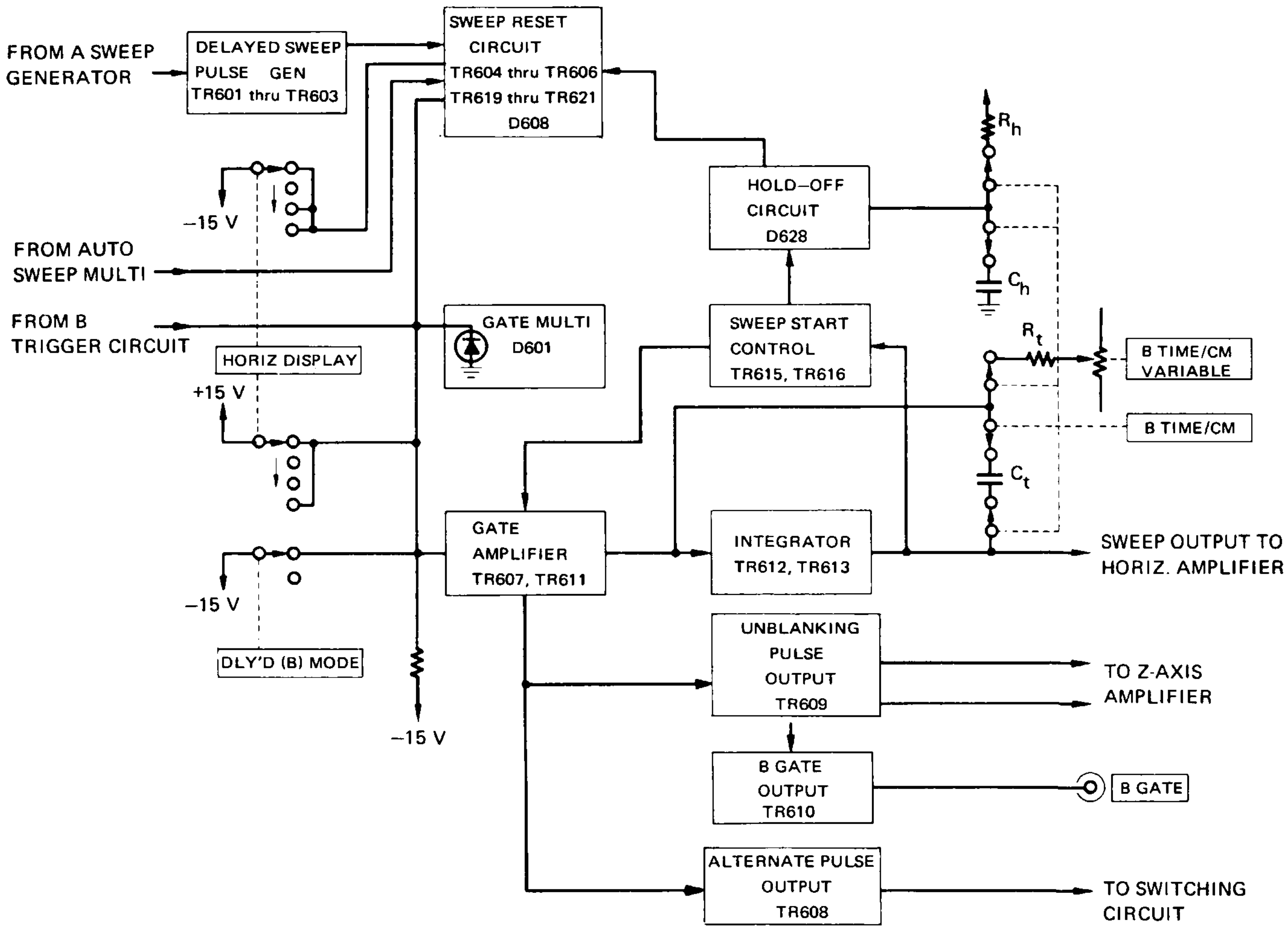


Figure 3-23 Block Diagram, B Sweep Generator

TR502, and the amplified input signal fed to the deflection plates of CRT, are in phase, the sweep can be triggered from an optional point on the positive going slope of the input signal waveform.

When SLOPE switch S503 is set to the – position, the initial conditions of TR503 and TR504 are reversed. In this case, TR504 is conducting and TR503 is off. When the trigger signal passes through the trigger level, TR503 turns on,. TR504 turns off, and D513 is switched from the low-voltage state to the high-voltage state.

A switching circuit composed of a diode and a switch is provided between the input emitter follower and the level comparator. The function of this circuit is to switch the trigger signal or the horizontal signal to the following circuits.

When the HORIZ DISPLAY switch is set at the A position, –15 volts is applied to R517; D507 turns on and D506 turns off, and the trigger signal is not fed to the shaping circuit.

When the HORIZ DISPLAY switch S401 is set at A INTEN BY B or DLY'D (B) position, D507 turns off. During this time D506 is controlled by the DLY'D (B) MODE switch. When this switch is set at the TRIG'D position, D506 turns on and the trigger signal is fed to the shaping circuit. In the AUTO position, D506 turns off.

When the HORIZ DISPLAY switch is set at the EXT HORIZ position, D506 and D507 turn off and D565 turns on. Consequently, the horizontal input signal connected to the TRIG OR HORIZ INPUT connector is fed to the horizontal signal amplifier.

k. **B SWEEP GENERATOR** (Schematic 10). The B Sweep Generator is configured as shown in Figure 3-23. The basic concept of this circuit is similar to the A Sweep Generator circuit. The B Sweep Generator is actuated when the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position, to generate the following signals:

(1) Sawtooth Sweep Waveform
(2) Unblanking Signal
(3) Gate Pulse
(4) Alternate Signal

Basic operation of the A INTEN BY B mode is similar to that of the single sweep operation in the A Sweep Generator. The B Sweep Circuit, in this case, is actuated by the A Sweep Signal.

The condition required to actuate the A or B Sweep Generator is to drive the tunnel diode, D429 (A Sweep), or D608 (B Sweep), to its high voltage region. The sweep is inactivated by placing the tunnel diode in its low voltage region. The circuit from TR404 in the A Sweep Generator to TR614 and D625 in the B Sweep Generator is used to inhibit the B sweep, based on this principle.

In the A INTEN BY B (and DLY'D (B) sweep which will be described later) operation, the B sweep always starts after the A sweep, however the duration of the two sweeps usually differs. When the A sweep ends before the B sweep, the B sweep is terminated with the end of the A sweep. A case where the B sweep ends faster than the A sweep will now be described. Waveforms in this mode of operation are shown in Figure 3-24. The B Sweep Generator, as previously described, operates in a manner similar to single sweep operation in the

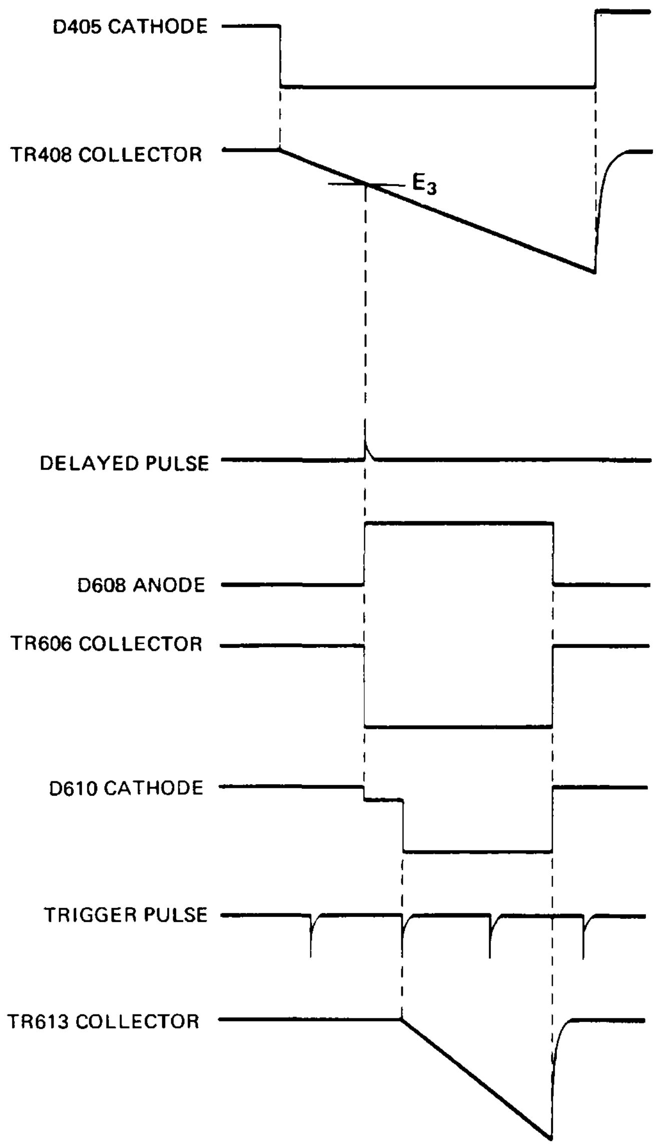


Figure 3-24 Waveforms, A INTEN BY B Sweep Mode

A sweep. The delay pulse in the B sweep mode corresponds to the reset pulse in the A sweep operation.

A sawtooth is supplied from the A Sweep Generator to the delayed sweep pulse generator, or the base of TR601. Transistor TR601A/B is a voltage comparator, with the left side (TR601A) conducting and the right side (TR601B) cut off. When the sawtooth sweep waveform from the A Sweep Generator reaches the amplitude set by DELAY TIME MULTI R607, TR601B turns off. The operating point of tunnel diode D602 steps to the low voltage region, and the base voltage of TR602 becomes negative causing its collector voltage to become positive. This positive transition is differentiated by R614 and C605 and forms a positive pulse. The positive pulse, the timing of which is controlled by DELAY TIME MULTI R607, is fed to the anode of D608.

The delay pulse drives D608 to its high voltage region, causing the collector voltage of TR606 to become negative.

The operating point of D610 steps to point C in Figure 3-17 to reset the B Sweep Generator. The B sweep starts with a trigger pulse, but after one cycle of sweep operation is completed, the operating point of D610 returns to point A in Figure 3-17, and the circuit operation stops until another delay pulse is applied to reset the circuit. Triggered operation with the DLY'D (B) MODE switch is set to the TRIG'D position as follows. When the bias voltage of D610 is determined so that the operating point steps to point C in Figure 3-17 at the same time that D608 steps to its low voltage region and shuts off TR606 at the end of a sweep, the sweep will be repeated, being triggered by the delay pulse regardless of the trigger pulse. This is the non-triggered operation which is performed when the DLY'D (B) MODE switch is placed in the AUTO position. The operation of the circuit, when the A sweep ends sooner than the B sweep, will be described using non-triggered operation as an example. (Following this description, operation of the triggered operation will be understood easily).

First, the A sweep starts, and the delay pulse actuates the B sweep. The operation of this circuit is the same as the previous description until just prior to the end of the A sweep. At the end of the A sweep, TR401 shuts off and the collector of TR401 and the base of TR402 go negative. The emitter of TR402 is connected to the emitter of TR605 and its base voltage is fixed at an intermediate value between the positive and negative voltage on the base of TR402. Therefore, when the base of TR402 becomes positive, TR402 conducts and current flows through the common emitter resistor. When the base of TR402 becomes negative, TR402 is shut off, and the current flows through TR605. The negative change on the base of TR402 at the end of the A sweep, causes TR605 to conduct and drives D608 to its low voltage region through D606. TR606 turns off, and its collector voltage becomes positive to end the B sweep. In this manner, the B sweep ends simultaneously with the end of the A sweep. The B sweep unblanking signal is fed to the Z-Axis Amplifier in this mode to intensify the trace during the B sweep time.

The operation in the DLY'D (B) MODE is substantially the same as that of the A INTEN BY B MODE. The following explanations are for a case in which the DLY'D (B) MODE switch is set at the AUTO position; non-triggered delayed sweep. The DLY'D (B) sweep is of two types differentiated by the relative time positions of the ends of the A and B sweeps, i.e., when the end of the B sweep lags behind the end of the A sweep and vice versa. See Figure 3-25.

First, consider the case in which the end of the B sweep lags behind the end of the A sweep. Suppose sweep A begins and then sweep B is triggered by the delay pulse. The action up to the moment sweep B ends upon completion of sweep A is identical to the case in which the end of sweep B lags behind the end of sweep A in the A INTEN BY B MODE. In the DLY'D (B) MODE, as shown in Figure 3-25, the B sawtooth which is terminated at the completion of sweep A (a sawtooth whose amplitude is smaller than that of E_4 which is required to display a full trace on the viewing area of the CRT) is fed to the horizontal preamplifier, and since the sweep is controlled by this waveform, the length of a trace becomes shorter as its amplitude decreases. The slower the B sweep becomes as compared to the A sweep, the shorter the length of the trace gets. (However, since an expanded display of the input signal by the DLY'D (B) MODE cannot be

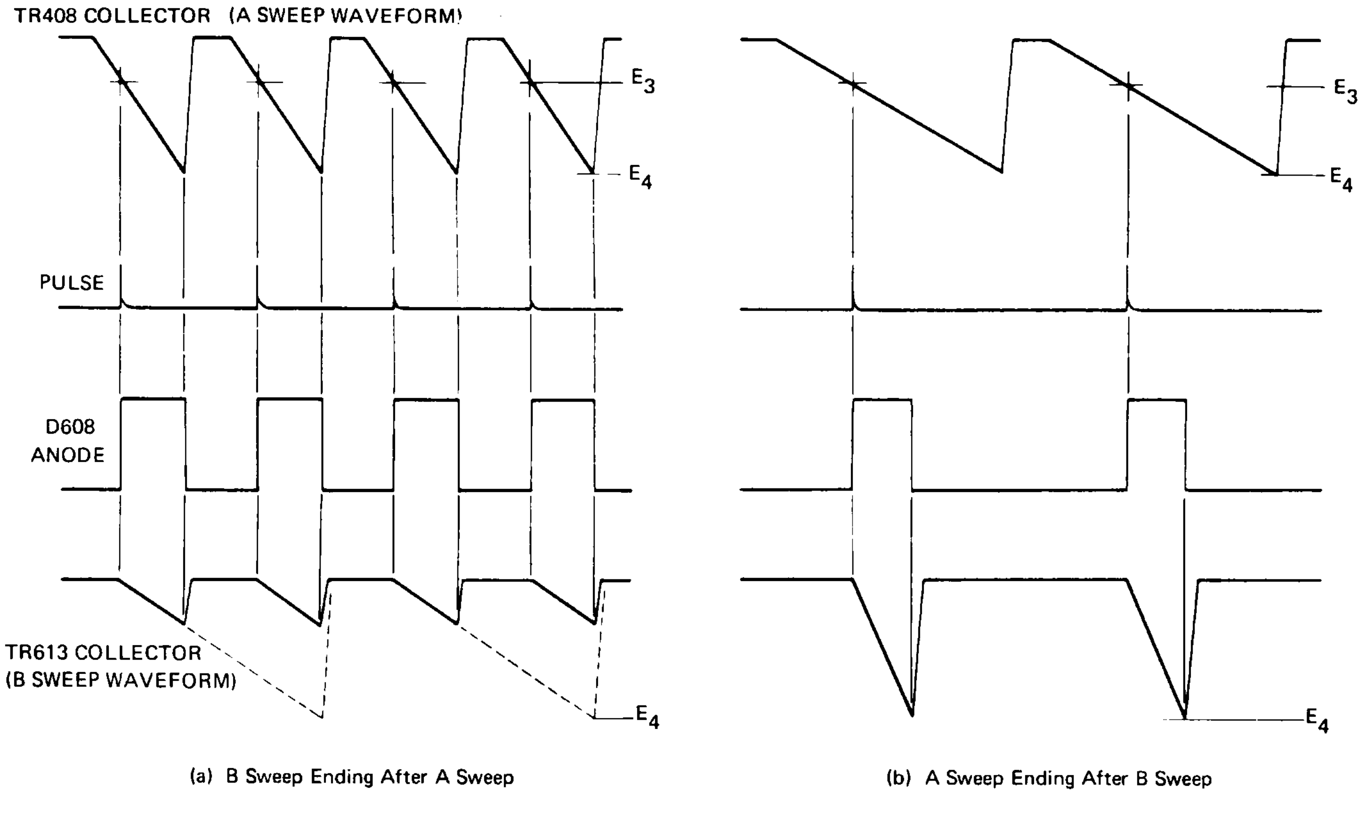


Figure 3-25 Waveforms, DLY'D (B) Sweep Mode

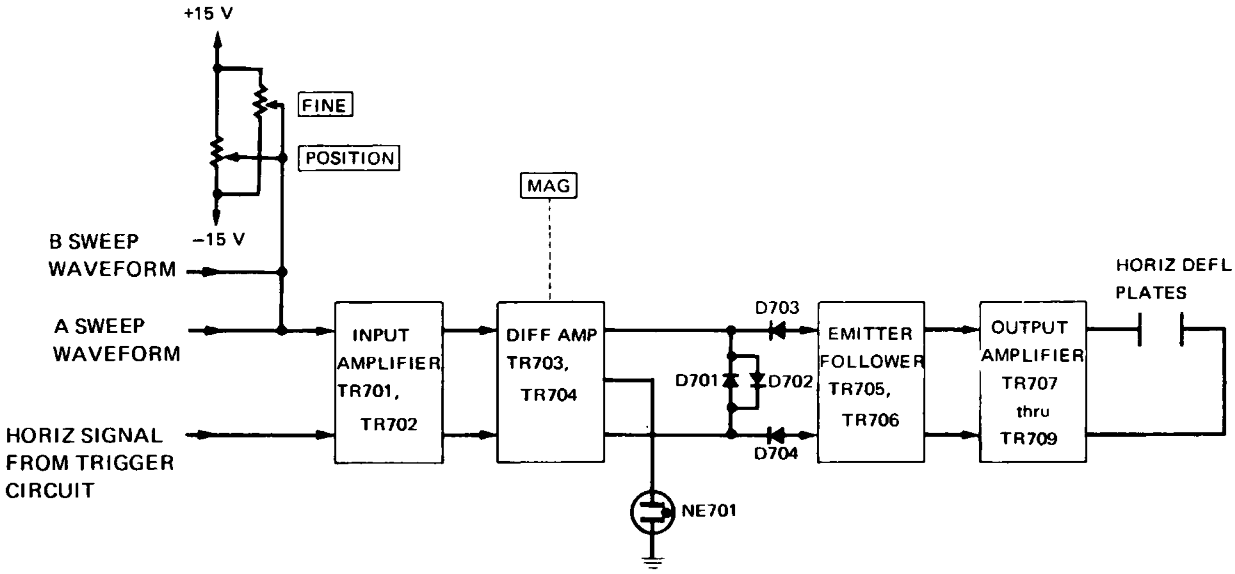


Figure 3-26 Horizontal Amplifier Block Diagram

effected unless the B sweep rate is faster, it will not present any problem in actual measurements.)

Next, consider a case in which the end of the B sweep leads the end of A sweep. As shown in Figure 3-25, since the B Sweep Waveform is not terminated by the A sweep even if its slope is steep, the voltage is always maintained at a level of E_4 and therefore the length of a trace will not be shortened.

l. **Horizontal Amplifier.** (Schematic 12) The horizontal amplifier accepts inputs from either of the two sweep generators or from a horizontal input, either from an external source or from the Channel 2 input signal. Cascaded differential amplifier stages provide amplification to the levels required by the horizontal deflection plates of the CRT.

Referring to Figure 3-26, the input amplifier consists of a pair of grounded-emitter amplifiers with collector-base feedback. Input stage TR701 accepts signals from the A or B Sweep Generators; TR702 accepts signals from the external horizontal inputs. Coarse and fine POSITION controls R710/R711 vary the dc voltage at the base of TR701 to move the position of the trace on the CRT screen. The input stages are followed by emitter-coupled differential stages TR703/TR704. These stages convert the single-ended sweep or external horizontal signals to the balanced (push-pull) signals required by the horizontal deflection plates. The emitter resistance of these stages can be selected by RL701 to give a X10 gain increase in the X10 position of the MAG switch. This gives an effective increase of the sweep speed to 10 times the setting of the TIME/CM switch. The output of the differential pair drives an operational amplifier composed of TR705/TR707 and TR706/TR708. The input to these stages is protected by a diode network which clips large-amplitude signals. The output to the deflection plates is taken from the collector of TR708 and the emitter of emitter follower TR709.

m. **Z-Axis Amplifier** (Schematic 13). The Z-Axis circuit provides intensity modulation and blanking of the CRT. Referring to Figure 3-27, the input signal is applied to the emitter of grounded-base amplifier TR801. Diodes D801 and D802 form a protective network for TR801. The dc level

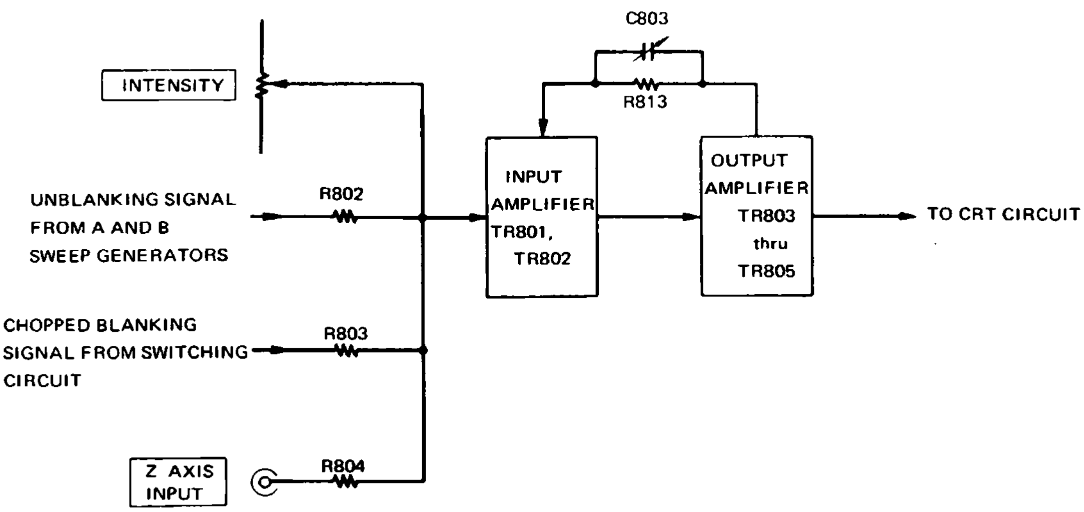


Figure 3-27 Z-Axis Amplifier Block Diagram

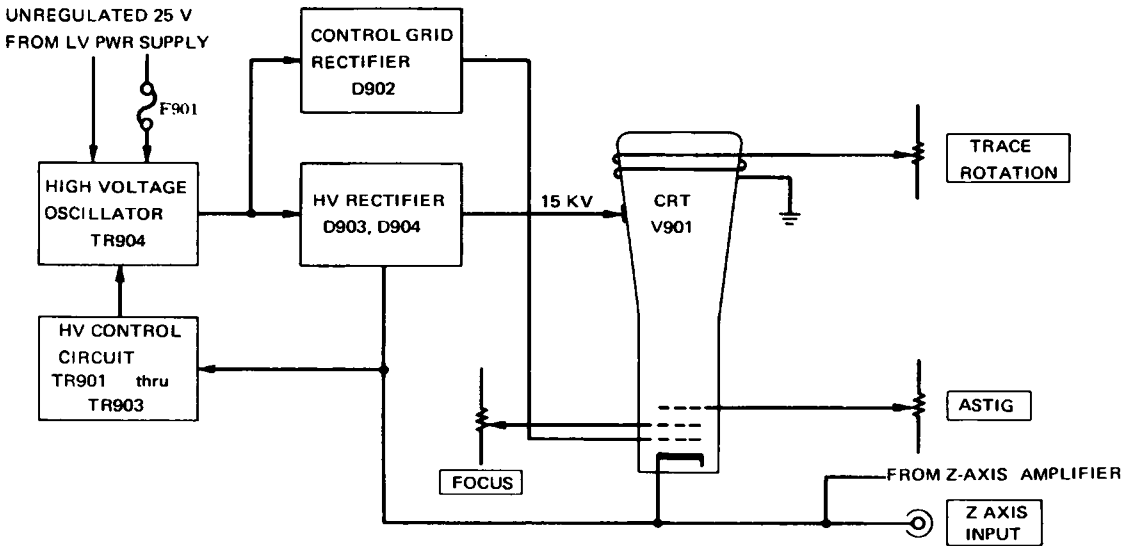


Figure 3-28 High Voltage Power Supply Block Diagram

at the emitter of TR801 is varied by INTENSITY control R806, which shifts the dc level at the amplifier output to increase or decrease the intensity. When R806 is turned fully counterclockwise, the collector current of TR801 is nearly zero, and the voltage at the collector starts to rise toward +65 V. When the voltage reaches approximately +1.5 V it is clamped by D801. D801 and D802 operate in a similar manner when the unblanking signals from the A and B sweep generators are applied to the amplifier.

When HORIZ DISPLAY switch S401 is in either the A INTEN BY B or DLY'D (B) position, the unblanking signal is connected to TR801 through R802. The level of the unblanking signal is approximately −0.7 V in the "off" or blanked state. This is enough to turn off TR801 and blank the CRT. When either of the unblanking signals goes positive, TR801 turns on and the CRT is unblanked. R806 can provide enough current to turn on TR801 even in the blanked state, so that a spot will appear on the CRT when R806 is turned clockwise. A blanking signal from the switching circuit is connected for the dual-trace chopped mode. This signal blanks the CRT during the time that the switching circuit is switching between vertical channels. The main Z-Axis amplifier is a cascaded feedback amplifier composed of TR802, TR803, and TR804. A feedback network is connected from the collector of TR803 to the base of TR802 to provide flat frequency response. The CRT grid is driven by emitter follower TR805, which incorporates diodes D803, D804, and D805 as protection against overloads.

n. CRT Circuit (Schematic 14). The CRT circuit consists of a high-voltage anode power supply and control grid power supply, together with CRT geometry adjustments. Figure 3-28 is a block diagram of the circuit.

The control grid power supply consists of a half-wave rectifier and RC filter network. The ac voltage at pins 7 and 8 of T901 is rectified by D902. The resulting pulsating dc is filtered by C906, R915, and C907/C908. Intensity modulation signals from the Z-Axis amplifier are coupled to the grid through C907 and C908. Neon lamps NE901A, B, and C protect the CRT from excessive grid-cathode voltages.

High voltage for the CRT anode is provided by a regulated supply composed of an oscillator, transformer, voltage multiplier, filter, and regulator circuit. Anode voltage is generated by a positive supply consisting of D404A, B, C, and D and C910 through C914. A negative supply for the CRT cathode is obtained by a half-wave rectifier connected at the center tap of the high-voltage winding. Filtering for the −1450 V supply is provided by C912. A sample of the cathode voltage is connected to an error amplifier consisting of TR901 through TR903. The feedback through R905A-G is connected to a voltage divider network composed of HV adjustment R901 and R902. The voltage divider is connected to the base of TR901, which is a differential amplifier. The difference between the cathode voltage sample and the −15 V regulated voltage is amplified and applied to TR902 and TR903, which limit the current available to 30 kHz oscillator TR904. If the output of the oscillator or voltage multiplier varies, the feedback from the supply output causes a correction in the oscillator current to return the supply output to the required value. Potentiometer R901 unbalances the regulator to adjust the output voltage to +13.5 kV.

o. LOW VOLTAGE POWER SUPPLY (Schematic 16). Configuration of the power supply circuit is shown in Figure 3-29. The power supply consists of three regulated power supplies, a 6.3 Vac source, and unregulated +150 V and +130 V sources.

Power is applied to transformer T2001 through POWER ON switch S1001, LINE VOLTAGE RANGE switch S1003 and THERMO CUTOUT S2002. When this instrument is used on an 100 Vac line, the two primary windings of T1001 are connected in parallel. In the LOW position of the LINE VOLTAGE RANGE switch, terminals 1 - 2 and 4 - 5 are connected in parallel, and in the HIGH position of the switch, windings 1 - 3 and 4 - 6 are connected in parallel.

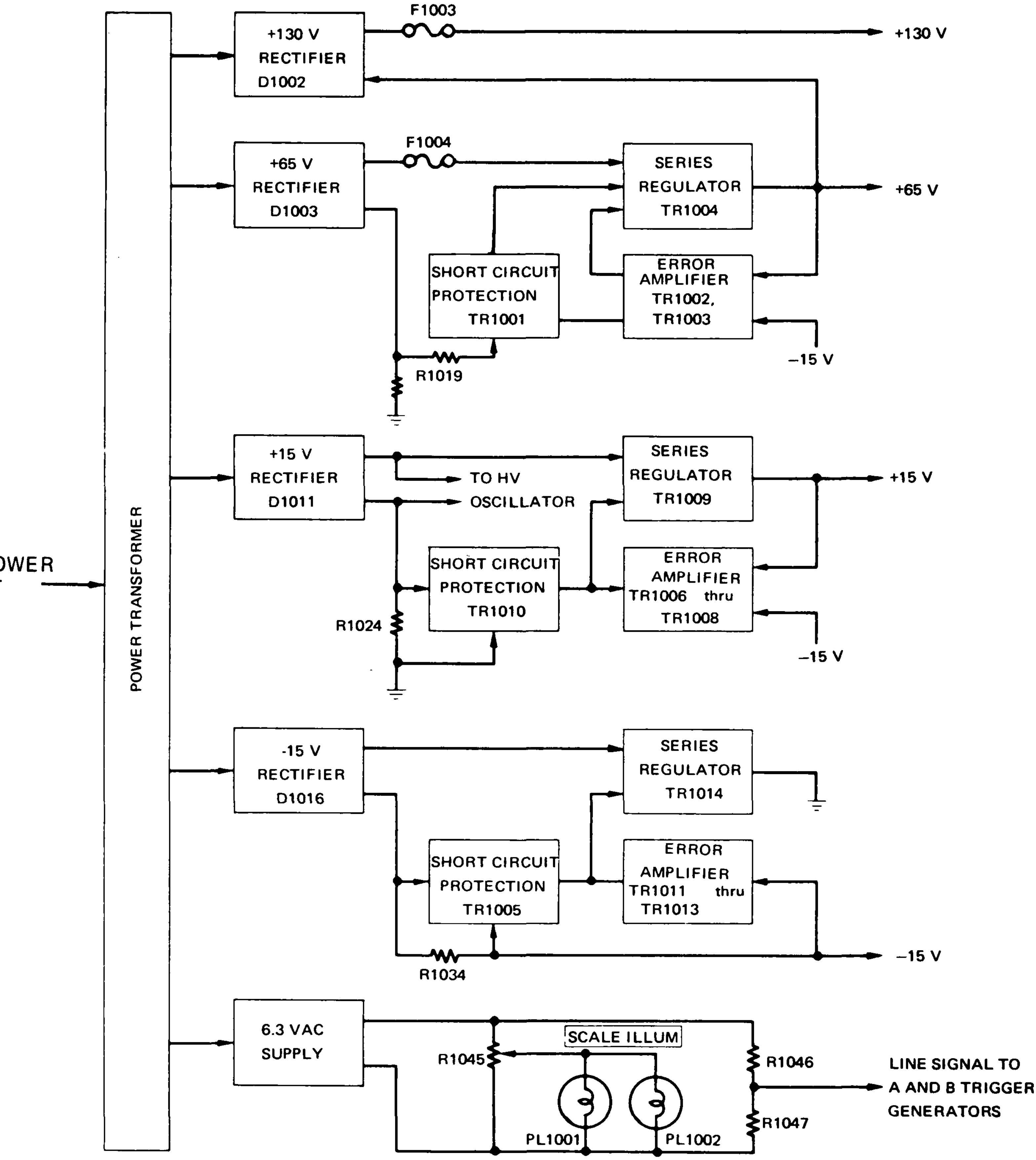


Figure 3-29 Low Voltage Power Supply Block Diagram

When the instrument is used on a 200 Vac line, the two primary windings are connected in series, as shown in the diagram enclosed by a dashed line.

If the internal temperature of this instrument becomes excessively high, THERMO CUTOUT S1002 operates to disconnect the power supply. This switch automatically restores when the instrument temperature returns to normal.

The −15 V supply is used as the reference voltage for the other power supplies. The voltage from the secondary winding (across terminals 15 - 16) is rectified by bridge rectifier D1016A-D and filtered by C1018. The output of the filter is fed to the −15 V series regulator TR1014. The series regulator may be considered as a variable resistor controlled by the output of the error amplifier.

The error amplifier is a voltage comparator which compares the −8.5 V reference voltage on the base of TR1011A (determined by D1017), with voltage on the base of TR1011B (determined by the voltage divider R1034, R1040, R1041). Potentiometer R1040 adjusts the −15 V output voltage. R1038 is connected to the emitters of both TR1011A and B. The collector current of TR1011A flows through TR1012 and TR1013 and controls the series regulator, TR1014. The current in TR1014 varies to supply the low ripple −15 V regulated voltage. By turning variable resistor R1040 in the direction indicated by the arrow, the current through TR1011B increases, that through TR1011A decreases, and the currents through TR1012 and TR1013 increase. Finally the current through TR1014 increases and output voltage rises.

To supply a constant voltage to the load, a portion of the output voltage is fed back, through the error amplifier to the series regulator. For example, if the −15 V output rises due to variation in the load or line voltage, this increase raises the base voltage of TR1011B through the voltage divider. This increase in base voltage causes the emitter voltage to become more negative, and the collector of TR1011A becomes more negative. The emitter voltages of TR1012 and TR1013 also decrease to reduce current through TR1014. Finally, the output voltage decreases until it reaches −15 V.

Transistor TR1010 protects the series regulator if the −15 V output is shorted to ground. Normally, TR1010 is shut off, but if a large current flows through R1034 due to a short circuit in the −15 V output, the voltage drop across R1034 causes the emitter of TR1010 to become negative, allowing the transistor to conduct. TR1012 and TR1013 are turned off, and protect TR1014 from excessive current.

The DC voltage rectified by bridge rectifier D1011A-D is filtered by C1013 and is supplied to the +15 V series regulator and CRT high voltage oscillator circuits. The regulated −15 V is used for the reference voltage of the +15 V circuit. The +15 V and the −15 V outputs are divided by resistors R1029, R1028, R1027, and the divided output is fed to the base of TR1006. If variation occurs in the +15 V output, the variation is amplified by error amplifier TR1006, TR1007, and TR1008, and is fed to series regulator TR1009 to regulate the output voltage. Diode D1014 is a thermal compensator whose temperature coefficient compensates for thermal variations of the TR1008 bias voltage source.

TR1005 also protects TR1009 from excessive current due to short circuits in the +15 V output circuits. The operation of R1024 is identical to that of R1034 in the -15 V supply.

The basic operation of the +65 V supply is similar to that of the +15 V supply.

Diode D1006 is normally shut off, and conducts only if a short circuit occurs in the +65 V output circuit. This diode functions to reduce the base potential of TR1003 and prevent excessive current in TR1004.

The output of a +65 V rectifier (D1002A-D and C1004A-B) is superimposed on the output of the +65 V supply to provide a voltage of approximately +130 V.

Two 6.3 Vac source circuits are provided; one is for the CRT filament and the other is for the scale illumination light PL1001 and PL1002 and is also divided by R1046/1047 to 1.5 Vac to provide line trigger signals for the A and B trigger generator.

p. **CALIBRATOR** (Schematic 15). Figure 3-30 shows a block diagram of the Calibrator (calibration voltage and current oscillator) which generates square wave voltage and current of highly accurate frequency and amplitude.

The calibrator oscillator is composed of two transistors, TR1101 and TR1102. Oscillation frequency is determined by the collector winding of T1101 and capacitor C1104.

High stability is obtained by employing low temperature coefficient components in this circuit. Oscillations of the LC circuit (T1101 - C1104) are sustained by the feedback winding of T1101 connected to the base of TR1101. The oscillator output is fed to the base of TR1102, through

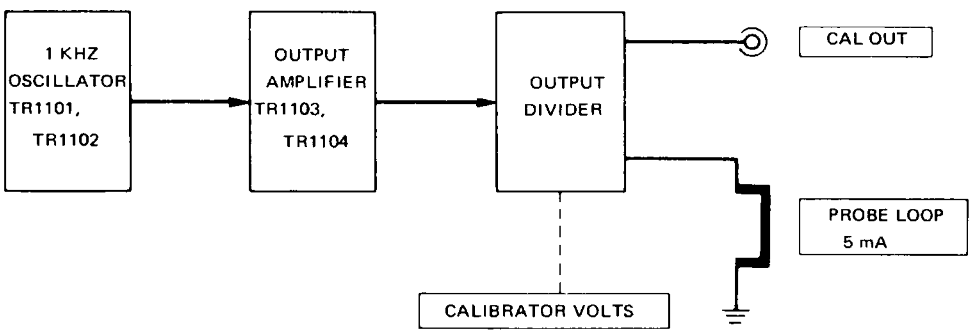


Figure 3-30 Calibrator Block Diagram

C1105, and the emitter is fed back (positive) to the emitter of TR1101 to accelerate the rise time of the output square wave. The oscillator frequency is adjusted by varying the inductance of T1101. The square wave output of TR1102 is then fed to the output amplifier.

The square wave signal drives the output amplifier, TR1104, to saturation and cutoff. When the base of TR1104 steps positive, TR1104 is shut off, and its collector potential is nearly zero. When the base becomes negative, TR1103 saturates causing its collector to become approximately 10 V (the collector voltage of TR1103 at saturation is adjusted with screwdriver adjust potentiometer CAL ADJ R1102). Emitter follower TR1103 supplies power to the emitter of TR1104 and collectors of TR1101 and TR1102.

The collector current of TR1104 flows through the voltage divider resistors and the PROBE LOOP. The current through the PROBE LOOP is a 5 mA square wave. The output voltage of TR1104 is divided and supplied to the CAL OUT connector through the CALIBRATOR VOLTS switch.

SECTION 4
MAINTENANCE

4-1 GENERAL INFORMATION

This section of the manual gives maintenance notes and calibration procedures for the Model SS-112. This instrument requires a normal amount of maintenance; however normal aging of electronic components may cause abnormal operation eventually. Use of the following procedures should prevent many minor malfunctions or permit their detection before a major repair is required.

4-2 PREVENTIVE MAINTENANCE

a. **Cleaning and Visual Inspection.** A regular program of inspection and maintenance is recommended to minimize downtime. The operating environment and amount of usage will dictate how often the instrument should be cleaned. A maximum of six months should elapse between inspections. Check the instrument as follows:

(1) Disconnect the power cable from the primary power source. Inspect the exterior of the instrument for broken knobs, switches, or connectors.

(2) Remove the two side panels and inspect the interior of the instrument. If an excessive amount of dust is present inside the instrument, use a soft paintbrush and low-pressure air stream or vacuum cleaner.

(3) Check circuit boards and switches for damage or signs of overheating. Check capacitors and the power transformer for leakage. Check all plug-in connections for security. If signs of overheating are detected, do not return the instrument to service until the cause of overheating has been corrected.

(4) Clean the exterior of the instrument, including the covers, with soap and water or a mild detergent and water. Do not use chemical cleaning agents such as acetone, xylol, lacquer thinner, or MEK. Any of these may damage the plastics used in this instrument.

(5) Clean the CRT faceplate with a soft cloth dampened with alcohol.

Table 4-1 Power Supply Wiring Color Code

Power Supply	Base Color	Stripe Color
-15 V	white	black
+15 V	white	red
+65 V	white	blue
+130 V	white	brown

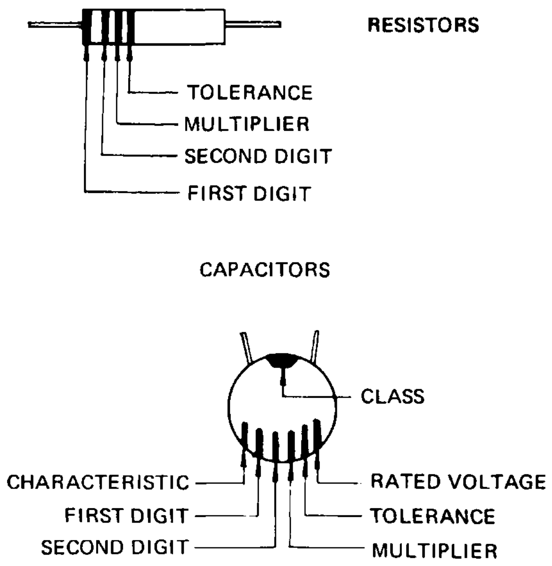


Figure 4-1 Resistor and Capacitor Color Code

(6) The mesh CRT filter can be cleaned by using a soft artist's brush to remove dust, and a mild detergent and water to remove stains. After washing, rinse with clear water and allow the filter to air dry. Do not use a hard or sharp-pointed tool on the filter; the mesh may be damaged.

4-3 TROUBLESHOOTING

As an aid to troubleshooting, waveforms and voltage levels are indicated on the schematic diagrams in Section 6. Also, component location illustrations are included. The block diagram in Section 3 will aid in localizing the trouble to a specific circuit block.

a. **Schematic Conventions.** The schematic diagrams included in Section 6 use conventional circuit symbols and reference designations. Diodes are designated D, and transistors are designated TR. In the vertical input and vertical preamplifier sections, the components have identical numerical designations with an alphabetic suffix to differentiate between channels. For example, Channel 1 components are designated TR1A, C2A, R3A, etc. Channel 2 components are designated TR1B, C2B, R3B, etc. Wafers of rotary switches have a designation defining their location on the switch and whether the switch section is on the front or rear of the wafer. For example, S401A-F designates the front of the wafer nearest the front panel. The TIME/CM switch shown in

Schematic 11 has an additional designation indicating that the particular switch section is part of the A sweep circuit or the B sweep circuit. For example, aA-R indicates the rear of the first wafer of the A sweep TIME/CM switch; bA-R indicates the rear of the first wafer in the B TIME/CM switch.

b. Circuit Board and Component Identification. Component location photographs are included in Section 6 just preceding the schematic diagrams. These photographs locate complete assemblies within the instrument and components on each assembly.

c. Wire Color Codes. All insulated wire used in the instrument is color-coded to aid in tracing signals and power supply voltages. Although there are some exceptions, the color codes generally follow the patterns shown in Tables 4-1 and 4-2.

d. Component Value Color Codes. Resistor values are indicated with standard RETMA color codes (see Figure 4-1 and Table 4-1). Capacitor values are indicated with the color codes shown in Figure 4-1 and listed in Table 4-3. Values of other components are marked on the body of the component.

e. Diode and Transistor Lead Identification. The lead configuration of transistors and diodes used in the Model SS-112 are shown in Figures 4-2 and 4-3.

f. Recommended Test Equipment for Troubleshooting. The following is a list of the test equipment recommended for locating troubles in the Model SS-112.

(1) High-impedance Volt-Ohmmeter with high-voltage probe to measure up to 2 kV. Input resistance not less than 10 megohms with voltage range 0-300 Vdc. Capable of measuring 2 kV with high-voltage probe. Ohmmeter range 0-20 megohms.

(2) Transistor Curve Tracer.

(3) Oscilloscope with 50 MHz bandwidth and 5 mV/cm sensitivity.

g. Troubleshooting Procedures. Since the SS-112 is a relatively complex instrument, troubles can occur through a number of channels; operator controls may be set improperly, calibration of the instrument may not be correct, or a circuit failure may have occurred. The following paragraphs serve as a general guide to systematic troubleshooting.

(1) Check control settings to ensure that they are set properly for the measurement conditions. Input signals with low repetition frequencies may require adjustment of intensity, especially at high sweep speeds. Check triggering controls to determine that source, slope and polarity are

Table 4-2 General Wire Color Code

Circuit	Wire Color
Collector or Drain	red
Base or Gate	yellow
Emitter or Source	blue
Positive Voltage	brown
Negative Voltage	violet or gray
Ground	black

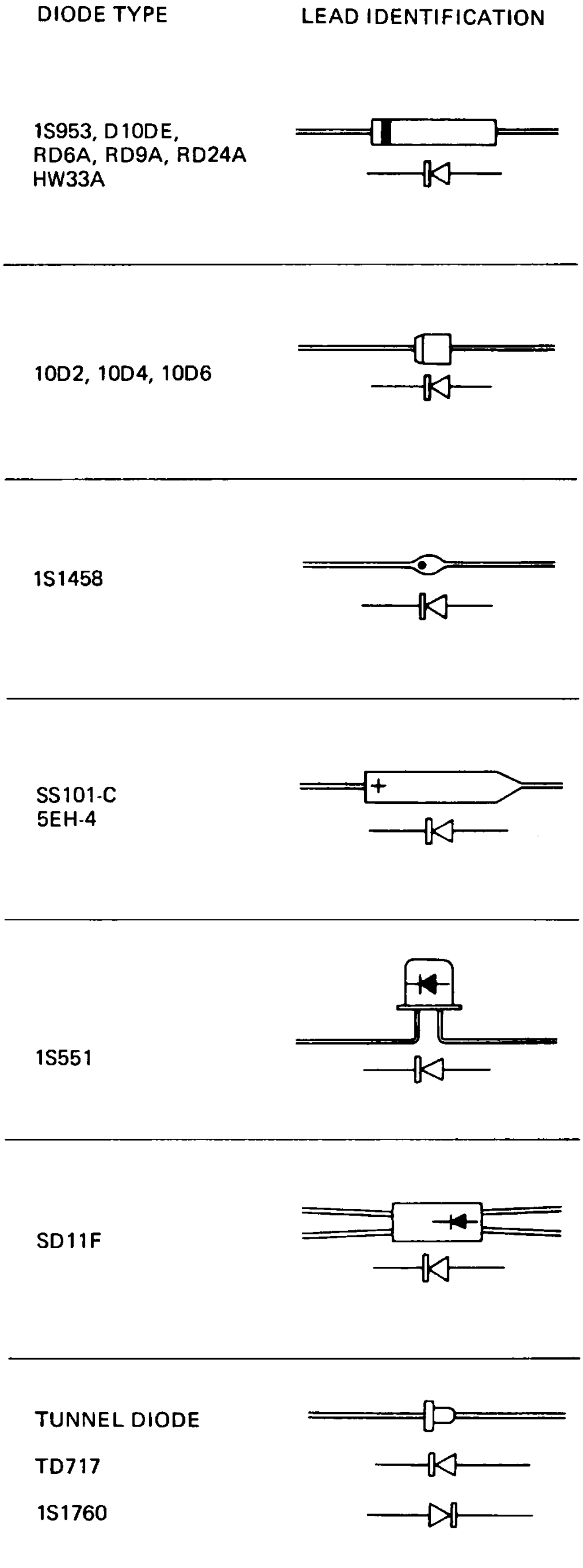


Figure 4-2 Diode Lead Identification

correct. If the sweep cannot be triggered normally, use the automatic triggering mode to determine if an input signal is present. If the trace is off-screen and the position controls will not bring it on, use ac coupling of the input signal. If this brings the trace into view, check the dc level of the input signal.

(2) Check the external equipment to see that it is providing a signal to the SS-112. If possible, check the external signal source with another oscilloscope.

(3) Check the suspected portion of the instrument for broken wires, loose connections, or damaged components.

(4) Attempt to isolate the trouble to a single circuit by a process of elimination. For example, if vertical deflection is obtained on each channel, but no sweep is possible either from internal sweep or external horizontal input, the trouble is likely to be in the horizontal amplifier. If a sweep is obtained, but no vertical deflection is obtained on either channel, the trouble is likely to be in the vertical amplifier. If a sweep can be obtained from an external source, but not from the internal sweep generator, even on auto trigger mode, the trouble is likely to be in the sweep generator.

Once a trouble has been localized, use the voltages and waveforms on the schematic diagrams to isolate the defective stage.

4-4 REPAIR

Once a defective component has been located, it should be removed and replaced with a new part which meets or exceeds the specifications of the part which it is replacing. Certain transistors are selected and should be replaced with selected transistors obtained from the factory. Table 4-4 lists transistors which are selected.

a. **Replacement of Components on Terminal Strips and Printed Circuit Boards.** Removal and replacement of parts on printed circuit boards requires some care to avoid damage to the printed wiring on the board. Use a low-wattage soldering iron and high-quality, resin core 60/40 solder. Use as little heat as possible to remove the component. Clean out the holes for the leads with a toothpick or use a vacuum desoldering tool. When replacing a component, use only as much heat as necessary to melt the solder and make it flow around the joint. Protect heat-sensitive components by using a pair of pliers or heat sink tweezers around the leads.

If wires or components mounted on ceramic terminal strips are removed, care must be taken to avoid damage to the ceramic-metal bond. Use just enough heat to melt the solder and remove the component or wire. When resoldering, use a hot soldering iron and a small amount of solder. Use just enough solder to make a secure joint. Remove all flux from the strip after soldering.

b. **Replacement of the CRT.** If CRT replacement becomes necessary, use the following procedure:

(1) Remove both side covers, and the rear panel.

(2) Unsolder leads from trace rotation and geometry coils (connected to terminal strip on top of CRT shield).

(3) Disconnect the anode cap.

(4) Remove the deflection plate leads carefully.

(5) Remove the socket from the CRT base.

(6) Remove two horizontal mounting screws from CRT neck.

(7) Remove the bezel from the front panel.

(8) Remove the CRT from the instrument.

WARNING

Dropping the CRT or striking it against a hard object may cause the glass envelope to crack and implode. Use a protective face mask or safety glasses when handling the CRT. When storing, place the CRT faceplate down on a soft surface.

Table 4-3 Resistor and Capacitor Color Code

Color	Value: 1st and 2nd Significant digits	Value: Multiplier	Resistance Tolerance (%)	Capacitance Tolerance (%) >10 pF	Capacitance Tolerance (%) <10 pF	Rated Voltage (capacitor)
Black	0	1	—	±20	±2	—
Brown	1	10	±1	±1	—	—
Red	2	10^2	±2	±2	—	250 V
Orange	3	10^3	—	±2.5	—	300 V
Yellow	4	10^4	—	—	—	—
Green	5	10^5	—	±5	±0.5	500 V
Blue	6	10^6	—	+100,-0	—	—
Violet	7	10^7	—	—	—	—
Gray	8	10^8	—	±10	±0.25	—
White	9	10^9	—	—	±1	1000 V
Gold	—	1/10	±5	—	—	—
Silver	—	1/100	±10	—	—	—
none	—	—	±20	—	—	—

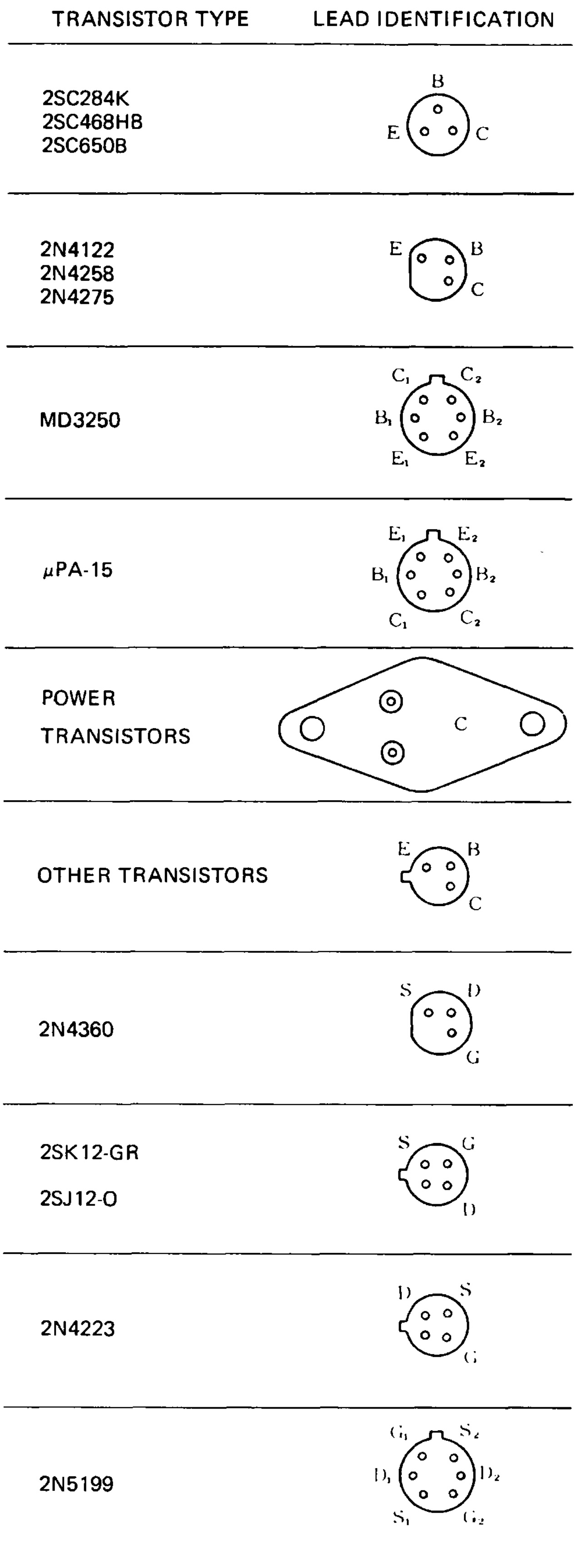


Figure 4-3 Transistor Lead Identification

Table 4-4 Selected Transistors

Circuit	Selected Transistor Circuit Reference
Channel 1 Preamplifier	TR1A, TR4A (dual transistor) TR3A, TR5A through TR13A
Channel 2 Preamplifier	TR1B, TR4B (dual transistor) TR3B, TR5B through TR13B
Switching Circuit	TR121, TR122
Main Vertical Amplifier	TR201 through TR206
A Sweep Generator	TR407
B Sweep Generator	TR612

4-5 CALIBRATION

The following procedures should be used when a check of performance indicates that calibration is required, or when components have been replaced.

a. **Low Voltage Power Supply Calibration.** The low voltage power supplies are located on a circuit board at the rear of the instrument. To gain access to the test points and adjustments, remove the rear panel.

Figure 4-4 shows the location of test points and adjustments on the low voltage power supply board. Perform the adjustments given in Table 4-5 and check the unregulated +130 V supply against the values given in the table.

b. **High Voltage Power Supply Adjustment.** Adjust R901, H.V. Adj (see Figure 4-7) for a voltage of -1450 V ± 10% at the HV supply test point (see Figure 4-5).

c. **Intensity adjustment.** Adjust Inten Adj R917 so that a spot appears on the screen when INTENSITY is fully clockwise with no sweep, and the trace just disappears when a sweep is present and INTENSITY is fully counterclockwise.

d. **CRT Geometry Adjustment.** This procedure aligns the X and Y axes with the vertical and horizontal graticule lines and corrects the CRT for distortion.

(1) Alignment of X and Y Axes. Set A SWEEP MODE to the AUTO position and obtain a free-running sweep. Adjust TRACE ROTATION to align the trace with the horizontal graticule lines. With a clip lead, short the collectors and TR207 and TR208 together. Adjust R925 and R928 (see Figure 4-7) to align the trace with the center horizontal graticule line. Remove the clip lead from the collectors of TR207 and TR208.

Connect a time-mark generator to the vertical input. Set the output of the time-mark generator for 0.1 ms markers. Set the VOLTS/CM switch so that the markers are off-screen in both directions. Adjust R925 and R928 so that the markers are parallel to the vertical graticule lines. Check the alignment of the horizontal axis and repeat the adjustment with TRACE ROTATION and R925/R928 until the vertical and horizontal axes are aligned properly.

(2) Pattern Distortion. With the time-mark generator

Table 4-5 Power Supply Adjustment

Power Supply	Lead Color	Accuracy	Ripple	Calib Seq.	Adjustment
−15 V Regulated	white/black	0%	50 μV	1	R1040
+15 V Regulated	white/red	±0.5%	50 μV	2	R1028
+65 V Regulated	white/blue	±0.5%	500 μV	3	R1016
+130 V Unregulated	white/brown	±5%	2.5 V	check	-

NOTE: Adjustments should be made at a line voltage of 115 volts, with the LINE VOLTAGE RANGE switch in the HIGH position, or a line voltage of 100 volts, in the LOW position. Corresponding voltages should be used if the instrument is connected for 200 or 230 Vac operation.

connected, set TIME/CM so that one mark appears at each vertical graticule line. Set VOLTS/CM so that the markers are off-screen in both vertical directions. Adjust Int Shield R930 and Geom R931 (see Figure 4-5) for minimum distortion (see Figure 4-6).

e. Vertical Deflection System Adjustments. The following procedures adjust the gain and frequency response of the vertical channels.

(1) Step Attenuator Balance Adjustment. Set MODE to CH 1 position and set front-panel STEP ATTEN BAL adjustment to center of adjustment range. Adjust R42A (see Figure 4-8) so that no trace shift is observed when switching the Channel 1 VOLTS/CM switch from the 5 mV position to the 10 mV position. Repeat the procedure for Channel 2. The adjustment is R42B.

(2) Deflection Sensitivity Adjustment. Connect the output of an amplitude calibrator to the Channel 1 input. Set the calibrator output for 10 mV p-p. Adjust 5 mV Gain R49A for a display exactly 2 cm high, with the VOLTS/CM switch in the 5 mV position. Set the VOLTS/CM switch to the 10 mV position, and set the output of the calibrator for 20 mV. Adjust 10 mV Gain R81A for a display exactly 2 cm high. Repeat the procedure for Channel 2 (the 5 mV adjustment is R49B; the 10 mV adjustment is R81B). Check the other sensitivity ranges; each range should be within ± 3%. Some readjustment of the 10 mV gain may be required to bring all ranges within ± 3% accuracy.

(3) Attenuator Compensation Adjustment. To reach the attenuator compensation adjustments, the front panel of the vertical amplifier assembly must be removed. Remove the knobs from all the vertical amplifier controls and the nut from the MODE switch. The front-panel overlay can then be removed to expose the attenuator adjustments. Replace the knobs temporarily.

Connect the CAL OUT connector of the SS-112 to the Channel 1 input through the 1014 probe. Set VOLTS/CM to 10 mV. Set the calibrator output to 0.5 V. Adjust the compensation capacitor in the probe connector so that the calibrator waveform is properly compensated (see Figure 4-10). Set VOLTS/CM to 20 mV and the calibrator output to 1 V. Adjust C1A and C11A (see Figure 4-9) for a properly compensated waveform. C11A controls the portion of the waveform designated with an "A" in Figure 4-10; C1A controls the portion designated by "B". Adjust the other ranges in the same manner; Table 4-6 lists ranges and adjustments for each range.

(4) Polarity Shift Adjustment. With no signal input to Channel 2, switch CH 2 POLARITY from NORM to INV.

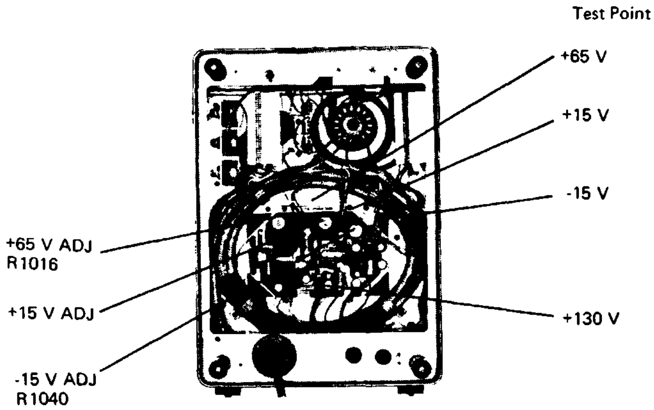


Figure 4-4 Power Supply Test Point and Adjustment Location

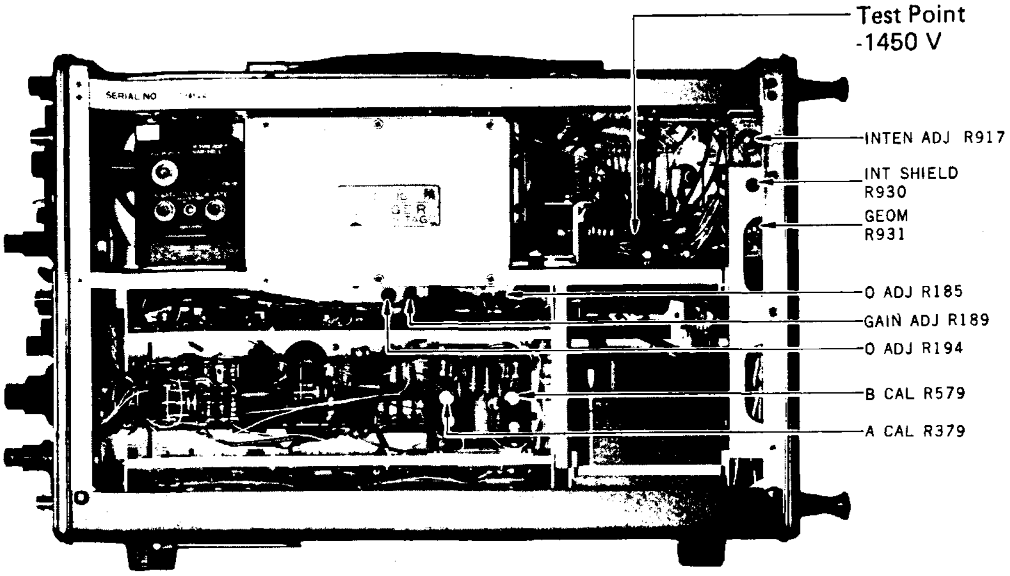


Figure 4-5 Right Side View

Table 4-6 Attenuator Adjustments

VOLTS/CM Setting	Compensation Adjustment A Portion of waveform	Compensation Adjustment B Portion of waveform
5 mV	–	–
10 mV	–	–
20 mV	C11A/B	C1A/B
50 mV	C12A/B	C2A/B
.1	C13A/B	C3A/B
.2	C14A/B	C4A/B
.5	C15A/B	C5A/B
1	C16A/B	C6A/B
2	C17A/B	C7A/B
5	C18A/B	C8A/B

Adjust R85B until no trace shift is observed when switching from NORM to INV.

(5) Frequency Compensation Adjustment. The following procedure adjusts the vertical amplifier frequency response. Table 4-7 gives a step-by-step procedure for compensation adjustments, with representative waveforms shown.

Channel 2 is calibrated first, then Channel 1 is matched to Channel 2. Adjust the output of the Square Wave Generator for a display 40 mm high on the 10 mV/cm range. Adjust the square wave frequency to approximately 500 kHz. Set A TIME/CM to a range which will show the waveforms as in Table 4-6. Follow steps 1-6 in Table 4-7.

Connect the Pulse Generator to the Channel 2 input. Adjust the pulse amplitude to obtain a display 40 mm high. Follow steps 7-9 in Table 4-7. Adjust for fastest risetime with minimum overshoot.

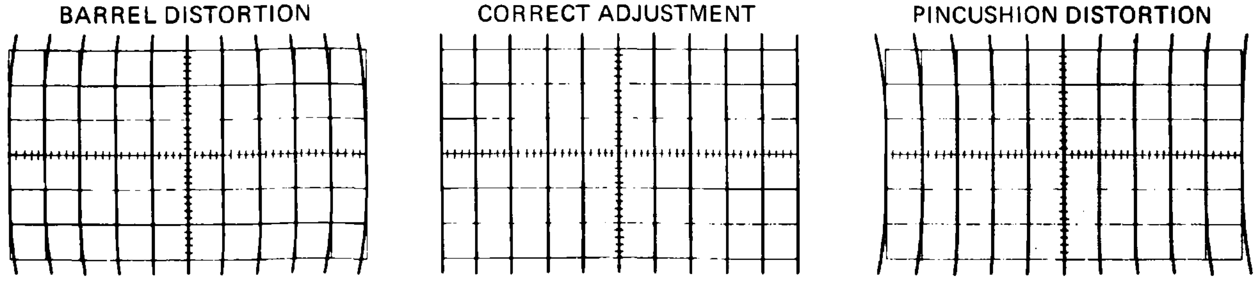
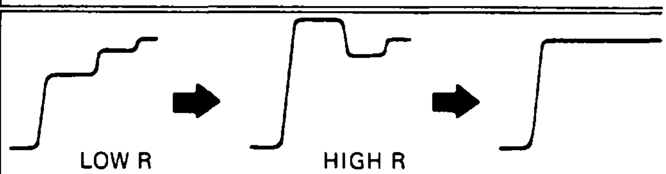
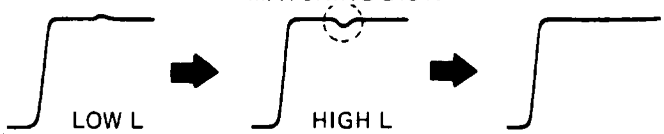
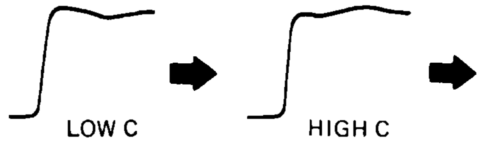
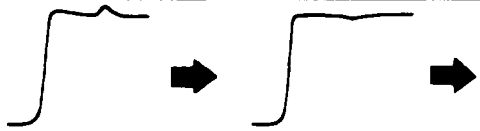
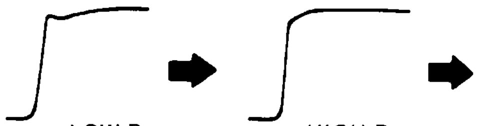
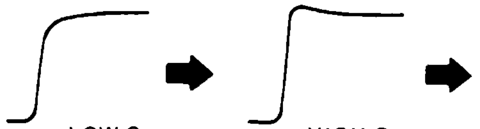
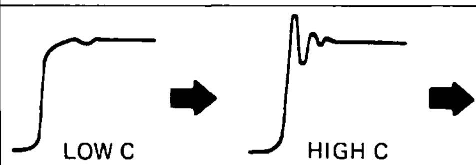


Figure 4-6 CRT Geometry Adjustment

RANGE (VOLTS/CM)	EQPT USED	CAL SEQ	ADJUSTMENT Channel 1	ADJUSTMENT Channel 2	WAVEFORMS	OPTIMUM
10 mV	SQUARE WAVE GENERATOR (less than 20 ns risetime)	1	R201 (both channels)		 LOW R → HIGH R →	
		2	L201 (both channels)		 LOW L → MATCHING DIST. HIGH L →	
		3	C201 (both channels)		 LOW C → HIGH C →	SAME AS ABOVE
		4	R203 (both channels)		 LOW R → HIGH R →	SAME AS ABOVE
		5	R219, R218, C206, R136 (both channels common) MATCH CHANNEL 1 TO CHANNEL 2 WITH R92A, C47A		 LOW R → HIGH R →	SAME AS ABOVE
		6	C125, C207 (both channels)		 LOW C → HIGH C →	SAME AS ABOVE
	PULSE GENERATOR (less than 1 ns risetime)	7	C207, R219 (both channels)		 LOW C HIGH R → HIGH C LOW R →	
		8	R218, C206 (both channels)		 LOW C HIGH R → HIGH C LOW R →	SAME AS ABOVE
		9	C202, C205, C210 (both channels)		 LOW C → HIGH C →	SAME AS ABOVE
			C40B C43B C48B	C41A C44A C48A		
5 mV		10	C36B	C37A	SAME AS ABOVE	

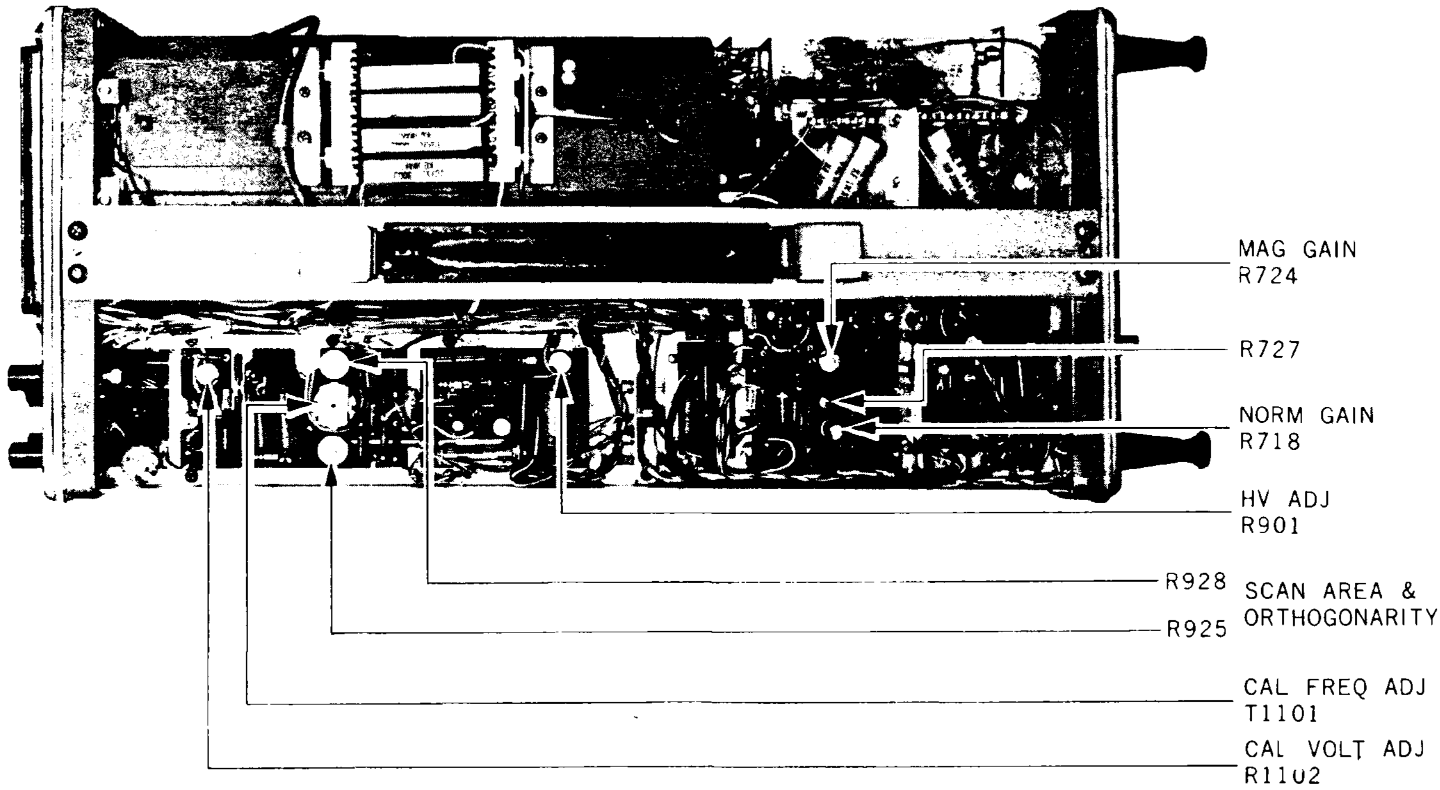


Figure 4-7 Top View

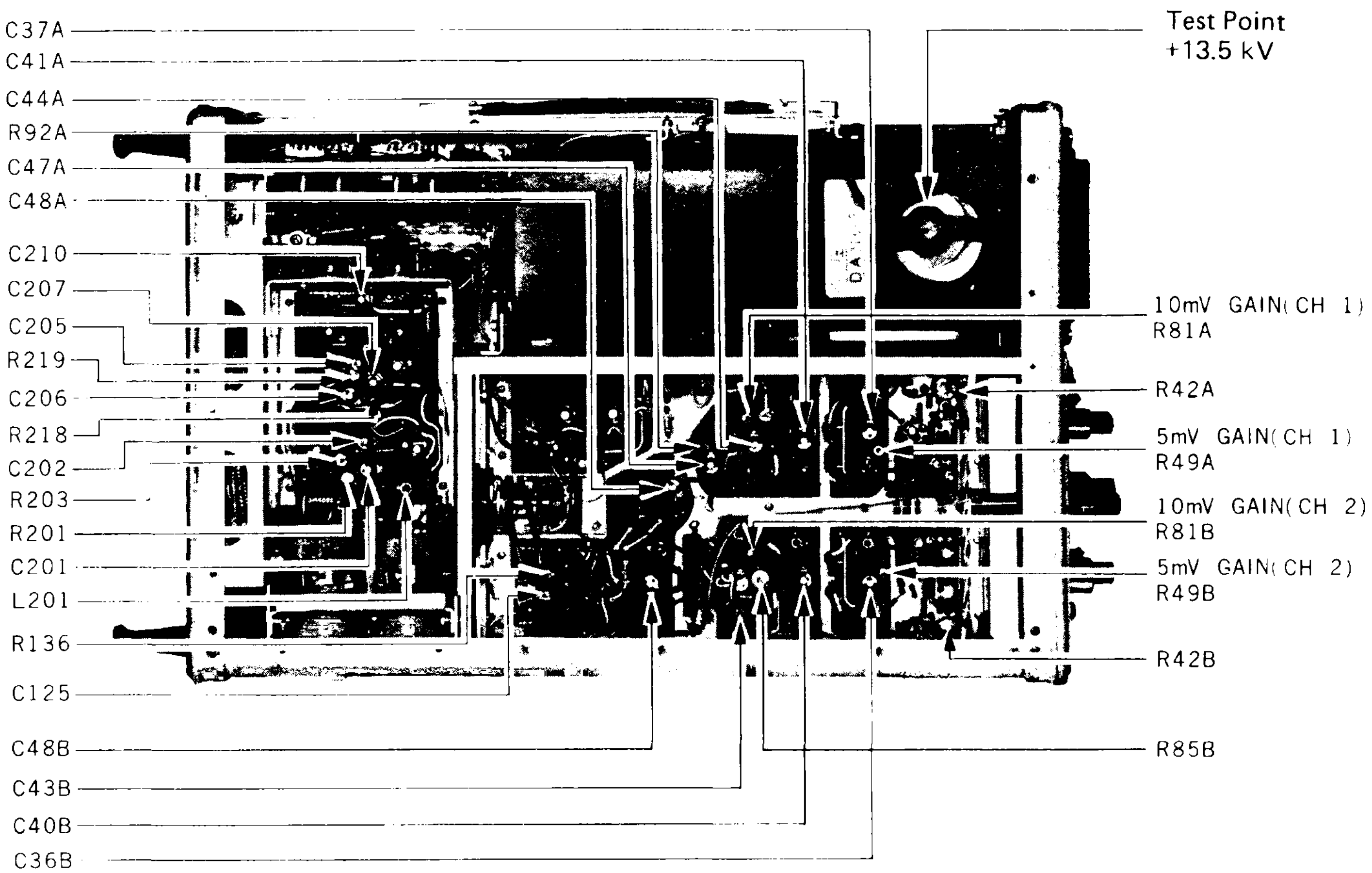


Figure 4-8 Left Side View

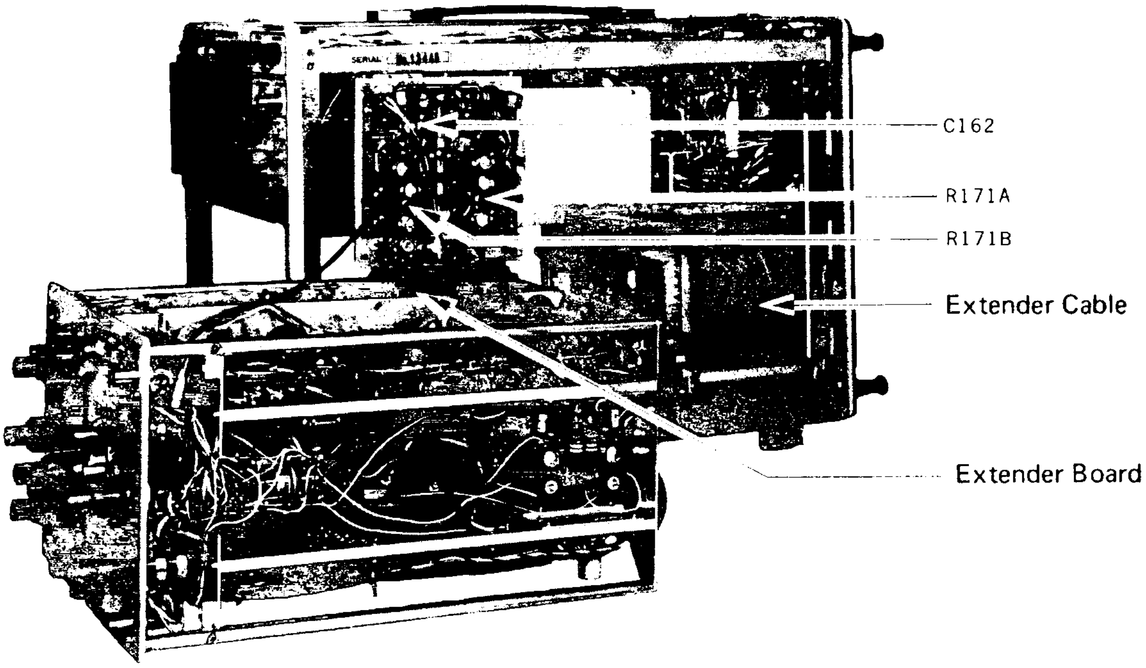


Figure 4-11 Trigger Adjustment Location

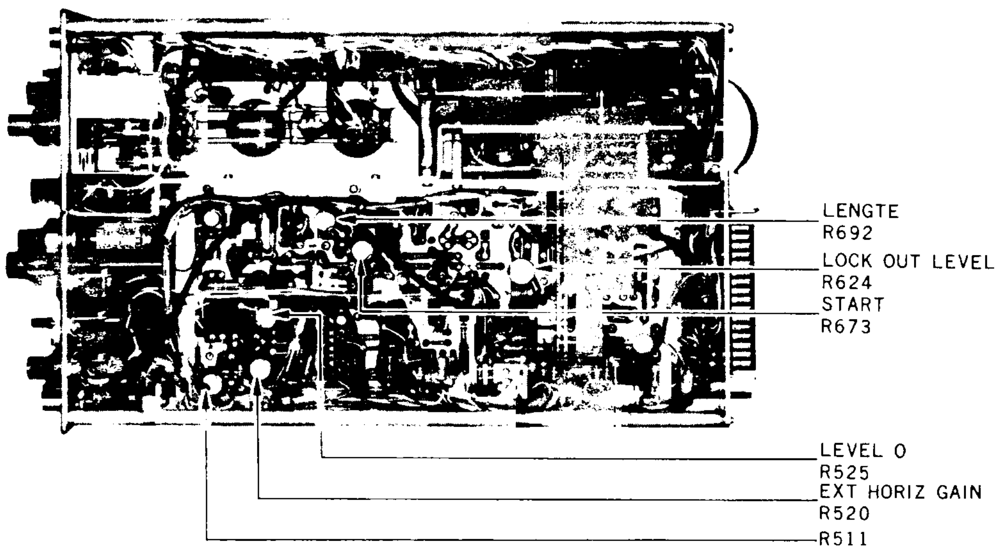


Figure 4-12 Plug-In Unit Top View

COUPLING .... AC
LEVEL (A) .... center

Adjust R316 (see Figure 4-13) so that the sweep is symmetrical for both + and – settings of the SLOPE switch.

(7) B Trigger Level Centering. Set controls as follows:

HORIZ DISPLAY .... DLY'D (B)
DLY'D (B) MODE .... TRIG'D
LEVEL (B) .... center

Adjust R525 (see Figure 4-12) so that the sweep is symmetrical for both + and – settings of the SLOPE (B) switch.

g. **Sweep Calibration.** The following procedures calibrate both A and B sweep generators. A Time Mark Generator especially designed for oscilloscope calibration is recommended for this procedure, but such alternatives as a stable pulse generator and electronic counter may be used.

(1) Delay Time Calibration. Connect the output of the Time Mark Generator to the Channel 1 input. Set controls as follows:

HORIZ DISPLAY .... A INTEN BY B
DLY'D (B) MODE .... AUTO
A TIME/CM .... 1 msec
B TIME/CM .... 10 μsec
A VARIABLE .... CALIB
B TIME/CM VARIABLE .... CALIB

Set the Time Mark Generator output for 1 ms pulses. Adjust triggering and horizontal position controls so that the display appears as in Figure 4-14. Set DELAY TIME MULTI to 1.00 and adjust R446 until the intensified area is centered on the second pulse (see Figure 4-14).

Set DELAY TIME MULTI to 9.00 and adjust R379 (see Figure 4-5) until the intensified zone is centered on the 10th pulse in the display.

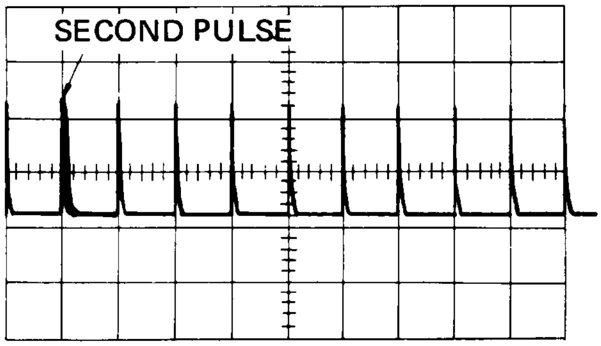


Figure 4-14 Delay Adjustment Waveform

Set DELAY TIME MULTI to 2.00 and adjust R446 (Figure 4-13) until the intensified area is centered on the third pulse.

Set DELAY TIME MULTI to 8.00 and adjust R379 until the intensified area is centered on the 9th pulse. Some interaction may occur; check the steps above and readjust if necessary.

Adjust R718 (Figure 4-7) so that the 11th pulse occurs exactly at the 11th graticule line.

Set controls:

DLY'D (B) MODE .... TRIG'D
HORIZ DISPLAY .... DLY'D (B)
A TIME/CM .... 0.1 msec
B TIME/CM .... 1 msec

Adjust R673 (Figure 4-12) so that the start of A and B is the same.

(2) Magnifier Accuracy. Set HORIZ DISPLAY to A and A TIME/CM to 1 msec. Set the Time Mark Generator output to 1 ms. Adjust R724 (Figure 4-7) so that the markers are exactly 10 cm apart when MAG is switched to the X10 position.

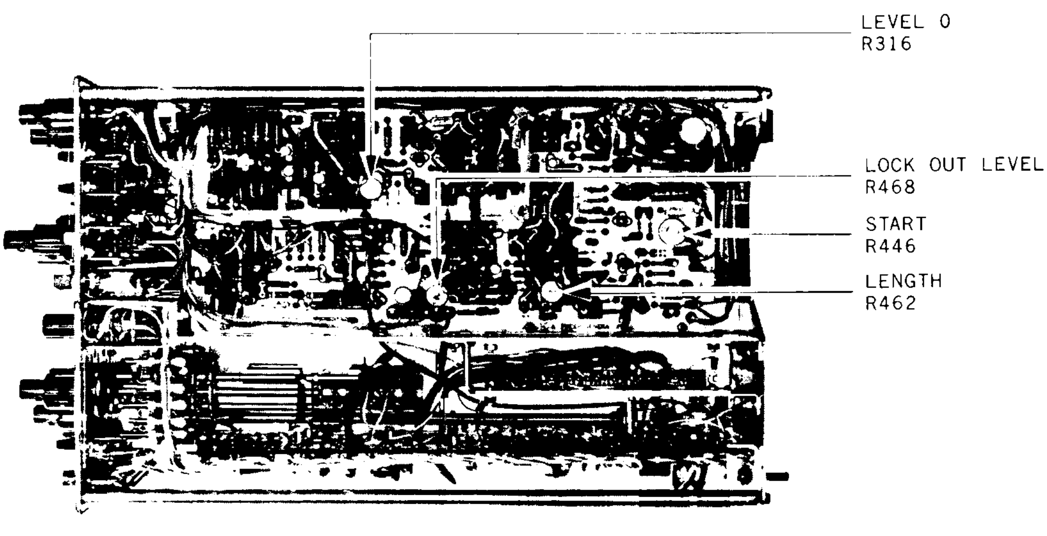


Figure 4-13 Plug-In Unit Bottom View

(3) Magnifier Centering. Set MAG to X10 and adjust the horizontal position controls to place the start of the sweep at the center vertical graticule line. Set MAG to X1 and adjust R727 to place the start of the trace at the center graticule line.

(4) External Horizontal Sensitivity Adjustment. Set controls as follows:

MODE	CH 1
HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
COUPLING (B)	DC
CALIBRATOR VOLTS	50 mV

Connect the calibrator output to the Channel 2 input. Set the Channel 2 VOLTS/CM switch to the 10 mV position. Adjust R520 to obtain a horizontal deflection of exactly 5 cm.

h. Calibrator Amplitude Adjustment. Connect the calibrator output to the Channel 1 input. Set CALIBRATOR VOLTS to 10. Set Channel 1 VOLTS/CM to 2. Adjust R1102 (Figure 4-7) for a display exactly 5 cm high.

NOTE

Before performing this adjustment, check the calibration of the Channel 1 amplifier.

i. Calibrator Frequency Adjustment. Connect the calibrator output to the Channel 2 input, and an accurate 1 kHz signal to the Channel 1 input. Set controls:

HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
COUPLING (B)	DC
MODE	CH 1

Adjust T1101 (Figure 4-7) for a 1:1 Lissajous pattern.

SECTION 5
PARTS LIST

5-1 ORDERING INFORMATION

Replacement parts may be ordered directly from Iwatsu or through E-H. To be certain of receiving the proper parts, always 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 our local representative. 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.

5-2 HOW TO USE THIS PARTS LIST

The parts list is divided into subsections corresponding to the physical subsections of the instrument (printed circuit boards, chassis and subassemblies, miscellaneous hardware). Component locations can be determined from the schematic diagrams and printed circuit board photographs in Section 6; 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".

In the component descriptions, capacitor dielectrics are abbreviated as follows: polyethylene (poly.), ceramic (cer.), printed circuit (P.C.), electrolytic (elect.) and tantalum (tant.). Resistor and potentiometer values are given in ohms; the symbol for "ohm" (Ω) has been omitted. If no material is listed, resistors may be assumed to be carbon composition; other resistor types are metal film (MF) and wire-wound (WW).

All resistor tolerances are 5% unless otherwise indicated.

5-3 Vertical Input and Attenuator Assembly

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1 A/B	Cap., poly, var.	74110-0300
C2 A/B	Same as C1 A/B	
C3 A/B	Same as C1 A/B	
C4 A/B	Same as C1 A/B	
C5 A/B	Same as C1 A/B	
C6 A/B	Same as C1 A/B	
C7 A/B	Same as C1 A/B	
C8 A/B	Same as C1 A/B	
C9 A/B	Cap., 8 pF, 500 V, cer	74050-0350
C10 A/B	Cap., 15 μF, 500 V, cer	74050-5150
C11 A/B	Same as C1 A/B	
C12 A/B	Same as C1 A/B	
C13 A/B	Same as C1 A/B	
C14 A/B	Cap., 1.5 pF, var	74110-0290
C15 A/B	Same as C14 A/B	
C16 A/B	Same as C14 A/B	
C17 A/B	Same as C14 A/B	
C18 A/B	Same as C14 A/B	
C19 A/B	Cap., 20 pF, 300 V, mica	74010-4870
C20 A/B	Cap., 50 pF, 300 V, mica	74090-4690
C21 A/B	Cap., 100 pF, 300 V, mica	74090-4660
C22 A/B	Cap., 200 pF, 300 V, mica	74030-4670
C23 A/B	Cap., 8 pF, 500 V, cer	74050-0200
C24 A/B	Same as C23 A/B	
C25 A/B	Cap., 500 pF, 300 V, mica	74090-4700
C26 A/B	Cap., 0.047 μF, 400 V, cer.	74130-3310
C27 A/B	Cap., 10 μF, 500 V, cer	74050-5440
C28 A/B	Cap., 27 pF, 500 V, cer	74050-2040
C29 A/B	Cap., 15 – 60 pF (variable), cer	74110-0570
J1 A/B	Connector	74500-2530
J2 A/B	Connector	74500-3170
L1 A/B	Inductor	74400-2740
L2 A/B	Inductor	74400-3070
L3 A/B	Same as L1 A/B	
L4 A/B	Inductor	74400-2760
L5 A/B	Inductor	74400-2750
L6 A/B	Core, ferrite inductor	74560-0090
L7 A/B	Same as L5 A/B	
L8 A/B	Same as L6 A/B	
L9 A/B	Same as L5 A/B	
L10 A/B	Same as L6 A/B	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
L11 A/B	Same as L5 A/B	
L12 A/B	Same as L5 A/B	
L13 A/B	Inductor	74400-2770
R1 A/B	Res., 68, 1/8 W, 5 %	74257-0790
R2 A/B	Res., 10, 1/8 W, 5 %	74257-0020
R3 A/B	Res., 500 k, 1/8 W, 1 %	74226-0080
R4 A/B	Res., 1 M, 1/8 W, 1 %	74226-0150
R5 A/B	Res., 800 k, 1/8 W, 1 %	74226-0090
R6 A/B	Res., 250 k, 1/8 W, 1 %	74226-0070
R7 A/B	Res., 900 k, 1/4 W, 1 %	74226-0100
R8 A/B	Res., 111 k, 1/8 W, 1 %	74226-0060
R9 A/B	Same as R1 A/B	
R10 A/B	Res., 950 k, 1/4 W, 1 %	74226-0110
R11 A/B	Res., 52.6 k, 1/8 W, 1 %....	74226-0050
R12 A/B	Same as R1 A/B	
R13 A/B	Res., 980 k, 1/4 W, 1 %	74226-0120
R14 A/B	Res., 20.4 k, 1/8 W, 1 %....	74226-0040
R15 A/B	Same as R1 A/B	
R16 A/B	Res., 990 k, 1/4 W, 1 %	74226-0130
R17 A/B	Res., 10.1 k, 1/8 W, 1 % ...	74226-0030
R18 A/B	Res., 75, 1/8 W, 5 %	74257-0800
R19 A/B	Res., 995, 1/4 W, 5 %	74226-0140
R20 A/B	Res., 5.03 k, 1/8 W, 1 % ...	74226-0020
R21 A/B	Res., 47, 1/8 W, 5 %	74257-0140
R22 A/B	Res., 998 k, 1/4 W, 1 %	74226-1790
R23 A/B	Res., 2 k, 1/8 W, 1 %	74226-2190
R24 A/B	Same as R2 A/B	
R25 A/B	Same as R7 A/B	
R26 A/B	Res., 100 k, 1/4 W, 1 %	74226-2020
S1 A/B	Switch, Lever (AC-GND-DC)	74440-1260
S2 A/B	Switch, Rotary (VOLTS/CM)	74431-5300

5-4 Channel 1 Preamplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C30 A	Cap., 10 μF, 25 V, elect....	74120-3970
C31 A	Cap., 1.5 pF, var	74110-0290
C33 A	Cap., 3.3 μF, 10 V, elect ...	74120-3990
C34 A	Cap., 0.02 μF, 25 V, cer ...	74060-0570
C35 A	Same as C34 A	
C36 A	Same as C34 A	
C37 A	Cap., cer, var	74110-0080
C39 A	Cap., 2000 pF, 50 V, cer ...	74060-2040
C40 A	Same as C39	
C41 A	Cap., 2 – 8 pF (variable), cer	74110-0070
C42 A	Same as C39	
C43 A	Same as C39	
C44 A	Same as C37 A	
C45 A	Same as C39 A	
C46 A	Same as C39 A	
C47 A	Same as C41 A	
C48 A	Same as C37 A	
C49 A	Cap., 470 pF, 500 V, cer ...	74060-0140
C50 A	Same as C49 A	
C51 A	Cap., 0.01 μF, 500 V, cer ..	74060-0340
D30 A	Diode, IS1544	74040-3670
D31 A	Same as D30 A	
D32 A	Diode, IS551	74040-0640
L31 A	Core, ferrite	74560-1030
L33 A	Same as L31	
L34 A	Same as L31	
L35 A	Inductor	74400-2910
R1 A/B	Res., 68, 1/8 W	74257-0790
R2 A/B	Res., 10, 1/8 W	74257-0020
R9 A/B	Same as R1	
R12 A/B	Same as R1	
R15 A/B	Same as R1	
R18 A/B	Res., 75, 1/8 W	74257-0800
R21 A/B	Res., 47, 1/8 W	74257-0140
R24 A/B	Res., 10, 1/8 W	74257-0020
R26 A/B	Res., 330 k, 1/8 W	74257-0810
R27 A/B	Res., 10, 1/8 W	74257-0020
R33 A	Res., 100, 1/4 W	74230-0130
R34 A	Res., 22, 1/4 W	74230-0870
R35 A	Res., 3 – 10 k, 1/2 W, (select)	74241-0530
R36 A	Res., 100, 1/4 W	74230-0130
R37 A	Res., 3.3 k, 1/4 W	74230-0350
R38 A	Res., 100, 1/4 W, 5 %......	74253-0080
R40 A	Res., 51 k, 1/4 W	74230-1010
R41 A	Res., 330, 1/4 W	74230-0470
R43 A	Res., 33 k, 1/4 W	74230-0300
R44 A	Res., 100, 1/4 W	74230-0130
R45 A	Same as R44	
R46 A	Same as R35 A	
R47 A	Res., 47, 1/4 W, 5 %	74253-0070
R48 A	Same as R37	
R50 A	Res., 22, 1/4 W	74230-0870
R51 A	Res., 150, 1/2 W, 2 %	74241-0240
R52 A	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R53 A	Same as R52	
R54 A	Res., 270, 1/4 W	74253-0930
R55 A	Same as R54	
R56 A	Res., 91, 1/2 W, 2 %	74241-0190
R57 A	Same as R56	
R58 A	Res., 549, 1/2 W, 1 %	74226-2100
R59 A	Res., 186, 10 %, var	74322-1760
R60 A	Res., 91, 1/4 W	74253-0840
R61 A	Same as R60	
R62 A	Res., 110, 1/4 W	74253-0860
R63 A	Same as R61	
R64 A	Same as R61	
R65 A	Res., 200, 1/2 W, 2 %	74241-0270
R66 A	Res., 100, 1/4 W	74230-0130
R67 A	Same as R66	
R68 A	Res., 75, 1/2 W, 2 %	74241-0170
R69 A	Res., 1.8 k, 1/2 W, 2 %	74241-0480
R70 A	Same as R69	
R71 A	Res., 200, 1/4 W	74253-0370
R72 A	Same as R71	
R73 A	Res., 57, 1/4 W	74230-0940
R74 A	Same as R73	
R75 A	Res., 91, 1/4 W	74230-1230
R76 A	Same as R75	
R77 A	Res., 270, 1/2 W, 2 %	74241-0300
R78 A	Res., 22, 1/4 W	74253-0690
R79 A	Same as R78	
R80 A	Res., 470, 1/4 W	74230-0160
R81 A	Res., 200, var............	74349-0770
R82 A	Res., 22, 1/4 W	74230-[illegible]870
R83 A	Res., 820, 1/2 W, 2 %	74241-0420
R84 A	Same as R83	
R86 A	Res., 100, 1/4 W	74253-0080
R88 A	Res., 120, 1/4 W, 2 %	74244-0500
R89 A	Same as R88	
R92 A	Res., 1 k, 0.1 W, var	74349-0710
R93 A	Res., 2 k, 1/4 W, 2 %	74244-0060
R94 A	Same as R93	
R95 A	Res., 22, 1/4 W	74253-0690
R96 A	Same as R95	
R97 A	Res., 100, 1/2 W, 2 %	74241-0200

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R98 A	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R99 A	Same as R98	
R100 A	Res., 1.2 k, 1/2 W, 2 %	74241-0450
R101 A	Res., 330, 1/4 W	74253-0950
R102 A	Same as R101	
R103 A	Res., 3 k, 1/4 W	74230-0530
R104 A	Same as R103	
R105 A	Res., dual section, Var	74322-1750
TR1 A	Transistor	74030-3680
TR2 A	Transistor, 2SJ12-0	74030-3240
TR3 A	Transistor	74030-3670
TR4 A	Same as TR1 A	
TR5 A	Same as TR3 A	
TR6 A	Same as TR3 A	
TR7 A	Same as TR3 A	
TR8 A	Same as TR3 A	
TR9 A	Same as TR3 A	
TR10 A	Same as TR3 A	
TR11 A	Same as TR9 A	
TR12 A	Transistor	74030-3150
TR13 A	Same as TR12 A	

5-5 Channel 2 Preamplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C31 B	Cap., teflon, var	74110-0290
C32 B	Cap., 0.02 μF, 25 V	74060-0570
C33 B	Cap., 3.3 μF, 10 V, elect ...	74120-3990
C34 B	Cap., 0.02 μF, 25 V, cer ...	74060-0570
C35 B	Same as C34	
C36 B	Cap., cer, var	74110-0080
C38 B	Cap., 2000 pF, 50 V, cer ...	74060-1580
C39 B	Same as C38 B	
C40 B	Cap., 2 – 8 pF, (variable) cer	74110-0070
C41 B	Same as C38 B	
C42 B	Same as C38 B	
C43 B	Same as C36 B	
C44 B	Same as C38 B	
C45 B	Same as C38 B	
C46 B	Cap., 1000 pF, 50 V, cer ...	74060-2050
C47 B	Same as C46 B	
C48 B	Cap., cer, var	74110-0080
C49 B	Cap., 47 pF, 500 V, cer	74060-0140
C50 B	Same as C49 B	
C51 B	Cap., 0.1 μF, 25 V, cer	74060-1130
C52 B	Cap., 0.01 μF, 500 V, cer ..	74060-0340
C53 B	Same as C40 B	
D30 B	Diode, IS1544	74040-3630
D31 B	Same as D30 B	
D33 B	Diode, IS1458	74040-2920
D34 B	Diode, IS1458	74040-2920
D35 B	Diode, IS551	74040-0640
D36 B	Same as D35 B	
D37 B	Diode, IS1458	74040-2920
D38 B	Same as D37 B	
D39 B	Same as D37 B	
D40 B	Same as D33 B	
L31 B	Core, ferrite	74560-1030
L33 B	Inductor, 27 μH..........	74470-0910
L34 B	Same as L31 B	
L35 B	Inductor	74400-2910
R33 B	Res., 100, 1/4 W	74230-0130
R34 B	Res., 22, 1/4 W	74253-0690
R36 B	Same as R33 B	
R37 B	Res., 3 – 10 k, 1/2 W, ... (selected)	74241-0530
R38 B	Res., 100, 1/4 W	74253-0080
R39 B	Res., 10 k, var	74321-0070
R40 B	Res., 51 k, 1/4 W.........	74230-1010
R41 B	Res., 330, 1/4 W	74230-0470
R42 B	Res., 5 k var, WW.........	74331-0420
R43 B	Res., 33 k, 1/4 W	74230-0300
R44 B	Same as R33 B	
R45 B	Same as R33 B	
R46 B	Same as R37 B	
R47 B	Res., 47, 1/4 W	74253-0070
R48 B	Res., 3.3 k, 1/4 W	74230-0350
R49 B	Res., 200, var	74349-0770
R50 B	Res., 22, 1/4 W	74230-0870
R51 B	Res., 150, 1/2 W, 2 %	74241-0240
R52 B	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R53 B	Same as R52 B	
R54 B	Res., 270, 1/4 W	74253-0930
R55 B	Same as R54 B	
R56 B	Res., 91, 1/2 W, 2 %	74241-0190
R57 B	Same as R56 B	
R58 B	Res., 549, 1/2 W, 1 %	74226-2100
R59 B	Res., 186, 10 %, var.......	74332-1760
R60 B	Res., 91, 1/4 W	74253-0840
R61 B	Same as R60 B	
R62 B	Res., 110, 1/4 W	74253-0860
R63 B	Same as R60 B	
R64 B	Same as R60 B	
R65 B	Res., 200, 1/2 W, 2 %	74241-0270
R66 B	Same as R33 B	
R67 B	Same as R33 B	
R68 B	Res., 75, 1/2 W	74241-0170
R69 B	Res., 1.8 k, 1/2 W, 2 %	74241-0480
R70 B	Same as R69 B	
R71 B	Res., 200, 1/4 W	74253-0370
R72 B	Same as R71 B	
R73 B	Res., 56, 1/4 W	74230-0940
R74 B	Same as R73 B	
R75 B	Res., 91, 1/4 W	74230-1230
R76 B	Same as R75 B	
R77 B	Res., 270, 1/2 W, 2 %	74241-0300
R78 B	Res., 22, 1/4 W	74253-0690
R79 B	Same as R78 B	
R80 B	Res., 470, 1/4 W	74230-0160
R81 B	Res., 200, var	74349-0770
R82 B	Res., 22, 1/4 W	74230-0870
R83 B	Res., 560, 1/2 W, 2 %	74241-0380
R84 B	Same as R83 B	
R85 B	Res., 500, var	74349-0630
R86 B	Res., 100, 1/4 W	74253-0080
R87 B	Same as R86 B	
R88 B	Res., 120, 1/4 W, 2 %	74244-0500
R89 B	Same as R88 B	
R90 B	Same as R88 B	
R91 B	Same as R88 B	
R93 B	Res., 2 k, 1/4 W, 2 %	74244-0060
R94 B	Same as R93 B	
R95 B	Res., 22, 1/4 W	74253-0690
R96 B	Same as R95 B	
R97 B	Res., 100, 1/2 W, 2 %	74241-0200
R98 B	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R99 B	Same as R98 B	
R100 B	Res., 1.2 k, 1/2 W, 2 %	74241-0450
R101 B	Res., 330, 1/4 W	74253-0950
R102 B	Same as R101 B	
R103 B	Res., 3 k, 1/4 W..........	74230-0530

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R104 B	Same as R103 B	
R105 B	Res., dual section, var	74322-1750
S31 B	Switch Lever (POLARITY)	74440-1380
TR1 B	Transistor	74030-3680
TR3 B	Transistor	74030-3670
TR4 B	Same as TR1 B	
TR5 B	Same as TR3 B	
TR6 B	Same as TR3 B	
TR7 B	Same as TR3 B	
TR8 B	Same as TR3 B	
TR9 B	Same as TR3 B	
TR10 B	Same as TR3 B	
TR11 B	Same as TR3 B	
TR12 B	Transistor	74030-3150
TR13 B	Same as TR12 B	

5-6 Switching Circuit

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C121	Cap., 2000 pF, 50 V, cer	74060-2040
C122	Same as C121	
C125	Cap., 3 – 12 pF (variable) cer	74110-0080
C126	Cap., 10 μF, 25 V, elect	74120-3960
C127	Same as C126	
C128	Cap., 3.3 μF, 25 V, elect	74120-3990
C129	Cap., 0.01 μF, 500 V, cer	74060-0340
C130	Cap., 0.1 μF, 25 V, cer	74060-0440
C261	Cap., 0.02 μF, 25 V, cer	74060-0570
C262	Cap., 4700 pF, 50 V, cer	74060-2520
C263	Cap., 82 pF, 50 V, cer	74050-4730
C264	Same as C261	
C265	Cap., 0.1 μF, 25 V, cer	74060-1130
D121 A/B	Diode, IS953	74040-1720
D122 A/B	Same as D121 A/B	
D123 A/B	Same as D121 A/B	
D124 A/B	Same as D121 A/B	
D261	Same as D121 A/B	
D262	Same as D121 A/B	
D263	Same as D121 A/B	
D264	Same as D121 A/B	
D265	Same as D121 A/B	
D266	Same as D121 A/B	
D267	Same as D121 A/B	
D268	Same as D121 A/B	
L121	Inductor, 27 μFH	74470-0910
L122	Core, ferrite	74560-0090
L123	Same as L122	
R121	Res., 3.3 k, 1/4 W	74230-0350
R122	Same as R121	
R123	Res., 1 k, 1/4 W	74230-0030
R124	Same as R123	
R125	Res., 240, 1/2 W, 2 %	74241-0290
R126	Res., 100, 1/4 W	74253-0080
R127	Same as R126	
R128	Res., 330, 1/2 W, 2 %	74241-0320
R129	Same as R128	
R130	Res., 160, 1 W, 2 %	74242-1180
R131	Res., 100, 1/4 W, 2 %	74244-0030
R132	Same as R131	
R133	Same as R131	
R134	Same as R131	
R136	Res., 1 k, var	74349-0710
R261	Res., 220, 1/4 W	74230-0480
R262	Res., 620, 1/2 W, 2 %	74241-0390
R263	Same as R262	
R264	Same as R261	
R265	Same as R261	
R266	Res., 20, 1/4 W	74230-1140
R267	Same as R266	
R268	Res., 750, 1/4 W	74230-0540
R269	Same as R268	
R270	Same as R121	
R271	Res., 5.2 k, 1/4 W	74230-0890
R272	Same as R271	
R273	Res., 200, 1/2 W, 2 %	74241-0270
R274	Same as R273	
R275	Res., 200, 1/4 W	74230-1340
R276	Same as R275	
R277	Res., 68, 1/4 W	74230-1050
R278	Same as R123	
R279	Res., 24 k, 1/4 W	74230-0800
R280	Res., 680, 1/4 W	74230-0150
R281	Res., 75 k, 1/4 W	74230-0590
R282	Res., 2.7 k, 1/4 W	74230-0420
R283	Res., 2.2 k, 1/4 W	74230-0270
R284	Res., 330, 1/2 W, 2 %	74241-0320
R285	Res., 6.8 k, 1/4 W	74230-0330
TR121	Transistor	74030-3150
TR122	Same as TR121	
TR261	Transistor, 2SC321 Ⓗ B	74030-4500
TR262	Same as TR261	
TR263	Same as TR261	
TR264	Transistor, 2N4275	74030-3160
TR265	Transistor, 2N4121	74030-2990
T261	Pulse Transformer	74473-0070

5-7 Main Vertical Amplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C201	Cap., cer, var	74110-0470
C202	Cap., cer, var	74110-0070
C203	Cap., 2000 pF, 50 V	74060-2040
C204	Same as C203	
C205	Same as C202	
C206	Cap., 3 – 12 pF (variable) cer	74110-0080
C207	Cap., var, cer	74110-0100
C208	Cap., 82 pF, 50 V	74050-4730
C210	Cap., var, cer	74110-0100
C211	Cap., 2000 pF, 500 V	74060-2030
C212	Same as C211	
C213	Cap., 0.03 μF, 200 V	74060-1090
C214	Cap., 0.1 μF, 25 V	74060-1130
C215	Same as C214	
C216	Cap., 47 pF, 500 V, cer	74050-2080
C217	Same as C216	
D201	Diode, RD6A-M	74040-0800
D202	Same as D201	
D203	Diode IS1458	74040-2920
D204	Same as D203	
L201	Inductor	74400-2900
L202	Inductor	74400-2910
L203	Core, ferrite	74560-1030
L204	Same as L203	
L205	Inductor	74400-2780

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
L207	Inductor	74400-2860
L208	Same as L207	
L209	Inductor, 10 uH	74470-0950
R201	Res., 500, var	74349-0720
R202	Res., 47	74230-0100
R203	Res., 10 k, var	74349-0840
R204	Res., 10, 1/4 W	74230-0070
R205	Same as R204	
R206	Res., 68, 2 %	74241-0160
R207	Res., 470, 2 %	74241-0360
R208	Same as R207	
R209	Res., 360, 2 %	74241-0330
R210	Res., 150, 1/4 W	74253-0580
R211	Same as R210	
R212	Res., 100, 2 %	74241-0200
R213	Same as R212	
R214	Res., 130, 2 %	74241-0230
R215	Same as R205	
R216	Same as R205	
R217	Res., 180, 2 %	74241-0260
R218	Res., 200, var	74349-0540
R219	Same as R203	
R220	Res., 560, 2 %	74241-0380
R221	Res., 560, 2 %	74241-0380
R222	Res., 200, 2 %	74241-0270
R223	Same as R222	
R225	Res., 10	74230-0070
R226	Same as R225	
R227	Res., 820, 2 %	74241-0420
R228	Same as R227	
R229	Res., 10 k, 2 %	74241-0660
R230	Same as R229	
R231	Res., 120, 2 W, 2 %	74243-0180
R232	Same as R212	
R233	Same as R212	
R235	Res., 120, 2 %	74241-0220
R236	Res., 220, 2 %	74243-0210
R237	Same as R236	
R238	Res., 150, 2 %	74243-0190
R239	Res., 36, 1/2 W, 2 %	74241-0100
R240	Same as R201	
R241	Same as R239	
R242	Same as R238	
R243	Res., 43, 1/2 W, 2 %	74241-1290
R244	Same as R243	
R245	Res., 10, 1/2 W, 2 %	74241-0010
R246	Res., 2 k, 2 %	74241-0490
R247	Res., 15 k, var	74349-1230
R248	Res., 10 k, 1 W, 2 %	74242-0520
S201	Switch, (TRACE FINDER)	74440-0730
S202	Switch Toggle	74430-0350
TR201	Transistor	74030-3660
TR202	Same as TR201	
TR203	Same as TR201	
TR204	Same as TR201	
TR205	Transistor	74030-3670
TR206	Same as TR205	
TR207	Transistor, TA2761	74030-3170
TR208	Same as TR207	

5-8 Trigger Amplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C151 A/B	Cap., 0.02 µF, 25 V, cer	74060-0570
C152 A/B	Same as C151 A/B	
C153 A/B	Cap., cer, var	74110-0470
C154 A/B	Same as C153 A/B	
C155 A/B	Same as C153 A/B	
C156 A/B	Cap., 0.02 µF, 25 V, cer	74060-0570
C157 A/B	Same as C156 A/B	
C158	Cap., 0.1 µF, 25 V, cer	74060-1130
C159 A/B	Same as C151 A/B	
C160	Cap., 2000 pF, 25 V, cer	74060-1140
C161	Same as C160	
C162	Cap., cer, var	74110-0100
C163	Same as C151 A/B	
C164	Same as C151 A/B	
C165	Same as C151 A/B	
C166	Same as C151 A/B	
C167	Cap., 1000 pF, 50 V, cer	74060-1750
C168	Same as C167	
D151 A/B	Diode, IS953	74040-1720
D152 A/B	Same as D151 A/B	
D153 A/B	Same as D151 A/B	
D154 A/B	Same as D151 A/B	
J151	Connector	74500-2980
J152	Connector	74500-2480
R151 A/B	Res., 91, 1/4 W	74230-1230
R152 A/B	Same as R151 A/B	
R153 A/B	Res., 47, 1/4 W	74230-0100
R154 A/B	Same as R153 A/B	
R155 A/B	Res., 2.4 k, 1/4 W	74230-0220
R156 A/B	Same as R155 A/B	
R157 A/B	Same as R153 A/B	
R158 A/B	Res., 10, 1/4 W	74230-0070
R159 A/B	Same as R158 A/B	
R160 A/B	Res., 150, 1/2 W, 2 %	74241-0240
R161 A/B	Res., 750, 1/4 W	74230-0540
R162 A/B	Same as R161 A/B	
R163 A/B	Res., 200, 1/4 W	74230-1340
R164 A/B	Same as R163 A/B	
R165 A/B	Res., 390, 1/4 W	74230-0550
R166 A/B	Res., 33, 1/4 W	74230-0280
R167 A/B	Same as R166 A/B	
R168 A/B	Res., 100, 1/2 W, 2 %	74241-0200
R169 A/B	Same as R165 A/B	
R170 A/B	Same as R165 A/B	
R171 A/B	Res., 100, var	74349-0830
R172 A/B	Res., 150, 1/4 W	74230-0510
R173 A/B	Same as R172 A/B	
R174 A/B	Res., 160, 1/4 W	74230-1410
R175 A/B	Res., 33, 1/4 W	74230-0280
R176 A/B	Same as R175 A/B	
R177 A/B	Res., 91, 1/2 W, 2 %	74241-0190
R178 A/B	Res., 750, 1/4 W	74230-0540
R179 A/B	Same as R178 A/B	
R180 A/B	Res., 100, 1/4 W	74230-0130
R181	Res., 560, 1/4 W	74230-0580
R182	Same as R181	
R183	Res., 620, 1 W, 2 %	74242-0250
R184	Same as R183	
R185	Res., 100, var, WW	74331-0500
R186	Res., 470, 1 W	74242-0220
R187	Same as R180 A/B	
R188	Same as R180 A/B	
R189	Res., 200, var	74322-1690
R190	Res., 820, 1/4 W	74230-0490
R191	Same as R190	
R192	Res., 390, 1/4 W	74253-0960

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R193	Same as R192	
R194	Res., 10 k, var, WW	74331-0540
R195	Res., 7.5 k, 1/4 W	74230-0570
R196	Res., 51, 1/4 W	74230-0600
R197	Res., 15 k, 1/4 W	74230-0110
S151	Switch (TRIGGER)	74431-5310
S152	Same as S151	
TR151 A/B	Transistor, PA-15	74030-1520
TR152 A/B	Same as TR151 A/B	
TR153 A/B	Transistor, 2N4258	74030-3150
TR154 A/B	Same as TR153 A/B	
TR155 A/B	Same as TR153 A/B	
TR156 A/B	Same as TR153 A/B	
TR157 A/B	Same as TR153 A/B	
TR158 A/B	Same as TR153 A/B	
TR159	Same as TR153 A/B	
TR160	Same as TR153 A/B	
TR161	Same as TR153 A/B	
TR162	Same as TR153 A/B	

5-9 A Trigger Generator

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C301	Cap., 22 pF, 500 V, cer	74050-0490
C302	Cap., 0.01 μF, 500 V, cer	74060-0340
C303	Cap., 100 pF, 500 V, cer	74050-0690
C304	Cap., 12 pF, 500 V, cer	74050-0450
C305	Cap., 2 pF, 500 V, cer	74050-5170
C306	Same as C302	
C307	Cap., 0.1 μF, 25 V, cer	74060-1130
C308	Cap., 0.02 μF, 25 V, cer	74060-0570
C309	Cap., 0.02 μF, 25 V, cer	74060-0570
C310	Same as C309	
C311	Same as C309	
C312	Cap., 0.02 μF, 25 V, cer	74060-0570
C313	Cap., 0.1 μF, 25 V, cer	74060-1130
C314	Same as C313	
C315	Same as C313	
C316	Cap., 150 pF, 50 V, cer	74050-3010
C317	Cap., 68 pF, 50 V, cer	74050-3390
C319	Cap., 100 pF, 50 V, cer	74050-1710
C320	Cap., 3.3 μF, 25 V, elect	74120-3970
C321	Same as C312	
C324	Cap., 10 μF, 25 V, elect	74120-3960
C325	Same as C324	
C333	Cap., 0.03 μF, 200 V, cer	74060-1090
D301	Diode, RD9A	74040-0840
D302	Diode, IS953	74040-1720
D303	Same as D302	
D304	Same as D301	
D305	Diode, IS307	74040-0630
D306	Same as D305	
D309	Same as D302	
D310	Same as D302	
D311	Same as D302	
D312	Same as D302	
D313	Diode, TD717 (4.7 mA)	74040-2900
D314	Same as D302	
D315	Same as D302	
D316	Same as D302	
D317	Same as D302	
D318	Same as D302	
J301	Connector	74500-2530
L301	Inductor (Pulse Transformer)	74400-4530
L302	Inductor (Pulse Transformer)	74400-4350
L303	Inductor (Pulse Transformer)	74400-4360
L304	Core ferrite	74560-0090
L305	Same as L304	
R301	Res., 10, 1/4 W	74253-0440
R302	Res., 100 k, 1/4 W	74253-1290
R303	Same as R302	
R304	Res., 910 k, 1/4 W, 2 %	74244-0640
R305	Res., 110 k, 1/4 W, 2 %	74244-0730
R306	Res., 1M, 1/2 W, 2 %	74241-1130
R307	Res., 1M, 1/4 W	74253-0210
R308	Res., 47, 1/4 W	74253-0070
R309	Res., 8.2 k, 1/4 W	74230-0430
R310	Res., 2.4 k, 1/2 W, 2 %	74241-0510
R311	Res., 2 k, 1/4 W	74253-0510
R312	Res., 3 k, 1/2 W, 2 %	74241-0530
R313	Res., 1.2 k, 1/2 W, 2 %	74241-0450
R314	Same as R312	
R315	Same as R311	
R317	Res., 2 k, 1/4 W	74230-0410
R318	Res., 3 k, 1/4 W	74230-0530
R319	Res., 15 k, 1/4 W	74230-0140
R321	Res., 68, 1/4 W	74253-0430
R322	Res., 82, 1/4 W	74253-0810
R323	Res., 620, 1/2 W, 2 %	74241-0390
R324	Same as R308	
R325	Res., 22 k, 1/2 W, 2 %	74241-0730
R326	Res., 22, 1/4 W	74253-0690
R327	Res., 200, 1/4 W	74230-1340
R328	Res., 4.7 k, 1/4 W	74230-0290
R329	Res., 100, 1/4 W	74230-0130
R330	Res., 15 k, 1/2 W, 2 %	74241-0690
R331	Res., 27, 1/4 W	74230-1380
R332	Res., 33 k, 1/4 W	74253-1230
R333	Res., 100 k, 1/4 W	74230-0260
R334	Same as R333	
R335	Same as R308	
R336	Same as R312	
R337	Res., 270, 1/4 W	74230-0910
R338	Res., 12 k, 1/4 W	74230-0440
R339	Res., 1.8 k, 1/2 W, 2 %	74241-0480
R340	Same as R308	
S301	Switch, Rotary (SOURCE)	74440-1360
S302	Switch, Rotary (COUPLING)	74440-1370
S303	Switch, Rotary (SLOPE)	74440-1380
TB301	Ground terminal	74510-0140
TR301	Transistor, MK10-2 Ⓟ	74030-3870
TR302	Transistor, 2N4275	74030-3160
TR303	Transistor, 2SC689	74030-3660
TR304	Same as TR303	
TR305	Transistor, 2SC284	74030-4740
TR306	Transistor, 2N4121	74030-2990
TR307	Same as TR306	
TR308	Same as TR306	
TR309	Same as TR306	
TR310	Same as TR302	

5-10 A Sweep Generator

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C401	Cap., 82 pF, 50 V, cer	74050-4730
C402	Cap., 0.02 μF, 25 V, cer	74060-0570
C403	Cap., 470 pF, 500 V, cer	74060-0140

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C404	Same as C402	
C405	Cap., 22 pF, 50 V, cer	74050-3050
C407	Cap., 47 pF, 50 V, cer	74050-2730
C408	Same as C407	
C409	Cap., 10 pF, 50 V, cer	74050-1700
C410	Cap., 39 pF, 50 V, cer	74050-3380
C411	Cap., 0.01 µF, 500 V, cer	74060-0340
C412	Same as C402	
C413	Cap., 10 µF, 25 V, elect	74120-3960
C414	Cap., 100 pF, 50 V, cer	74050-1710
C415	Same as C411	
C416	Same as C405	
C418	Same as C411	
C419	Same as C414	
C422	Cap., 330 pF, 500 V, cer	74060-0130
C423	Cap., 10 µF, 16 V, elect	74120-3980
C424	Cap., 1000 pF, 500 V, cer	74060-0180
C425	Same as C424	
C427	Cap., 100 µF, 25 V, elect	74120-0880
C428	Same as C413	
D401	Diode, IS953	74040-1720
D402	Same as D401	
D403	Same as D401	
D404	Same as D401	
D405	Diode, TD717 (4.7 mA)	74040-2900
D406	Same as D401	
D407	Same as D401	
D408	Same as D401	
D409	Diode, RD5A	74040-0770
D410	Diode, RD9A	74040-0840
D411	Same as D401	
D413	Same as D401	
D414	Same as D401	
D415	Same as D401	
D416	Same as D401	
D417	Same as D401	
D418	Same as D401	
D419	Same as D401	
D420	Same as D401	
D421	Same as D401	
D422	Same as D401	
D424	Same as D401	
D425	Same as D401	
D426	Same as D401	
D427	Diode, SD104	74040-1160
D428	Same as D401	
D429	Same as D405	
D430	Same as D401	
D431	Same as D401	
D432	Same as D405	
D433	Diode, RD6A	74040-0790
J401	Connector	74500-2530
L401	Core, ferrite	74560-0090
L402	Same as L401	
L405	Same as L401	
R401	Res., 7.5 k, 1/4 W	74230-0570
R402	Res., 3.9 k, 1/4 W	74230-0090
R403	Res., 3 k, 1/4 W	74230-0530
R404	Res., 12 k, 1/2 W, 2 %	74241-0670
R405	Res., 200, 1/2 W, 2 %	74241-0270
R406	Res., 5.6 k, 1/4 W	74230-0520
R407	Res., 100, 1/2 W, 2 %	74241-0200
R408	Same as R405	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R409	Res., 470, 1/2 W, 2 %	74241-0360
R410	Res., 820, 1/2 W, 2 %	74241-0420
R411	Res., 1 k, 1/2 W, 2 %	74241-0440
R412	Res., 680, 1/2 W, 2 %	74241-0400
R413	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R414	Res., 47, 1/4 W	74253-0070
R415	Res., 62, 1/4 W	74253-0790
R416	Same as R413	
R417	Same as R413	
R418	Res., 2 k, 1/2 W, 2 %	74241-0490
R419	Res., 510, 1/2 W, 2 %	74241-0370
R420	Same as R414	
R421	Res., 100, 1/4 W	74253-0080
R422	Res., 10 k, 1/4 W	74230-0120
R423	Same as R419	
R424	Same as R411	
R425	Res., 3.9 k, 1/2 W, 2 %	74241-0560
R427	Res., 100, 1/4 W	74230-0130
R428	Res., 30 k, 1/2 W, 2 %	74241-0760
R429	Same as R414	
R430	Res., 1 k, 1/4 W	74230-0030
R432	Res., 10 k, 1/2 W, 2 %	74241-0660
R433	Same as R30	
R434	Res., 15 k, 1/4 W	74230-0140
R435	Same as R427	
R436	Res., 56, 1/4 W	74253-0770
R437	Same as R414	
R438	Res., 6.8 k, 2 W, 2 %	74243-0530
R439	Same as R414	
R440	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R441	Same as R405	
R442	Same as R421	
R443	Same as R414	
R444	Res., 47, 1/4 W	74230-0100
R445	Res., 1 k, 1/4 W	74253-0500
R446	Res., 500, var, WW	74331-0360
R447	Same as R418	
R448	Res., 150, 1/4 W	74230-0510
R449	Res., 150, 1/4 W	74253-0580
R450	Same as R414	
R451	Res., 5.6 k, 2 W, 2 %	74243-0510
R452	Res., 1.5 M, 1/4 W	74281-0270
R453	Same as R421	
R456	Res., 47, 1/4 W	74230-0100
R457	Same as R414	
R458	Res., 8.2 k, 1 W, 2 %	74242-0500
R459	Res., 330, 1/2 W, 2 %	74241-0320
R460	Same as R414	
R462	Res., 1 k, var	74349-0640
R464	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R465	Res., 8.2 k, 1/4 W	74230-0430
R466	Res., 20 k, 1/4 W	74230-0310
R467	Res., 13 k, 1/4 W	74230-1390
R468	Res., 50 k, var	74349-0890
R469	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R470	Res., 6.8 k, 1/4 W	74230-0330
R471	Same as R459	
R472	Res., 100 k, 1/4 W	74230-0260
R473	Same as R472	
R474	Res., 220 k, 1/4 W	74253-1350
R475	Res., 910, 1/2 W, 2 %	74241-0450
R476	Res., 3.9 k, 1/4 W	74230-0090
R477	Res., 150, 1/2 W, 2 %	74241-0240
R478	Res., 4.7 k, 1/4 W	74230-0290
R481	Same as R478	
R482	Res., 100, 1/4 W	74230-0130
R483	Res., 390, 1/2 W, 2 %	74241-0340

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R484	Res., 390, 1/2 W, 2 %	74241-0340
R485	Res., 750, 1/2 W, 2 %	74241-0410
R486	Same as R434	
R487	Same as R467	
R488	Same as R478	
R489	Res., 2.2, 1/4 W	74253-0010
R490	Res., 2.2, 1/4 W	74253-0010
R491	Same as R407	
S401	Switch (HORIZ DISPLAY)	74431-5330
S402	Switch (A SWEEP MODE)	74440-1250
S403	Switch (RESET WITH NE401)	74430-0240
S701	Same as S401	
TR401	Transistor, 2N4258	74030-3150
TR402	Transistor, 2N4275	74030-3160
TR403	Transistor 2SC321 Ⓗ B	74030-4500
TR404	Same as TR402	
TR405	Same as TR402	
TR406	Transistor, 2N4121	74030-2990
TR407	Transistor	74030-2920
TR408	Same as TR402	
TR409	Same as TR406	
TR410	Same as TR409	
TR412	Transistor, 2N4360	74030-3710
TR413	Same as TR406	
TR414	Same as TR406	
TR415	Same as TR402	
TR416	Same as TR403	
TR417	Transistor, 2SC154C	74030-4000
TR418	Same as TR406	
TR419	Same as TR402	

5-11 B Trigger Generator

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C501	Cap., 22 pF, 500 V, 10 %	74050-0490
C502	Cap., 0.01 μF, 500 V, cer	74060-0340
C503	Cap., 100 pF, 500 V, 10 %, cer	74050-0690
C504	Cap., 12 pF, 500 V, 10 %, cer	74050-0450
C505	Cap., cer, var	74110-0440
C506	Same as C502	
C507	Cap., 0.02 μF, 25 V, cer	74060-0570
C508	Same as C507	
C509	Same as C507	
C510	Same as C507	
C511	Same as C507	
C512	Same as C507	
C513	Same as C507	
C514	Same as C507	
C515	Cap., 0.1 μF, 25 V, cer	74060-1130
C516	Same as C515	
C517	Same as C515	
C518	Cap., 47 pF, 50 V, 10 %, cer	74050-2730
C519	Same as C518	
C520	Cap., 68 pF, 50 V, 10 %, cer	74050-3390
C521	Cap., 100 pF, 50 V, 10 %, cer	74050-1710
C522	Cap., 0.03 μF, 200 V, cer	74060-1090
C523	Cap., 10 μF, 25 V, elect	74120-3960
C524	Same as C523	
C526	Cap., poly, var	74110-0300
D501	Diode, RD9A	74040-0840
D502	Diode, IS953	74040-1720
D503	Same as D502	
D504	Diode, RD6A	74040-0790
D505	Same as D502	
D506	Same as D502	
D507	Same as D502	
D509	Same as D502	
D510	Same as D502	
D511	Same as D502	
D512	Same as D502	
D513	Diode, IS1760	74040-2900
D514	Same as D502	
D515	Same as D502	
J501	Connector	74500-2530
L501	Inductor	74400-4530
L502	Pulse Transformer	74400-4350
L503	Inductor	74560-0090
L504	Same as L503	
R501	Res., 10, 1/4 W	74253-0440
R502	Res., 100 k, 1/4 W	74253-1290
R503	Res., 910 k, 1/4 W, 2 %	74244-0760
R504	Res., 110 k, 1/4 W, 2 %	74244-0780
R505	Same as R502	
R506	Res., 1 M, 1/2 W, 2 %	74241-1130
R507	Res., 1 M, 1/4 W	74253-0210
R508	Res., 47, 1/4 W	74253-0070
R509	Res., 8.2 k, 1/4 W	74230-0430
R510	Res., 2.2 k, 1/2 W	74241-0500
R511	Res., 5 k, var	74349-0620
R512	Res., 2 k, 1/4 W	74253-0510
R513	Res., 22 k, 1/4 W	74230-0320
R514	Res., 22 k, 1/4 W	74230-0320
R515	Res., 3.9 k, 1/4 W	74230-0090
R516	Res., 22 k, 1/4 W	74230-0320
R517	Same as R515	
R518	Same as R515	
R519	Res., 5.6 k, 1/4 W	74230-0520
R520	Same as R511	
R521	Res., 820 k, 1/4 W	74253-1370
R522	Res., 1.2 k, 1/2 W, 2 %	74241-0450
R523	Same as R512	
R524	Res., 3 k, 1/2 W, 2 %	74241-0530
R525	Res., 1 k, var	74349-0640
R526	Res., 2 k, 1/4 W	74230-0410
R527	Res., 3 k, 1/4 W	74230-0530
R528	Res., 15 k, 1/4 W	74230-0140
R529	Res., 10 k, var	74322-1070
R530	Res., 82, 1/4 W	74253-0810
R531	Res., 620, 1/2 W, 2 %	74241-0390
R532	Res., 68, 1/4 W	74253-0430
R533	Res., 47, 1/4 W	74230-0100
R534	Res., 22 k, 1/2 W, 2 %	74241-0730
R535	Res., 27, 1/4 W	74253-0050
R536	Res., 22, 1/4 W	74253-0690
R537	Res., 200, 1/2 W, 2 %	74241-0270
R538	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R540	Same as R508	
R541	Res., 100, 1/2 W, 2 %	74241-0200
S501	Switch, (SOURCE)	74440-1360
S502	Switch, (COUPLING)	74440-1370
S503	Switch, (SLOPE, MODE)	74440-1380
S504	Same as S503	
TR501	Transistor MK10-2 Ⓓ	74030-3870
TR502	Transistor, 2N4275	74030-3160

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
TR503	Transistor 2SC689 Ⓗ	74030-3660
TR504	Same as TR503	
TR505	Transistor 2SC284	74030-4740
TR506	Transistor, 2N4121	74030-2990

5-12 B Sweep Generatar

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C601	Cap., 0.01 μF, 500 V, cer ..	74060-0340
C602	Cap., 33 μF, 25 V, elect ...	74120-4000
C603	Cap., 4700 pF, 50 V, 20 %, . cer	74060-2520
C604	Cap., 0.02 μF, 25 V, cer ...	74060-0570
C605	Cap., 1000 pF, 500 V, cer ..	74060-0180
C606	Same as C605	
C607	Cap., 82 pF, 50 V, 10 %, cer	74052-4730
C608	Same as C604	
C609	Cap., 470 pF, 500 V, 20 %, . cer	74060-0140
C610	Same as C604	
C611	Cap., 22 pF, 50 V, 10 %, cer	74050-3050
C613	Cap., 47 pF, 50 V, 10 %, cer	74050-2730
C614	Same as C613	
C615	Cap., 10 pF, 50 V, cer	74050-1700
C616	Cap., 39 pF, 50 V, 10 %, cer	74050-3380
C617	Same as C601	
C618	Same as C604	
C619	Cap., 10 μF, 25 V, elect ...	74120-3960
C620	Cap., 100 pF, 50 V, cer ...	74050-1710
C621	Same as C601	
C622	Same as C611	
C625	Same as C601	
C626	Same as C620	
C629	Cap., 100 μF, 25 V, elect ..	74120-0880
C630	Same as C619	
D601 A/B	Diode, SD11F	74040-2080
D602	Diode, TD717 (4.7 mA) ...	74040-2900
D603	Diode, RD6A	74040-0790
D604	Diode, IS953	74040-1720
D605	Same as D604	
D606	Same as D604	
D607	Same as D604	
D608	Same as D602	
D609	Same as D604	
D610	Same as D602	
D611	Same as D604	
D612	Same as D604	
D613	Same as D604	
D614	Same as D604	
D615	Diode, RD5A	74040-0770
D616	Diode, RD9A	74040-0840
D617	Same as D604	
D618	Same as D616	
D619	Same as D604	
D620	Same as D604	
D621	Same as D604	
D622	Same as D604	
D623	Same as D604	
D624	Same as D604	
D625	Same as D604	
D626	Same as D604	
D627	Same as D604	
D628	Same as D604	
D629	Same as D604	
J601	Connector	74500-2530

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
L601	Core ferrite	74560-0090
L602	Same as L601	
L605	Same as L601	
R601	Res., 47, 1/4 W, cer	74253-0070
R602	Res., 6.8 k, 1 W, 2 %	74242-0480
R603	Res., 47, 1/4 W	74230-0100
R604	Res., 100, 1/4 W	74253-0080
R605	Res., 100, 1/2 W, 2 %.....	74241-0200
R606	Res., 100, 1/4 W	74230-0130
R608	Res., 910, 1/2 W, 2 %	74241-0430
R609	Res., 15 k, 1/4 W.........	74230-0140
R610	Res., 4.7 k, 1/4 W	74230-0290
R611	Res., 6.2 k, 1/2 W, 2 %	74241-0610
R612	Res., 1 k, 1/2 W, 2 %	74241-0440
R613	Res., 180, 1/4 W	74253-0890
R614	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R615	Res., 510, 1/2 W, 2 %	74241-0370
R616	Res., 10 k, 1/4 W.........	74230-0120
R617	Same as R610	
R618	Res., 3 k, 1/4 W..........	74230-0530
R619	Res., 2.2 k, 1/4 W	74230-0270
R620	Same as R618	
R621	Same as R614	
R622	Res., 8.2 k, 1/4 W	74230-0430
R623	Res., 20 k, 1/4 W.........	74230-0310
R624	Res., 50 k, var	74349-0890
R625	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R626	Res., 1.8 k, 1/2 W, 2 %	74241-0480
R627	Res., 3.9 k, 1/4 W	74230-0090
R628	Res., 150, 1/2 W, 2 %	74241-0240
R629	Same as R610	
R630	Res., 330, 1/2 W, 2 %	74241-0320
R631	Same as R618	
R632	Same as R618	
R633	Res., 8.2 k, 1/4 W, cer	74230-0430
R634	Res., 200, 1/2 W, 2 %	74241-0270
R635	Res., 5.6 k, 1/4 W	74230-0520
R636	Same as R605	
R637	Same as R634	
R638	Res., 470, 1/2 W, 2 %	74241-0360
R639	Res., 680, 1/2 W, 2 %	74241-0400
R640	Same as R614	
R641	Same as R601	
R642	Res., 62, 1/4 W	74253-0790
R643	Same as R614	
R645	Same as R612	
R646	Same as R601	
R647	Res., 33 k, 1/2 W, 2 %	74241-0770
R648	Res., 2 k, 1/2 W, 2 %	74241-0490
R649	Same as R604	
R650	Same as R616	
R651	Same as R615	
R652	Same as R612	
R653	Res., 3.9 k, 1/2 W, 2 %	74241-0560
R655	Same as R604	
R656	Res., 30 k, 1/4 W, 2 %	74241-0760
R657	Same as R601	
R658	Res., 10 k, 1/2 W, cer	74241-0660
R659	Res., 1 k, 1/4 W	74230-0030
R660	Same as R609	
R661	Same as R659	
R662	Same as R609	
R663	Same as R606	
R664	Res., 56, 1/4 W	74253-0770
R665	Same as R601	
R666	Res., 6.8 k, 2W, 2 %	74243-0530

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R667	Same as R601	
R668	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R669	Same as R604	
R670	Same as R601	
R671	Same as R601	
R672	Res., 1 k, 1/4 W	74253-0500
R673	Res., 500, var, WW	74331-0360
R674	Same as R648	
R675	Res., 150, 1/4 W, cer	74253-0580
R676	Res., 150, 1/4 W	74230-0510
R677	Same as R601	
R678	Res., 5.6 k, 2 W, 2 %	74243-0510
R679	Res., 3.3 M, 1/4 W	74281-0170
R680	Same as R604	
R687	Same as R601	
R688	Res., 8.2 k, 1 W, 2 %	74242-0500
R689	Same as R605	
R690	Same as R601	
R691	Res., 2 k, 1/4 W	74230-0410
R692	Res., 1 k, var	74349-0640
R693	Res., 300, 1/4 W	74230-1160
R694	Res., 2.2, 1/4 W	74253-0010
R695	Same as R694	
R696	Same as R605	
TR601	Transistor, MD3250	74030-3220
TR602	Transistor, 2N4121	74030-2990
TR603	Transistor, 2N4275	74030-3160
TR604	Same as TR603	
TR605	Same as TR603	
TR606	Transistor 2SC321 Ⓗ B	74030-4500
TR607	Transistor, 2N4258	74030-3150
TR609	Same as TR603	
TR610	Same as TR603	
TR611	Same as TR602	
TR612	Transistor	74030-2920
TR613	Same as TR603	
TR614	Same as TR602	
TR615	Same as TR602	
TR619	Transistor, 2N4360	74030-3710
TR620	Same as TR602	
TR621	Same as TR602	

5-13 A & B Timing Switch

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C374	Cap., 10 μF, elect	74100-9820
C375	Cap., 1000 pF, cer	74060-0180
C376	Same as C375	
C574	Same as C374	
C371A	Cap., 22 pF, 500 V, cer	74050-0490
C372A	Cap., cer, var	74110-0320
C373A	Same as C372A	
C571A	Same as C371A	
C572A	Same as C372A	
C573A	Same as C372A	
C371B	Cap., 100 pF, cer	74050-0690
C372B	Cap., 39 pF, cer	74050-5160
C373B	Same as C371B	
C571B	Same as C371B	
C572B	Same as C372B	
C573B	Same as C372B	
C371C	Cap., 2200 pF, 50 V, 10 %, poly	74130-1960
C373C	Cap., 950 pF, mica	74090-4680
C571C	Cap., 1000 pF, 50 V, 10 %, poly	74130-1310
C573C	Same as C373C	
C371D	Cap., 0.022 μF, 50 V, 10 %, poly	74130-2560
C373D	Cap., 0.01 μF, poly	74130-1760
C571D	Cap., 0.01 μF, 50 V, 10 %, poly	74130-2430
C573D	Same as C373D	
C371E	Cap., 0.22 μF, 50 V, 10 %, poly	74130-2370
C373E	Cap., 0.1 μF, poly	74130-1770
C571E	Cap., 0.1 μF, 50 V, 10 %, poly	74130-2390
C573E	Same as C373E	
C371F	Cap., 4.7 μF, 16 V, elect	74120-4010
C373F	Cap., 1 μF, poly	74130-1780
C571F	Same as C371F	
C573F	Same as C373F	
C371G	Cap., 4.7 μF, elect	74100-9880
C373G	Cap., 10 μF, poly	74130-1790
C374	Cap., 10 μF, 25 V, elect	74120-3960
D371	Diode, SD104	74040-1160
NE371	Neon lamp NE-68	74020-1170
NE372	Same as NE371	
R371A	Res., 47 k, 1/2 W, 2 %	74241-0810
R371B	Res., 100 k, 1/2 W, 2 %	74241-0890
R371C	Res., 200 k, 1/2 W, 2 %	74241-0960
R371D	Res., 390 k, 1/2 W, 2 %	74241-1030
R371E	Res., 680 k, 1/2 W, 2 %	74241-1090
R371F	Res., 1 M, 1/2 W, 2 %	74241-1130
R371G	Res., 3.3 M, 1/4 W	74281-0170
R371H	Res., 4.7 M, 1/4 W	74281-0290
R372	Res., 4 k, 1/4 W, 0.5 %	74226-2260
R373A	Res., 9.3 k, 1/4 W, 0.5 %	74226-2270
R373B	Res., 31 k, 1/4 W, 0.5 %	74226-2280
R373C	Res., 66 k, 1/4 W, 0.5 %	74226-2290
R373D	Same as R373C	
R373E	Res., 171 k, 1/4 W, 0.5 %	74226-2300
R373F	Res., 346 k, 1/2 W, 0.5 %	74226-2310
R373G	Res., 696 k, 1/2 W, 0.5 %	74226-2320
R373H	Res., 1.746 M, 1/2 W, 0.5 %	74226-2330
R373I	Res., 3.5 M, 1/2 W, 0.5 %	74226-2340
R373J	Same as R373I	
R373K	Res., 10.5 M, 1/2 W, 0.5 %	74226-2350
R374	Res., 3.3 k, 2 W, 2 %	74243-0450
R375	Res., 20 k, 1/2 W, 2 %	74241-0720
R376	Res., 10 k, 1/2 W, 2 %	74241-0660
R377	Res., 15 k, 1/2 W	74241-0690
R378	Res., 5 k	74235-2330
R379	Res., 10 k, 0.1 W, var	74349-0690
R380	Res., 300, 1/2 W, 2 %	74241-0310
R381	Res., 1 k, 1/4 W	74230-0030
R382	Res., 100 k, 1/4 W	74230-0260
R383	Res., 10 k, 1/2 W, 2 %	74241-0660
R385	Res., 100 k, 1/4 W	74253-1290
R386	Same as R385	
R571A	Same as R371A	
R571B	Same as R371B	
R571C	Same as R371C	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R571D	Same as R371D	
R571E	Same as R371E	
R571F	Same as R371F	
R571G	Res., 1.5 M, 1/4 W	74281-0270
R571H	Same as R371H	
R572	Same as R372	
R573A	Same as R373A	
R573B	Same as R373B	
R573C	Same as R373C	
R573D	Same as R373D	
R573E	Same as R373E	
R573F	Same as R373F	
R573G	Same as R373G	
R573H	Same as R373H	
R573I	Same as R373I	
R573J	Same as R373I	
R573K	Same as R373K	
R573M	Res., 17.5 M, 1/2 W, 0.5 %	74226-2360
R574	Same as R374	
R575	Same as R375	
R577	Same as R377	
R578	Res., 5 k	74325-2320
R579	Same as R379	
R580	Res., 300, 1/2 W, 2 %	74241-0310
S404	Switch, Rotary	74431-5350
S601	Same as S404	
TR371	Transistor 2SD221G	74030-4670
TR571	Same as TR371	

5-14 Horizontal Amplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C701	Cap., 0.02 μF, 25 V, cer	74060-0570
C702	Same as C701	
C703	Cap., teflon, var	74110-0290
C704	Same as C703	
C705	Cap., 100 pF, 50 V, cer	74050-1710
C706	Cap., 0.03 μF, 200 V, cer	74060-1090
C708	Same as C706	
C709	Same as C701	
C710	Same as C706	
C711	Cap., 10 μF, 25 V, elect	74120-3960
C712	Same as C711	
C713	Cap., 1000 pF, 500 V, cer	74060-0700
D701	Diode, IS953	74040-1720
D702	Same as D701	
D703	Same as D701	
D704	Same as D701	
D705	Diode, SD-1	74040-1010
D707	Diode, HW22A	74040-2680
D716	Diode, HW33A	74040-3240
R701	Res., 10 k, 1/4 W, 2 %	74224-0090
R702	Same as R701	
R703	Res., 51, 1/4 W	74253-0760
R704	Same as R703	
R705	Res., 6.2 k, 1/2 W, 2 %	74241-0610
R706	Res., 6.8 k, 1/2 W, 2 %	74241-0620
R707	Res., 2.4 k, 1/2 W, 2 %	74241-0510
R708	Same as R707	
R709	Res., 2.7 k, 1/2 W, 2 %	74241-0520
R710	Res., dual section, var	74325-2190
R711	Same as R710	
R712	Res., 180 k, 1/4 W	74253-1330
R713	Res., 8.2 k, 1/4 W	74253-0550
R714	Res., 9.1 k, 1 W, 2 %	74242-0510
R715	Same as R714	
R716	Res., 12.7 k, 1/2 W, 1 %	74226-1250
R717	Same as R716	
R718	Res., 1 k, var	74349-0640
R719	Res., 2 k, 1/2 W, 2 %	74241-0490
R720	Res., 15 k, 1/4 W	74230-0140
R721	Same as R720	
R722	Res., 2.2 k, 1/4 W	74230-0270
R723	Same as R722	
R724	Res., 100, var	74349-0830
R725	Res., 200, 1/4 W	74230-1340
R726	Res., 10 k, 1/4 W	74253-1160
R727	Res., 20 k, var	74349-0690
R728	Same as R726	
R729	Res., 47 k, 1/4 W	74253-0410
R730	Same as R729	
R731	Res., 680, 1/4 W	74253-0380
R732	Same as R731	
R734	Same as R723	
R735	Res., 24 k, 1/2 W, 2 %	74241-0740
R736	Same as R735	
R737	Res., 3.9 k, WW	74291-0900
R738	Res., 100, 1/2 W, 2 %	74241-0200
R739	Res., 3 k, WW	74227-0130
R740	Same as R739	
R741	Res., 47, 1/2 W, 2 %	74241-0120
R742	Res., 510, 2 W, 2 %	74243-0290
R743	Same as R738	
R744	Res., 5.6 k, 2 W, 2 %	74343-0510
R745	Same as R738	
R746	Res., 110, 1/4 W	74253-0860
R747	Res., 120 k, 1/4 W	74253-1310
R748	Res., 10, 1/4 W	74253-0440
R749	Same as R748	
R750	Same as R748	
RL701	Relay, SM-12	74450-0640
NE701	Neon lamp, NE-68	74020-1170
TR701	Transistor, 2N4275	74030-3160
TR702	Same as TR701	
TR703	Transistor, 2N4121	74030-2990
TR704	Same as TR703	
TR705	Same as TR703	
TR706	Same as TR703	
TR707	Transistor, 2N3119	74030-1830
TR708	Same as TR707	
TR709	Same as TR707	

5-15 Z Axis Amplifier

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C801	Cap., 0.02 μF, 25 V	74060-0570
C802	Same as C801	
C803	Cap., teflon, var	74110-0290
C805	Cap., 0.1 μF, 100 V	74060-0490
C806	Same as C805	
C807	Same as C801	
C808	Cap., 0.03 μF, 200 V	74060-1090
C809	Same as C801	
C810	Same as C801	
D801	Diode, IS953	74040-1720
D802	Same as D801	
D803	Same as D801	
D804	Diode, IS1226	74040-3230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
D805	Same as D804	
D806	Diode, HW33A	74040-3240
L801	Core, ferrite	74560-1030
R801	Res., 22 k, 1/4 W, 2 %	74244-0120
R802	Res., 47, 1/4 W	74253-0070
R803	Same as R802	
R804	Res., 47 k, 1/4 W	74253-0410
R805	Res., 1 k, 1/2 W	74241-0440
R806	Res., 10 k, var	74349-0860
R807	Res., 2 k, 2 %	74241-0490
R808	Res., 3 k, 1/2 W	74241-0530
R809	Res., 7.5 k, 2 %	74242-0490
R810	Res., 75 k, 1/4 W, 5 %	74253-1260
R811	Res., 3.9 k, 2 %	74241-0560
R812	Res., 1.2 k, 2 %	74241-0450
R813	Res., 15 k, 2 %	74242-0560
R814	Res., 750	74230-0540
R815	Same as R814	
R816	Res., 3 k, WW	74227-0130
R817	Res., 68	74230-1050
R818	Same as R802	
R819	Res., 2.2 k, 2 W	74243-0410
R820	Res., 100, 1/4 W	74253-0080
R821	Res., 8.2 k, 2 %	74243-0500
R822	Same as R820	
R823	Res., 10, 1/4 W	74253-0440
R824	Same as R823	
R825	Same as R823	
TR801	Transistor 2SC321 Ⓗ B	74030-4500
TR802	Same as TR801	
TR803	Transistor 2N3119	74030-1830
TR804	Transistor, 2SC689	74030-3620
TR805	Same as TR803	

5-16 CRT Circuit

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C901	Cap., 47 pF, 50 V, elect	74120-4590
C902	Cap., 0.1 μF	74130-1810
C903	Cap., 0.02 μF, 20 V, cer	74060-0570
C904	Cap., 0.015 μF, 2 kV, cer	74060-1960
C905	Same as C902	
C906	Same as C904	
C907	Cap., 5000 pF, 2 kV, cer	74060-1640
C908	Same as C907	
C909	Cap., 1 μF, 200 V, elect	74120-1210
C910	Cap., 1000 pF, 10 kV, cer	74060-2190
C911	Same as C910	
C912	Same as C904	
C913	Same as C910	
C914	Same as C910	
C915	Cap., 500 pF, 500 V, cer	74060-2080
C916	Cap., 10 μF, 63 V, elect	74120-2650
C917	Same as C904	
C918	Cap., 0.03 μF, 200 V, cer	74060-1090
C919	Cap., 1000 pF, 500 V, cer	74060-0180
C920	Same as C919	
C921	Same as C919	
C922	Same as C919	
C923	Cap., 0.01 μF, 500 V, cer.	74060-0340
C924	Cap., 1000 pF, 3 kV, cer	74060-1180
C925	Cap., 100 pF, 500 V, cer	74050-0690
D901	Diode, HFSD-1	74040-3140
D902	Diode, VFS-5X	74040-3570
D903	Same as D902	
D904A – D	Diode, VFS-12X	74040-3560
D905	Same as D901	
D906	Diode, RD24A	74040-0950
D907	Diode, RD29A	74040-2060
D908	Same as D906	
F901	Fuse, 1A	74480-1580
J901	Connector	74500-2530
NE901A – C	Neon lamp, NE-68	74020-1170
R901	Res., 100 k, var	74349-0650
R902	Res., 3.3 M, 1/4 W	74281-0170
R903	Res., 10 k, 1/2 W	74241-0660
R904	Res., 1.5 M, 1/4 W	74281-0270
R905A – G	Res., 3 M, 1/4 W	74281-0260
R906	Res., 1.2 k, 1/2 W	74241-0450
R907	Res., 10, 1/4 W	74253-0440
R908	Res., 100, 1/4 W	74253-0080
R909	Res., 100 k, 1/4 W	74253-1290
R910	Res., 56 k, 1/2 W	74241-0830
R911	Same as R909	
R912	Res., 15 k, 1/2 W	74241-0690
R913	Res., 115 M, 2 W, ±10 %	74256-0070
R914	Res., 47 k, 1/2 W	74241-0810
R915	Res., 1 M, 1/2 W	74241-1130
R916	Res., 1 k, 1/2 W	74241-0440
R917	Res., 100 k, var	74325-2310
R918	Res., 33 k, 1/2 W	74241-0770
R919	Res., 1 M, 1/4 W	74281-0340
R920	Res., 3.9 k, 1/2 W	74241-0560
R921	Same as R903	
R922A – D	Same as R902	
R923	Res., 5 M, var	74322-0750
R924 A/B	Same as R905	
R925	Res., 2 k, var	74331-0380
R926	Res., 200, 1/2 W	74241-0270
R927	Same as R926	
R928	Same as R925	
R929	Res., 2 k, var	74331-0430
R930	Same as R917	
R931	Same as R917	
R932	Res., 100 k, 0.5 W	74349-0850
R933	Res., 12 k, 1/2 W	74241-0670
R934	Same as R914	
R935	Res., 100, 1/2 W	74241-0200
R936	Res., 22 k, 1/2 W	74241-0730
R937	Same as R935	
R938	Res., 470, 1/2 W	74241-0360
R939	Res., 4.7 k, 1/2 W	74241-0580
T901	Transistor, 2SC907 Ⓗ C	74030-3980
TR901	Transistor, 2SC650B	74030-2310
TR902	Transistor, 2N4121	74030-2990
TR903	Transistor, 2SC511-0	74030-2320
TR904	Transistor, 2SD93	74030-3760
V901	CRT, ILD-947/D13-45GH/ EZ025B31C	74010-122-0/ 74010-0810/ 74010-1160

5-17 Power Supply

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1001	Cap., 33 μF, elect	74120-2760

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1002	Cap., 0.01 µF, 500 V, cer	74060-0340
C1003	Same as C1002	
C1004 A/B	Cap., dual section, elect	74100-7960
C1005	Same as C1002	
C1006	Cap., 470 µF, 160 V, elect	74120-2740
C1007	Same as C1002	
C1008	Cap., 0.1 µF, cer	74060-0490
C1009	Cap., 1000 pF, 500 V, cer	74060-0180
C1010	Cap., 2.5 µF, 100 V, elect	74120-4020
C1011	Cap., 22 µF, 160 V, elect	74120-1610
C1012	Same as C1002	
C1013	Cap., 3300 µF, 35 V, elect	74120-2750
C1014	Same as C1009	
C1015	Cap., 10 µF, 25 V, elect	74120-3960
C1016	Cap., 47 µF, 25 V, elect	74120-2250
C1017	Same as C1002	
C1018	Same as C1013	
C1019	Same as C1009	
C1020	Cap., 100 µF, 16 V, elect	74120-3020
C1021	Same as C1016	
C1022	Cap., 0.02 µF, 25 V, cer	74060-0570
C1023	Same as C1009	
C1024	Same as C1022	
C1025	Same as C1009	
C1026	Same as C1022	
C1027	Same as C1002	
D1001	Diode, 10D6	74040-2100
D1002 A – D	Same as D1001	
D1003 A – D	Same as D1001	
D1004	Diode, HW33A	74040-3010
D1005	Diode, IS955	74040-1840
D1006	Diode, IS953	74040-1720
D1007	Diode, HW39A	74040-3120
D1008	Same as D1005	
D1009	Diode, HFSD-1	74040-3140
D1010	Same as D1006	
D1011 A – D	Diode, 10D2	74040-2110
D1012	Same as D1006	
D1013	Same as D1006	
D1014	Same as D1006	
D1015	Diode, HW30A	74040-3210
D1016 A – D	Diode, 10D2	74040-2110
D1017	Diode, IS552	74040-3220
F1001	Fuse, 2 A slow	74540-0330
F1003	Fuse, 0.25 A	74540-0030
F1004	Fuse, 0.5 A	74540-0050
J1001	Connector	74500-0500
NE1001	Neon lamp, NE-68	74020-1170
P1001	Connector	74500-0390
P1002	Connector	74500-0490
PL1001	Lamp, 6.3 V, 150 mA	74490-0150
PL1002	Same as PL1001	
R1001	Res., 100 k, 1/2 W, 2 %	74241-0890
R1002	Same as R1001	
R1003	Res., 27, 2 %	74241-0070
R1004	Same as R1001	
R1005	Res., 8.2 k	74230-0430
R1006	Res., 68 k, 1/4 W	74230-0010
R1007	Res., 33 k	74230-0300
R1008	Res.,10, 2 %	74243-0010

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
R1011	Res., 10 k	74230-0120
R1012	Res., 120	74230-1130
R1013	Res., 82 k, 1/4 W	74230-0340
R1014	Res., 64.3 k, 1/8 W, 1 %	74221-0320
R1015	Res., 16.3 k, 1/2 W	74221-0610
R1016	Res., 300, var, WW	74331-0360
R1017	Res., 2.8 k, 1/8 W	74221-0560
R1018	Res., 200	74230-1340
R1019	Res., 47	74230-0100
R1020	Res., 1.2, WW	74220-0100
R1021	Res., 10 k, 2 %	74241-0660
R1022	Same as R1013	
R1023	Same as R1018	
R1024	Res., 0.3, WW	74220-0110
R1025	Res., 15 k	74230-0140
R1026	Same as R1014	
R1027	Res., 3.9 k, 1/8 W	74221-0570
R1028	Same as R1016	
R1029	Res., 2.98 k, 1/8 W	74221-0580
R1030	Res., 47 k	74230-0170
R1031	Same as R1012	
R1032	Res., 30, WW	74220-0080
R1033	Same as R1021	
R1034	Same as R1018	
R1035	Same as R1024	
R1036	Res., 620	74230-1040
R1037	Res., 56 k, 1/4 W	74230-0560
R1038	Res., 2.7 k, 1/4 W	74230-0420
R1039	Res., 3.02 k, 1/8 W	74221-0590
R1040	Same as R1016	
R1041	Res., 2.08 k, 1/8 W	74221-0600
R1042	Res., 39 k	74230-0780
R1043	Same as R1012	
R1044	Same as R1032	
R1045	Res., 50 V, var, WW	74331-0640
R1046	Res., 30 k, 1/2 W	74241-0760
R1047	Res., 4.7 k, 2 %	74241-0580
R1048	Res., 1 k, 2 %	74241-0440
S1001	Switch, toggle	74440-0150
S1002	Switch, thermal	74450-0870
S1003	Same as S1001	
T1001	Transformer, power	74471-1930
TR1001	Transistor, 2SC154C	74030-4000
TR1002	Transistor, 2SC907 Ⓗ C	74030-3980
TR1003	Transistor, 2SD221	74030-4010
TR1004	Transistor, 2SC1030B	74030-4920
TR1005	Transistor, 2N4275	74030-3160
TR1006	Same as TR1002	
TR1007	Same as TR1002	
TR1008	Transistor, 2SD220	74030-5230
TR1009	Same as TR1004	
TR1010	Same as TR1005	
TR1011	Transistor, u PA-15	74030-1520
TR1012	Same as TR1002	
TR1013	Same as TR1008	
TR1014	Same as TR1004	

5-18 Cablirator

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1101	Cap., 0.02 µF, 25 V, cer	74060-0570
C1102	Cap., 10 µF, 16 V, elect	74120-3980
C1103	Cap., 0.01 µF, 500 V, cer	74050-0560
C1104	Cap., 0.1 µF, 100 V, 1 %	74050-1830
C1105	Cap., 0.05 µF, 25 V, cer	74060-1220

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART NO.
C1106	Cap., 470 pF, 500 V, 20 %, cer	74060-0140
C1107	Cap., 100 pF, 500 V, 10 %, cer	74050-0690
C1108	Cap., 0.1 μF, 25 V, cer	74060-0440
J1101	Connector	74500-2480
R1101	Res., 510, 1/2 W, 2 %	74241-0370
R1102	Res., 500, 1/10 W, var	74349-0630
R1103	Res., 2 k, 1/2 W, 2 %	74241-0490
R1104	Res., 2.2 k, 1/2 W, 2 %	74241-0500
R1105	Res., 470, 1/2 W, 2 %	74241-0360
R1106	Res., 10 k, 1/2 W, 2 %	74241-0660
R1107	Res., 7.5 k, 1/2 W, 2 %	74241-0630
R1108	Same as R1105	
R1109	Res., 47, 1/4 W	74253-0070
R1110	Same as R1106	
R1111	Res., 1 k, 1/8 W, 0.5 %	74221-0990
R1112	Res., 667, 1/8 W, 0.5 %	74221-0940
R1113	Res., 179, 1/8 W, 0.5 %	74221-0930
R1114	Res., 801, 1/8 W, 0.5 %	74221-0920
R1115	Res., 45.2, 1/8 W, 0.5 %	74221-0980
R1116	Res., 28.7, 1/8 W, 0.5 %	74221-0970
R1117	Res., 5 k, 1/8 W, 0.5 %	74221-0950
R1118	Res., 21.3, 1/8 W, 0.5 %	74221-0960
R1119	Same as R1117	
R1120	Res., 50, 1/8 W, 0.5 %	74221-0910
R1121	Res., 0.25, 1/2 W, WW	74310-1180
R1122	Res., 2 k, 1/8 W, 0.5 %	74221-1000
S1101	Switch, rotary (CALIBRATOR VOLTS)	74431-5320
T1101	Transformer	47472-0830
TR1101	Transistor, 2N4275	74030-3160
TR1102	Same as TR1101	
TR1103	Same as TR1101	
TR1104	Transistor, 2N4121	74030-2990

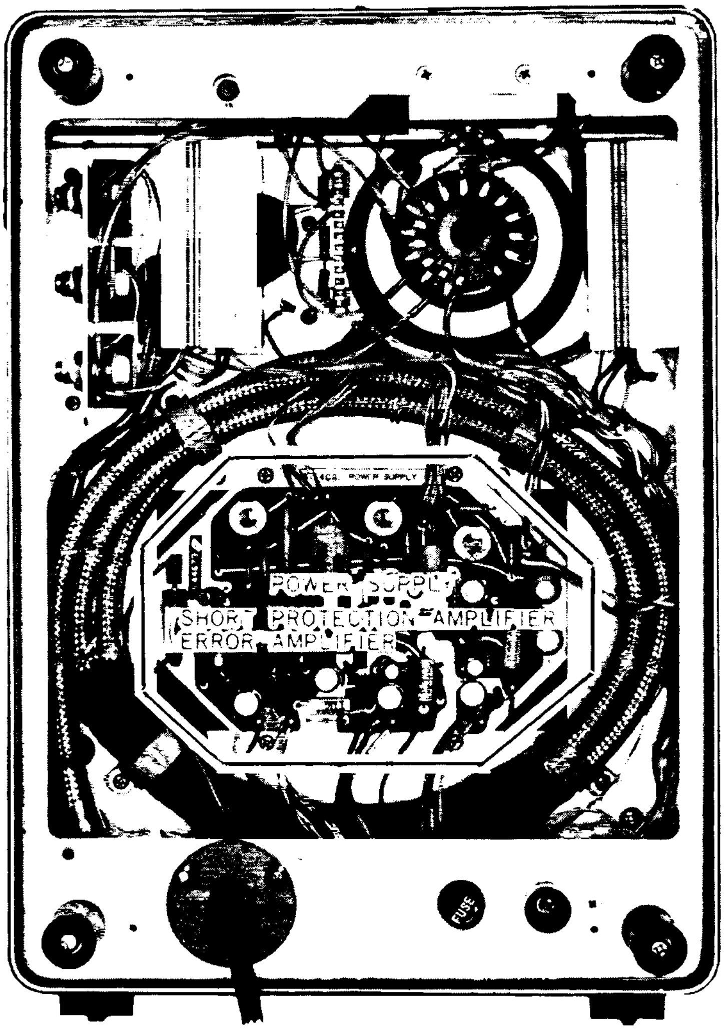
SECTION 6
DRAWINGS

6-1 GENERAL INFORMATION

This section of the manual contains photographs and drawings of the subassemblies and circuits used in the SS-112. The photographs contain component circuit references and show the location of each component. Overall assembly location diagrams show the location of circuit assemblies within the instrument. Figures 6-1 through 6-4 show the location of major subassemblies. Figures 6-5 through 6-10 show detailed component location diagrams for each subassembly.

6-2 SCHEMATIC DIAGRAMS

There are 16 schematic diagrams following the component location diagrams. As much as possible, the convention of signal flow is from the left portion of the schematic toward the right. Component symbology and nomemclature follow generally-accepted practices. Resistance is given in ohms. Capacitor values less than 1 are in microfarads and more than 1 are in picofarads unless otherwise indicated. Multi- wafer rotary switches are shown inline on the schematics. Waveforms on the schematics were taken under the conditions listed on each schematic.



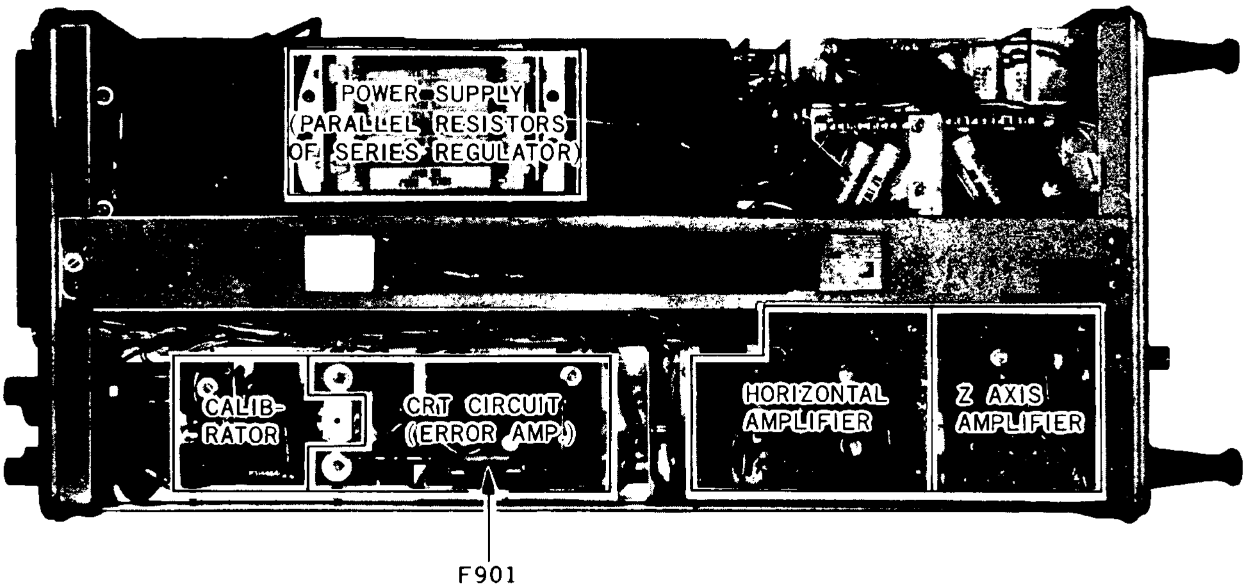
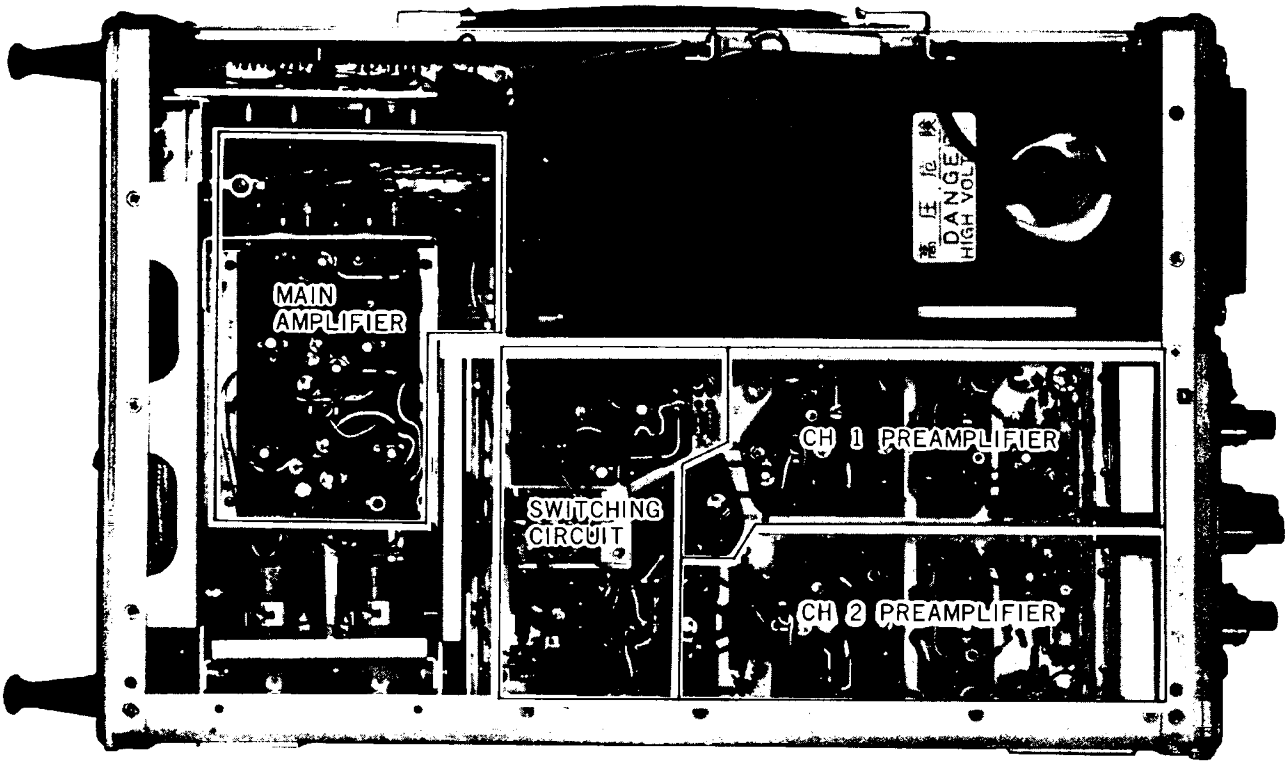


Figure 6-1 Overall Top and Rear Views



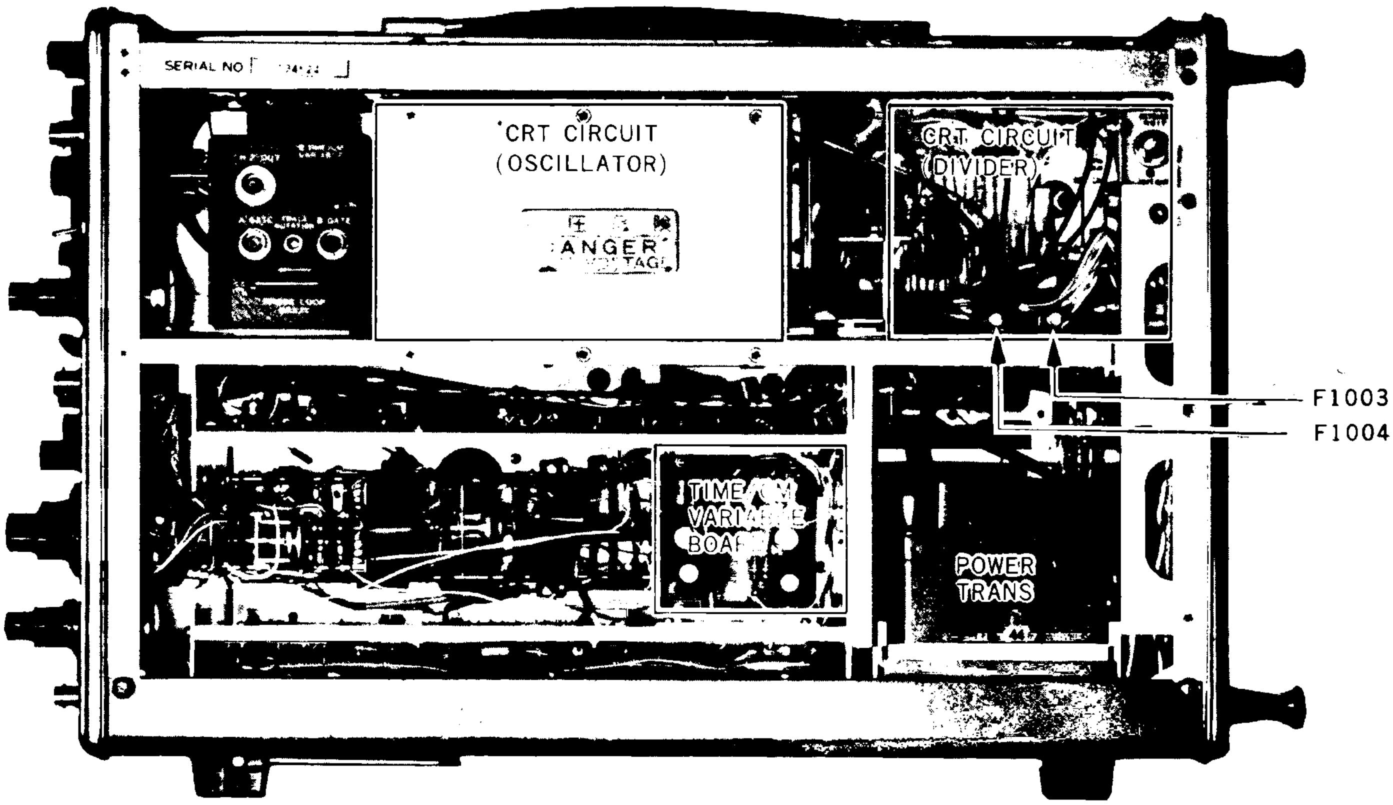


Figure 6-2 Side Views

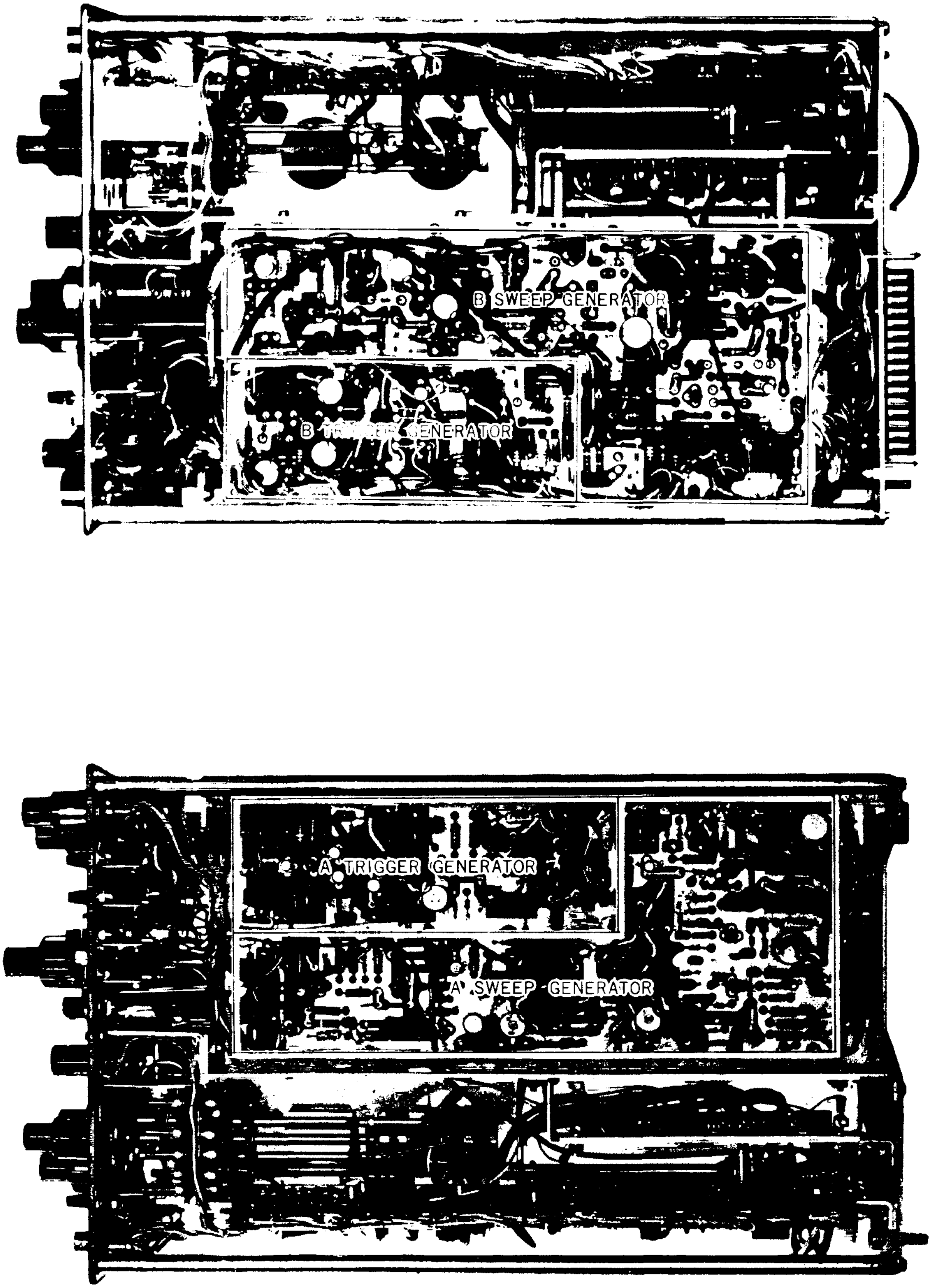


Figure 6-3 Top and Bottom Views, Plug-In Unit

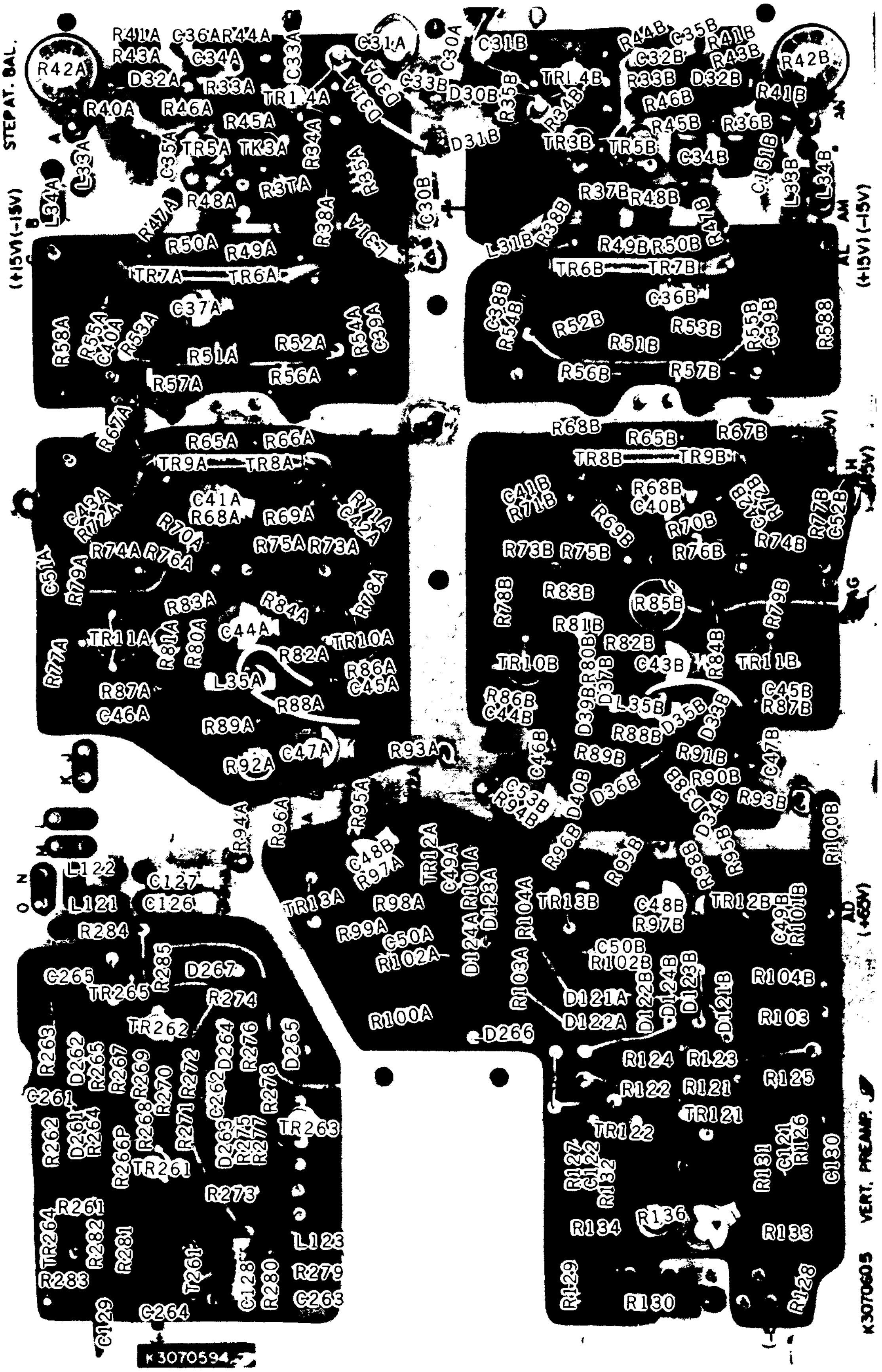


Figure 6-4 Preamplifier and Switching Circuit Assembly

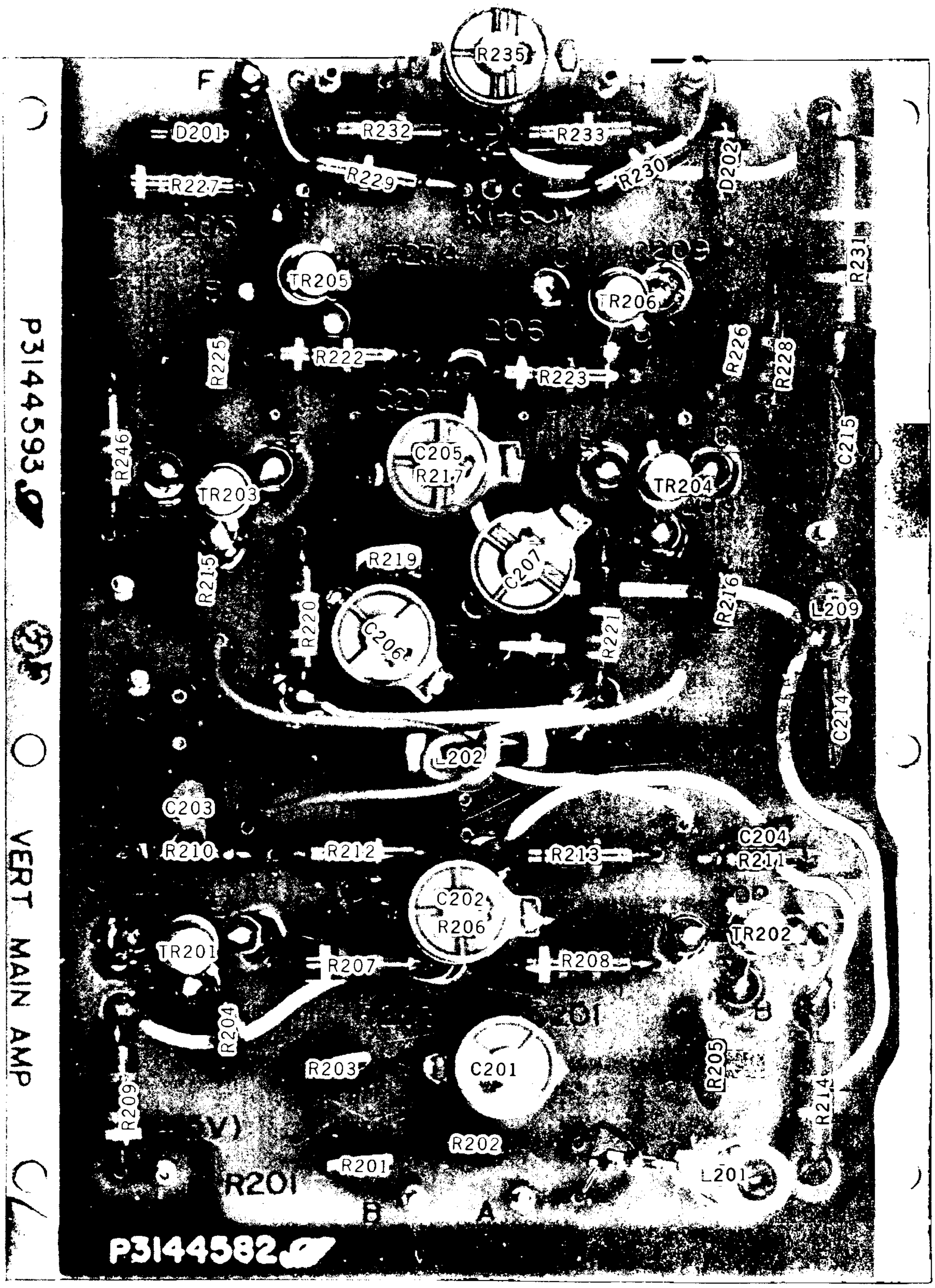


Figure 6-5 Main Vertical Amplifier Assembly

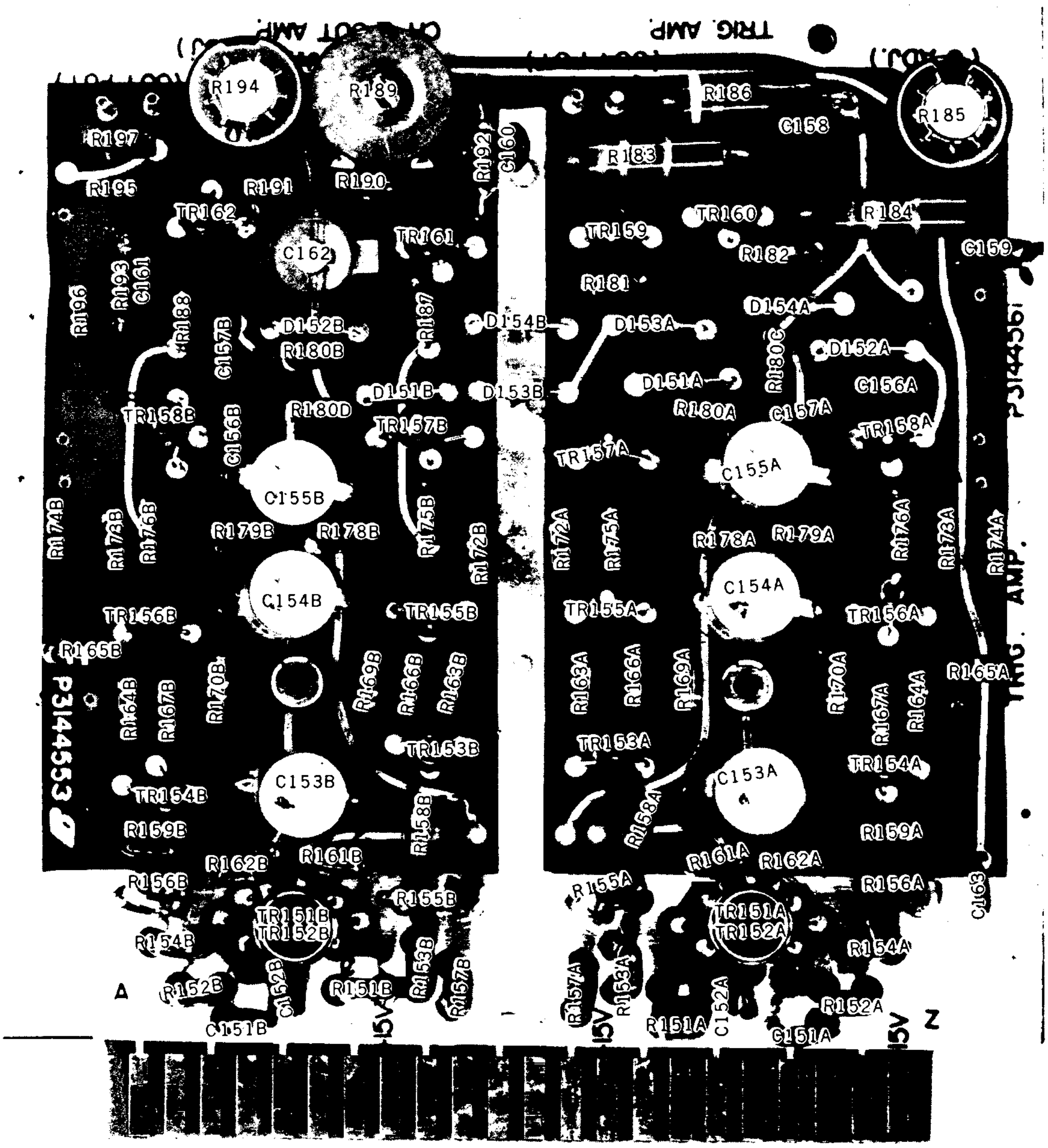


Figure 6-6 Trigger Amplifier Assembly

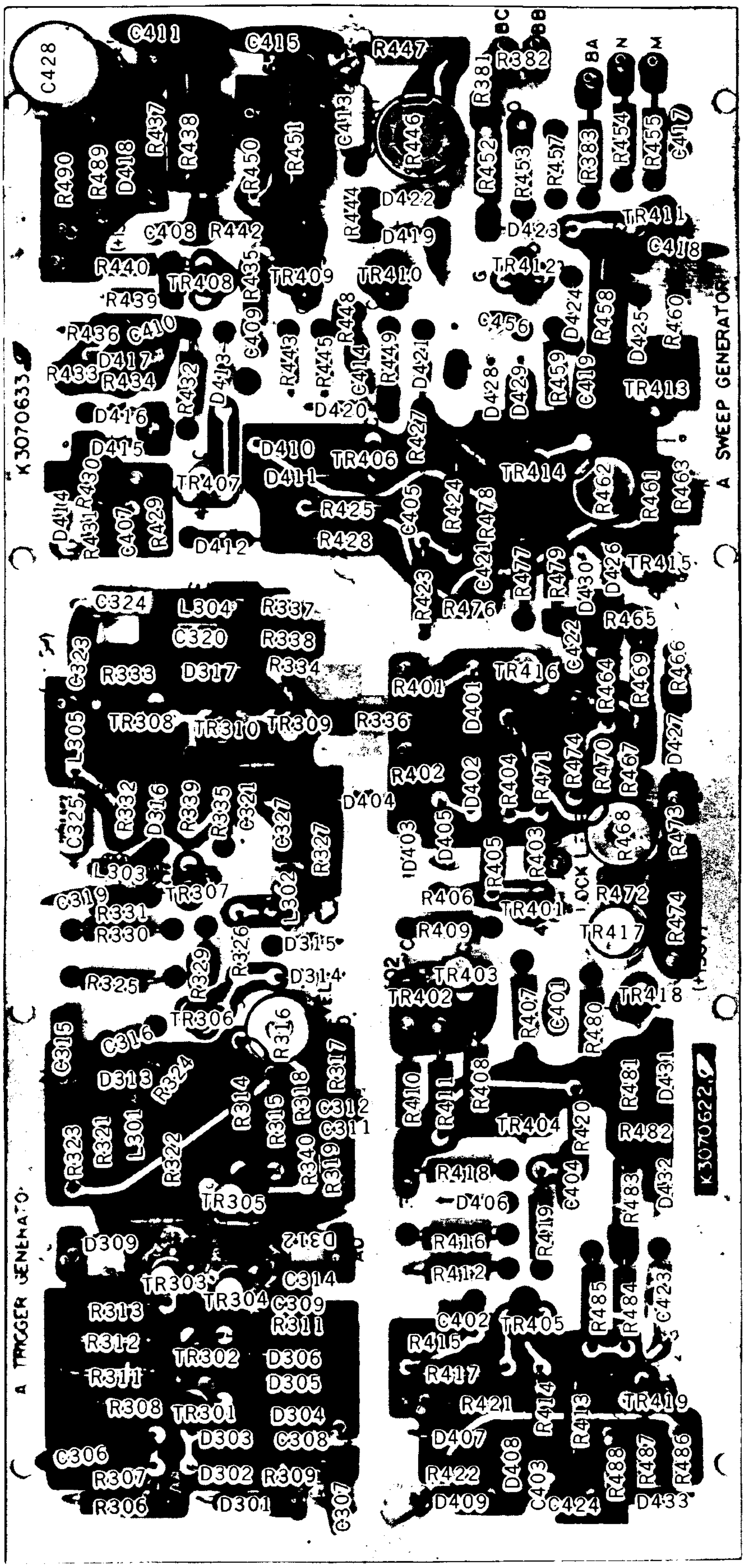


Figure 6-7 A Trigger and Sweep Generator Assembly

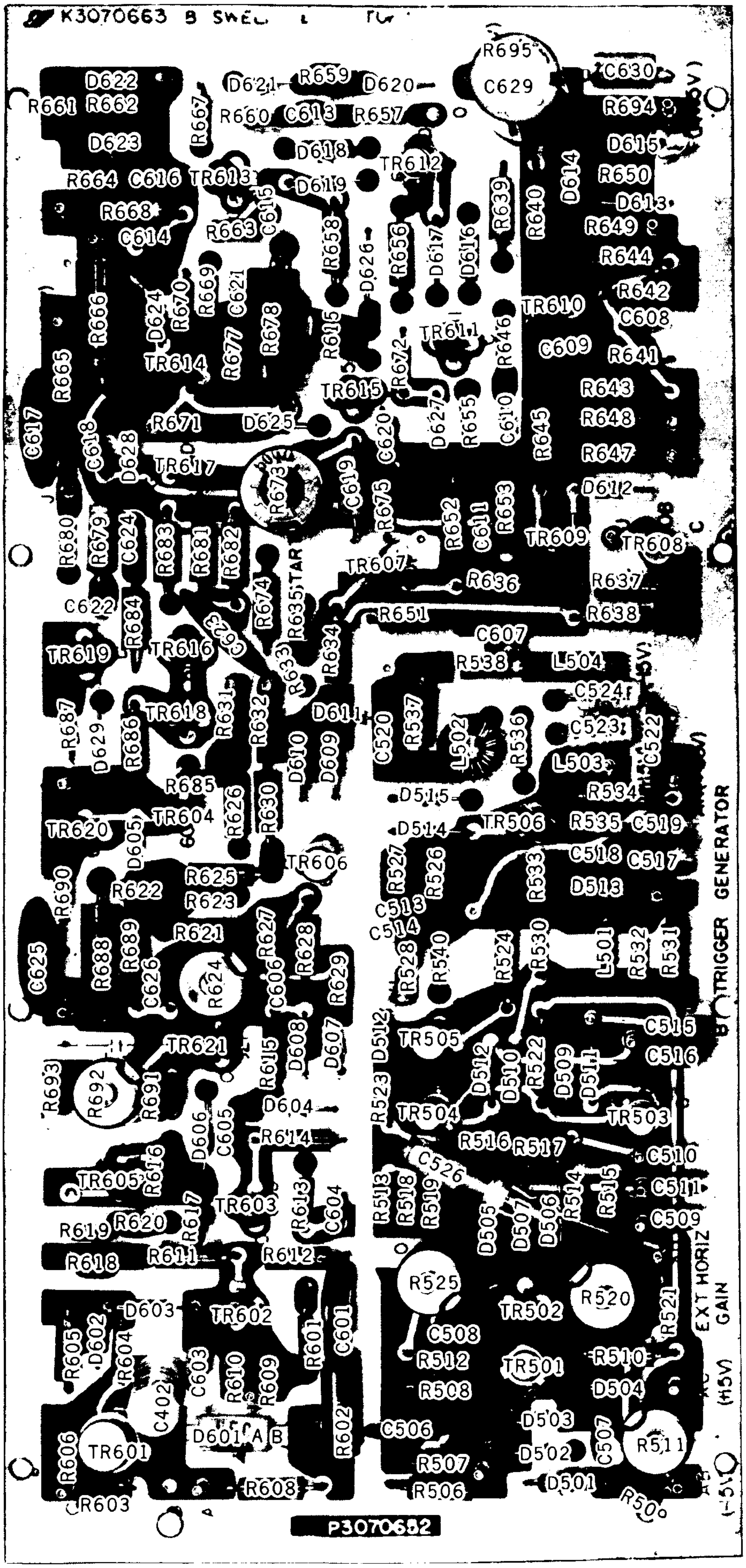


Figure 6-8 B Trigger and Sweep Generator Assembly

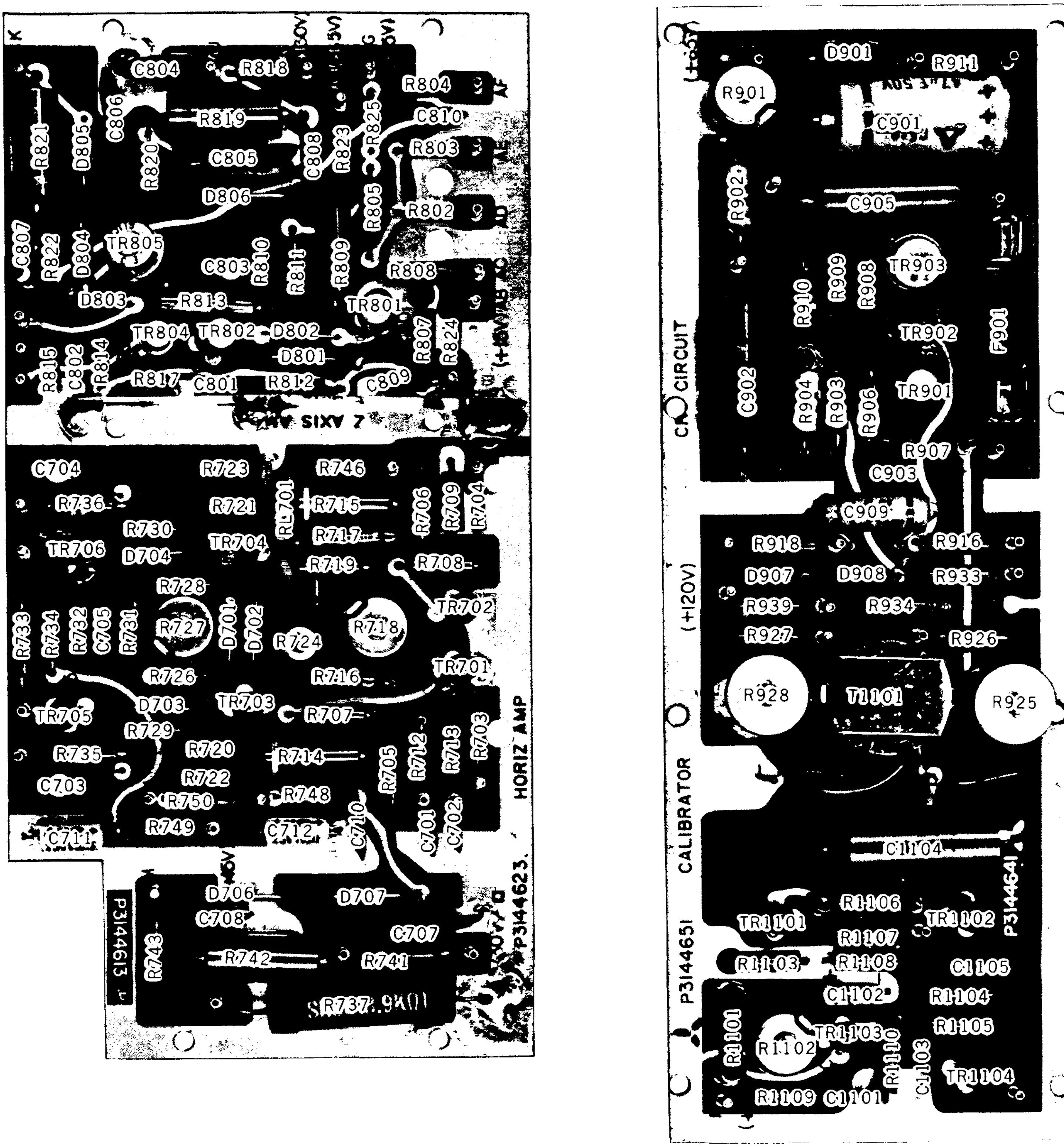


Figure 6-9 Horizontal, Z-Axis, CRT, and Calibrator Assemblies

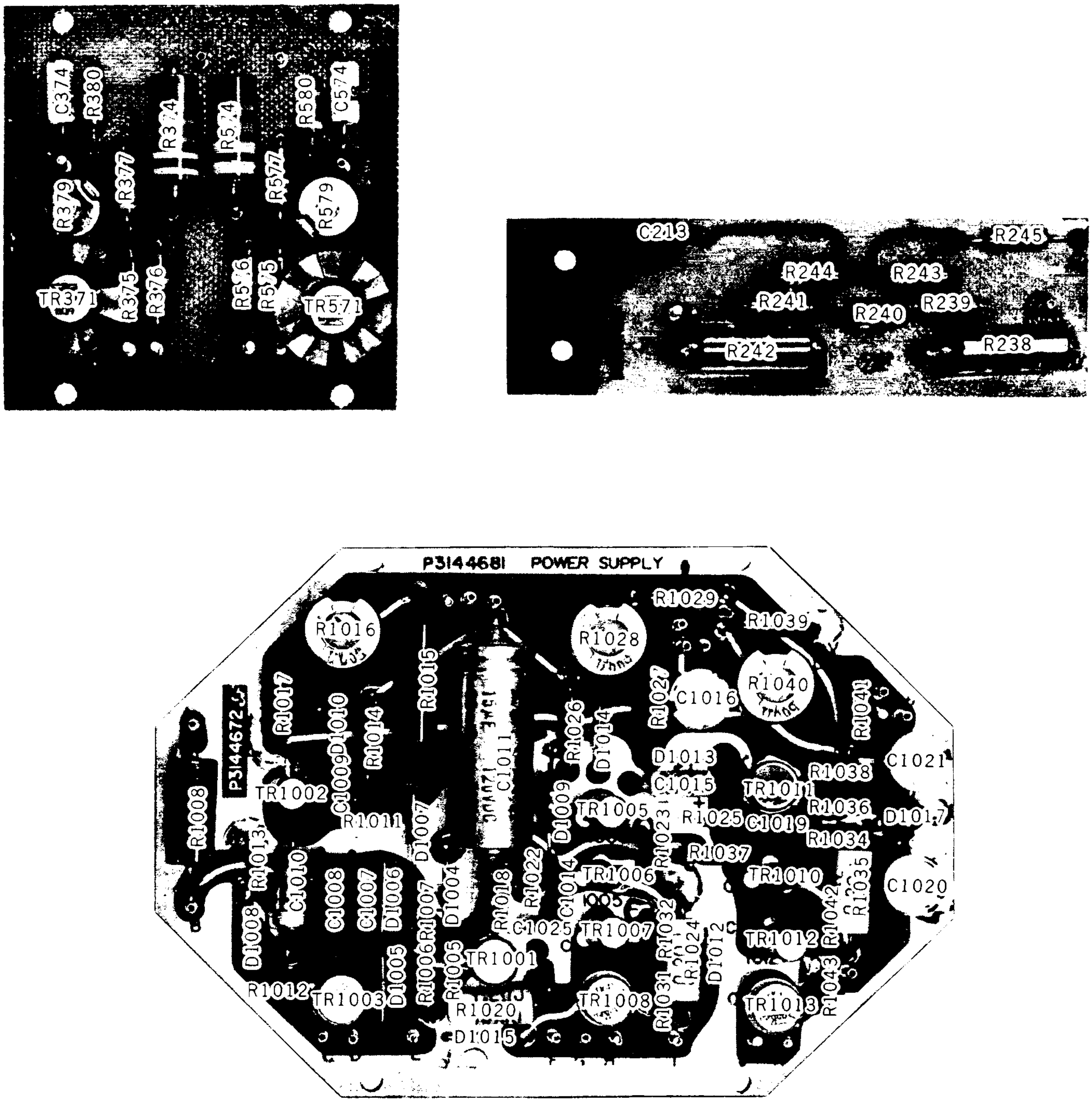
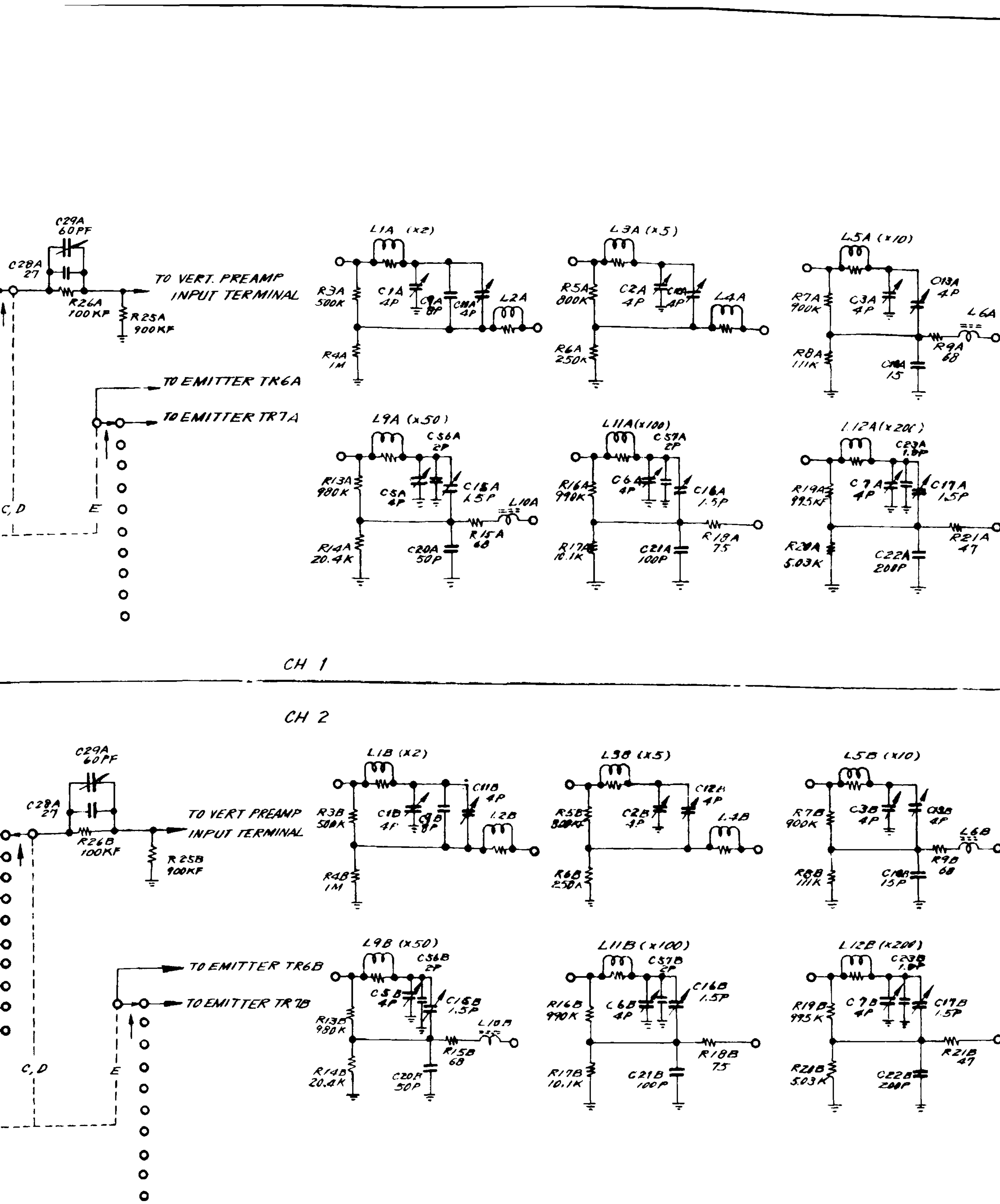
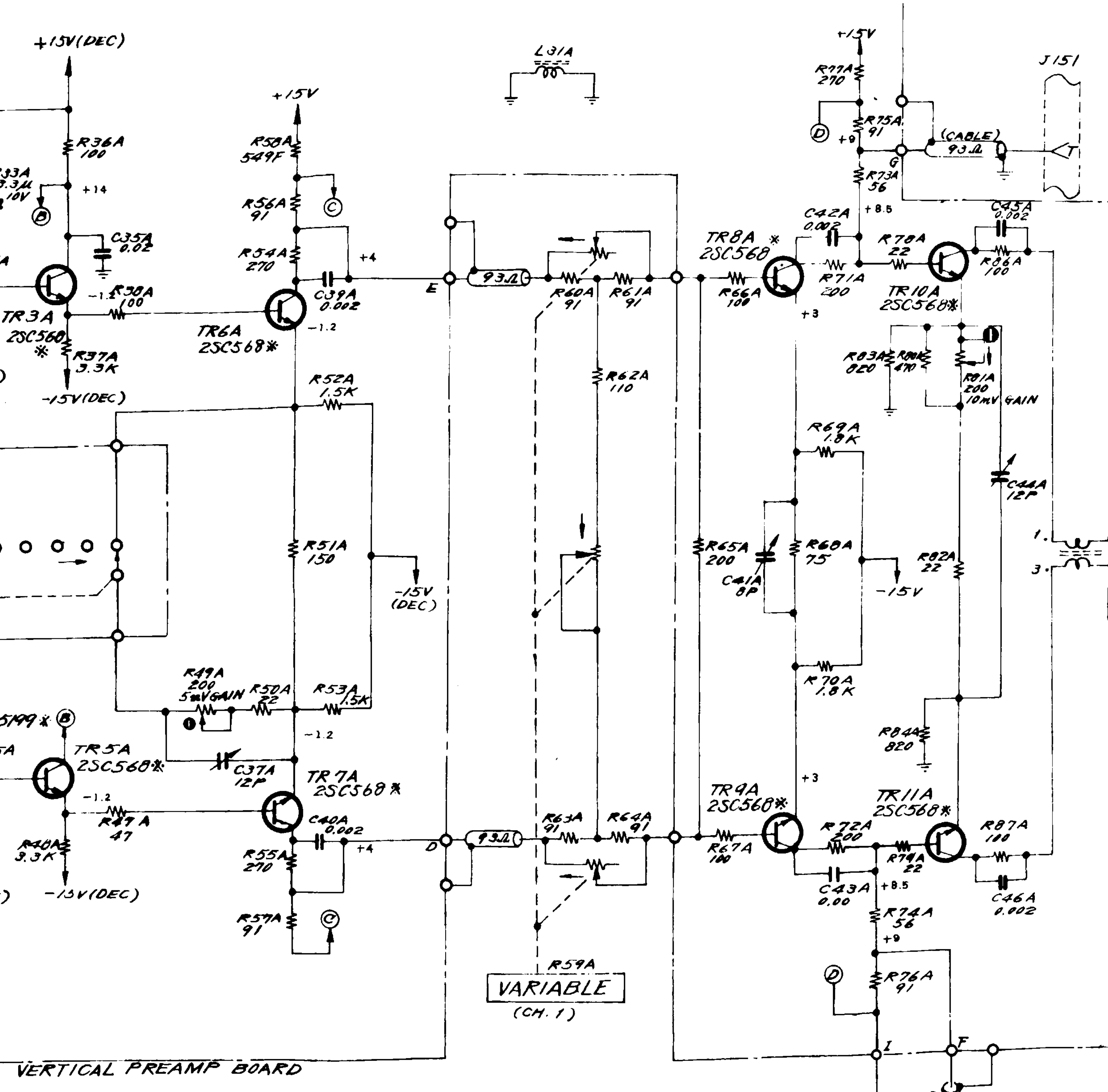


Figure 6-10 Miscellaneous Assemblies

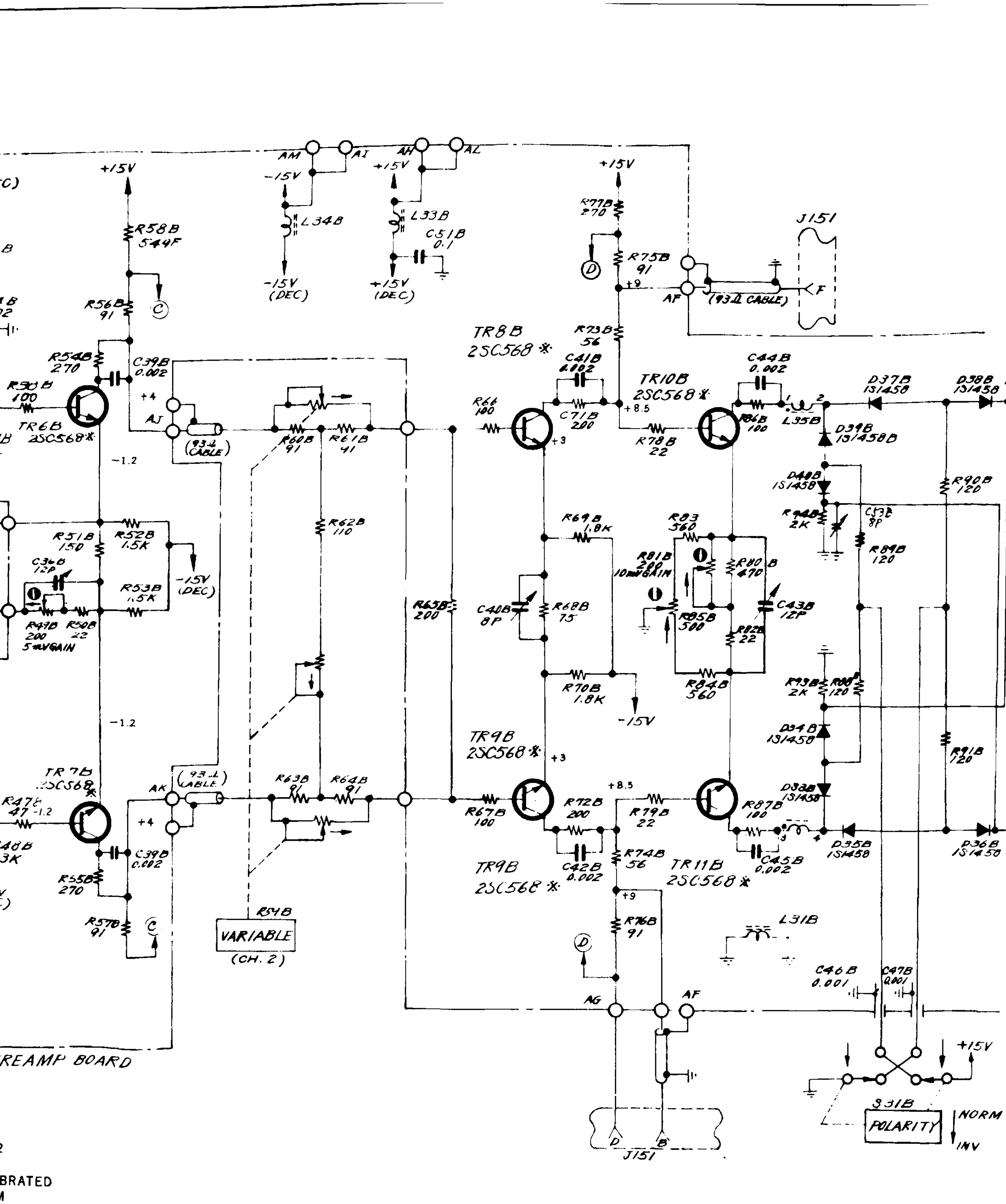


C29A 60PF
C28A 27
TO VERT. PREAMP INPUT TERMINAL
R26A 100KF
R25A 900KF
TO EMITTER TR6A
TO EMITTER TR7A
C, D
E
L1A (x2)
R3A 500K
C1A 4P
R4A 1M
L2A
L3A (x5)
R5A 800K
C2A 4P
R6A 250K
L4A
L5A (x10)
R7A 900K
C3A 4P
C13A 4P
R8A 111K
L6A
R9A 68
L9A (x50)
C56A 2P
R13A 980K
C5A 4P
C15A 1.5P
L10A
R15A 68
R14A 20.4K
C20A 50P
L11A (x100)
C57A 2P
R16A 990K
C6A 4P
C16A 1.5P
R18A 75
C21A 100P
C17A 1.5P
R21A 47
C22A 200P
CH 1
CH 2
C29A 60PF
C28A 27
TO VERT PREAMP INPUT TERMINAL
R26B 100KF
R25B 900KF
TO EMITTER TR6B
TO EMITTER TR7B
C, D
E
L1B (x2)
R3B 500K
C1B 4P
C11B 4P
L2B
R4B 1M
L3B (x5)
C12B 4P
C2B 4P
L4B
L5B (x10)
R7B 900K
C3B 4P
C13B 4P
L6B
R9B 68
R8B 111K
C18B 15P
L9B (x50)
C56B 2P
C5B 4P
C15B 1.5P
R13B 980K
L10B
R15B 68
R14B 20.4K
C20B 50P
L11B (x100)
C57B 2P
C16B 1.5P
R16B 990K
C6B 4P
R18B 75
R17B 10.1K
C21B 100P
R19B 995K
C7B 4P
C17B 1.5P
R21B 47
R20B 5.03K
C22B 200P

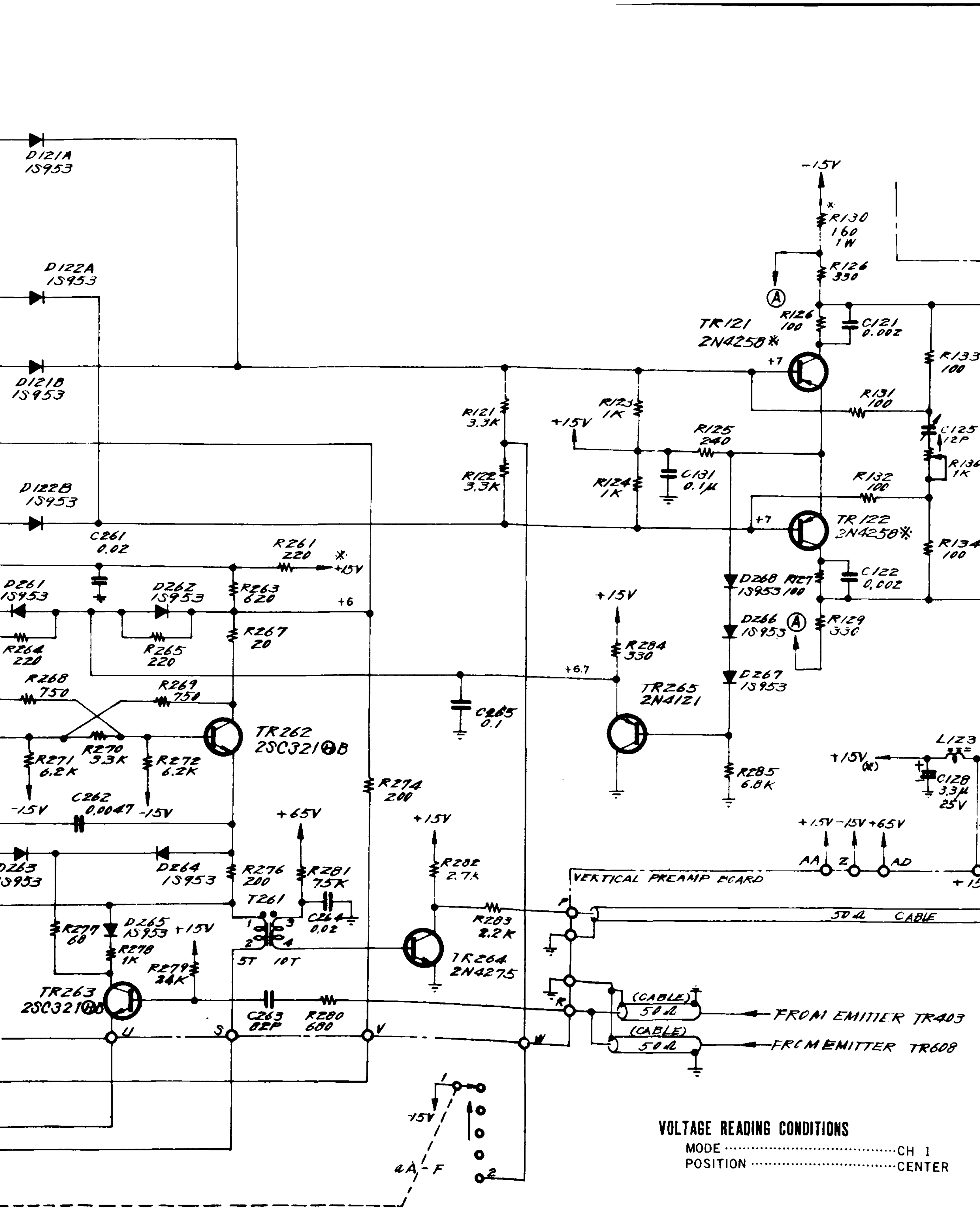


ONS

…………CH 1
…………GND
…………CALIBRATED



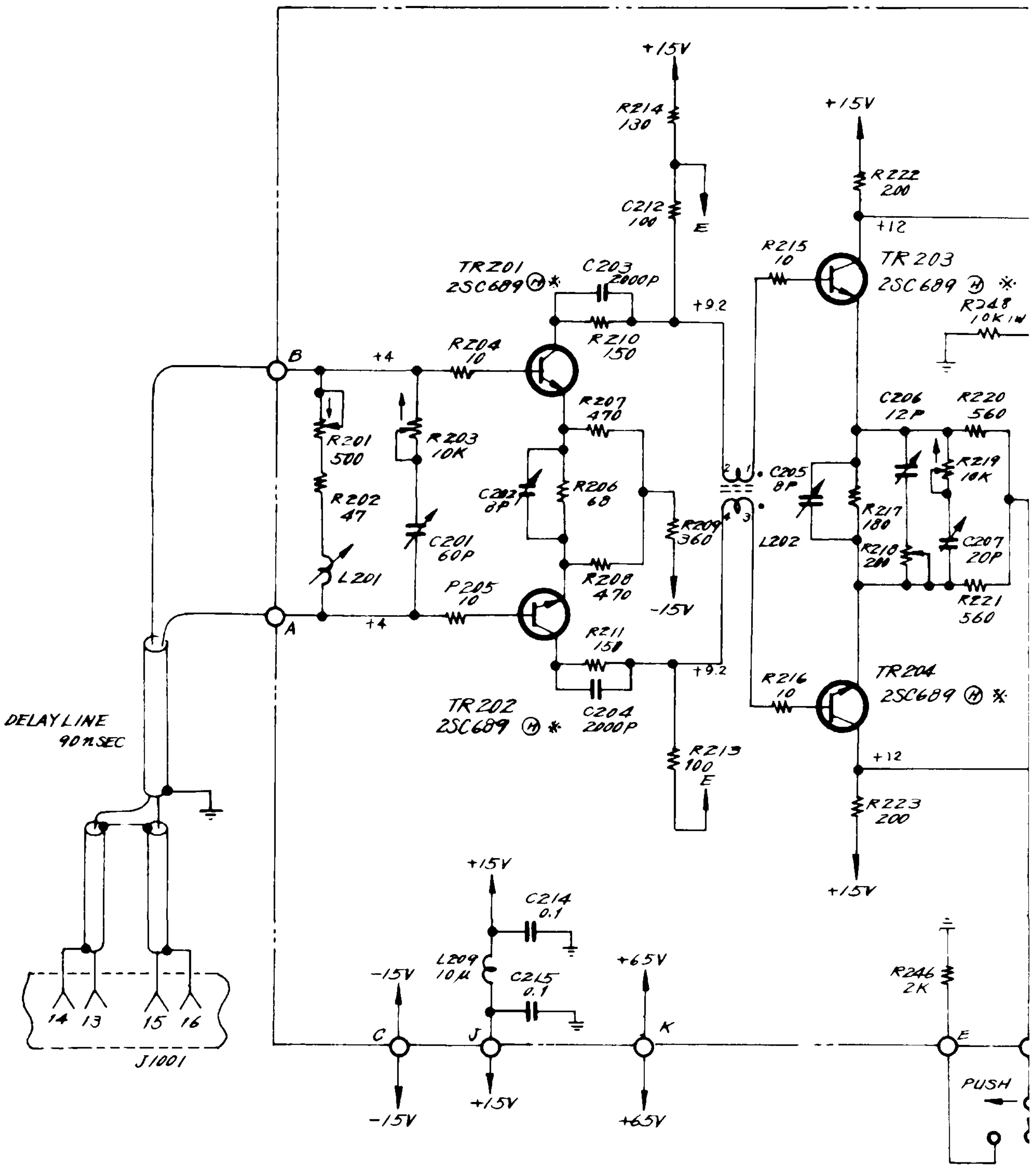
+15V
R58B 544F
R56B 91
R54B 270
C39B 0.002
R50B 100
TR6B 2SC568※
R51B 150
R52B 1.5K
R53B 1.5K
C36B 12P
R49B 200 5mV GAIN
R50B 22
-15V (DEC)
TR7B 2SC568※
R55B 270
R57B 91
-1.2
+4
AM
AI
AH
AL
L34B
L33B
C51B 0.1
AJ
AK
(93Ω CABLE)
R60B 91
R61B 41
R62B 110
R63B 91
R64B 91
R65B 200
R54B
VARIABLE
(CH. 2)
REAMP BOARD
TR8B 2SC568※
TR9B 2SC568※
TR10B 2SC568※
TR11B 2SC568※
R66 100
R67B 100
C41B 0.002
C71B 200
R77B 270
R75B 91
R73B 56
R78B 22
R69B 1.8K
C40B 8P
R68B 75
R70B 1.8K
R72B 200
C42B 0.002
R74B 56
R76B 91
R79B 22
R83 560
R81B 200 10mV GAIN
R80B 470
R85B 500
R82B 22
R84B 560
C43B 12P
C44B 0.002
R86B 100
L35B
R87B 100
C45B 0.002
D37B 1S1458
D38B 1S1458
D39B 1S1458B
D40B 1S1458
R94B 2K
C53B 8P
R89B 120
R90B 120
R93B 2K
R88 120
D34B 1S1458
D33B 1S1458
D35B 1S1458
D36B 1S1458
R91B 120
J151
AF
AG
L31B
C46B 0.001
C47B 0.001
S31B
POLARITY
NORM
INV
+8.5
+9
+3
BRATED
M



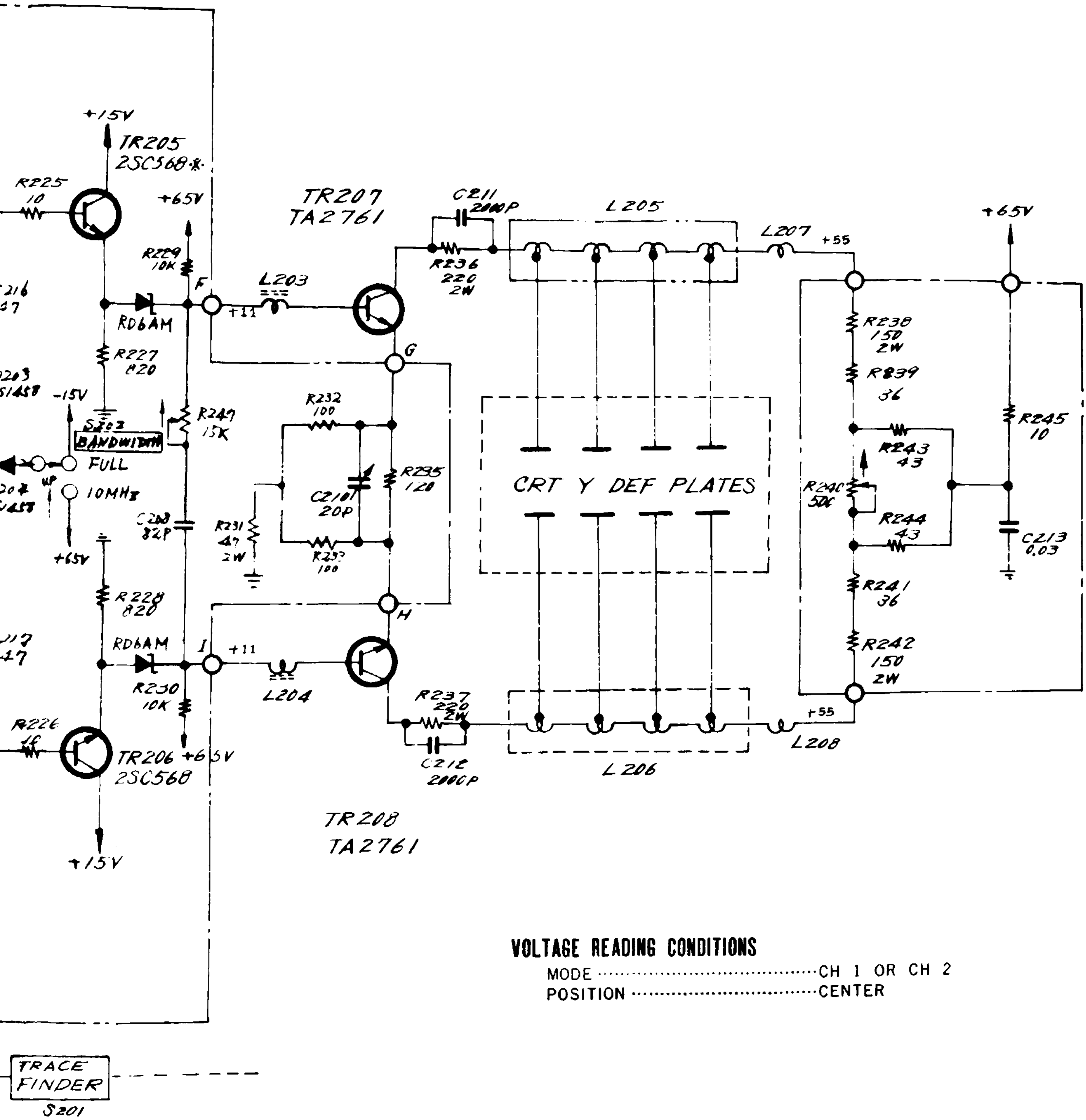
VOLTAGE READING CONDITIONS

MODE .... CH 1

POSITION .... CENTER



+15V
R214 130
C212 100
E
TR201 2SC689 Ⓗ*
C203 2000P
R210 150
+9.2
R204 10
B
+4
R201 500
R202 47
L201
R203 10K
C201 60P
C202 8P
R206 68
R207 470
R208 470
R209 360
-15V
P205 10
A
+4
R211 150
C204 2000P
TR202 2SC689 Ⓗ*
R213 100
E
DELAY LINE 90nSEC
14 13 15 16
J1001
+15V
R222 200
+12
R215 10
TR203 2SC689 Ⓗ*
R248 10K 1W
C206 12P
R220 560
C205 8P
L202
R217 180
R219 10K
R218 200
C207 20P
R221 560
R216 10
TR204 2SC689 Ⓗ*
+12
R223 200
+15V
+15V
C214 0.1
L209 10μ
C215 0.1
-15V
C
J
+65V
K
R246 2K
E
PUSH
-15V
+15V
+65V



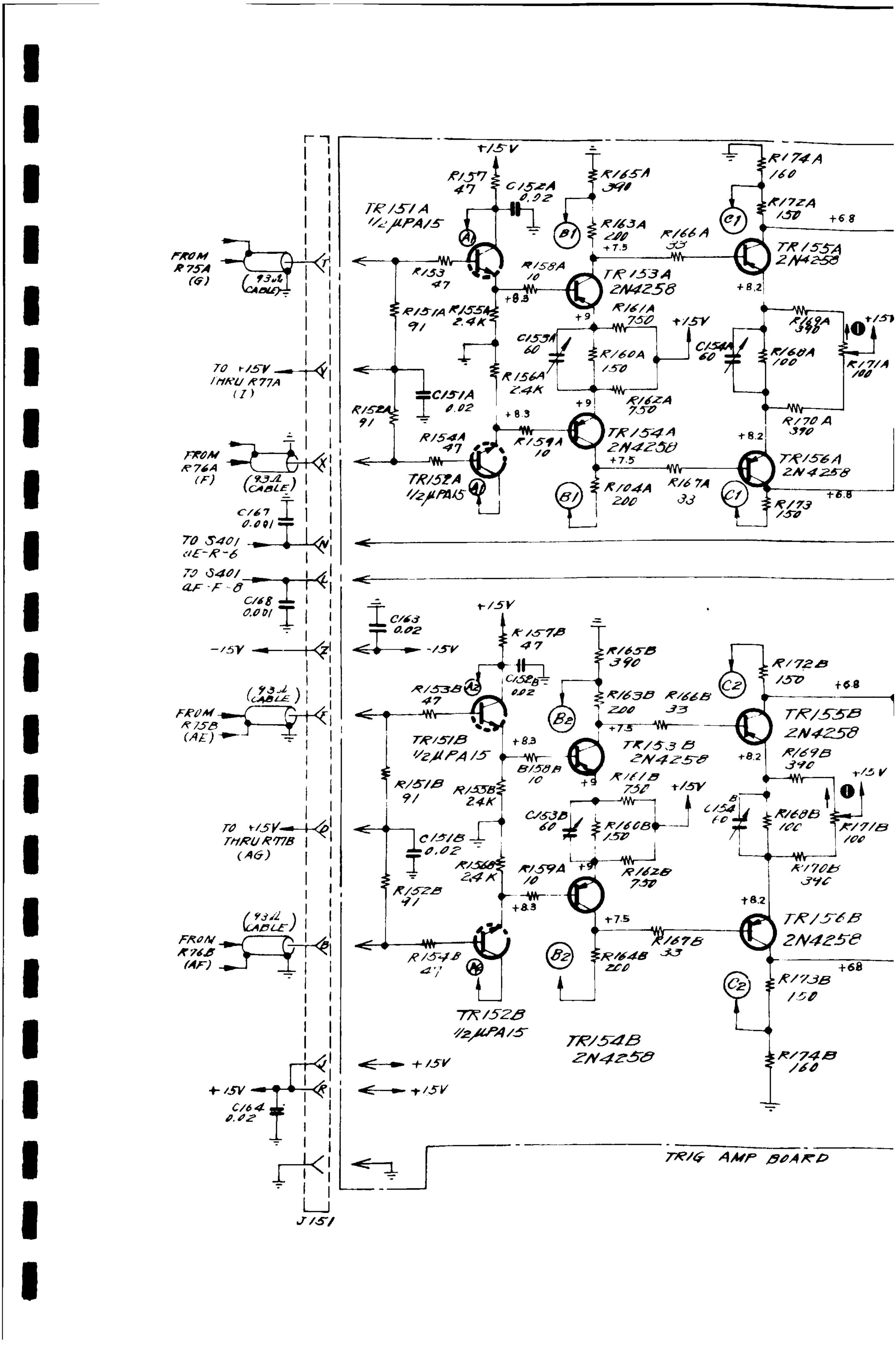
VOLTAGE READING CONDITIONS

MODE ································CH 1 OR CH 2
POSITION ·····························CENTER

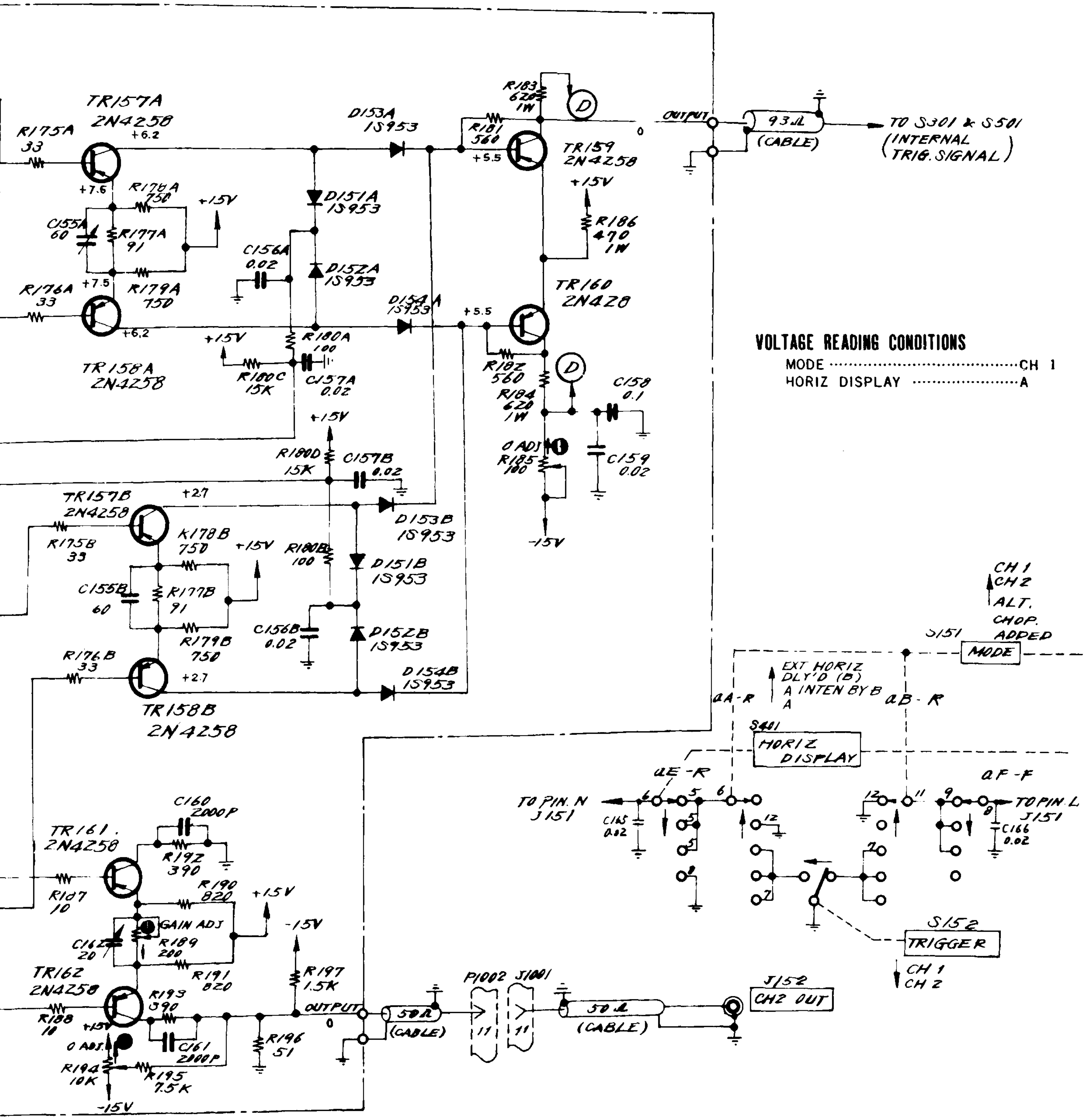
SS-112

⑤ **MAIN AMPLIFIER**

K-604978-3



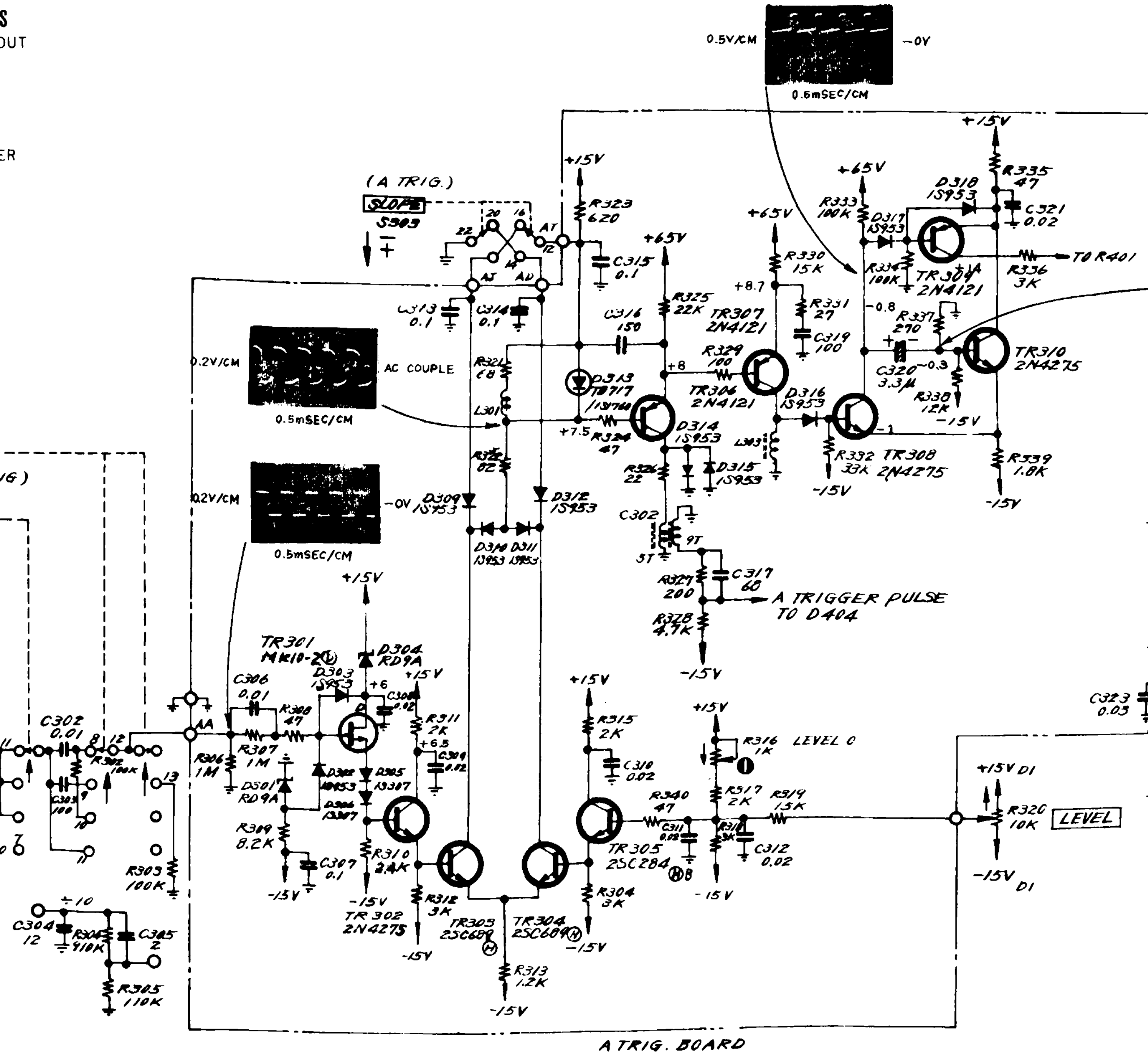
FROM R75A (G)
93Ω CABLE
TO +15V THRU R77A (I)
FROM R76A (F)
93Ω CABLE
C167 0.001
TO S401 4E-R-6
TO S401 4F-F-8
C168 0.001
-15V
FROM R75B (AE)
93Ω CABLE
TO +15V THRU R77B (AG)
FROM R76B (AF)
93Ω CABLE
+15V
C164 0.02
J151
+15V
R157 47
C152A 0.02
TR151A 1/2 μPA15
R153 47
R151A 91
R155A 2.4K
R156A 2.4K
C151A 0.02
R152A 91
R154A 47
TR152A 1/2 μPA15
R165A 390
R163A 200
R158A 10
TR153A 2N4258
R161A 750
C153A 60
R160A 150
R162A 750
R159A 10
TR154A 2N4258
R104A 200
R166A 33
R167A 33
+15V
R174A 160
R172A 150
TR155A 2N4258
R169A 390
C154A 60
R168A 100
R171A 100
R170A 390
TR156A 2N4258
R173 150
C163 0.02
-15V
+15V
R157B 47
C152B 0.02
R153B 47
TR151B 1/2 μPA15
R151B 91
R155B 2.4K
C151B 0.02
R156B 2.4K
R152B 91
R154B 47
TR152B 1/2 μPA15
R165B 390
R163B 200
R158B 10
TR153B 2N4258
R161B 750
C153B 60
R160B 150
R159A 10
R162B 750
R164B 200
TR154B 2N4258
R166B 33
R167B 33
R172B 150
TR155B 2N4258
R169B 390
C154B 60
R168B 100
R171B 100
R170B 390
TR156B 2N4258
R173B 150
R174B 160
+15V
+15V
TRIG AMP BOARD



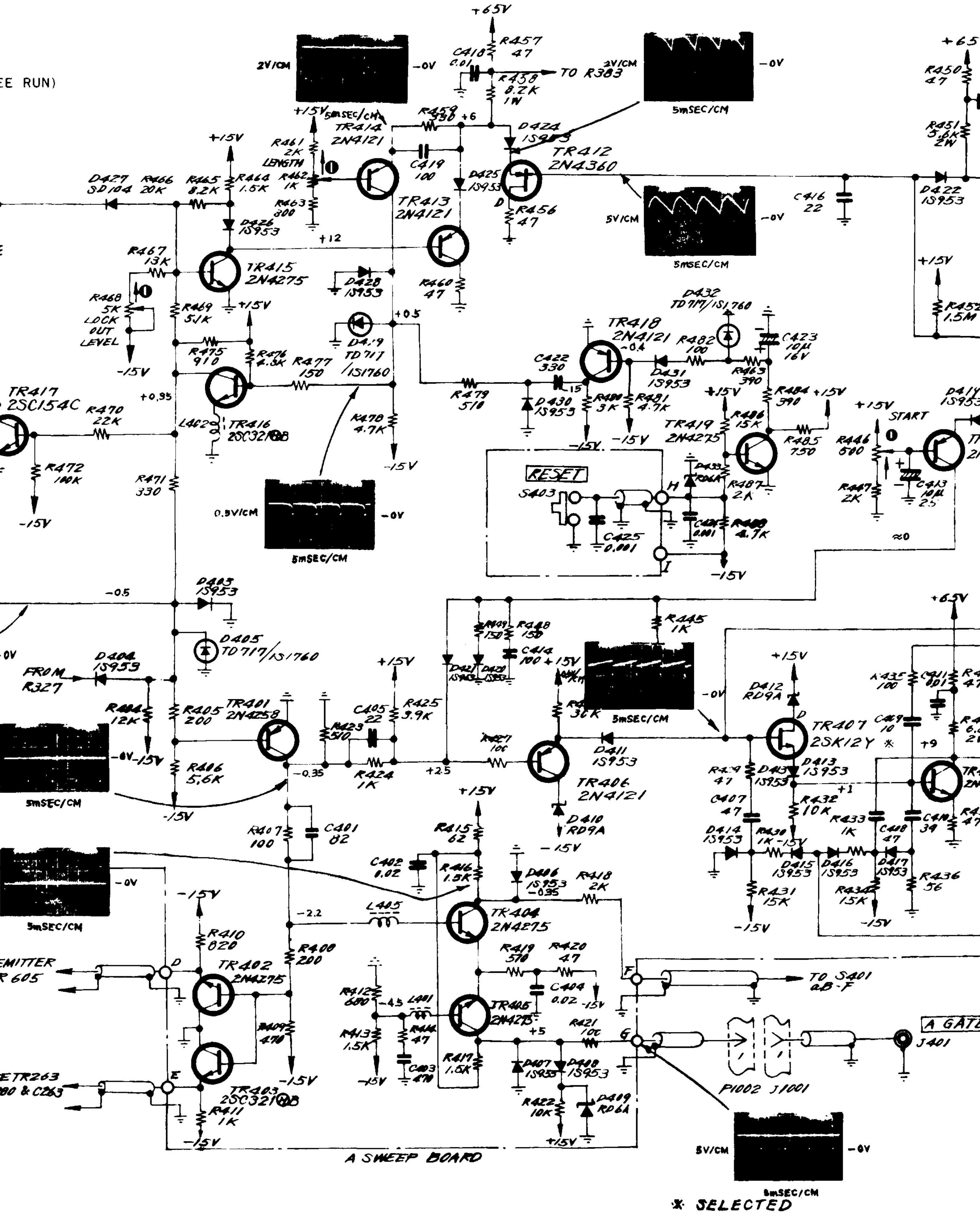
VOLTAGE READING CONDITIONS

MODE ....CH 1
HORIZ DISPLAY ....A

SS-112
⑥ **TRIGGER AMPLIFIER**
K-604979-2



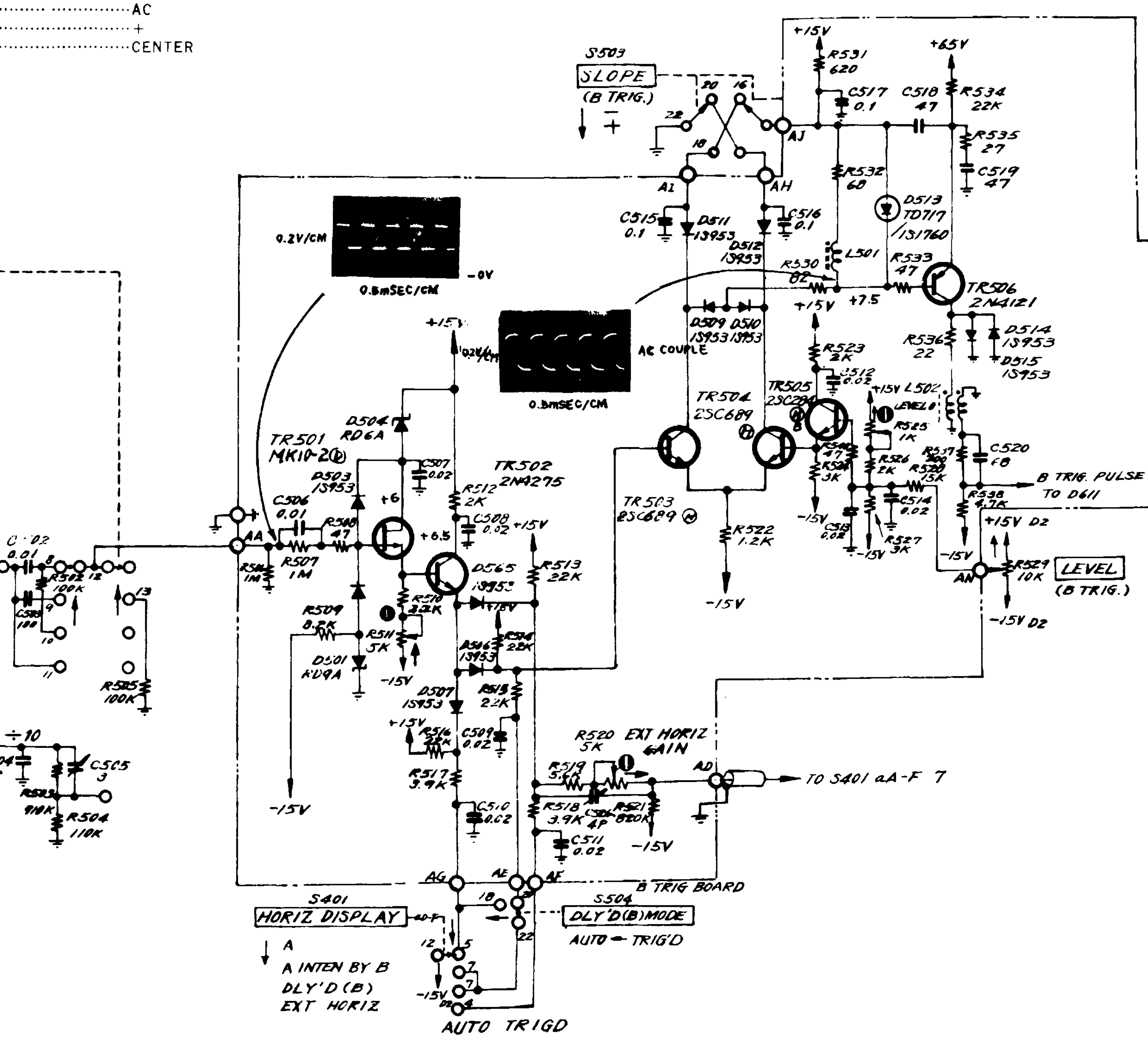
S
OUT
ER
(A TRIG.)
SLOPE
S303
+15V
R323 620
C315 0.1
+65V
R325 22K
C316 150
TR307 2N4121
R329 100
TR306 2N4121
D313
D314 1S953
D315 1S953
D316 1S953
R330 15K
R331 27
C319 100
+8.7
R333 100K
D317 1S953
D318 1S953
R334 100K
TR309 2N4121
R335 47
C321 0.02
R336 3K
TO R401
R337 270
C320 3.3μ
R338 12K
TR310 2N4275
R339 1.8K
R332 33K
TR308 2N4275
-15V
0.5V/CM
-0V
0.6mSEC/CM
0.2V/CM
AC COUPLE
0.5mSEC/CM
C313 0.1
C314 0.1
L301
D309 1S953
D312 1S953
D310 1S953
D311 1S953
9T
5T
R327 200
C317 60
R328 4.7K
A TRIGGER PULSE
TO D404
TR301
D304 RD9A
D303 1S953
C306 0.01
R308 47
R307 1M
R306 1M
D501 RD9A
R309 8.2K
C307 0.1
R311 2K
C309 0.02
D305 1S307
D306 1S307
R310 2.4K
TR302 2N4275
R312 3K
TR303 2SC689
TR304 2SC689
R313 1.2K
R315 2K
C310 0.02
R340 47
C311 0.02
TR305 2SC284
R304 3K
R316 1K
LEVEL 0
R317 2K
R319 1.5K
C312 0.02
R318 3K
+15V D1
R320 10K
LEVEL
-15V D1
C323 0.03
C302 0.01
R302 100K
C303 100
R303 100K
C304 12
R304 910K
C305 2
R305 110K
A TRIG. BOARD

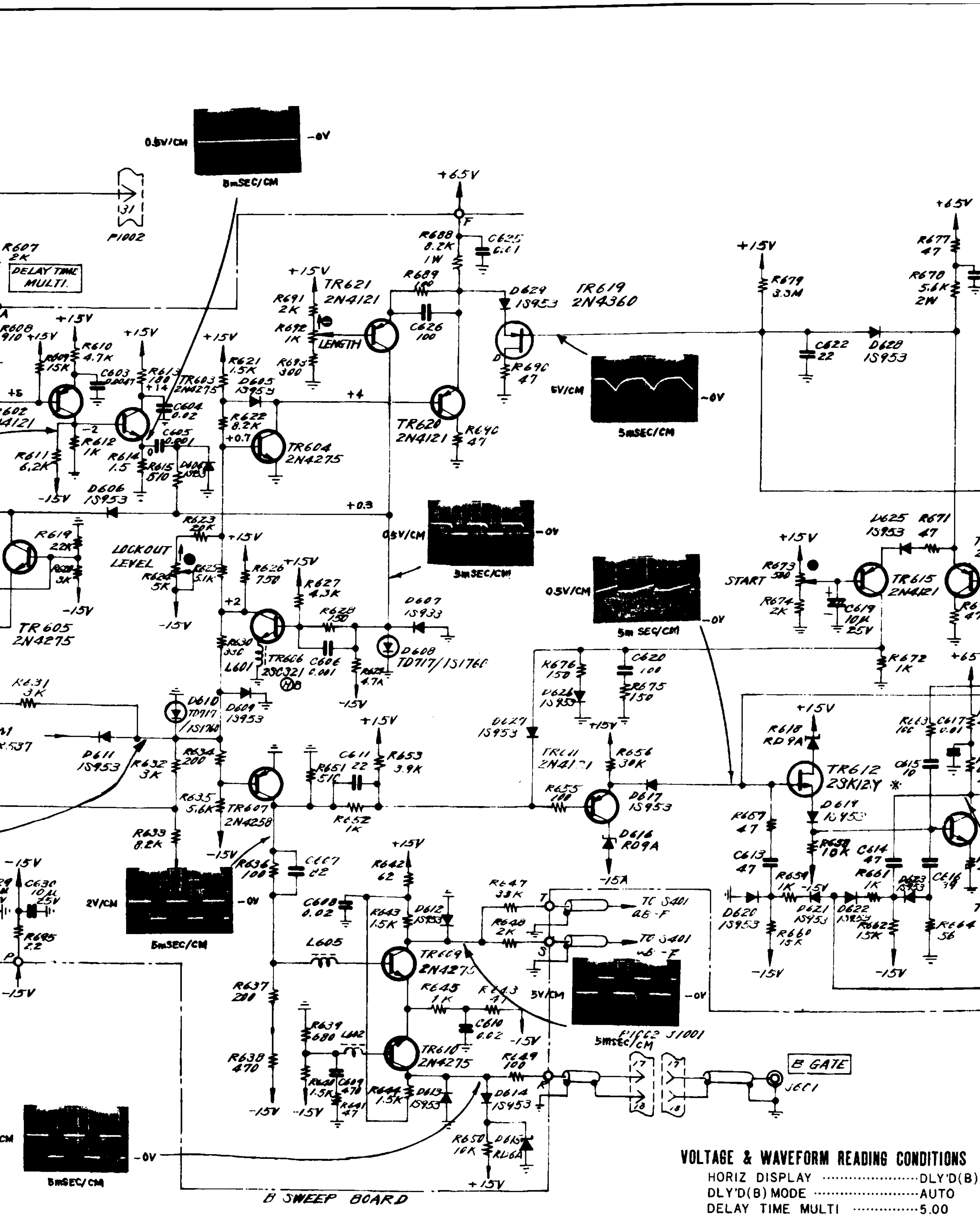


A SWEEP BOARD
※ SELECTED
RESET
S403
TO R383
FROM R327
TO S401 aB-F
A GATE
J401
P1002 J1001
TR412 2N4360
TR413 2N4121
TR414 2N4121
TR415 2N4275
TR416 2SC321
TR417 2SC154C
TR418 2N4121
TR419 2N4275
TR401 2N4258
TR402 2N4275
TR403 2SC321
TR404 2N4275
TR405 2N4275
TR406 2N4121
TR407 2SK12Y
+65V
+15V
-15V
LENGTH
LOCK OUT LEVEL
START
EMITTER
R605
TR263
2V/CM
5V/CM
0.5V/CM
5mSEC/CM
-0V

RM CONDITIONS

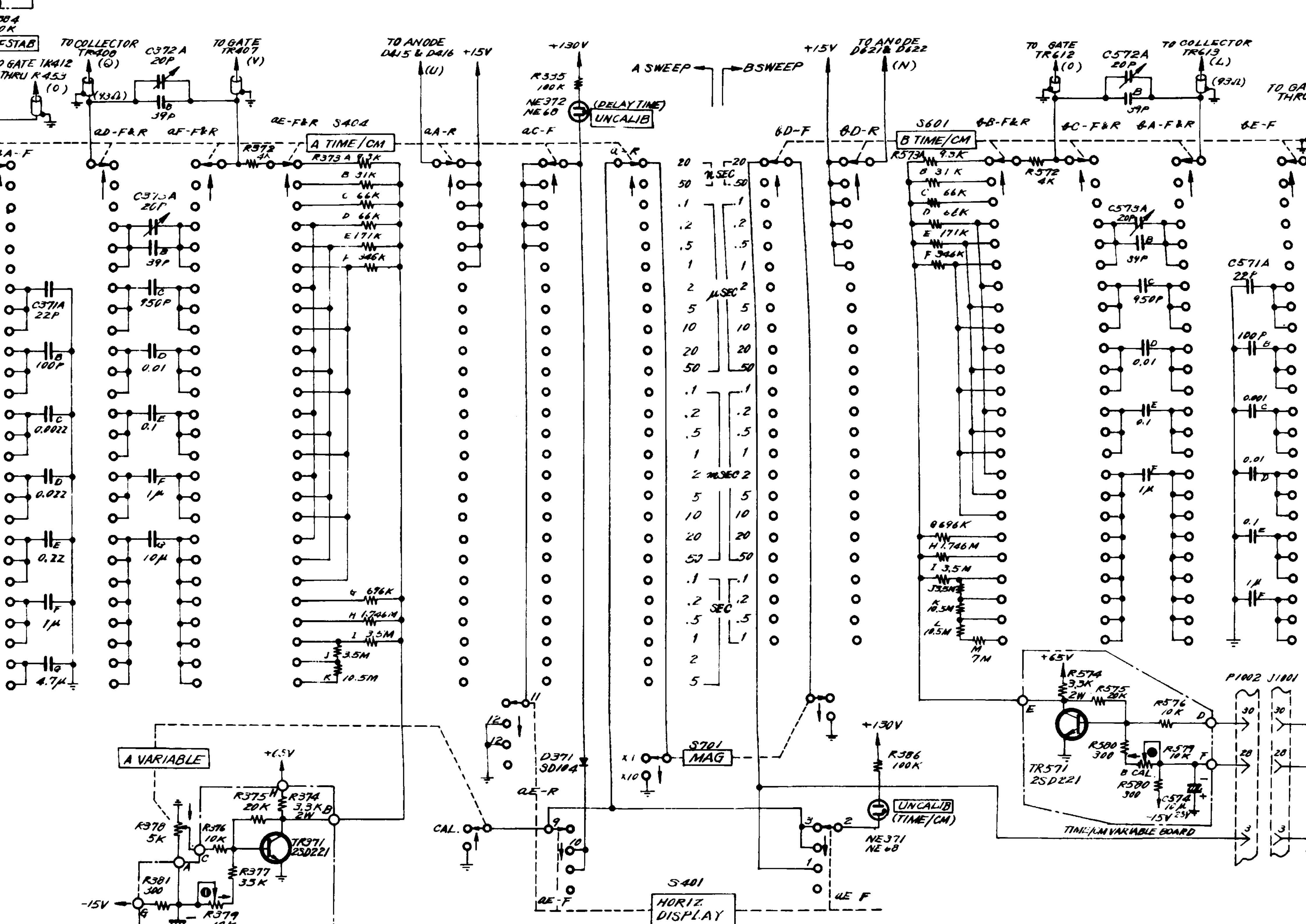
........................CAL OUT
........................A INTEN BY B
........................TRIG'D
........................INT
........................AC
........................+
........................CENTER



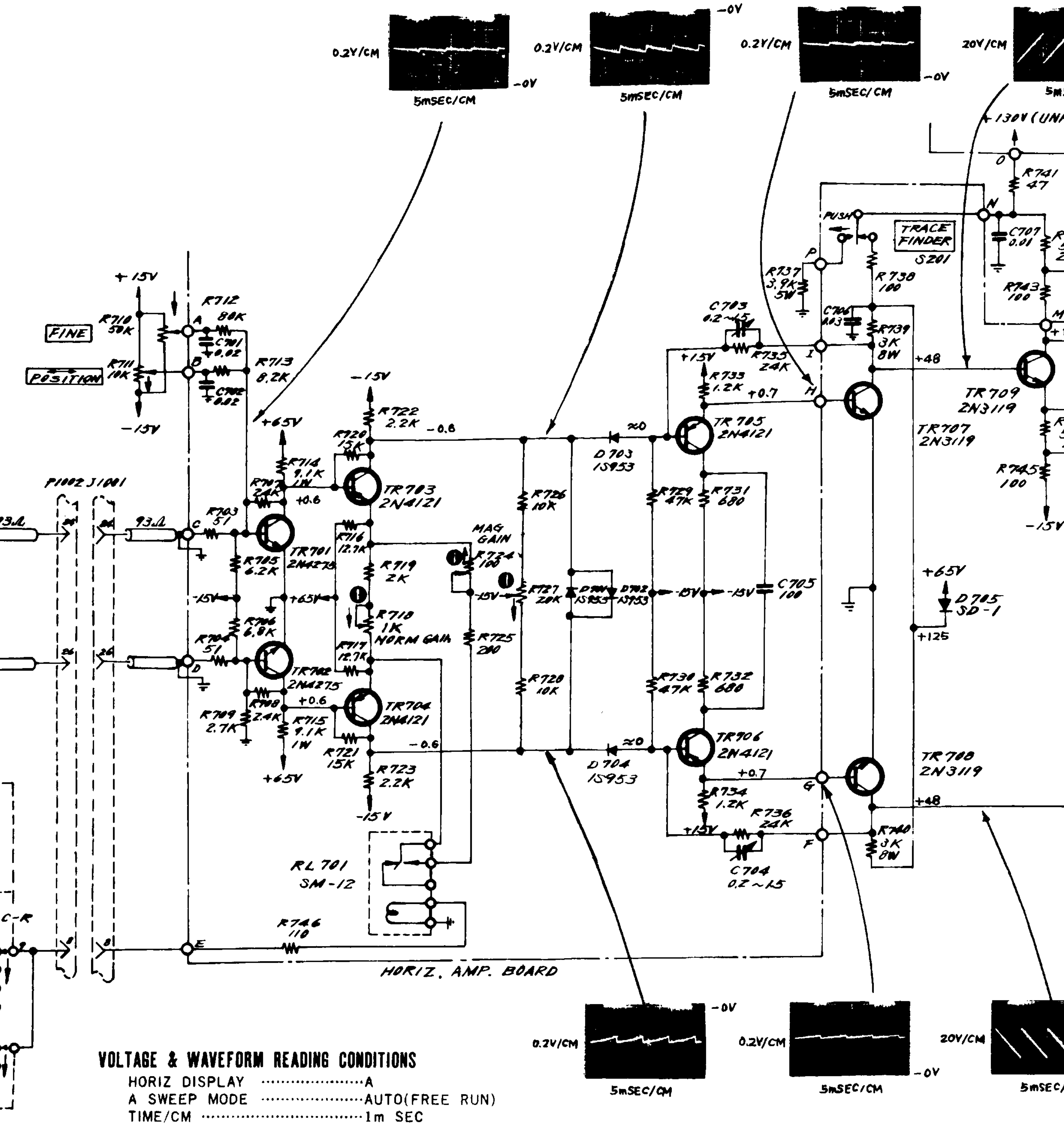


VOLTAGE & WAVEFORM READING CONDITIONS

HORIZ DISPLAY	DLY'D(B)
DLY'D(B) MODE	AUTO
DELAY TIME MULTI	5.00
A TIME/CM	1m SEC
※ SELECTED	1m SEC

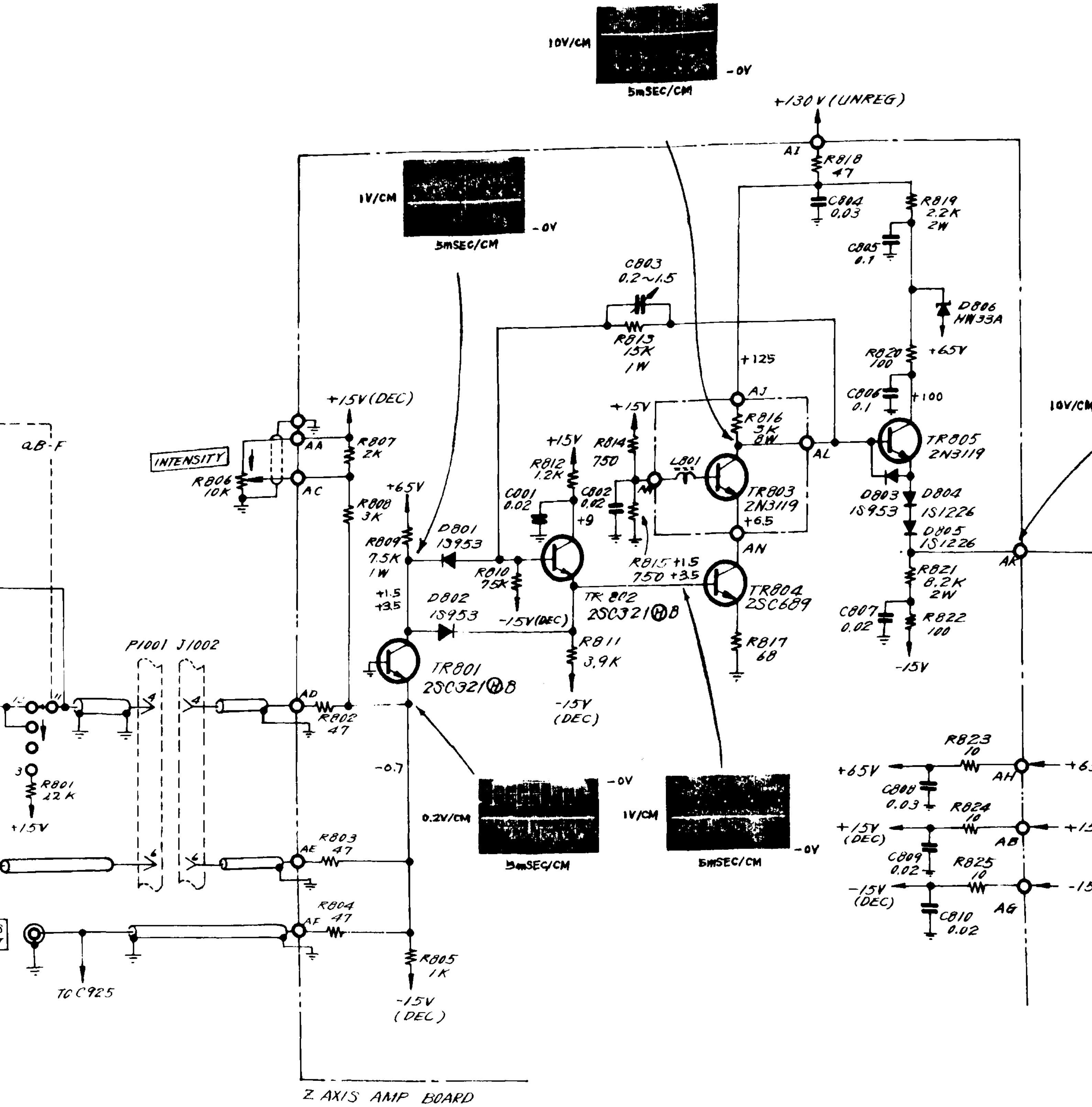


TO COLLECTOR TR400 (Q)
C372A 20P
TO GATE TR407 (V)
TO GATE TR412 THRU R453 (O)
STAB
C372B 39P
QD-F&R
QF-F&R
QE-F&R S404
A TIME/CM
R372 4K
R373 A 9.3K
B 31K
C 66K
D 66K
E 171K
F 346K
G 696K
H 1.746M
I 3.5M
J 3.5M
K 10.5M
C373A 20P
B 39P
C 950P
D 0.01
E 0.1
F 1μ
G 10μ
C371A 22P
B 100P
C 0.0022
D 0.022
E 0.22
F 1μ
G 4.7μ
TO ANODE D415 & D416 (U)
+15V
QA-R
QC-F
+130V
R335 100K
NE372 NE68
(DELAY TIME) UNCALIB
A SWEEP
B SWEEP
20 50 .1 .2 .5 1 2 5 10 20 50 .1 .2 .5 1 2 5 10 20 50 .1 .2 .5 1 2 5
nSEC
μSEC
mSEC
SEC
+15V
TO ANODE D621 & D622 (N)
BD-F
BD-R
S601
B TIME/CM
BB-F&R
BC-F&R
BA-F&R
BE-F
R573A 9.3K
B 31K
C 66K
D 66K
E 171K
F 346K
G 696K
H 1.746M
I 3.5M
J 3.5M
K 10.5M
L 10.5M
M 7M
R572 4K
TO GATE TR612 (O)
C572A 20P
B 39P
TO COLLECTOR TR613 (L)
(93Ω)
(93Ω)
C573A 20P
B 39P
C 950P
D 0.01
E 0.1
F 1μ
C571A 22P
B 100P
C 0.001
D 0.01
E 0.1
F 1μ
A VARIABLE
+6.5V
R375 20K
R374 3.3K 2W
R376 10K
TR371 2SD221
R377 33K
R378 5K
R381 300
R379 10K
-15V
CAL.
D371 SD104
QE-R
QE-F
S401
HORIZ. DISPLAY
X1
X10
S701
MAG
+130V
R386 100K
UNCALIB (TIME/CM)
NE371 NE68
QE F
+65V
R574 3.3K 2W
R575 20K
R576 10K
TR571 2SD221
R580 300
R577 10K
B CAL.
R580 300
C574 10μ 25V
-15V
TIME/CM VARIABLE BOARD
P1002
J1001



VOLTAGE & WAVEFORM READING CONDITIONS

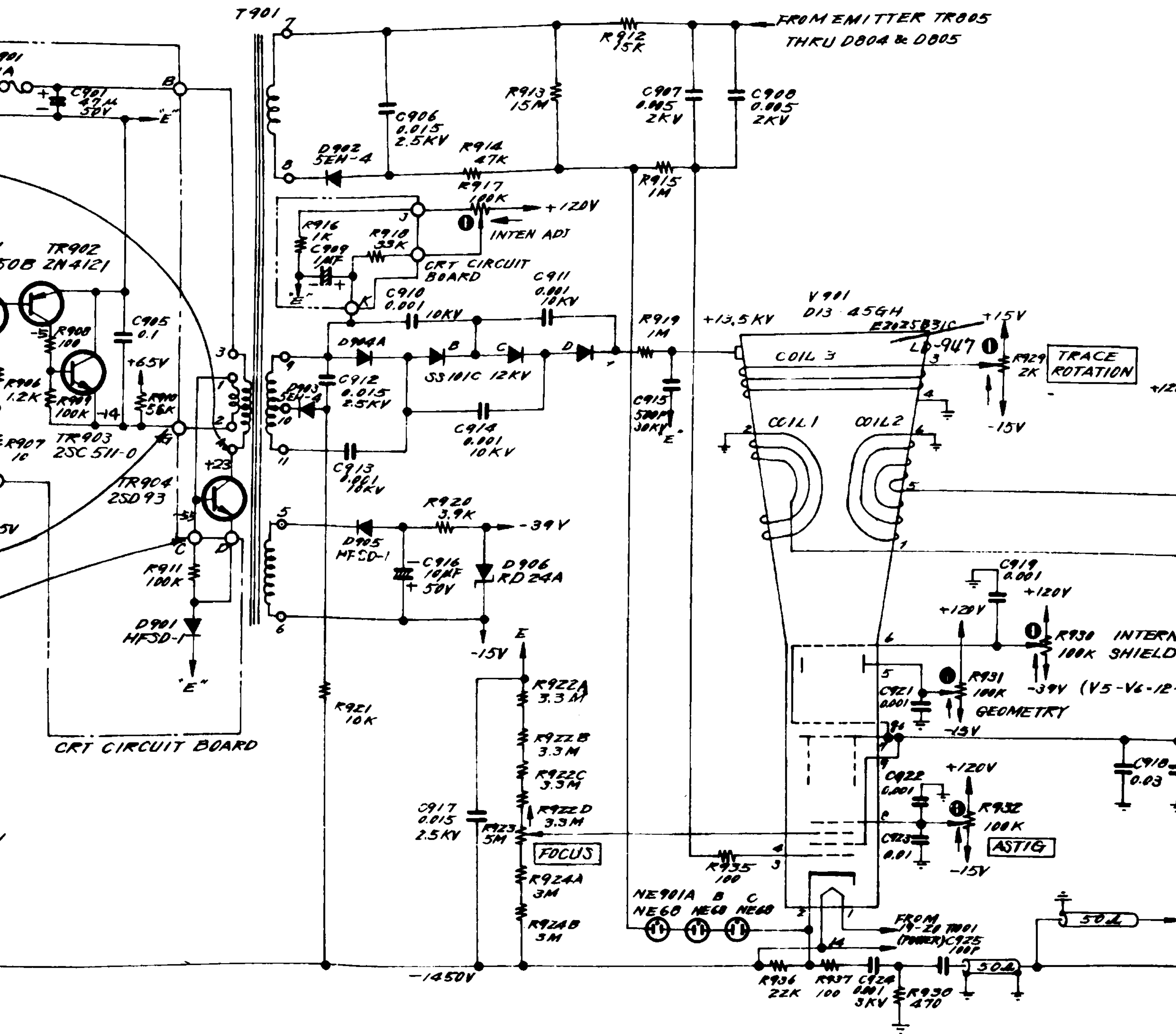
HORIZ DISPLAY ······················A
A SWEEP MODE ····················AUTO(FREE RUN)
TIME/CM ·······························1m SEC



VOLTAGE & WAVEFORM READING CONDITIONS

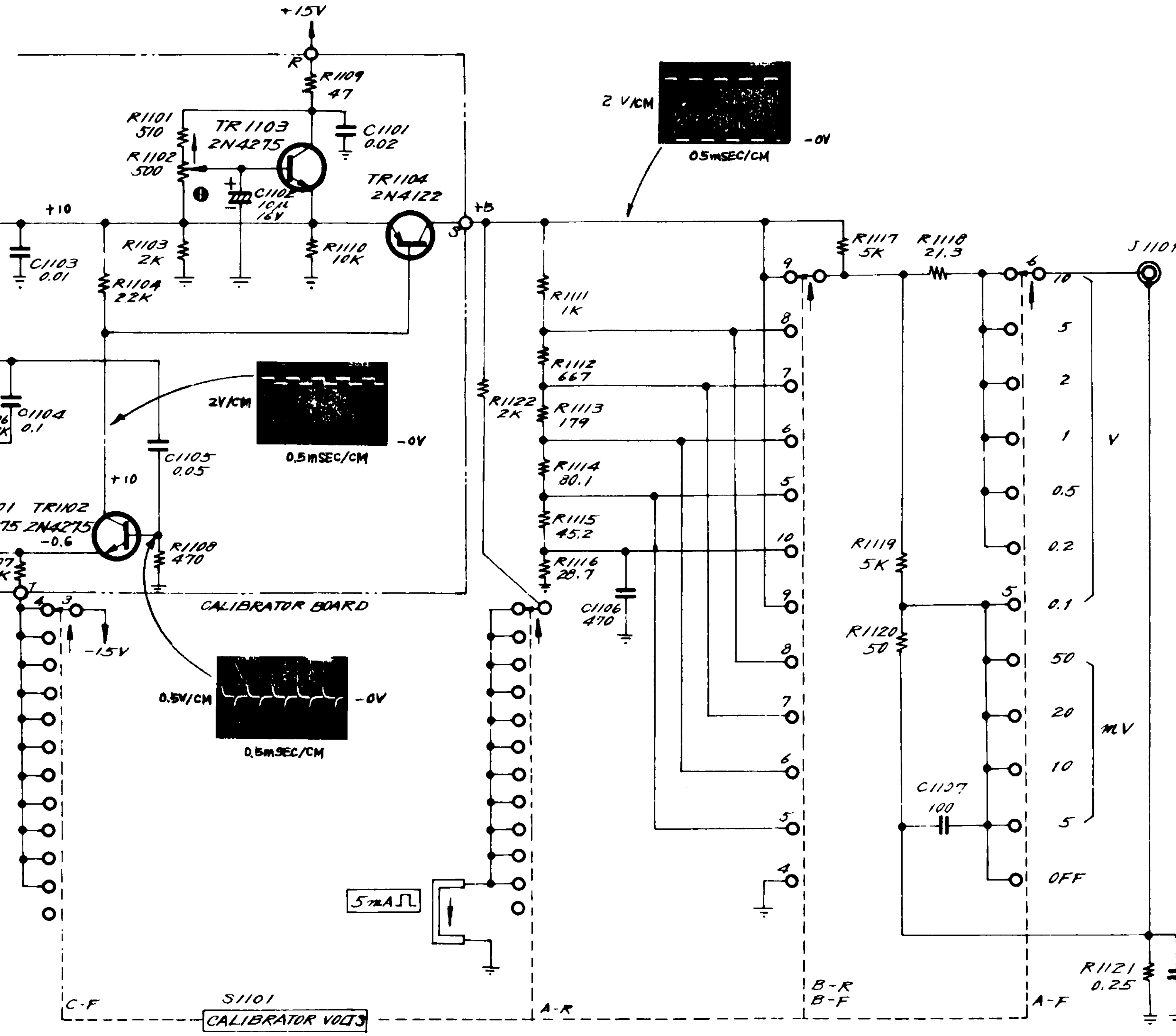
HORIZ DISPLAY ························A
A SWEEP MODE ························AUTO(FREE RUN)
A TIME/CM ······························1m SEC

INTENSITY CW →[ ]
INTENSITY CCW →[ ]

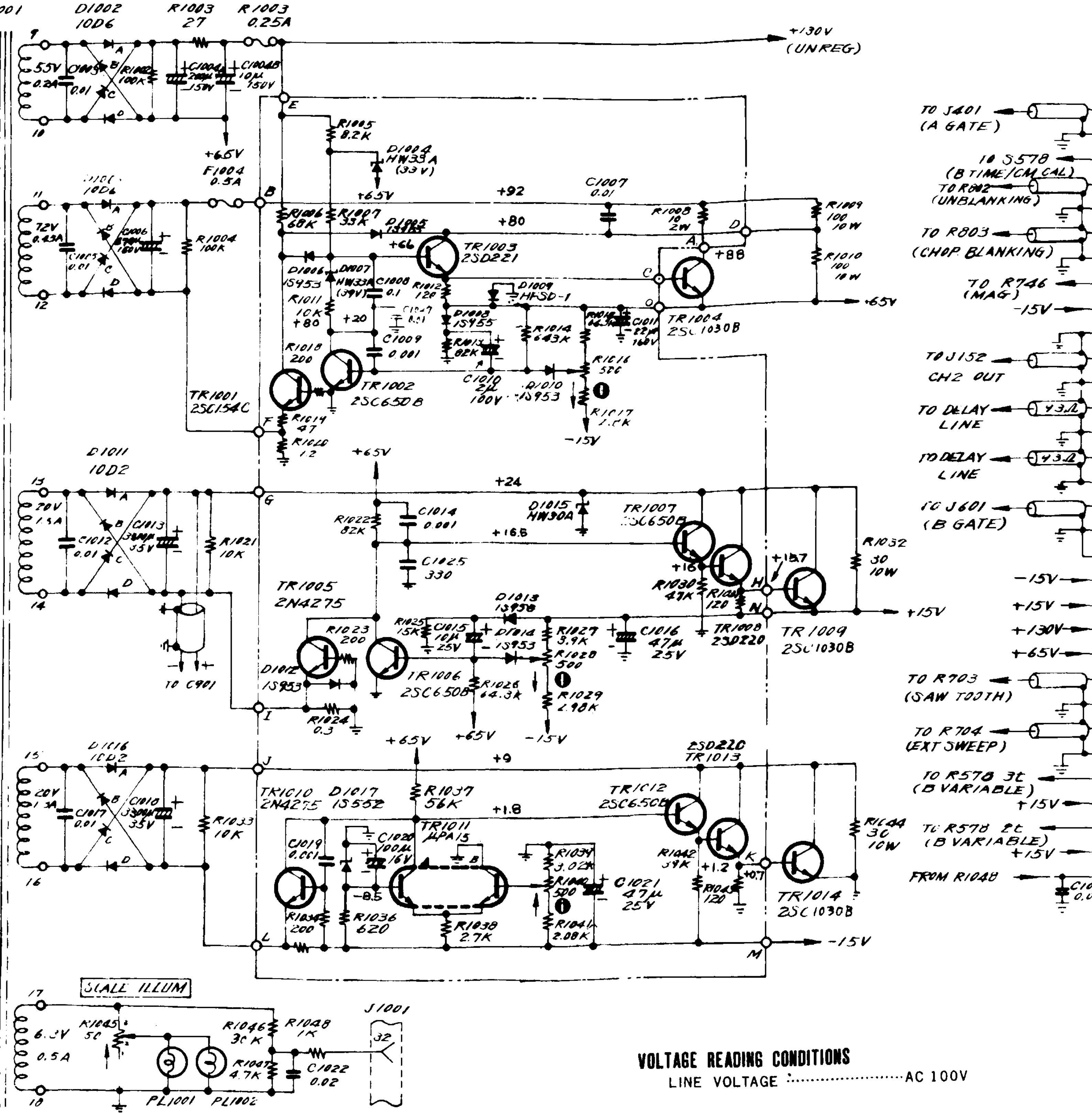

T901
FROM EMITTER TR805
THRU D804 & D805
R912 15K
R913 15M
C907 0.005 2KV
C908 0.005 2KV
C906 0.015 2.5KV
D902 5EH-4
R914 47K
R917 100K
+120V
INTEN ADJ
R915 1M
R916 1K
C909 1MF
R910 33K
CRT CIRCUIT BOARD
C910 0.001
C911 0.001 10KV
10KV
TR902 2N4121
C905 0.1
R908 100
+65V
R906 1.2K
R909 100K
R910 56K
TR903 2SC511-0
TR904 2SD93
D904A
B
C
D
SS101C 12KV
C912 0.015 2.5KV
D903 5EH-4
C914 0.001 10KV
C913 0.001 10KV
R919 1M
+13.5KV
C915 500PF 30KV
V901
D13 45GH
E2025B31C
LD-947
+15V
COIL 3
R929 2K
TRACE ROTATION
-15V
COIL 1
COIL 2
R920 3.9K
-39V
D905 HFSD-1
C916 10MF 50V
D906 RD24A
R911 100K
D901 HFSD-1
"E"
-15V
R921 10K
R922A 3.3M
R922B 3.3M
R922C 3.3M
R922D 3.3M
C917 0.015 2.5KV
R923 5M
FOCUS
R924A 3M
R924B 3M
-1450V
CRT CIRCUIT BOARD
C919 0.001
+120V
R930 100K
INTERNAL SHIELD
-39V
GEOMETRY
R931 100K
C921 0.001
C918 0.03
C922 0.001
R932 100K
ASTIG
C923 0.01
R935 100
NE901A B C
NE68 NE68 NE68
FROM 14-20 T1001 (POWER)
C925 100P
50Ω
R936 22K
R937 100
C924 0.001 3KV
R930 470

NS

BRATED


+15V
R1109 47
R1101 510
TR1103 2N4275
C1101 0.02
R1102 500
C1102 10µ 16V
TR1104 2N4122
+10
+B
R1103 2K
R1110 10K
C1103 0.01
R1104 2.2K
2 V/CM
-0V
0.5mSEC/CM
R1117 5K
R1118 21.3
J1101
R1111 1K
R1112 667
R1113 179
R1114 80.1
R1115 45.2
R1116 28.7
R1122 2K
C1104 0.1
2V/CM
-0V
0.5mSEC/CM
C1105 0.05
+10
TR1102 2N4275
-0.6
R1108 470
CALIBRATOR BOARD
C1106 470
-15V
0.5V/CM
-0V
0.5mSEC/CM
10
5
2
1
V
0.5
0.2
0.1
50
20
mV
10
5
OFF
R1119 5K
R1120 50
C1107 100
5mA
R1121 0.25
C-F
S1101
CALIBRATOR VOLTS
A-R
B-R
B-F
A-F

ATED



VOLTAGE READING CONDITIONS

LINE VOLTAGE .... AC 100V

IWATSU