INSTRUCTION MANUAL

Serial Number ____________

TYPE 1A1
Dual-Trace Plug-in Unit
SN 20,000--Up

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix

070-0885-00

468

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial or Model Number with all requests for parts or service.

Specifications and price change privileges reserved.

CONTENTS

Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units", MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

Fig. 1-1. Type 1A1 Dual-Trace Plug-In Unit.

SECTION 1
CHARACTERISTICS

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type 1A1 Dual-Trace Plug-In Unit contains two identical high-gain fast-rise calibrated preamplifier channels. Either channel can be used independently to produce a single display or electronically switched to produce dual-trace displays. In addition, both channels can be combined at the output, adding or subtracting according to the settings of the polarity switches.

For single- or dual-trace operation, each channel has its own input selector, attenuator, gain, polarity and position controls so the display can be adjusted for optimum viewing and information.

In dual-trace operation there are two operating modes, chopped or alternate. In the chopped mode, an internal multivibrator switches the channels at a free-running rate of about 1 MHz. In the alternate mode, the oscilloscope time-base generator internally switches the channel at the end of each sweep during the retrace interval.

Each channel has a basic deflection factor of 0.005 volt/cm. Channel 1 can be used as a 10X (uncalibrated) AC-coupled preamplifier for Channel 2, thus extending the deflection factor of Channel 1 to 500 μV/cm.

The Type 1A1 can be used with any of the Tektronix 530-, 540-, or 550-Series oscilloscopes. It can also be used with the 580-Series oscilloscopes in conjunction with the Type 81 or 81A Plug-In Adapter. The Type 1A1 can also be used with other oscilloscopes and devices through the use of the Types 127, 132, or 133 Plug-In Power Supplies.

CALIBRATED PREAMPLIFIER

Characteristic	Performance Requirement			Supplemental Information
Deflection Factor	5 mV/cm to 20 volts/cm in 12 calibrated steps for each channel.			Steps in 1-2-5 sequence.
Deflection Accuracy	Within ±3% of indicated deflection with VARIABLE VOLTS/CM control set to the CALIB position.			With gain correct at 50 mV/cm.
Variable Deflection Factor	Uncalibrated deflection factor at least 2.5 times the VOLTS/CM indication. This provides a maximum uncalibrated deflection factor of 50 volts/cm in the 20 volts/cm position.			
Frequency Response (not more than —3 dB): Type 1A1 with Tektronix oscilloscopes;	≈500 μV/cm Channels 1 and and 2 cascaded.	5 mV/cm	50 mV/cm	With VARIABLE VOLTS/CM control set to CALIB.
544, 546, 547, 556, 581, 581A, 585, or 585A	2 Hz to 15 MHz	DC to 28 MHz	DC to 50 MHz	Using a Type 81A Plug-In Adapter with Type 580-Series Oscilloscope.
581, 581A, 585 or 585A	2 Hz to 14 MHz	DC to 23 MHz	DC to 33 MHz	Type 81 Plug-In Adapter must be used.
541, 541A, 543, 543A, 543B, 545, 545A, or 545B	2 Hz to 14 MHz	DC to 23 MHz	DC to 33 MHz	
551 or 555	2 Hz to 13 MHz	DC to 21 MHz	DC to 27 MHz	
531, 531A, 533, 533A, 535, or 535A	2 Hz to 10 MHz	DC to 14 MHz	DC to 15 MHz	
536	2 Hz to 8 MHz	DC to 10.5 MHz	DC to 11 MHz	
[1]Risetime (calculated minimum): Type 1A1 with Tektronix oscilloscopes;				Using a Type 81A Plug-In Adapter with Type 580-Series Oscilloscope.
544, 546, 547, 556, 581, 581A, 585, or 585A	24 ns	13 ns	7 ns	

[1]**Calculated using this formula**

$$\text{Risetime} = \frac{.35}{^{*}\text{Frequency}}$$

***Use the upper bandwidth limit stated for the system.**

CALIBRATED PREAMPLIFIER (Cont)

Characteristic	Performance Requirement			Supplemental Information
581, 581A, 585, or 585A	25 ns	16 ns	11 ns	Using a Type 81 Plug-In Adapter.
541, 541A, 543, 543A, 543B, 545, 545A, 545B, or 555	25 ns	16 ns	11 ns	
551	27 ns	17 ns	13 ns	
531 531A, 533, 533A, 535, or 535A	35 ns	25 ns	24 ns	
536	44 ns	35 ns	32 ns	
Input RC Characteristics				Typically 1 MΩ (±1%) parallel with approximately 15 pF.
Maximum Input Voltage				600 volts combined DC and peak AC.
Input Coupling Modes	AC or DC, selected by front-panel switch.			GND, disconnects signal and grounds amplifier input.
AC Low-Frequency Response				Down less than —3 dB at 2 Hz direct, 0.2 Hz with 10X probe.
Vertical Display Modes	Channel 1 only. Channel 2 only. Dual-trace, alternate between channels. Dual-trace, chopped between channels. Added algebraically.			
Chopped Mode Rate	Approximately 1-MHz rate to show successive 500-ns segments of each trace.			Approximately 300-ns of each segment is visible when the CRT cathode selected switch is set to Chopped Blanking.
Common-Mode Rejection Ratio	20:1 for 1-kHz common-mode signals up to 10 cm in amplitude.			With optimum GAIN adjustment for both channels.
Polarity Inversion	Signal on either Channel 1 or 2 can be inverted.			
Trace Drift (after warm up) VOLTS/CM at .005				Typically less than 5 mV/hour.
Noise, any position of INPUT SELECTOR switch				Approximately 200 μvolts internal noise, peak to peak.
Channel 1 SIGNAL OUT				
Output Signal Voltage	Gain of 10, ±10%			Channel 1 VOLTS/CM at .005.
Output Impedance				Approximately 50 ohms.
Output Coupling	DC			DC level approximately 0.45 volt, not affected by Channel 1 POSITION control.
Frequency Response (not more than —3 dB down)	DC to 35 MHz.			Channel 1 VOLTS/CM set to .05.
	DC to 24 MHz.			Channel 1 VOLTS/CM set to .005.
Channel 1 TRIGGER OUT				
Output Trigger Voltage	Gain of 100, ±20%.			Channel 1 VOLTS/CM set to .005.
Bandwidth	Sufficient to obtain stable triggering on a 50 MHz waveform which is two cm or more in displayed amplitude.			With Type 544, 546, 547, or 556 Oscilloscopes only.
Output Coupling	DC			DC level —0 volt, ±1 volt. Not affected by Channel 1 POSITION control.
Output Impedance				Approximately 5 k ohms at DC decreasing to essentially 50 Ω at 2 MHz.

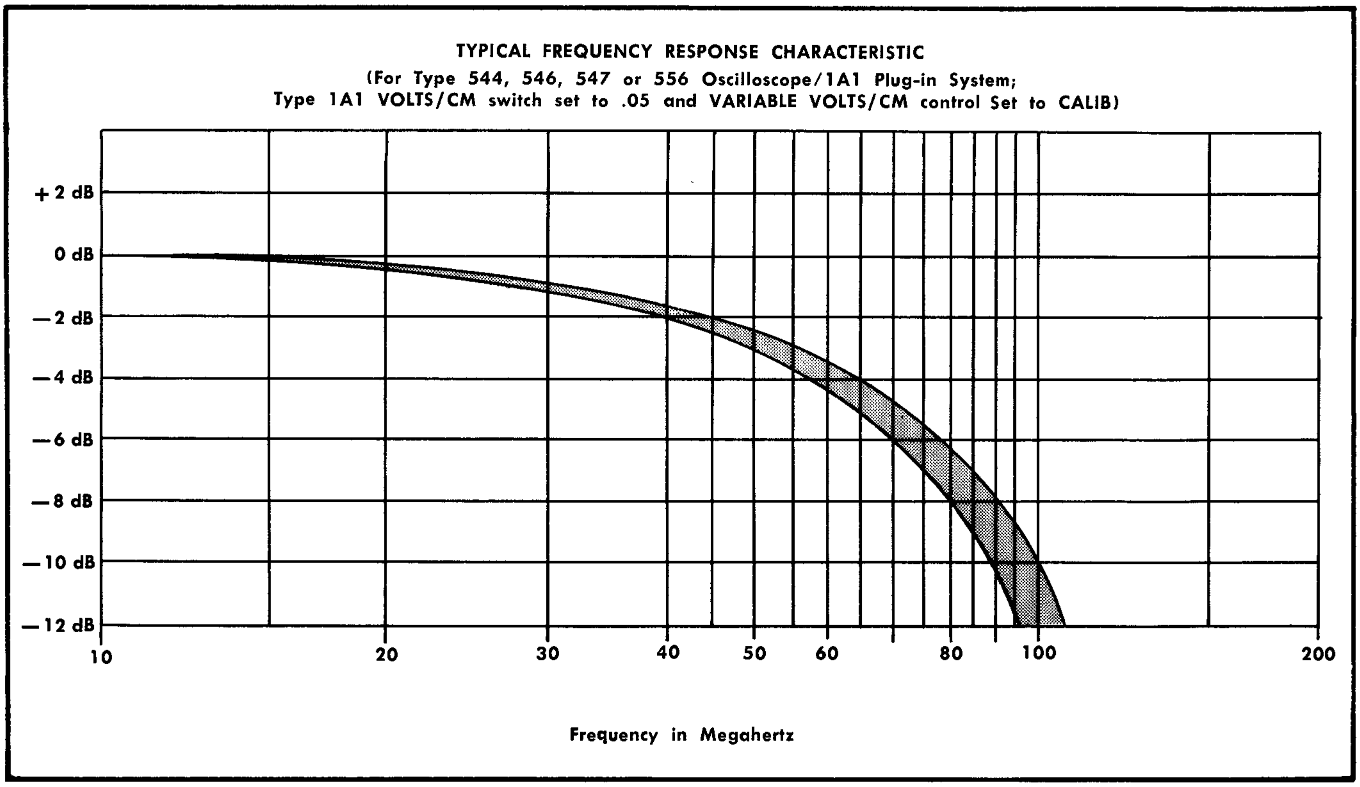


Fig. 1-2. Typical frequency response curve of the Type 1A1 when used in conjunction with the Type 544, 546, 547 or 556 Oscilloscope. A 25-ohm resistor source (generator 50-ohm output applied through a 50-ohm cable terminated in 50 ohms) was used to drive the Type 1A1.

MECHANICAL CHARACTERISTICS

Characteristic	Information
Construction	Aluminum-alloy chassis with three plug-in circuit cards and two circuit boards.
Finish	Anodized front panel.

ACCESSORIES

Standard accessories supplied with this instrument will be found on the last pull-out page of the Mechanical Parts List. For optional accessories, see the current Tektronix, Inc. catalog.

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

FUNCTIONS OF FRONT PANEL CONTROLS AND CONNECTORS

The functions of all front-panel controls, adjustments and connectors except the MODE switch, CH 1 SIGNAL OUT and CH 1 TRIGGER OUT connectors are identical for both channels.

POSITION	Positions the trace vertically on the CRT.
PULL FOR INVERT	Two-position switch that presents the input signal in either normal or inverted polarity.
VARIABLE VOLTS/CM	Provides overlapping variable uncalibrated attenuation between the calibrated deflection factors and extends the attenuation range to about 50 V/cm. The control activates a switch when moved out of the CALIB (calibrated) position to provide the overlapping coverage.
.05 V/CM GAIN	Screwdriver adjustment that sets the basic deflection factor of the channel at 0.05 V/cm.
.005 V/CM VAR ATTEN BAL	Screwdriver adjustment for setting the amplifier DC levels so the trace does not shift position under no-signal conditions as the VARIABLE VOLTS/CM control is turned.
VOLTS/CM	Twelve-position switch to select the calibrated vertical-deflection factors.
INPUT SELECTOR	Three-position switch to provide either AC- or DC-coupled input into the amplifier. A third position (GND) connects the amplifier input to ground without grounding the input signal.
Channel 1 and 2 INPUT Connector	Signal input connector for the channel.
MODE	Five-position switch that sets the mode of operation as follows: CH 1—Allows the use of Channel 1 only. ALT—Dual-trace alternate mode of operation (triggered electronic switching between channels during the retrace interval). CHOP—Dual-trace chopped mode of operation (free-running electronic switching of channels at about a 1-MHz rate). ADD—Permits adding the outputs of the two channels algebraically. CH 2—Permits the use of Channel 2 only.
CH 1 SIGNAL OUT	Output signal from Channel 1. Permits patching the amplified Channel 1 signal into Channel 2.
CH 1 TRIGGER OUT	Trigger signal from Channel 1. Permits the use of Channel 1 as an external trigger source.

CAUTION

If the Type 1A1 is inserted in the upper-beam vertical plug-in compartment of a modified Type 555 Oscilloscope SN 101 to 6999 or in a Type 555 SN 7000 and up when the Type 21 and 22 Time-Base units are used instead of the Types 21A and 22A, +87 V from pin 19 in the Time-Base units is applied to pin 5 of the Type 1A1 interconnecting plug (see Fig. 2-1). This voltage will damage components in the Type 1A1 Trigger Amplifier circuit and cause the circuit to be inoperative.

In addition, the +87 V is a hazard because it is also applied to the SIGNAL OUTPUT connector. For proper Type 1A1 operation, remove the +87 V by disconnecting the white-gray wire that goes from pin 19 in the Types 21 and 22 to the ceramic terminal notch above V152.

(The Types 21A and 22A Time-Base units are compatible with the Type 1A1 and therefore do not require modification.)

FIRST-TIME OPERATION

The following procedure will help you become familiar with the Type 1A1 operation.

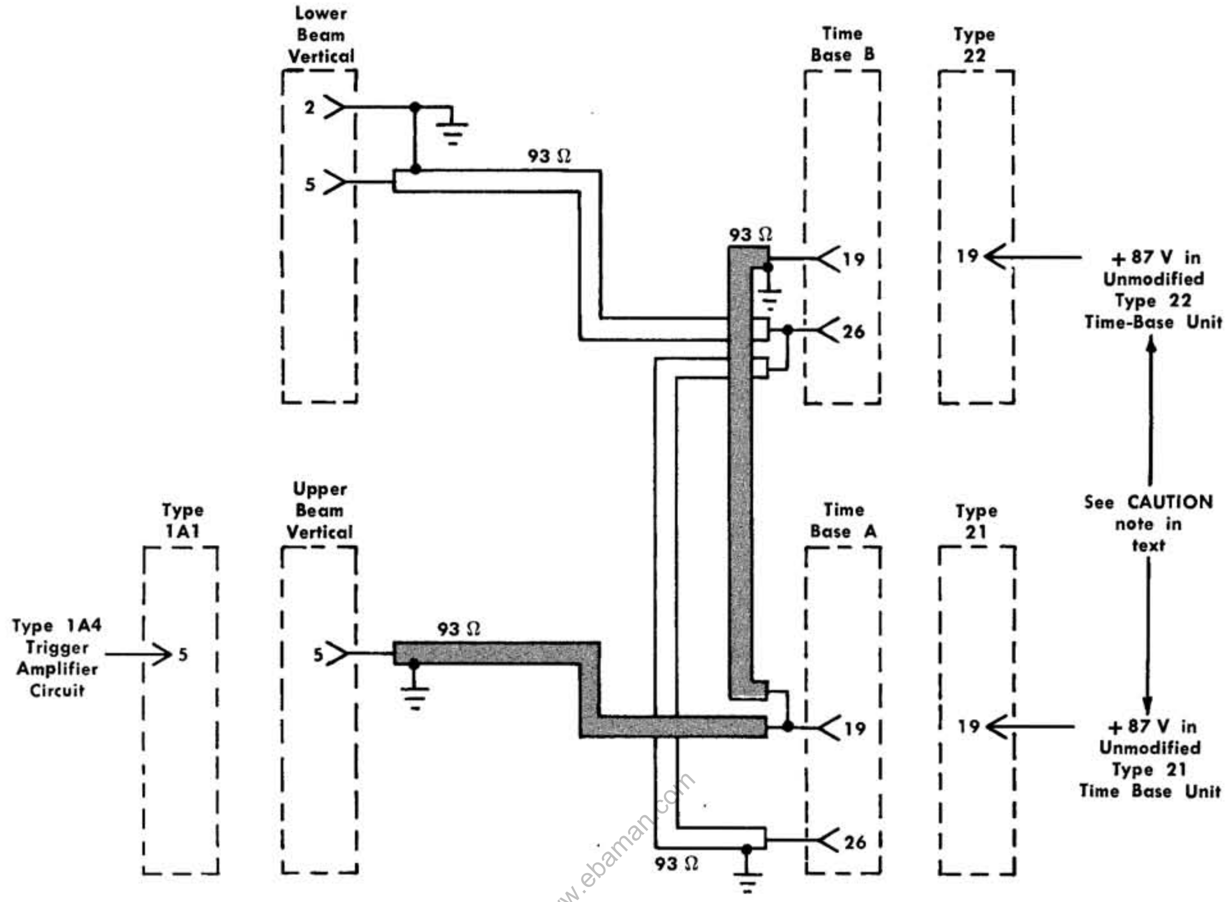
1. Insert the Type 1A1 into the oscilloscope, tighten the securing rod, and turn the oscilloscope power on.

2. Allow about 2 to 3 minutes warm-up time and free run the oscilloscope sweep at 0.5 ms/cm.

3. Set the applicable Type 1A1 front-panel controls for both channels as follows:

INPUT SELECTOR	DC
VOLTS/CM	.05
VARIABLE VOLTS/CM	CALIB
PULL FOR INVERT	IN (normal)
POSITION	Centered
MODE	CH 1

4. Position the trace about 1 cm above the graticule centerline with the Channel 1 POSITION control.



Partial Interconnecting Plug Diagram for Type 1A4 Unit.

Partial Interconnecting Socket Diagrams for Type 555 Oscilloscopes SN 7000 and Up. (This diagram also applies to modified Type 555 Oscilloscopes SN 101 to 6999 using Modification Kit 040-0328-00.)

Partial Interconnecting Plug Diagram for Types 21 and 22 Time-Base Units.

Fig. 2-1. Partial diagrams of the plug-in connectors to show why it is necessary to modify the Type 21 and 22 Time-Base units before inserting the Type 1A1 in the Type 555 upper-beam vertical plug-in compartment.

5. Place the MODE switch to CH 2 and position the trace 1 cm below the graticule centerline with the Channel 2 POSITION control.

6. Place the MODE switch to ALT. Both Channel 1 and 2 traces should be displayed.

7. Set the oscilloscope Time/Cm switch to 50 ms. Note that for each sweep cycle one channel is displayed and the other is shut off. Electronic switching from one channel to the other occurs during the retrace interval.

8. Set the MODE switch to CHOP. Notice that both traces seem to start simultaneously and continue across the CRT.

9. Set the oscilloscope Time/Cm switch to 5 μs and adjust the oscilloscope trigger controls to obtain a stable display. Notice that each trace is composed of many short-duration bits or segments with visible switching transients existing between channels (see Fig. 2-2A).

10. To see the chopped-mode switching action clearly, increase the sweep rate to 0.2 μs/cm. Notice that Channel 1 is on for about 0.5 μs while Channel 2 is off for 0.5 μs for the first half cycle. Then, for the last half cycle, Channel 2 is on for 0.5 μs while Channel 1 is off (see Fig. 2-2B). Chopping rate per channel, determined by the free-running multivibrator switching rate, is about 1 MHz.

11. Blank out the switching transients between channels by setting the CRT cathode Selector switch (located on the rear panel of most Tektronix oscilloscopes) to the Dual-Trace Chopped Blanking position (see Fig. 2-2C).

12. Set the oscilloscope Time/Cm switch to 0.5 ms. Using coaxial cables, a T connector connected to Channel 1 and

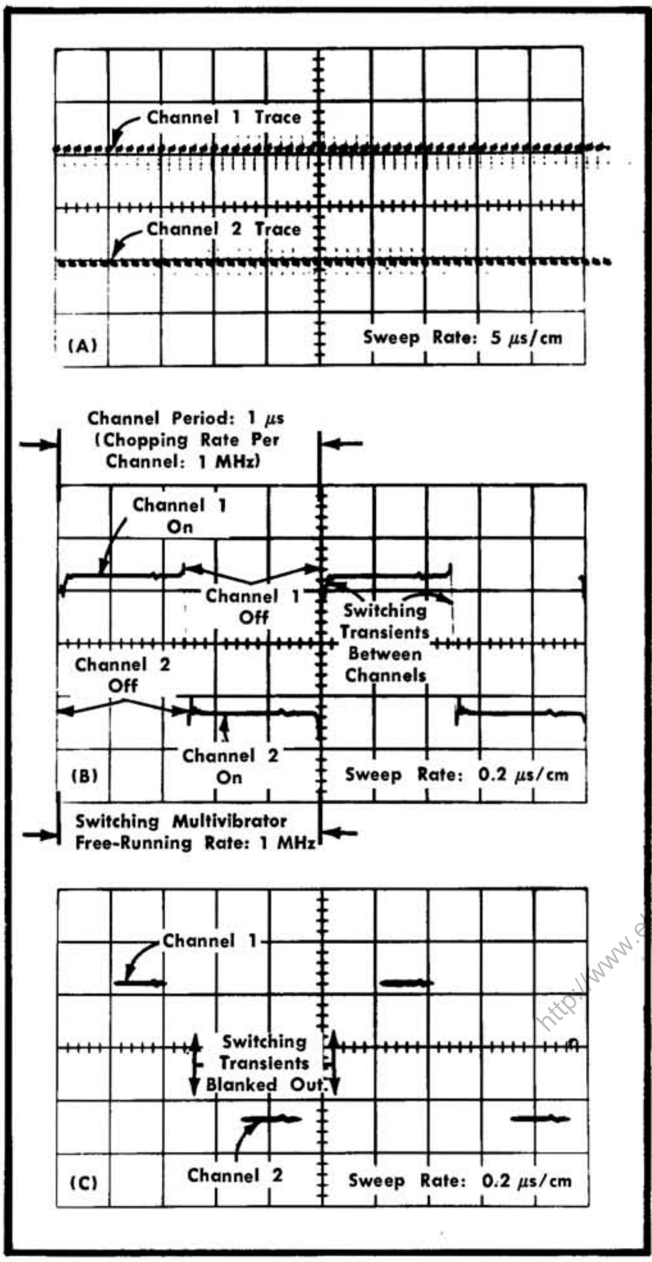


Fig. 2-2. Chopped-mode waveforms: (A) trace broken up into segments; (B) chopped-mode switching action from channel to channel; and (C) switching transients blanked out.

a connector adapter (if calibrator has a UHF connector), apply 0.1 volt from the oscilloscope Amplitude Calibrator to the Channel 1 and 2 INPUT connectors.

13. Connect a coaxial cable from the CH 1 TRIGGER OUT connector to the oscilloscope Trigger Input connector. Set the trigger controls for + external triggering. Both Channel 1 and 2 calibrator waveforms should be displayed. Each waveform should be 2 cm in amplitude.

NOTE

If the waveforms are not exactly 2 cm in amplitude, overlook the inaccuracy until completing this operating procedure. Subsequent paragraphs describe how to properly set the gain of the unit.

14. Now set the MODE switch to ADD. There should be one waveform display, 4 cm in amplitude. This is the addition of the Channel 1 and 2 signals (2 cm each). Notice that either POSITION control will move the display vertically.

15. Set the Channel 1 PULL FOR INVERT switch to invert and free run the time base. The display should be a straight line, indicating the algebraic difference between the two signals. Since both signals have equal amplitudes and waveshape, the difference is zero.

16. Set the oscilloscope calibrator for 20-mV output.

17. Set the Channel 1 VOLTS/CM switch to .005 and the MODE switch to CH 2.

18. Disconnect the Channel 1 end of the coaxial cable that connects between Channels 1 and 2. (Do not disconnect the calibrator signal applied to Channel 1.) Reconnect the cable to the CH 1 SIGNAL OUT connector. The Channel 1 output signal should now be applied to Channel 2.

19. Set the Channel 2 INPUT SELECTOR switch to AC and the Channel 2 VOLTS/CM switch to .1. Adjust the oscilloscope triggering controls to obtain a stable display. A calibrator waveform 2 cm or more in amplitude should be displayed. This indicates that Channel 1 has amplified the calibrator signal 10× or more before the signal reached the Channel 2 INPUT connector (10 × 20 mV = 200 mV or 0.2 volt).

20. Disconnect the cable connected between the CH 1 SIGNAL OUT and Channel 2 INPUT connector.

Before the Type 1A1 is used for accurate measurements, the GAIN and .005 V/CM VAR ATTEN BAL front-panel adjustments for each channel should be adjusted. These adjustments are described in the following paragraphs.

Gain Adjustments

The gain adjustments should be checked periodically to assure correct vertical deflection factors, particularly when the Type 1A1 is used for the first time or is moved from one oscilloscope to another. Use the following procedure to check the gain of each channel:

1. Set the applicable Type 1A1 front-panel controls for both channels as follows:

INPUT SELECTOR	DC
VOLTS/CM	.05
PULL FOR INVERT	IN (normal)
POSITION	Centered
VARIABLE VOLTS/CM	CALIB
MODE	CH 1

2. Set the oscilloscope sweep rate and triggering controls for a 0.1-ms/cm free-running sweep.

3. Apply a 0.2-volt peak-to-peak signal from the oscilloscope calibrator through a coaxial cable to the Channel 1 INPUT connector.

4. The resulting display should be exactly 4 cm in amplitude. If not, adjust the Channel 1 GAIN control for correct waveform amplitude. (Use the Channel 1 POSITION control to align the display with the graticule markings.)

NOTE

For maximum accuracy use a calibrator signal source which has an amplitude accuracy of better than 3%.

5. Set the MODE switch to CH 2 and apply the calibrator signal to the Channel 2 INPUT connector.

6. The display should be exactly 4 cm in amplitude. If not, adjust the Channel 2 GAIN control for the proper display amplitude. Use the Channel 2 POSITION control to align the display with the graticule markings.

7. Disconnect the calibrator signal.

Variable Attenuator Balance Adjustments

Channel 1 and 2 .005 V/CM VAR ATTEN BAL adjustments are of the dual-range or coarse-fine type. They have a 30° range which provides a fine adjustment; if this range is exceeded, the coarse adjustment takes over to provide a fast coarse setting. If the DC levels of a channel are not properly set, the position of a no-signal trace will shift vertically as the VARIABLE VOLTS/CM control is turned.

If there is a trace shift, set the .005 V/CM VAR ATTEN BAL adjustment for each channel as follows:

1. Set the Type 1A1 front-panel controls to the same positions as in the Gain Adjustments procedure, except the INPUT SELECTOR switch must be set to GND and the VOLTS/CM switch to .005.

2. Carefully adjust the Channel 1 .005 V/CM VAR ATTEN BAL control to a point where there is no trace shift as the Channel 1 VARIABLE VOLTS/CM control is turned back and forth through its full range.

3. Set the MODE switch to CH 2.

4. Carefully adjust the Channel 2 .005 V/CM VAR ATTEN BAL control to a point where there is no trace shift as the Channel 2 VARIABLE VOLTS/CM control is turned back and forth through its full range.

GENERAL OPERATION

Either of the channels can be used independently by setting the MODE switch to the channel desired. Connect the signal to be observed to the appropriate input connector. Table 2-1 lists several methods for applying the signal to the Type 1A1. Fig. 2-3 shows a component-sequence illustration for Method 8 outlined in Table 2-1. Fig. 2-4 shows the input impedance vs frequency curves for the Type 1A1 to show that capacitive reactance (X_c) and resistance (R) decrease as frequency increases. This effect increases loading on the circuit under test as frequency increases.

Use of Probes

A conventional passive attenuator probe having a standard 42-inch cable lessens both capacitive and resistive loading, but at the same time reduces sensitivity. The attenuation

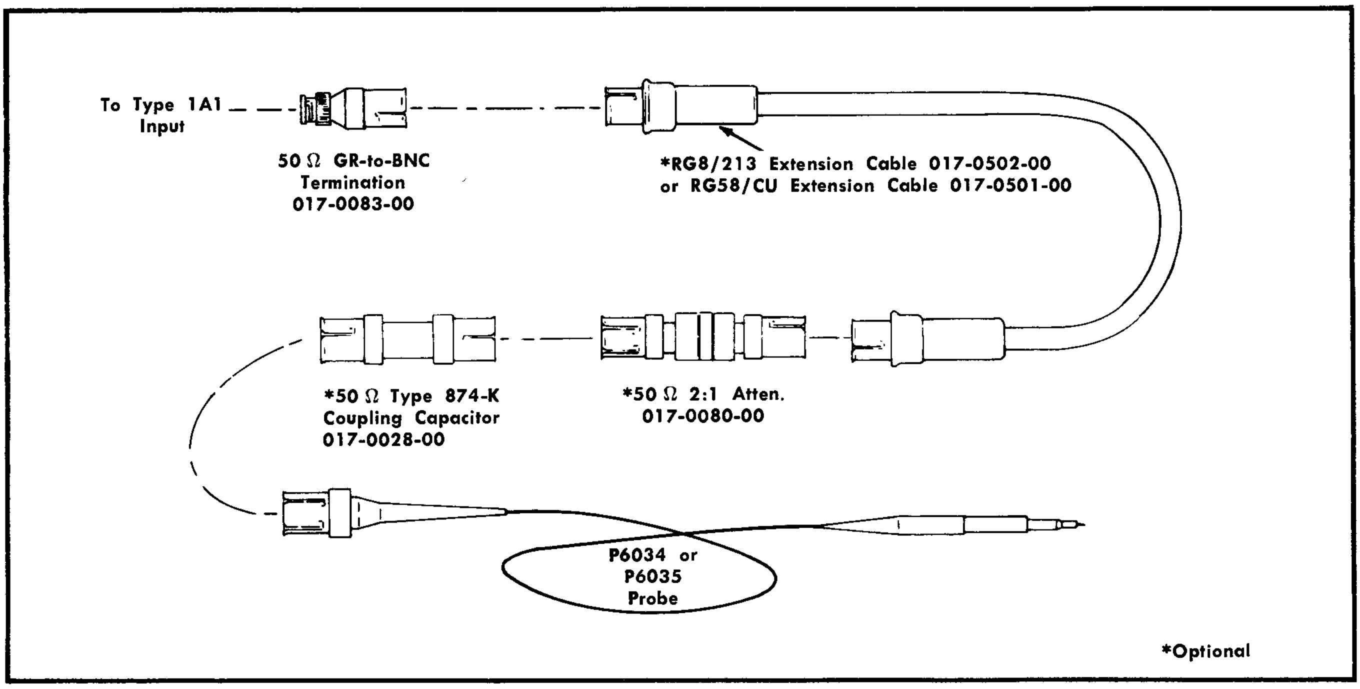


Fig. 2-3. Recommended component sequence when using the P6034 or P6035 probe. See Table 2-1.

introduced by the probe permits measurement of signal voltages that would overscan the CRT if applied directly to the Type 1A1. However, in applying high-amplitude signal voltages to either the probe or Type 1A1, do not exceed their maximum voltage ratings. When making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude by the probe attenuation.

To assure the accuracy of the pulse or high-frequency measurements, check the probe compensation. To make the adjustment, proceed as follows:

1. Set the oscilloscope Amplitude Calibrator for a calibrator output signal of suitable amplitude.

2. Place the MODE switch to appropriate channel setting (CH 1 or CH 2) to be used with the probe.

3. Touch the probe tip to the calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform.

4. Adjust the probe compensation for best square-wave response as shown in the right-hand picture of Fig. 2-5.

NOTE

If a square-wave source other than the oscilloscope calibrator is used for compensating the probe, do not use a repetition rate higher than 5 kHz. At higher repetition rates, the waveform amplitude appears to change as the probe is compensated. Thus, proper compensation is difficult. If the probe remains improperly compensated, transient and frequency response of the system will be poor and measurements will be inaccurate.

INPUT SELECTOR Switch

To display both the DC and AC components of an applied signal, set the INPUT SELECTOR switch to DC; to display only the AC component of a signal, set the INPUT SELECTOR switch to AC.

In the AC position of the switch, the DC component of the signal is blocked by a capacitor in the input circuit. The input time constant of the input circuit is about 0.1 second and the low-frequency —3 dB point is below 2 Hz. Some drop in duration response (droop) exists even when

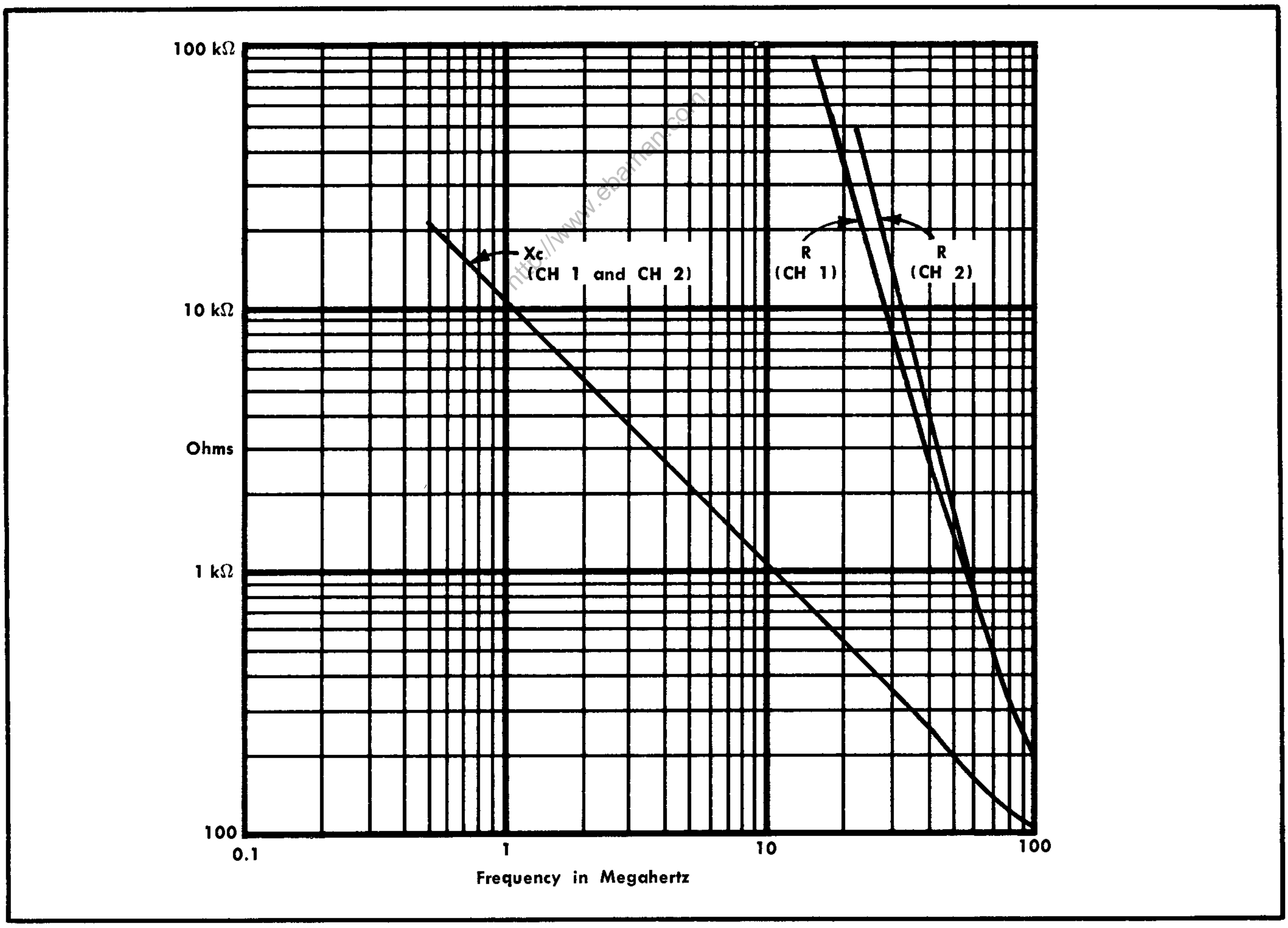


Fig. 2-4. Type 1A1 nominal input resistance and capacitive reactance vs frequency at any position of the VOLTS/CM switch. Note that input impedance (R and X_C) decreases as frequency increases.

TABLE 2-1

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading See Fig. 2-3, Input X_c and R Curves	Precautions
1. Open (unshielded) test leads.	Simplicity.	Limited frequency response. Subject to stray pickup.	BNC to banana jack adapter (103-0033-00). Two test leads.	1 MΩ and 15 pF at input, plus test leads and adapter.	Stray pickup and spurious oscillations.
2. Unterminated coaxial cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coaxial cable with BNC connector(s).	1 MΩ and 15 pF plus cable capacitance.	High-capacitance loading.
3. 1×, 1 MΩ probe.	Full sensitivity.	High capacitance of cable.	P6028 is 1× equipped with BNC connector.	1 MΩ and ≈ 63 pF.	High-capacitance loading.
4. Terminated coaxial cable. Termination at Type 1A1 input.	Full sensitivity. Total Type 1A1/Oscilloscope bandwidth. Relatively flat resistive loading. Long cable with uniform response.	Presents R_o (typically 50 Ω) loading at end of coaxial cable. May need blocking capacitor to prevent DC loading or damage to termination.	Coaxial cable with BNC connector(s). R_o termination at Type 1A1 input. (BNC 50 Ω termination, 011-0049-00).	R_o plus 15 pF at Type 1A1 end of coaxial cable can cause reflections.	Reflections from 15 pF at input. DC and AC loading on test point. Power limit of termination.
5. Same as 4, with coaxial attenuator at termination.	Less reflection from 15 pF at termination.	Sensitivity is reduced (increased deflection factor).	BNC coaxial attenuators.	R_o only.	DC and AC loading on test point. Power limit of attenuator.
6. Tap into terminated coaxial system. (BNC T: US-274/U at Type 1A1 input.	Permits signal to go to normal load. DC or AC coupling without coaxial attenuators.	15 pF load at tap point.	BNC T and BNC connectors on signal cables.	1 MΩ and 15 pF at tap point.	Reflections from 15 pF input.
7. 10×, 10 MΩ probe 100×, 10 MΩ probe. 1000×, 100 MΩ probe.	Reduce resistance and capacitive loading, nearly full Type 1A1 Oscilloscope bandwidth.	×0.1 sensitivity. ×0.01 sensitivity. ×0.001 sensitivity.	P6006 P6008, P6010 are 10×. P6007, P6009 are 100×. P6015 is 1000×.	P6006: ≈ 7 pF, 10 MΩ. P6008: ≈ 7.5 pF, 10 MΩ. P6010: ≈ 10 pF, 10 MΩ. P6007: less than 2 pF, 10 MΩ. P6009: ≈ 2.5 pF, 10 MΩ. P6015: ≈ 3 pF, 100 MΩ.	Check probe frequency Compensation. Use square-wave frequency less than 5 kHz, preferably 1 kHz.
8. 500 Ω and 5 kΩ probes (must be terminated in 50 Ω at Type 1A1 input).	Reduced capacitive loading to about 0.7 pF. Bandwidth that of Type 1A1/Oscilloscope. Probe compensation need not be adjusted, since effect is not apparent when used with the Type 1A1/Oscilloscope.	Resistive loading. X0.1 or X0.01 sensitivity. May need blocking capacitor to prevent DC loading or damage to termination. Limited low-frequency response when AC coupled: 70 kHz for P6034; 7 kHz for P6035.	P6034-10X. P6035-100X. Items in Fig. 2-3.	P6034: 500 Ω, 0.7 pF. P6035: 5 kΩ, 0.6 pF.	DC and AC loading. Voltage rating of probe.

TABLE 2-1 (Cont)

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-3, Input X_C and R Curves	Precautions
9. Current transformer. Terminated in 50 Ω at Type 1A1. Upper bandwidth is that of Type 1A1 Oscilloscope.	Current transformer can be permanent part of test circuit. Less than 2.2 pF to test circuit chassis. Measure signal currents in transistor circuits.	RMS current rating: CT-1: 0.5 A. CT-2: 2.5 A. Sensitivity: CT-1: 5 mV/mA. CT-2: 1 mV/mA.	CT-1: Coaxial adapter with BNC termination. CT-2: Nothing extra. (Perhaps additional coaxial cable for either transformer.)	CT-1: Insertion; 1 Ω paralleled by about 5 μH. Up to 1.5 pF. CT-2: Insertion; 0.04 Ω paralleled by about 5 μH. Up to 2.2 pF.	Not a quick-connect device. CT-1: Low-frequency limit about 75 kHz. CT-2: Low frequency limit about 1.2 kHz, and is 1/5 as sensitive as the CT-1.
10. P6019 Current Probe with Type 134 Amplifier. System bandwidth with Type 1A1/Oscilloscope: ≈30 MHz.	Measure signal currents without breaking the circuit under test. Basic deflection factor: 0.2 mA/cm with Type 1A1 VOLTS/CM switch set to .01.[4]	Low frequency limit: ≤ 12 Hz.	None if probe and amplifier are purchased with power supply as a complete set.	Insertion Z: 2.8 μH paralleled by 0.004 Ω in series with 1.7 nH.	When changing probes, check the Low Freq. and Gain adjustments. Be sure the Type 134 Probe Selector switch is set to the proper position.
11. P6020 Current Probe with Type 134 Amplifier. System bandwidth with Type 1A1/Oscilloscope: ≈40 MHz.	Measure signal currents without breaking the circuit under test. Basic deflection factor: 0.2 mA/cm with Type 1A1 VOLTS/CM switch set to .01.[4]	Low frequency limit: ≤ 100 Hz.	None if probe and amplifier are purchased with power supply as a complete set.	Insertion Z: 0.6 μH paralleled by 0.025 Ω in series with 0.2 nH.	When changing probes, check the Low Freq. and Gain adjustments. Be sure the Type 134 Probe Selector switch is set to the proper position.

[4]Type 134 Current/Div switch is calibrated when the Type 1A1 VOLTS/CM switch is set to .05.

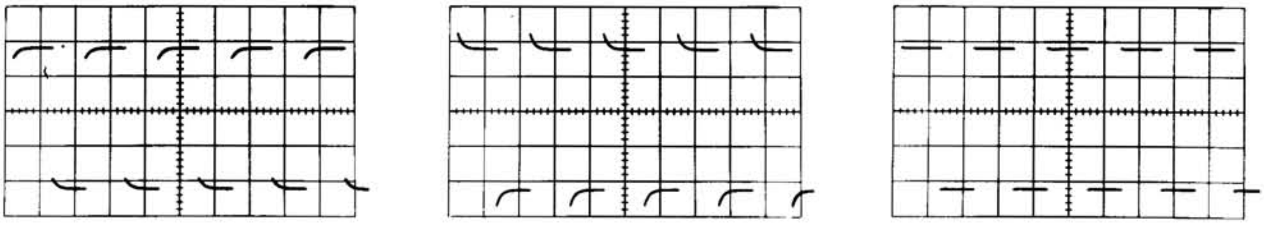


Fig. 2-5. Probe compensation waveforms using a 1-kHz calibrator signal.

observing a symmetrical 60-hertz square-wave signal. If a 10× attenuator probe is used with the Type 1A1, the low-frequency response will be extended to about 0.2 Hz; with a 100× probe, low-frequency response is about 2 Hz.

Placing the INPUT SELECTOR switch to the GND position grounds the input circuit of the Type 1A1 to provide a DC zero reference. When the INPUT SELECTOR switch is set to GND, the switch internally disconnects, but does not ground the applied signal at the INPUT connector. The GND position of the switch eliminates the need for externally grounding the input of the unit or probe tip to establish the ground reference.

VOLTS/CM Switch and VARIABLE VOLTS/CM Control

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of the probe, the setting of the VOLTS/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the settings of the VOLTS/CM switch apply only when the VARIABLE VOLTS/CM control is set to the CALIB position. Errors in display measurements may result if the setting of this control is moved away from the CALIB position; also, there may be a slight change in transient response when a fast rise pulse is observed.

The range of the VARIABLE VOLTS/CM control is at least 2.5 to 1 to provide continuously variable (uncalibrated) vertical-deflection factors between the calibrated settings of the VOLTS/CM switch. As the control is rotated a few degrees counterclockwise from the CALIB position, a switch is actuated to increase the gain of the channel and provide overlapping coverage. When the control is turned to its maximum counterclockwise position and the VOLTS/CM switch is set to 20, the VARIABLE VOLTS/CM control extends the vertical-deflection factor to about 50 volts/cm. By applying the oscilloscope calibrator voltage or any other calibrated voltage source to the Type 1A1, any specific deflection factor can be set within the range of the VARIABLE VOLTS/CM control.

PULL FOR INVERT Switch

The PULL FOR INVERT (NORM-INVERT) switch may be used to invert the displayed waveform, particularly when using the dual-trace feature of the Type 1A1. The PULL FOR INVERT switch has two positions. In the normal (in) position, the displayed waveform will have the same polarity as the applied signal; that is, a positive-going pulse applied to the Type 1A1 will be displayed as a positive-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A1, the beam will move up.

In the inverted (pulled) position, the displayed waveform will be inverted; that is, a positive-going pulse applied to the Type 1A1 will be inverted or displayed as a negative-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A1, the beam will move down.

MODE Switch

The MODE switch has five positions: CH 1, ALT, CHOP, ADD and CH 2. These positions and their purposes are described in the subsequent paragraphs. Useful triggering information is included in the description of the ALT and CHOP switch positions.

CH 1, CH 2—Single-Trace Operation

To display a single signal (single-trace operation), apply the signal either to the Channel 1 or Channel 2 INPUT connector and set the MODE switch to the corresponding position: CH 1 (Channel 1) or CH 2 (Channel 2).

To display a signal in one channel independently when the same signal or a different signal is applied to the other channel, simply select the signal in the channel to be displayed by setting the MODE switch to the appropriate CH 1 or CH 2 position.

ALT, CHOP—Dual-Trace Operation

To display two signals together (dual-trace operation), apply one signal to the Channel 1 INPUT connector and apply the other signal to the Channel 2 INPUT connector. Set the appropriate PULL FOR INVERT switch for normal or inverted operation, and set the MODE switch to ALT or CHOP.

In general, use the CHOP position (chopped-mode operation) with sweep rates up to about 10 μs/cm for displaying two non-repetitive signals occurring within the sweep-time interval set by the oscilloscope Time/Cm switch. Non-repetitive signals are those which are single-shot, transient, or random. The CHOP position is also useful for displaying low-frequency synchronous signals. Synchronous signals are those which have the same repetition rate or are frequency related by a whole number multiple.

NOTE

When using chopped-mode operation, be sure to set the oscilloscope CRT Cathode Selector switch to a Dual-Trace Chopped Blanking position to blank out the undesirable chopped-mode switching transients.

Use the ALT position (alternate-mode operation) when using sweep rates at about 0.5 ms/cm or faster to display high-frequency synchronous and asynchronous signals. Asynchronous signals are those which do not have the same repetition rate or are not frequency related to each other by a whole number multiple. Table 2-2 summarizes the following discussion on dual-trace operation.

Displaying Two Non-Repetitive or Low-Frequency (below 10 kHz) Synchronous Signals. To show true time and phase relationship between two non-repetitive or low-frequency synchronous signals, use chopped-mode operation. Transients as short as 0.1 ms can be well delineated or resolved. At 10 μs/cm a 0.1 ms duration transient, for example, will contain about 100 segments in its trace. If a higher sweep rate is used, the number of segments that make up each of the traces will be less, and, therefore, resolution will be poorer.

To make the display stable, use either internal triggering on Channel 1 Only (from pin 5 of interconnecting plug—see Block Diagram in Section 10) or use the CH 1 TRIGGER OUT connector as the external trigger source. If your oscilloscope has provisions for selecting the Channel 1 only internal trigger as a triggering source, then use this feature by setting the Triggering Source switch on the front panel of the oscilloscope to the Plug-in position.

NOTE

Use the oscilloscope Plug-In position of the Triggering Source switch in preference to external patching to obtain optimum bandwidth capabilities from the Channel 1 Trigger Output Amplifier.

If there is no Plug-In position, then use the signal available at the CH 1 TRIGGER OUT connector as the Channel 1 only trigger source. To use the signal, connect a coaxial cable from the CH 1 TRIGGER OUT connector to the oscilloscope Trigger Input connector and set the Triggering Source switch to Ext.

CAUTION

Do not apply external voltages to either the CH 1 TRIGGER OUT or CH 1 SIGNAL OUT connectors as this may damage the internal associated circuits. Shorting the connectors to ground, however, will not cause any damage.

If asynchronous signals are applied to the Type 1A1 while you are using chopped mode of operation and Channel 1 only triggering, the Channel 1 waveform will remain stationary while the Channel 2 waveform will appear to be free running. However, if the frequency of the Channel 2 signal is changed so that it becomes synchronized with the Channel 1 signal, or vice versa, then the two signals will appear as stationary displays on the CRT. This is one application which can be useful for determining the zero-beat frequencies of the two signals.

Do not set the oscilloscope Triggering Source switch to Norm Int or Int (oscilloscope vertical amplifier trigger take-off signal) because a stable display is difficult and sometimes impossible to obtain. During dual-trace chopped-mode operation the Norm Int or Int trigger source is a composite signal consisting of the signals applied to both channels superimposed on, but not synchronized with, the free-running rate of the chopped-mode switching signal. The switching signal has a square waveshape the same as the one shown in Fig. 2-1B. Its amplitude is dependent on the distance that the traces are positioned apart (providing no DC component is contained in the applied signals) and its rate is the chopping rate (about 1 MHz).

Since the internal trigger from the oscilloscope vertical amplifier is a composite trigger during chopped mode of operation and the trigger contains a non-synchronized chopped-mode switching signal, internal triggering may occur first on one of the applied signals and then on the chopped-mode switching signal, or vice versa, resulting in an unstable display.

Displaying Two Asynchronous Signals. To obtain a stable display of two asynchronous signals which do not exceed the system bandwidth, use alternate-mode operation and set the oscilloscope Triggering Source switch to Norm Int or Int. Set the oscilloscope Triggering Coupling switch to AC for stable triggering on signals below 1 kHz; set the Triggering Coupling switch to AC LF Reject or AC Fast for stable triggering and a bright display on signals above 1 kHz. Since the oscilloscope vertical amplifier internal trigger is the trigger source, the applied signals will not be displayed in their true time relationship because triggering occurs on the applied signal in each channel as it switches on.

To obtain a stable display in this mode of operation, it is very important to set the oscilloscope Triggering Level control to a point where the time base can trigger on the signal in one channel as it turns on, and on the signal in the other channel when it turns on. In addition, both applied signals must be of sufficient amplitude to meet the internal trigger signal amplitude requirements of the oscilloscope.

If one displayed signal has a smaller amplitude than the other, but is of adequate amplitude for internal triggering, set the Triggering Level control to a point that will assure triggering on the smaller amplitude signal. To do this, set the Triggering Level control near the 0 position.

Though it may seem easy to obtain stable triggering on asynchronous signals, there are certain conditions that may promote jitter. When using the AC Fast or AC LF Reject triggering mode, jitter most likely occurs when attempting to trigger on high-frequency asynchronous signals that are vertically positioned apart on the CRT with POSITION controls. If jitter occurs, it can be reduced and sometimes eliminated by positioning the displays close together or superimposing them. This not only reduces jitter, but may also increase the display brightness.

If you use the AC or AC Slow triggering mode, stable internal triggering on asynchronous signals above 1 kHz is more difficult to obtain and the jitter will be greater. At sweep rates faster than 0.5 ms/cm, the dual-trace display becomes noticeably brighter as the traces are vertically positioned closer together, and dimmer as the traces are more widely separated. These effects are normal and are caused by the problem of triggering on the alternate-mode composite trigger waveform. The waveform is very similar to the one described for chopped-mode operation.

The alternate-mode composite trigger consists of the asynchronous signals applied to the Type 1A1, superimposed on the DC positioning levels of the alternate-mode switching waveform. The switching waveform portion of the composite trigger is a low-frequency squarewave whose amplitude is governed by the setting of the POSITION controls and DC components (if any) of the applied signals. By itself, the switching waveform viewed on a test oscilloscope resembles the waveshape shown in Fig. 2-1B when the traces are positioned 2 cm apart. Repetition rate of the switching waveform is one half of the sweep repetition rate.

When the alternate-mode composite trigger is internally AC coupled to the oscilloscope trigger input circuit, the trigger circuit may not respond instantly to the signals superimposed on the alternate-mode switching signal. The delay is caused by the recovery time of the trigger input circuit as each cycle of the low-frequency switching waveform couples into the input stage of the trigger circuits. Since AC coupling is used in all the Triggering Coupling switch positions (AC, AC Slow, AC Fast, AC LF Reject) recovery time is dependent on the RC time constant of the trigger input circuit.

In conclusion, trigger circuit recovery time is shorter, hence, the sweep repetition rate is higher and the display is brighter, if AC Fast or AC LF Reject triggering mode is used. In either of these triggering modes, a smaller value coupling capacitor is used in the oscilloscope trigger input circuit as compared to the value used in the AC or AC Slow triggering mode. Trigger recovery time can be shortened and triggering will be more stable if high-frequency waveform displays are vertically positioned closer together or superimposed rather than positioned further apart.

Displaying Two Synchronous Signals, 250 Hz and Above. To show true time and phase relationship between two synchronous signals, 250 Hz and above, use alternate-mode operation and trigger on Channel 1 only. In practice, for displaying signals between 250 Hz and 10 kHz you can choose either alternate- or chopped-mode operation since

TABLE 2-2

Dual-Trace Operation

Applied Signals (one to Channel 1 and other to Channel 2)	Type 1A1 MODE Switch Setting	Oscilloscope Triggering Source Switch Setting	Oscilloscope Triggering Coupling Switch Setting	Display shows true time relationship between signals
1. Two non-repetitive signals or two low-frequency synchronous signals (below 10 kHz). Apply reference signal to Channel 1.	CHOP	Plug-In[3] or Ext (connect coaxial cable from CH 1 TRIGGER connector on oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject.	Yes Use sweep rates up to 10 μs/cm. Higher sweep rates reduce resolution.
2. Two asynchronous signals, any frequency within full bandwidth of the system.	ALT	Norm Int or Int[4]	AC or AC Slow for frequencies below 1 kHz. AC Fast or AC LF Reject for frequencies above 1 kHz.	No
3. Two synchronous signals, 250 Hz and above.	ALT	Plug-In[3] or Ext (connect coaxial cable from CH 1 TRIGGER OUT connector to Trigger Input connector on oscilloscope). Norm Int or Int[4]	AC or AC Slow or AC Fast or AC LF Reject. AC Fast or AC LF Reject.	Yes Apply reference signal to Channel 1. No

[3]Plug-In position is the Channel 1 only internal signal available at pin 5 of the Type 1A1 interconnecting plug to the oscilloscope. If your oscilloscope is not wired to permit use of this trigger source, use the Ext position and CH 1 TRIGGER OUT signal.

[4]Norm Int or Int switch position is the internal trigger takeoff signal from the oscilloscope vertical amplifier. In dual-trace operation this trigger is a composite of the applied signals superimposed on the DC positioning levels of the channels as they are switched.

this is an overlapping area. Apply the reference signal to Channel 1 and set the oscilloscope Triggering Source switch to the Plug-In position. Set the Triggering Coupling switch to the desired AC position. Set the Triggering Coupling switch to the desired AC position (AC, AC Slow, AC Fast or AC LF Reject). If your oscilloscope does not have the Plug-In switch position, apply the signal from the CH 1 TRIGGER OUT connector to the oscilloscope Trigger Input connector and set the Triggering Source switch to Ext.

When triggering on Channel 1, and if one of the signals changes frequency, the Channel 2 signal will appear to free run. This phenomenon is useful for determining the zero-beat points between the two signals.

In high-frequency applications where the bandwidth limit of the Type 1A1 Channel 1 trigger amplifier is a limiting factor, the reference trigger for the oscilloscope can be derived from external sources. If derived from the signal applied to the Type 1A1 from the device under test, consider the loading effect of the oscilloscope and interconnecting leads on the signal source. If loading is a factor, use other methods. For example, if you use a signal generator to drive the device under test, and the generator has a trigger-output connector, use the trigger from the generator to externally trigger the oscilloscope. Or, connect the cable end of an attenuator probe to the Trigger Input connector on the oscilloscope and connect the probe tip to the trigger source.

ADD—Algebraic Addition Of Two Signals

In many applications, the desired signal is superimposed on an undesired signal such as line frequency hum, etc. Algebraic addition makes it possible in many cases to improve the ratio of desired to undesired signal. To do this, connect one INPUT to the source containing both the desired and undesired signal. Connect the other INPUT to a source containing only the undesired signal. Place the MODE switch to the ADD position. Set the PULL FOR INVERT switches to opposite polarities (depending upon the polarity of the desired signal). By carefully adjusting (especially at low frequencies) the VARIABLE VOLTS/CM control of one of the channels, the undesired display signal can be reduced by a factor of 20 compared to the amplitude of the desired signal.

Using the CH 1 SIGNAL OUT Connector

If greater sensitivity is needed to observe low-level signals in a device under test, use Channel 1 as wideband AC-coupled 10X preamplifier for Channel 2. To do this, connect a coaxial cable (equipped with suitable connectors) from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector. Set the Channel 1 VOLTS/CM switch to .005 and the Channel 2 INPUT SELECTOR switch to AC. Apply the signal to be observed to the Channel 1 INPUT connector.

NOTE

For optimum bandwidth and transient response, use the coaxial cable (Tektronix Part No. 012-0076-00) furnished with the unit. As an alternative method, use a 3-inch wire made from No. 18 solid tinned-copper wire.

CAUTION

Do not apply external voltages to either the CH 1 SIGNAL OUT or TRIGGER OUT connectors as this may damage the internal circuits. Shorting the connectors to ground, however, will not cause any damage.

The following characteristics and brief operating notes are provided for your consideration:

1. Bandwidth of Channel 1 and Channel 2 connected in cascade (Channel 1 and 2 VOLTS/CM switches set to .005) between 3-dB down points is about 2 Hz to about 15 MHz (Channel 1 INPUT DC coupled).

2. Output impedance of the Channel 1 preamplifier is nominally 50 ohms.

3. Channel 1 preamplifier voltage gain is about 10X when the Channel 1 VOLTS/CM switch is set to .005; 5X when set to .01; 2½X when set to .02, and 1X when set to .05.

4. Use the Channel 1 preamplifier as an impedance transformer with or without voltage gain. With a 1-MΩ input and 50-Ω output the voltage gain is up to 10. The amount of voltage gain depends on the Channel 1 VOLTS/CM switch setting.

5. Maximum input signal that can be applied to Channel 1 with the VOLTS/CM switch set to .005 and the Channel 1 INPUT SELECTOR switch set to AC is about 50 mV to get full amplification without overdriving the channel. If the Channel 1 INPUT SELECTOR switch is set to DC and the Channel 1 POSITION control is centered, ±25 mV is maximum input signal that can be amplified without distortion.

6. During dual-trace operation, the signal in Channel 1 will be presented on the CRT when Channel 1 turns on. Then, the amplified Channel 1 signal will be displayed on the CRT when Channel 2 turns on. Thus, Channel 1 can be used as a monitor for its own signal while it is being applied to Channel 2.

7. In applications where the flat frequency response of the Type 1A1/oscilloscope combination is not desired, a suitable filter inserted between the CH 1 SIGNAL OUT connector and the Channel 2 INPUT connector will allow the oscilloscope to essentially take on the frequency response of the filter, providing the filter frequency response is within the system bandwidth.

8. Output noise level is approximately 200 μV, RMS, when the Channel 1 INPUT SELECTOR switch is set to AC or DC and no signal is applied to the Channel 1 INPUT connector. By inserting a frequency selective filter of your own choice in place of the CH 1 SIGNAL OUT to Channel 2 INPUT coaxial cable, the noise level can be reduced. For example, use a 400-hertz filter for observing low-level 400-hertz signals.

9. AC coupling blocks the no-signal DC level (typically +0.45 volts) of the Channel 1 Signal Pickoff Amplifier Q164/Q174 stage so the trace can be positioned on the CRT. AC coupling is most easily accomplished by setting the Channel 2 INPUT SELECTOR switch to AC.

10. The MODE switch, Channel 1 POSITION, PULL FOR INVERT and VARIABLE VOLTS/CM controls do not have any

effect on the signal available at the CH 1 SIGNAL OUT connector in any mode of operation. That is, these controls are not electrically located in the preamplifier circuitry since the Channel 1 signal is picked off for use as a Channel 1 front-panel output at a point ahead of the location of these controls.

11. By using Channel 1 as a 10X low-level voltage preamplifier, the Channel 1 signal available at the CH 1 SIGNAL OUT connector can be AC coupled into any input where a 10X preamplified signal is needed. Consider that if a 50-ohm load impedance is used, the signal amplitude is halved. The signal amplitude is correspondingly lower if the load impedance is lower than 50 ohms. Examples of other uses are: (a) X-Y displays by applying the X-axis signal to Channel 1 and the output from the CH 1 SIGNAL OUT connector to the oscilloscope External Horizontal input connector; use Channel 2 for the Y-axis signal; (b) the signal from the CH 1 SIGNAL OUT connector can be used to drive recording equipment.

Advantages of Using The Channel 1 Trigger Out Amplifier

In addition to the previously given operating information concerning the Type 1A1 CH 1 TRIGGER OUT connector and the Internal "Plug-In" triggering source, the following information is provided for consideration:

Use As An Amplifier For Low Level Triggering Signals

1. The amplitude of the signal from the Channel 1 Trigger Out amplifier is not affected by the Channel 1 VARIABLE (VOLTS/CM).

2. The DC level of the signal from the Channel 1 Trigger Out amplifier is not affected by the Channel 1 POSITION control. Thus when DC Triggering Coupling is used, readjustment of the Triggering Level control is not necessary

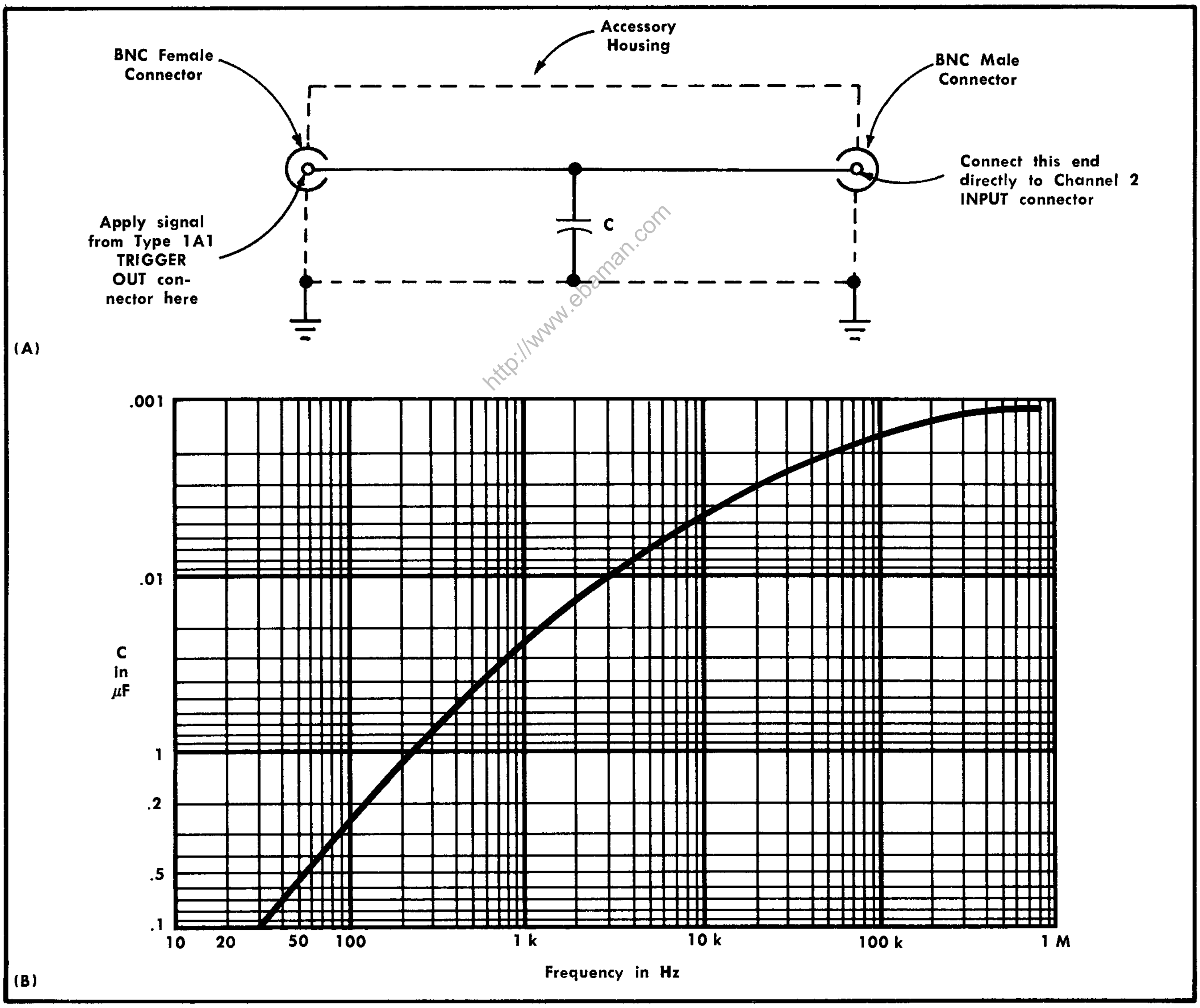


Fig. 2-6. Constructing a low-pass filter. The curve in (B) shows the approximate upper 3-dB down point for a given capacitance value.

when Channel 1 POSITION control is varied. Setting the Channel 1 POSITION control to its limits does not result in distortion of the triggering signal.

3. A gain of approximately 100 can be realized for the triggering signal by setting the Channel 1 VOLTS/CM switch to .005. Thus stable triggering can be obtained on low level input signals to Channel 1.

Use As A Preamplifier On Low Level Signals

Low level signals (within certain bandwidth limits) can be observed by utilizing the CH 1 TRIGGER OUT connector in a similar manner as was described for the CH 1 SIGNAL OUT connector. A gain of approximately 100 is realized when Channel 1 VOLTS/CM switch is set to .005. Maximum input signal before distortion occurs is 50 mV when Channel 1 VOLTS/CM switch is set to .005.

A suitable filter must be used to reduce the noise level accompanying the CH 1 TRIGGER OUT signal when observing such low level input signals. Fig. 2-6 shows how to construct a low-pass filter and determine the value of capacitance to use for the 3-dB down point (the bandwidth of the filter). The upper bandwidth 3-dB down point is valid only when a high impedance load is used at the output of the low-pass filter. This requirement is satisfied when the Channel 2 input circuit is used.

The capacitor should be mounted in an accessory housing which provides adequate shielding and convenient component mounting points. The accessory housing (similar to item 5 in the Calibration Section) can be ordered without components by using the following description: Coupler, test set with BNC connectors, Tektronix Part No. 011-0081-00.

SECTION 3
APPLICATIONS

Introduction

This section of the manual describes procedures and techniques for making basic measurements with the Type 1A1 and the associated Tektronix oscilloscope. When only one channel is involved, the step-by-step procedures use Channel 1 as the example. If both channels are involved, as when making phase-shift measurements, the reference signal is applied to Channel 1.

NOTE

Although Channel 1 is used as the example in the procedures in which only one channel is involved, these same procedures can be used for Channel 2 by first applying the signal to Channel 2, then setting the MODE switch to CH 2 and using the appropriate Channel 2 front-panel controls. All the procedures assume that the Type 1A1 is used with an oscilloscope which provides 6 cm of usable vertical scan. If the Type 1A1 is used with an oscilloscope which provides a usable vertical scan other than 6 cm, interpret the procedures accordingly.

No attempt has been made to describe specific applications, since familiarity with the unit enables the operator to apply these techniques to a wide variety of applications.

AC Component Voltage Measurements

Using One Channel. To measure the AC component of a waveform, the INPUT SELECTOR switch of the channel you intend to use should be set to the AC position. In this position, only the AC components of the input waveform are displayed on the CRT. (However, when the AC component of the input waveform is very low in frequency, use the DC position of the switch).

To make a peak-to-peak voltage measurement of the AC component of a waveform, perform the following steps (Channel 1 is used as the example):

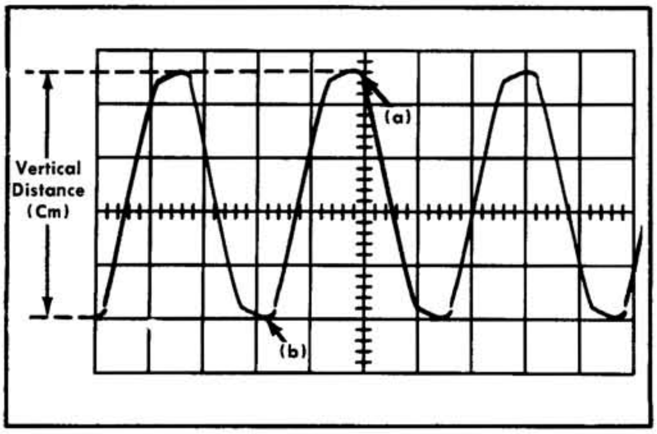


Fig. 3-1. Measuring the peak-to-peak voltage of a waveform.

1. Set the Channel 1 VOLTS/CM switch so that the voltage to be applied to the INPUT connector is not more than about six times the setting.

2. Apply the signal to the Channel 1 INPUT connector, preferably through a coaxial cable or an attenuator probe.

3. Set the MODE switch to CH 1.

4. Set the triggering controls to obtain a stable display and set the sweep rate to display several cycles of the waveform.

5. Use the Channel 1 POSITION control to vertically position the waveform to a point on the CRT where the waveform amplitude can be easily determined. For example, position the waveform so that the negative peaks coincide with one of the lower graticule lines and one of the positive peaks lies near the graticule vertical centerline (see Fig. 3-1).

6. Measure the vertical deflection in cm from peak to peak on the waveform. Make sure the VARIABLE VOLTS/CM control is set to the CALIB position.

NOTE

In measuring signal amplitudes, the width of the trace may be an appreciable part of the overall measurement. To make the measurement as accurate as possible, measure from one side of the trace (particularly when measuring low-amplitude signals). Notice in Fig. 3-1 that points (A) and (B) correspond to the bottom side of the trace. The measurement would be just as accurate if points (A) and (B) corresponded to the top side or center of the trace.

7. Multiply the peak-to-peak distance measured in step 6 by the setting of the Channel 1 VOLTS/CM switch and the attenuation factor, if any, of the probe.

As an example of this method, assume that the peak-to-peak vertical deflection is 4.6 cm using a 10× probe with the VOLTS/CM switch set to .5. Substituting these values in the following formula:

$$\text{Volts Peak To Peak} = \text{Vertical deflection in cm} \times \text{VOLTS/CM switch setting} \times \text{Probe attenuation factor}$$

Then:

$$\text{Volts Peak to Peak} = 4.6 \times .5 \times 10 = 23 \text{ volts}$$

Using Channel 1 as a 10× preamplifier for Channel 2. This procedure describes a method for making low-level AC-component measurements with a 10× attenuator probe without having to consider the probe attenuation factor. The 10× attenuation of the probe is offset by the 10× amplification of Channel 1. Thus, the following is the correct formula:

$$\text{Volts Peak to Peak} = \text{Vertical deflection in cm} \times \text{Channel 1 VOLTS/CM switch setting}$$

The following procedure describes how to calibrate the Type 1A1 so the Channel 1 VOLTS/CM switch deflection factors are correct for use in the preceding formula.

1. Set the Type 1A1 front-panel controls to these settings:

POSITION (Channel 2)	Centered
PULL FOR INVERT (Channel 2)	IN (normal)
VARIABLE VOLTS/CM (Channel 2)	CALIB
MODE	CH 2
VOLTS/CM (both channels)	.005
INPUT SELECTOR (both channels)	AC

NOTE

Channel 1 POSITION, PULL FOR INVERT and VARIABLE VOLTS/CM controls have no affect in this procedure.

2. Connect a coaxial cable from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector.

3. Connect another coaxial cable from the CH 1 TRIGGER OUT connector to the oscilloscope Trigger Input connector.

NOTE

If your oscilloscope has provisions for selecting the Channel 1 internal trigger as a triggering source, use this feature instead of externally patching the trigger to the oscilloscope. To use this feature, set the oscilloscope Triggering Source switch to the Plug-In position. Reliable triggering on the Channel 1 signal can be obtained on all signals within the bandwidth limits of the Channel 1 Trigger Output Amplifier.

4. Connect the 10× attenuator probe to the Channel 1 INPUT connector.

5. Set the oscilloscope Amplitude Calibrator for an output of 20 mV and connect the probe tip to the oscilloscope calibrator output connector.

6. Set the sweep rate to display several cycles of the calibrator waveform and set the triggering controls for stable triggering on the external trigger source. If necessary adjust the Channel 2 VARIABLE VOLTS/CM control so that the waveform is exactly 4 cm in amplitude. Do not move the Channel 2 VARIABLE VOLTS/CM control or the Channel 2 VOLTS/CM switch after you have obtained the desired deflection.

7. Disconnect the probe from the calibrator output connector.

The Type 1A1 is now ready to use in making signal measurements. Use the Channel 1 VOLTS/CM switch .005, .01, .02 and .05 positions in the conventional manner. The vertical-deflection factors will be the same as the Channel 1 VOLTS/CM switch reading.

For example, assume a vertical deflection of 3.5 cm using the 10× probe with the Channel 1 VOLTS/CM switch set to .01. Substituting these values in the formula given at the beginning of this procedure.

$$\text{Volts Peak To Peak} = 3.5 \times .01 = 0.035 \text{ volt or } 35 \text{ mV}$$

Instantaneous Voltage Measurements

To measure the DC level at a given point on a waveform proceed as follows:

1. Set the Channel 1 VOLTS/CM switch so that the voltage to be applied to the INPUT connector is not more than about six times the switch setting.

2. Set the oscilloscope triggering and time-base controls so that the time base free runs at the desired rate.

3. Set the Channel 1 INPUT SELECTOR switch to GND and position the trace (with the Channel 1 POSITION control) along one of the horizontal graticule lines such as point (B) in Fig. 3-2. This line will be used as a ground (or zero) reference line. In any case, the reference line chosen will depend upon the polarity and DC level of the signal to be measured. Do not move the Channel 1 POSITION control after the reference line has been established.

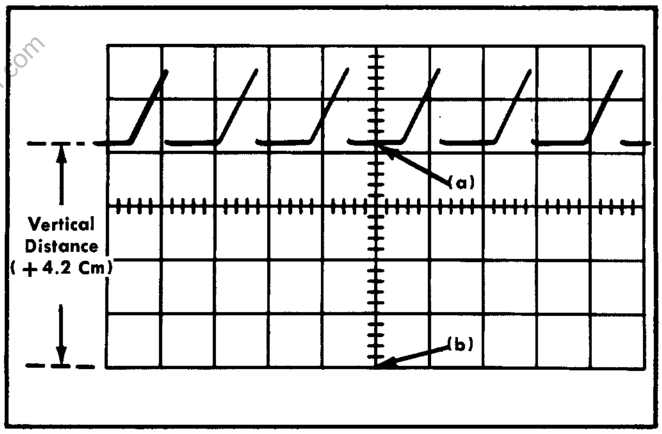


Fig. 3-2. Measuring instantaneous voltage with respect to some reference.

4. Set the Channel 1 INPUT SELECTOR switch to DC.

5. Apply the signal, preferably through a coaxial cable or an attenuator probe, to the Channel 1 INPUT connector.

6. Set the triggering controls of the time base for a stable display.

7. Measure the vertical distance in cm from the ground (zero) reference line established in step 3 to the point on the waveform that you wish to measure, such as between (A) and (B) in Fig. 3-2. If the PULL FOR INVERT switch is set to normal and the point on the waveform is above the reference line, the polarity is indicated to be positive (+). If the point is below the line, the polarity is negative (—). If the PULL FOR INVERT switch is set to inverted, the indicated polarities will be reversed.

8. Multiply the measured distance by the setting of the VOLTS/CM switch and the attenuation factor, if any, of the probe. This is the instantaneous DC level of the point measured. For example, assume the vertical deflection is 4.2 cm above the reference line (see Fig. 3-2) using a 10× attenuator probe with the PULL FOR INVERT switch set to normal and the VOLTS/CM switch set to 2. Substitute these values in the following formula:

$$\text{Instantaneous Volts (with respect to a ground reference)} = \text{Vertical deflection in cm and polarity} \times \text{VOLTS/CM switch setting} \times \text{Probe attenuation factor}$$

Then:

$$\text{Instantaneous Voltage (with respect to a ground reference)} = +4.2 \times 2 \times 10 = +84 \text{ volts}$$

9. To re-establish the (zero) reference line without disconnecting the applied signal, set the INPUT SELECTOR switch to GND. To establish a reference other than zero, set the INPUT SELECTOR switch to DC, touch the signal probe to the desired reference voltage and position the free-running sweep along one of the horizontal graticule lines.

Voltage Comparison Measurements

In some applications you may want to establish a set of deflection factors other than those indicated by the VOLTS/CM switch. This is useful for comparing signals which are exact multiples of a given voltage amplitude. The following procedure describes how to determine deflection factors for Channel 1. The same basic procedure can be used for Channel 2. To establish a set of deflection factors based upon some specific reference amplitude, proceed as follows:

1. Apply a known-amplitude reference signal to the Channel 1 INPUT connector and, with the Channel 1 VOLTS/CM switch and VARIABLE VOLTS/CM control, adjust the amplitude of the display for an exact number of graticule divisions. Do not move the VARIABLE VOLTS/CM control after obtaining the desired deflection.

2. Divide the amplitude of the reference signal (in volts) by the product of the deflection in cm (established in step 1) and the VOLTS/CM switch setting. The result is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{Reference signal amplitude in volts}}{\text{(Deflection in cm) (VOLTS/CM switch setting)}}$$

3. To calculate the True Deflection Factor at any setting of the Channel 1 VOLTS/CM switch, multiply the VOLTS/CM switch setting by the Deflection Conversion Factor obtained in step 2:

$$\text{True Deflection Factor} = \text{(VOLTS/CM switch setting)} \times \text{(Deflection Conversion Factor)}$$

The True Deflection Factor obtained for any setting of the Channel 1 VOLTS/CM switch applies to Channel 1 Only, and only if the VARIABLE VOLTS/CM control is not moved from the position to which it was set in step 1.

For example, assume the amplitude of the reference signal applied to Channel 1 is 30 volts, the VOLTS/CM switch is set to 5 and the VARIABLE VOLTS/CM control is adjusted to decrease the amplitude of the display to exactly 4 cm. Then, substitute the preceding values in the Deflection Conversion Factor and True Deflection Factor formulas:

$$\text{Deflection Conversion Factor} = \frac{30}{(4)\ (5)} = 1.5$$

$$\text{True Deflection Factor} = (5)\ (1.5) = 7.5 \text{ volts/cm}$$

4. To determine the peak-to-peak amplitude of a signal to be compared, disconnect the reference signal and apply the signal to Channel 1.

5. Set the Channel 1 VOLTS/CM switch to a setting that will provide enough deflection so that a measurement can be made.

6. Measure the vertical distance in cm and determine the amplitude by using the following formula:

$$\text{Signal Amplitude} = \text{Deflection Conversion Factor} \times \text{Deflection in cm} \times \text{VOLTS/CM switch setting}$$

For example, assume the signal to be compared causes a vertical deflection of 4.5 cm at a VOLTS/CM switch setting of 10 and the VARIABLE VOLTS/CM control is not moved from the setting used in the previous example. Then, substitute these values and a Deflection Conversion Factor of 1.5 in the Signal Amplitude formula:

$$\text{Signal Amplitude (in volts)} = (1.5)\ (4.5)\ (10) = 67.5 \text{ volts}$$

Time-Difference Measurements

The calibrated sweep rate of the oscilloscope and the dual-trace feature of the Type 1A1 allows measurement of the time difference between events. Measure time difference as follows:

1. Set the INPUT SELECTOR switches to identical settings; either AC or DC depending on the type of coupling desired.

2. Set the PULL FOR INVERT switches to normal.

3. Place the MODE switch to either CHOP or ALT, as desired. In general, the CHOP position is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals.

4. Connect a coaxial cable between the Type 1A1 CH 1 TRIGGER OUT connector and the oscilloscope Trigger Input connector. See the NOTE following step 3 under Using Channel 1 as a 10× Preamplifier for Channel 2 in this section of the manual for an alternative method.

5. Set the VOLTS/CM switches so that the expected voltages applied to the input connectors will provide suitable vertical deflection on the CRT.

6. Apply the reference signal to Channel 1 and the signal to be compared to Channel 2. Use coaxial cables or probes having equal delay.

7. Set the oscilloscope Trigger Slope switch to externally trigger on the signal.

8. Set the oscilloscope time-base controls for a calibrated sweep rate which will allow accurate measurement of the distance between the two waveforms.

9. Measure the horizontal distance between the reference waveform and the Channel 2 waveform (see Fig. 3-3).

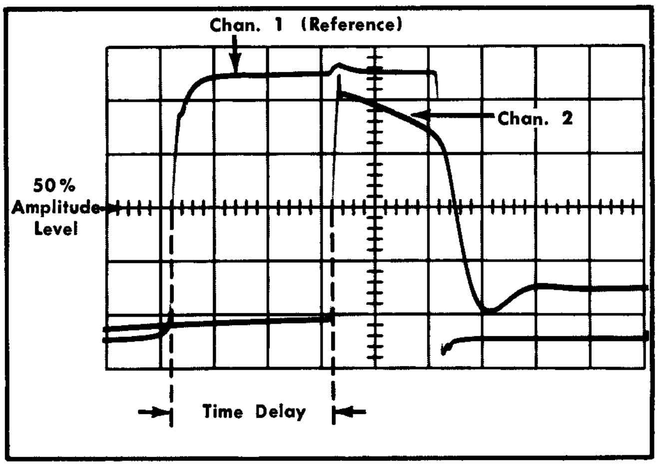


Fig. 3-3. Measuring time delay between pulse waveforms.

10. Multiply the distance measured for each channel by the setting of the oscilloscope Time/Cm switch to obtain the apparent time interval.

11. To obtain the actual time interval, divide the apparent time interval by the amount of sweep magnification, if sweep magnification is used, and by 1 if no sweep magnification is used. The formula is as follows:

$$\text{Time Delay} = \frac{(\text{Time/Cm switch setting})\ (\text{Distance in cm})}{\text{Sweep Magnification}}$$

For example, assume that the Time/Cm switch setting is 2 μs, the Magnifier is set for 5× magnification, and there is a horizontal distance of 3 cm (as shown in Fig. 3-3) between the leading edge of the reference waveform and the leading edge of the waveform displayed by Channel 2. Then, substitute these values in the preceding formula:

$$\text{Time Delay} = \frac{(2\ \mu s)\ (3\ cm)}{5} = 1.2\ \mu s$$

Phase Measurements

Phase comparison of two signals of the same frequency can be made using the dual-trace feature of the Type 1A1. To make the comparison, proceed as follows:

1. Follow the procedure outlined in the first seven steps under Time-Difference Measurements.

2. Set the oscilloscope sweep rate to obtain a display of less than 1 cycle of the waveform.

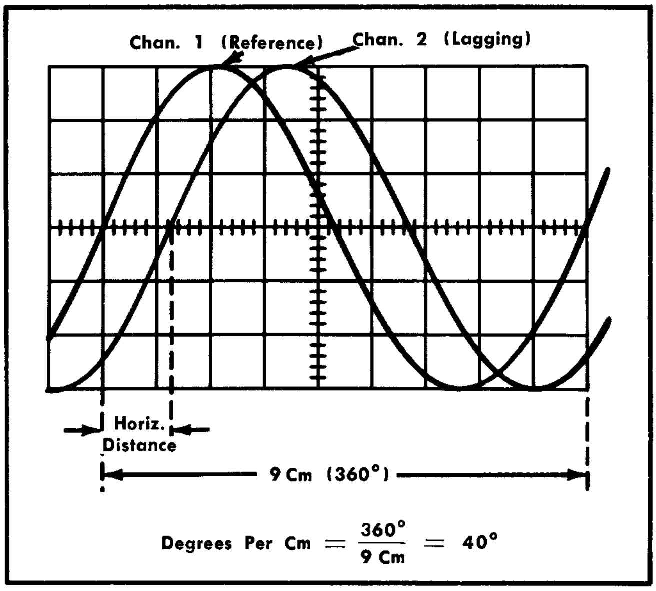


Fig. 3-4. Measuring phase shift between electrical waveforms.

3. Adjust the VARIABLE VOLTS/CM controls for each channel so the waveform amplitudes are equal and fill the graticule area vertically. Reset the VOLTS/CM switches, if necessary, to obtain equal-amplitude waveform displays. (Equal amplitudes are used to make comparisons easier.)

4. Use the POSITION controls to center the waveforms vertically; that is, an equal distance each side of the graticule centerline.

5. Turn the oscilloscope Variable Time/Cm control counterclockwise until 1 cycle of the reference signal occupies 9 cm horizontally. Use the Trigger Slope and Triggering Level controls to trigger on the reference waveform at any

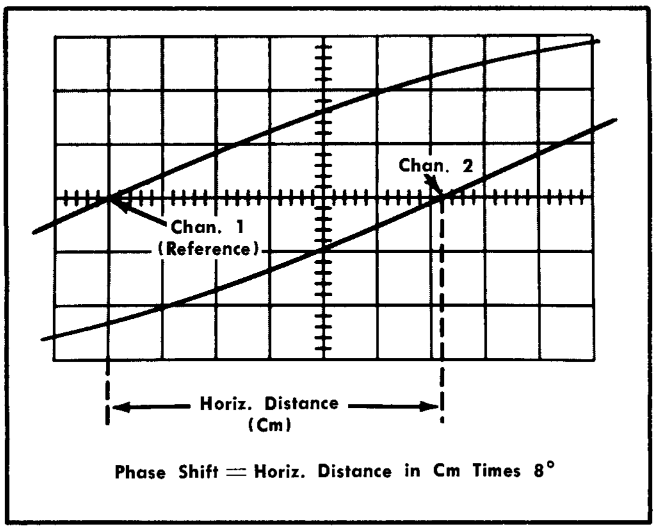


Fig. 3-5. Computing the phase shift when the oscilloscope sweep range is increased 5X.

point you desire. Each cm on the graticule now represents 40° of 1 cycle (see Fig. 3-4).

6. Measure the horizontal distance, in cm, between corresponding points on the waveforms. Note the distance and whether the Channel 2 waveform is leading or lagging (see Fig. 3-4).

7. Multiply the distance by 40°/cm to obtain the amount of phase difference.

For more precise measurements, increase the previous sweep rate, but do not change the setting of the oscilloscope Variable Time/Cm control. However, you must consider this increase in your calculations.

For example, if you increase the sweep rate by a factor of 5, and then measure the distance between waveforms, each cm will represent 8° (40° ÷ 5) of a cycle. Thus, phase difference up to 80° can be measured more accurately. When preparing to make the measurement, horizontally position the waveforms to points where the graticule markings aid in determining the exact distance. Fig. 3-5, for example, shows how the phase difference of the Channel 2 waveform can be computed using this method.

CIRCUIT DESCRIPTION
SECTION 4

Change information, if any, affecting this section can be found at the rear of the manual.

AMPLIFIERS

Introduction

The Type 1A1 Dual-Trace Plug-In Unit consists of two switched-amplifier channels and an output amplifier. Channel 1 is identical to Channel 2 except for additional stages which provide signal and trigger outputs for Channel 1. Therefore, only Channel 1 is described in the following description.

NOTE

Voltages and currents given in the circuit description are approximate. Throughout the circuit description discussion, refer to the block and circuit diagrams located in Section 10.

Input Coupling

The signal to be displayed is applied to Input Source Follower Q122 via INPUT SELECTOR switch SW101 and VOLTS/CM switch SW105. In the DC position of the INPUT SELECTOR switch, input coupling capacitor C102 is bypassed so the input is DC coupled. In the AC position, the signal must pass through C102, which blocks the DC component. Capacitor C102 limits the low-frequency response to less than 2 Hz at −3 dB. In the GND position, the signal path is open and the input circuit of the channel is grounded.

Input Attenuation

VOLTS/CM switch SW105 and SW129 is a 12-position two-section rotary switch. The first section (SW105), containing attenuator networks, is electrically connected in the gate circuit of Input Source Follower Q122; the second section (SW129), containing emitter resistors, controls the gain of Input Amplifier Q124/Q144. A special mechanical coupling between the two sections holds the first section (SW105) stationary while the second section (SW129) rotates through the first four positions (.005, .01, .02 and .05). Then, the mechanical coupling transfers the switch drive from the second section of the switch to the first section. As a result, the second section will remain stationary at the .05 position while the first section rotates through its positions.

In the first four positions of the VOLTS/CM switch, the signal is coupled straight through the first section of the switch without attenuation to the Input Source Follower Q122. When the signal arrives at Input Amplifier Q124/Q144, emitter resistors inserted by the second section of the switch set the gain of the stage and hence the amount that the signal is amplified.

In the remaining positions of the VOLTS/CM switch (.1 through 20) individual attenuator networks are switched into the gate circuit of Input Source Follower Q122 so the signal applied to the gate is always 0.05 volt for each centimeter of CRT deflection, providing the VARIABLE VOLTS/CM control is set to the CALIB position and the gain of the Type 1A1 and associated oscilloscope is set properly.

The attenuator networks are frequency compensated RC voltage dividers. Their attenuation factor can generally be expressed as follows:

$$\text{Attenuation Factor} = \frac{\text{total divider resistance (including R116)}}{\text{Ground-leg resistances (including R116)}}$$

Using the ×2 attenuator as a specific example (see Fig. 4-1), the formula is:

$$\text{Attenuation Factor} = \frac{(R105C)\,(R116) + (R105C)\,(R105E) + (R105E)\,(R116)}{(R105E)\,(116)} = 2$$

At low frequencies the dividers are resistive because the impedance of the capacitors is high and their effect in the circuit is negligible. As the frequency of the input signal increases, however, the impedance of the capacitors decreases and their effect in the circuit becomes more pronounced.

For high-frequency signals, the impedance of the capacitors is low in comparison to the resistance of the circuit and the attenuators become capacitive voltage dividers. For these frequencies, the attenuation factor is similar to the resistance case, except that the capacitive reactances are the dominant factors involved. A variable capacitor in each attenuator, such as C105C in the ×2 attenuator (see Fig. 4-1), provides a method for adjusting the capacitive reactance ratios equal to the resistance ratios.

The variable capacitor at the input to each attenuator (see Fig. 4-1), provides a means for adjusting the input RC of the attenuator to an arbitrary standard value of 15 pF x 1 MΩ when using a 15 pF input time constant normalizer as a reference. Similarly, C104 provides a method for normalizing the input time constant when the VOLTS/CM switch is set to any of the input straight-thru positions. In addition to providing the same input capacitance, the resistance values of the attenuators are chosen to provide an input resistance of 1 MΩ for each setting of the VOLTS/CM switch. Thus, an attenuator probe, when connected to the input connector of the Type 1A1, will work into the same time constant to eliminate the need for readjusting the probe capacitance compensation for different VOLTS/CM switch settings.

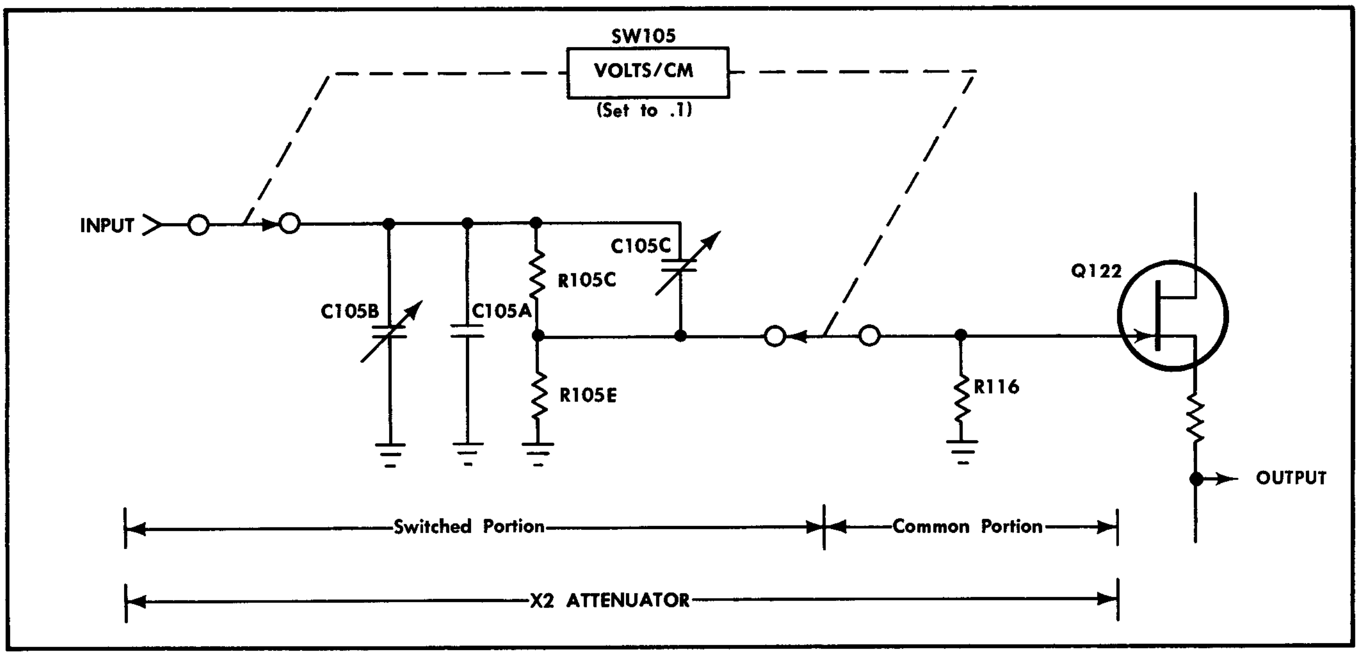


Fig. 4-1. Simplified circuit diagram showing the most important components involved when calculating the ×2 attenuation factor.

Input Source Follower (Q122)

Q122 is a field-effect transistor (FET) that presents a high-impedance, low-capacitance load to the input circuit and isolates the input from the remaining stages. Resistor R116 is the input resistor for the VOLTS/CM positions from .005 to .05, and then is part of the input attenuation network in all positions of the VOLTS/CM switch above .05.

A network consisting of C119, R119, D118, D119 and R118 form a protection circuit in Q122 gate circuit. The resistive component R119 limits the steady-state current if a negative- or positive-going overload signal is inadvertently applied to the Channel 1 INPUT connector. At normal signal amplitudes R119 will deteriorate the high-frequency AC response. To offset this effect, C119 is added to pass the high frequency information around R119.

If a negative-going overload signal is applied to the Channel 1 INPUT connector, D119 will conduct and limit the voltage to —20.6 V at the gate element of Q122. Zener diode D118 sets the voltage of D119 at —20 V. If a positive-going overload signal is applied, D122 conducts and clamps the base of Q123 at +5.6 V.

Zener diode D121, connected between ground and the drain elements of Q122 and Q142, clamps the drain elements at +10 V for all operating conditions.

A capacitive-coupled bootstrap circuit is connected between the source and the capacitive elements connected to the gate of Q122 to reduce the effective capacitance of the input circuit. By reducing the input capacitance, sufficient adjustment range is provided for the variable input capacitors in the attenuators and the ×1 input circuit, such as C104 for example. The input capacitance is effectively reduced two ways: (1) By encircling Q122 gate terminal with an etched wire and connecting this etched wire to the source element; (2) by connecting D119 diode case lead to Q122 source element instead of ground. (Capacitance exists between the diode case and the diode chip inside the case).

The capacitance that exists between the base of the mounting posts for C119 and R119 and the etched wire that encircles these posts improves the response of the circuit when a fast rising square wave is applied to the Channel 1 INPUT connector.

DC Balance Source Follower (Q142)

The DC Balance Source Follower (Q142), the Input Source Follower (Q122), and the Emitter Follower (Q123/Q143) stages constitutes a complete symmetrical circuit for the purpose of balancing out objectionable low-voltage power-supply fluctuations. Voltage variations common to the signal circuit and the DC balance drive circuit arrive in phase at the bases of the Input Amplifier stage (Q124/Q144) and therefore cancel.

In the gate circuit of Q142, the .005 V/CM VAR ATTEN BAL control (R130) is a dual concentric potentiometer with both sections driven by the same front-panel shaft. This control has built-in backlash coupling between its two sections. Thus, the control serves as a combined coarse-fine adjustment to permit setting the DC balance drive accurately and yet provide a wide range of coarse adjustment.

C138 bypasses any fast voltage fluctuations to ground. C140 bypasses the chopped mode switching transients that are induced in the ground-current loop when chopped mode of operation is used.

First Emitter Follower (Q123/Q143)

In addition to providing a means for balancing out power-supply fluctuations, as described previously, the First Emitter

Follower stage (Q123/Q143) provides a low-impedance drive to the Input Amplifier stage (Q124/Q144). The signal at the source element of Q122 is DC coupled to the base of Q124.

A plastic cover is placed over Q123 and Q143 to minimize the differential variations of ambient temperature between the transistors.

Input Amplifier (Q124/Q144)

This stage is an emitter-coupled paraphase amplifier. It converts the single-ended input signal applied to the base of Q124 to differential current signals at the collectors. Both emitters are long tailed (through R127, R147, R148 and R149) to the —150-volt supply for greater stability with respect to transistor parameters.

As mentioned previously, the second section of the VOLTS/CM switch controls the deflection factor for the first four steps by changing the emitter resistance of this stage, thus controlling the gain of the stage. At the .005 VOLTS/CM POSITION, gain ratio is 10 to 1; at the .05 position, gain ratio is 1 to 1. For the .005 position, the .005 V/CM GAIN adjustment (R128A) is adjusted so the 10-to-1 gain ratio is accurate. Precision resistors set the gain ratio accurately for the three remaining steps.

To balance the emitters of Q124 and Q144 under no-signal conditions, the VOLTS/CM switch is set to the .005 position and the .005 V/CM VAR ATTEN BAL control (R130) is adjusted for no trace shift while the VARIABLE VOLTS/CM control is rotated back and forth. After noting the position of the trace, the VOLTS/CM switch is set to .05 and .05 V/CM DC BAL control (R148) is adjusted to position the trace to the previously noted position. When the stage is correctly balanced, the emitters will be at the same voltage and there will be no current between emitter resistors regardless of the VOLTS/CM switch positions.

The value of the collector resistors R126 and R146 is chosen to provide proper base-emitter junction temperature compensation for their respective transistors. C125, C152 and C156 provide a means for adjusting the high-frequency response to compensate for losses introduced by temperature compensation resistor networks and to balance the output of the two channels.

Resistors R124, R125, R144 and R145 develop the signal for application to the following stage.

The second Emitter Follower stage (Q153A/Q153B) couples the push-pull signal from the Input Amplifier to the Output Amplifier first stage. In addition, the second Emitter Follower stage provides the necessary low-impedance drive for the circuit card connectors, the PULL FOR INVERT switch (SW405), and the interconnecting leads.

When the PULL FOR INVERT switch is set to the normal (in) position, the signal at the emitter of Q153A is coupled via the switch contacts to the base of Q414 (Output Amplifier) and the signal at the emitter of Q153B is coupled via the switch contacts to the base of Q404 (Output Amplifier). Thus, the display will have the same polarity as the input signal applied to the Channel 1 connector. If the input signal is positive-going at the Channel 1 connector, for example, the display waveform will also be positive going. However, when the switch is set to the invert position, the display will be inverted because the switch reverses the signal leads to the bases of the following stage. Thus, a positive-going signal will be displayed as a negative-going waveform.

The INV BAL control (R152) in the base circuit of Q153A DC balances the outputs of the second Emitter Follower stage so there is no trace shift when the PULL FOR INVERT switch is changed from normal to invert under no-signal conditions.

Output Amplifier First Stage (Q404/Q414)

This stage is an emitter-coupled push-pull amplifier providing a total gain of about 2. Collector current for the stage is supplied through the diode switches (see Fig. 4-2).

There are two gain controls located in the common-emitter circuit of Q404 and Q414—VARIABLE VOLTS/CM control (R408) and GAIN control (R409). Both controls vary the emitter degeneration and, thus, affect the gain of the stage. With the VOLTS/CM switch in the .05 position and the VARIABLE VOLTS/CM control set to CALIB, the GAIN control is adjusted so the CRT deflection agrees with the setting of the VOLTS/CM switch. The VARIABLE VOLTS/CM control has a gain attenuation ratio of 2.5 to 1. However, this ratio is actually greater than 2.5 to 1 due to SW409. As the VARIABLE VOLTS/CM control is rotated a few degrees from the CALIB position, SW409 closes and shorts out R409. Gain increases, thus providing overlapping coverage between the calibrated VOLTS/CM switch positions.

The POSITION control (R422), connected between the differential inputs to the diode switches, provides differential currents that act as positioning signals superimposed on the output signal currents of Q404 and Q414. When the POSITION control is set to its electrical center, no current flows in either leg. When the POSITION control is moved to either end from center, a change of about 0.6 volt per side occurs at pins 1 and 3 of the interconnecting plug to the oscilloscope. This voltage range corresponds to about 12 cm positioning range at the CRT.

Diode Switches

The push-pull signal from the Output Amplifier first stage is applied to diode switches D421, D422, D423 and D424. These diodes act like a double-pole double-throw switch. Each pair, D421 and D422 or D423 and D424, is on while the other pair is off. Switching of the diodes to connect or disconnect a channel is controlled by the MODE switch via the Switching Multivibrator in the Channel Switching Circuit.

Assume Channel 1 is turned on (MODE switch is set to CH 1) and the POSITION control is centered. The state of the Switching Multivibrator (Q305 and Q315) is such that +7.7 volts from its conducting transistor Q305 is applied to cathode junctions of Channel 1 shunt diodes D422 and D423 (see Fig. 4-2). The lowest voltage seen by the cathodes of the diodes switches is +4.6 volts at the cathodes of Channel 1 series diodes D421 and D424. The series diodes conduct and the drop across these diodes sets their anodes at +5.6 volts. The +5.6 volts reverse biases the shunt diodes. With the series diodes conducting, the Channel

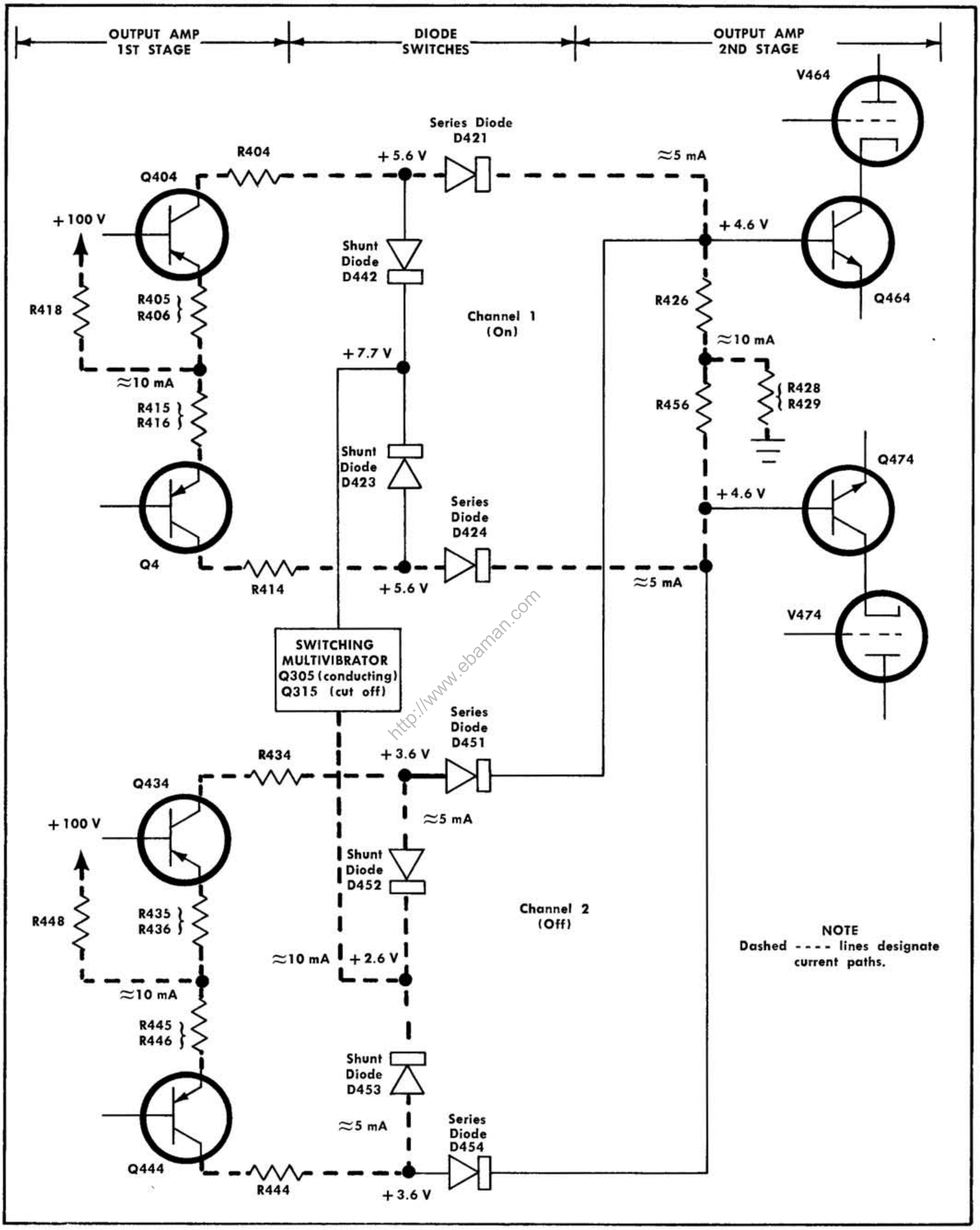


Fig. 4-2. Simplified circuit diagram showing the main DC current paths when Channel 1 is on and Channel 2 is off.

1 signal passes through these diodes to the Output Amplifier second stage.

Meanwhile, +2.6 volts is applied from the Switching Multivibrator's cutoff transistor Q315 to the cathode junctions of the Channel 2 shunt diodes D452 and D453 (see Fig. 4-2). This is the lowest voltage seen by cathodes of the Channel 2 diode switches. As a result, Channel 2 shunt diodes conduct and the voltage drop across the shunt diodes sets their anode level at +3.6 volts. The +3.6 volts reverse biases Channel 2 series diodes and blocks the signal from going to the Output Amplifier second stage. With the shunt diodes conducting, the Channel 2 signal is shunted into the common-mode point located at the cathode junction of the shunt diodes.

In the CH 2 position of the MODE switch, the opposite condition exists—Channel 1 is off and Channel 2 is on because the Switching Multivibrator changes state. The Switching Multivibrator's cutoff transistor Q305 applies +2.6 volts to the cathode junction of Channel 1 shunt diodes. Under these conditions, Channel 1 shunt diodes conduct and reverse bias the series diodes. The reverse-biased series diodes disconnect the Channel 1 signal from the Output Amplifier second stage. Simultaneously, Channel 2 diodes conduct and reverse bias the shunt diodes. With Channel 2 series diodes conducting, the Channel 2 signal passes through the series diodes to the Output Amplifier second stage.

During dual-trace operation when the MODE switch is set to either ALT or CHOP position, the diode switches connect and disconnect their respective channels to the Output Amplifier second stage alternately at the same rate as the Switching Multivibrator rate. The cycle of operation for the diode switches is as previously described.

When the MODE switch is set to ADD, the Switching Multivibrator goes into a state in which both of its transistors are conducting simultaneously. The conducting transistors apply +7.7 volts to the cathode junctions of the shunt diodes in both channels. As a result, the shunt diodes reverse bias and series diodes conduct. The signals in both channels pass through their respective series diodes and algebraically add in the input circuit of the Output Amplifier second stage.

In the ADD mode of operation, R429 is shorted by the MODE switch, thus decreasing the effective resistance to ground in the base and diode switch circuits. With two channels on, the decreased resistance sets the cathode voltages of the series diodes in both channels and the bases of Q464 and Q474 to their proper levels. The voltage levels will then be the same as those of the turned-on channel in the other modes of operation. Proper voltage levels in this portion of the circuitry allow the Switching Multivibrator to operate at its correct design levels.

Output Amplifier Second Stage (Q464/V464/Q474/V474)

This stage is a push-pull, hybrid, cascode configuration. The hybrid circuit is used to raise the +4.6-volt input level at the bases of Q464 and Q474 to the +67.5-volt output level required for driving the oscilloscope vertical amplifier for linear operation.

Signals applied to the bases of transistors Q464 and Q474 cause current variations in the base-collector circuit of the transistors. Since the transistors are connected in series with the cathode circuit of V464 and V474 and the grids of the tubes are at AC ground, any current variations in the cathode circuit of the tubes produce corresponding in-phase current signals at the plate of the tubes. The signals at the plates are then applied through pins 1 and 3 of the interconnecting plug to the oscilloscope vertical amplifier.

Voltage signals applied to the bases of Q464 and Q474 are inverted 180° at the collectors. No phase inversion occurs as the signals go through V464 and V474. With the PULL FOR INVERT switch set to normal, a positive-going signal applied to the input connector of a channel will be positive going at pin 1 of the interconnecting plug to the oscilloscope and negative going at pin 3 of the same plug (see Block Diagram, Section 10 for signal polarity comparisons).

Variable peaking inductors L460 and L470 in the base circuit of Q464 and Q474 provide interstage high-frequency compensation adjustments for the high frequencies. Variable capacitors C466 and C476 are emitter compensation adjustments for the high frequencies.

Resistors R464 and R474 aid in matching the output impedance of the Type 1A1 to the input impedance of the oscilloscope vertical amplifier.

Channel 1 Signal Pickoff Emitter Follower (Q163/Q173)

The Channel 1 signal is taken off in a push-pull fashion from the emitters of the second Emitter Follower stage (Q153A/Q153B). This is the signal which is applied to the Channel 1 Signal Pickoff Emitter Follower stage (Q163/Q173) and then to the following stages for use as Channel 1 Signal and Trigger outputs from the Type 1A1.

The reasons for taking the signal off at the emitters of Q153A and Q153B are as follows:

1. The emitters are low-impedance points where the signal can be extracted with least effect on the bandwidth or transient response of the Type 1A1.

2. The takeoff points are isolated from the diode switches.

3. A gain of 10 is obtained through the Input Amplifier stage when the VOLTS/CM switch is set to the .005 position.

4. The push-pull takeoff signal is not affected by use of the PULL FOR INVERT switch, POSITION control, VARIABLE VOLTS/CM control, GAIN control or MODE switch.

5. By using push-pull takeoff, common-mode signals such as noise, hum and DC drift are cancelled in the common collector circuit of Q163 and Q173, and in the common emitter circuit of Q164 and Q174.

Channel 1 Signal Pickoff Amplifier (Q164/Q174)

Q164 and Q174 with its associated circuitry is a push-pull amplifier for the Channel 1 signal arriving from the emitter of Q163 and Q173. Voltage gain for the stage is about 2 for Q164 and about 6 for Q174. In the collector circuit of Q164 the signal at the junction of R164 and R165 is applied to the CH 1 SIGNAL OUT connector. The polarity of the signal at the connector is the same as that of the signal applied to the Channel 1 INPUT connector.

Output DC level of the signal at the CH 1 SIGNAL OUT connector is about +0.45 volt.

Channel 1 Trigger Output Amplifier (Q184/Q194)

The Channel 1 takeoff signal which is used as a trigger output source, is obtained from the junction of divider resistors R174 and R175 in the collector circuit of Q174. This trigger takeoff signal is applied to the bases of Q184 and Q194.

Transistors Q184 and Q194 with associated circuitry form a complementary amplifier having a signal-voltage gain of about 3.3. The outputs from these two transistors are combined to produce a single-ended signal. This signal, which is used as a trigger source, is applied to the CH 1 TRIGGER OUT connector and to pin 5 of the interconnecting plug to the oscilloscope.

The trigger at pin 5 is available for use as an internal trigger source. However, to make use of this trigger, the associated oscilloscope must be capable of selecting it with a Triggering Source switch. If the Channel 1 trigger cannot be selected internally, external triggering must be used instead. The Channel 1 trigger has the same polarity as the signal applied to the Channel 1 INPUT connector. Output DC level is approximately zero volts.

SWITCHING CIRCUIT

Selection of the input channel whose output is to be applied to the Output Amplifier is accomplished by the Switching Circuit. The Switching Circuit consists of the following stages in order: Switching Multivibrator Q305/Q315, Alternate Trigger (Blocking Oscillator) Q330, and the Blanking Multivibrator Q343/Q353.

Switching Multivibrator (Q305/Q315)

The Switching Multivibrator stage (Q305/Q315) is basically a bistable circuit that switches Channels 1 and 2 in the Type 1A1. When Q305 conducts, Channel 1 signal or trace is displayed. When Q315 conducts, Channel 2 signal or trace is displayed. The setting of the MODE switch determines whether the Switching Multivibrator rests in one of its stable states (CH 1 or CH 2), is astable (CHOP), is bistable (ALT—base triggered by the alternate trigger pulse), or is dual-conducting (ADD).

(1) CH 1, CH 2

Assume that the MODE switch is set to CH 1. In this position, base-biasing network R302, R303 and R304 in the base circuit of Q305 is grounded at the switch end of R302. A similar network in the base circuit of Q315 is connected to +39 volts at the switch end of R312. The MODE switch disconnects emitter resistors R301 and R311 from the +39-volt supply. As a result, both emitters are now returned to +39 volts through D301, D311 and R300. Under these conditions, the Q315 base-biasing network cuts off Q315 and the base biasing network for Q305 turns on Q305. Diode D303 is conducting while D313 is reverse biased. These diodes control the base impedance of their respective transistors so that proper currents are provided for the operation of transistors in each of their states.

With Q305 conducting, its collector rests at +7.7 volts; the collector voltage of Q315 during cutoff is +2.6 volts. As described earlier, the +7.7 volts reverse biases the Channel 1 shunt switching diodes D422 and D423. Channel 1 series diodes D421 and D424 are forward biased and they connect Channel 1 Input Amplifier to the Output Amplifier. Simultaneously, the +2.6 volts at the collector of Q315 causes Channel 2 shunt diodes D452 and D453 to become forward biased and series diodes D451 and D454 to become reverse biased. Thus, Channel 2 Input Amplifier is disconnected from the Output Amplifier.

If the MODE switch is set to the CH 2 position, just the opposite occurs. The MODE switch connections cause Q305 to cut off and Q315 to conduct. Diode D303 becomes reverse biased and D313 forward biases. Then, the +2.6 volts at the collector of Q305 causes the Channel 1 diode switches to disconnect Channel 1 from the Output Amplifier. At the same time, the +7.7 volts at the collector of Q315 causes Channel 2 diode switches to connect Channel 2 to the Output Amplifier.

(2) Alternate Mode of Operation

When the MODE switch is set to the ALT position, the Switching Multivibrator becomes a bistable circuit. Initially, the circuit is resting in one of its stable states. When triggered by a positive-going pulse applied to the junction of diodes D308 and D318, the circuit switches to its other stable state, and remains there until triggered again.

With the MODE switch set to ALT, the switch ends of R302 and R312 in both base-biasing networks are connected to +39 volts. The emitters are tied to a common point through D301 and D311 at R300. Using this method of biasing, the Switching Multivibrator is converted into a bistable circuit. With initial application of DC power, one of the transistors begins to conduct first while the other is cut off. Regenerative action causes the conducting transistor to saturate, holding the other transistor in cutoff. Thus, the circuit initially rests in one of its stable states.

At the end of each sweep a positive-going trigger is generated by the time-base circuit in the oscilloscope. This alternate trace sync pulse is applied via the oscilloscope Sync Amplifier tube cathode circuit to pin 8 of the interconnecting plug. The sync pulse goes through pin 8 of the plug and then through a single-pin connector on the Output Amplifier board connector to the Alternate Trigger Blocking Oscillator stage (Q330). A positive-going trigger of suitable waveshape and amplitude is generated in the output winding of T330. The trigger is then applied to the junction of diodes D308 and D318. The trigger forward biases both diodes and goes through the diodes to the bases of both transistors in the Switching Multivibrator stage. The trigger affects only the conducting transistor in the stage.

Assume for this discussion that Q305 is conducting and Q315 is cut off. Since Q305 is conducting, it is affected by the trigger. The trigger causes Q305 collector current to decrease, which decreases collector voltage. The decreasing voltage is applied via C306 to the base of Q315, causing it to conduct. Q315 collector current increases, causing more positive voltage to be applied via C316 to the base of Q305. This regenerative feedback continues until Q315 is driven into saturation and Q305 is cut off.

Since the Switching Multivibrator controls the diode switches, Channel 1 is turned off as Q305 cuts off and Channel 2 is turned on as Q315 is driven into saturation, thus completing one-half cycle of the Switching Multivibrator action. For the other half cycle, the next trigger applied through diodes D308 and D318 will cause Q315 to decrease its collector current and the regenerative feedback action finally causes Q305 to saturate and Q315 to cut off. As a result, Channel 2 is turned off and Channel 1 is turned on.

By rapidly coupling the changing voltages to the bases of the transistors in the Switching Multivibrator, capacitors C306 and C316 speed up the regenerative feedback action and ensure rapid switching of the transistors.

In the alternate mode of operation, diodes D301 and D311 are forward biased, effectively shorting out C301 and C311. Thus, no pulses from the Switching Multivibrator are coupled through these capacitors to drive the Blanking Multivibrator stage. Since the channels switch states during the retrace interval and the trace is already blanked out by the oscilloscope circuitry, no blanking pulses from the Type 1A1 are needed.

In an oscilloscope which has an alternate sweep feature, the two time bases in the oscilloscope can be displayed alternately on the CRT by setting the oscilloscope Horizontal Display switch to the Alternate (A and B) position. In this position of the switch the A and B sweep generators are alternately generating sweeps. During the time that the B Sweep Generator is generating its sweep, this same generator also produces a negative-going (+45 volts to ground) slave pulse. The pulse is applied to pin 7 of the interconnecting plug between the oscilloscope and the Type 1A1. From pin 7 of the interconnecting plug the pulse is applied through pin X of the Output Amplifier card to the junction of R313 and D313 via C313.

The negative-going slave pulse, applied to the junction of R313 and D313, ensures that Q315 is triggered into conduction so that Channel 2 turns on while the B Sweep Generator is generating its sweep. While Channel 2 is on, Channel 1 is off because Q305 is cut off. At the end of the B sweep, the slave signal terminates and the alternate trace sync pulse from the B Sweep Generator triggers the Alternate Trigger Blocking Oscillator. The trigger from the Alternate Trigger Blocking Oscillator drives Q315 toward cutoff, turning Channel 2 off and Channel 1 on. During the time that Channel 1 is on, A Sweep Generator is generating its sweep so the signal in Channel 1 can be displayed. Channel 2, meanwhile, is turned off as long as Q315 is cut off.

(3) Chopped Mode of Operation

When the MODE switch is set to the CHOP position, the Switching Multivibrator becomes an astable circuit. It free runs at approximately a 1 MHz rate, driving the diode switches at the same rate. The diode switches alternately turn the channels off and on. Thus, each channel is on for about 0.5 μs while the other is off the same amount of time.

With the MODE switch set to the CHOP position, the base-biasing networks are connected to +39 volts, the same as for alternate mode of operation. The junction of emitter resistors R301 and R311 is now connected via the MODE switch to +39 volts. In addition, the switch end of R300 is grounded to reverse bias D301 and D311. The reverse-biased diodes remove the low-impedance path from across coupling capacitors C301 and C311. These capacitors AC couple the emitters together to make the Switching Multivibrator free run at a rate determined by the resistance and capacitance values used in the emitter circuits.

Each time the Switching Multivibrator switches states, a fast negative-going pulse followed by a slow-rise positive-going ramp is produced at the junction of C301 and C311. The ramp rises in amplitude until the Switching Multivibrator switches states, then the cycle is repeated. This ramp-type pulse at the junction of the capacitors is the algebraic addition of the timing voltage signals developed at the emitters of the transistors. The ramp pulse is applied to the base of Q343 in the Blanking Multivibrator stage.

(4) Added Mode Of Operation

Setting the MODE switch to the ADD position grounds the switch end of R302 and R312 of the base-biasing networks. The MODE switch disconnects the switch end of emitter resistors R301 and R311 from +39 volts. Instead, the emitter of the transistors are now tied through forward-biased diodes D301 and D311 to R300. The switch end of R300 is connected to +39 volts via the MODE switch to apply forward-bias voltage to the diodes. The bases of both transistors are lowered toward ground since the switch ends of R302 and R312 are tied to ground. As a result, both transistors go into conduction simultaneously. With both transistors conducting, both channels are turned on via their respective diode switches.

In order to make the diode switches operate properly in the ADD position, the collectors of Q305 and Q315 must be raised to about the same level as the collector level of the single conducting transistor in the other modes of operation. To raise the collector level, the switch end of R321 is disconnected from ground so it can be connected in series with R322. Resistor R322 raises the voltage level at the collectors to the normal +7.7-volt level.

Alternate Trigger Blocking Oscillator (Q330)

The main function of the Alternate Trigger Blocking Oscillator stage (Q330) is to provide a fast positive-going trigger of definite shape and energy content for triggering the Switching Multivibrator in alternate mode of operation. Reshaping the trigger assures that the Type 1A1 will function properly with any oscilloscope capable of accepting the unit.

When the MODE switch is set to the ALT position, the MODE switch connects +225 volts via R355 and pin 16 of the interconnecting plug to the plate of the Sync Amplifier tube in the oscilloscope circuitry. The Sync Amplifier stage operates as a cathode follower when the Type 1A1 is used with the oscilloscope, because the base winding of T330 is connected in the cathode circuit of the tube. The connection is made via a single-pin connector on the Output Amplifier card connector and pin 8 of the interconnecting plug.

In its quiescent state, Q330 is not conducting. At the end of each sweep cycle a positive-going pulse is generated in the base winding of T330, causing Q330 to conduct. The collector winding of T330 supplies regenerative feedback to the base winding to drive Q330 into saturation, and collector current ceases to increase.

Since the collector current becomes constant, no feedback voltage is induced, Q330 is reverse biased, and the collapsing field produces a slight backswing voltage. During the time that the Alternate Trigger Blocking Oscillator is going through its cycle, the approximate voltage induced in the output tertiary winding is about a 2-volt positive-going pulse which is applied to the Switching Multivibrator stage. This is the trigger which flips the Switching Multivibrator. The Switching Multivibrator in turn, switches the channels via the diode switches.

Diode D330 is in Output Amplifier cards Model 4-up to clip the slight backswing voltage caused by the collapsing field of T330. This prevents double triggering of the Switching Multivibrator.

The dots above the individual T330 windings, as shown on the schematic diagram, are phasing dots. They show that there is no phase reversal if pulse polarities are compared between the dot end of the windings. However, there is a phase reversal if the signal at the dot end of one winding is compared with the signal at the no-dot end of the other windings. The signals can be compared between the ends of the windings that are not at AC or DC ground.

When the MODE switch is set to any position other than ALT, the +225 volts is disconnected from the switch end of R355. The result is that the Sync Amplifier stage in the oscilloscope no longer functions as a cathode follower to drive the Alternate Trigger Blocking Oscillator stage. Since the Alternate Trigger Blocking Oscillator stage is not being driven, the stage is inoperative during these modes of operation.

Blanking Multivibrator (Q343/Q353)

The Blanking Multivibrator stage Q343/Q353 is a monostable, common-emitter, collector-to-base clamp multivibrator. When triggered during chopped mode of operation, this stage produces a blanking pulse of sufficient amplitude and duration to blank the beam during the switching interval. Timing of the switching and blanking multivibrators in the Switching Circuit of the Type 1A1 allows for the delay in the vertical amplifier of the oscilloscope. That is, the blanking pulse arrives at the CRT cathode at the same time that the switching-transient portion of the composite signal arrives at the vertical deflection plates. Correct timing and waveshape assures that the beam is blanked out during the switching time between channels. However, due to the nature of the circuitry, some intensification of the unblanked trace does occur during the sweep.

Setting the MODE switch to the CHOP position causes the Switching Multivibrator to free run, as stated earlier. The ramp pulses at the junction of C301 and C311 are applied through R341 to the base of Q343 in the Blanking Multivibrator stage.

In its quiescent state Q343 is cut off and Q353 is conducting. C343 is charged to about +12.5 volts at the base of Q353; clamp diode D345 is forward biased by about 0.2 volt. The instant that the Switching Multivibrator switches states, the ramp pulse terminates as it drops rapidly from its peak amplitude. The terminating ramp causes the voltage at the base of Q343 to drop from +12.7 volts to about +11 volts. This sudden drop in voltage drives Q343 into conduction. The rise in voltage at the collector of Q343 is coupled to the base of Q353. D345 unclamps and Q353 goes toward cutoff. With D345 unclamped, C343 discharges at a constant rate through R345 toward the −150-volt supply. Finally, a point is reached where Q353 is cut off. At about this time D345 conducts and clamps the base of Q353 at +12.5 volts, thus completing the first half of the cycle. For the last half of the cycle the ramp at the base of Q343 causes Q343 to go from saturation to cutoff as Q353 goes into conduction. Near the end of the cycle, the ramp pulse drives Q343 into cutoff. Then, the ramp pulse terminates and begins its slow rise to repeat the cycle.

Negative-going blanking pulses, about 6 volts or more in amplitude, are produced at the collector of Q353. The pulse reaches its peak about 0.25 μs after the Switching Multivibrator has triggered the Blanking Multivibrator. The 0.25-μs delay equals the delay of the applied signal as it goes through the vertical amplifier and delay line of the oscilloscope. Thus, the switching portion of the signal and the blanking pulse arrive at the same time at the CRT.

To get the pulse to the CRT, the pulse at the collector of Q353 is coupled through C353 and then through a single-pin connector on the Output Amplifier card to pin 16 of the interconnecting plug. From pin 16 the blanking pulse goes to the plate circuit of the Sync Amplifier tube in the oscilloscope. This tube is inoperative as a Sync Amplifier (or a cathode follower) during this mode of operation. The components in the plate circuit of the tube combined with R355 in the Type 1A1 Blanking Multivibrator stage form an RC coupling network to couple the pulse to the grid of the Blanking Amplifier, the pulse is applied through the CRT Cathode Selector switch to the cathode of the CRT to blank the beam during the time that the channels switch.

Diode D353 is in Output Amplifier cards Model 7-up to protect Q353 from being damaged by the large transients which occur at some positions of the MODE switch.

If the MODE switch is set to the ALT position, no pulses from the Switching Multivibrator stage are coupled through C302 and C311 to the Blanking Multivibrator. Conduction of diodes D301 and D311 effectively shorts out the coupling capacitors, thus, preventing the pulses from triggering the Blanking Multivibrator. Shorting out the coupling capacitors is an indirect result obtained when the Switching Multivibrator functions as a bistable circuit in the alternate mode. On the other hand, no blanking pulses need be generated in this mode because switching from channel to channel occurs during the retrace interval when the trace is already blanked.

In alternate mode of operation as well as all other modes except chopped, the Blanking Multivibrator remains in its quiescent state since no blanking pulses are needed or applied.

HEATER CIRCUIT

The heaters in the Type 1A1 are supplied with direct current from the +100-volt regulated supply in the oscilloscope. This DC source prevents the possibility of 60-hertz cathode modulation, which might result if the heaters were supplied with alternating current.

Power for the heater circuit (+75 V at about 150 mA) is obtained from pin 15 of the interconnecting plug to the oscilloscope. The +75 volts is obtained from the +100-volt regulated supply by dropping 25 volts either across two tubes or a resistor in the oscilloscope, depending on whether the oscilloscope has two time bases or one.

The nuvistors in the Type 1A1 draw about 135 mA which leaves about 15 mA to be shunted through R494. In the heater-string branch circuit, the total drop of the heaters, including R491 and R492, connected in series is about 36 volts. This 36-volt drop leaves about 39 volts which is applied to the Channel 1 and 2 emitter Follower stages, and the switching circuit. Resistors R493 and R499 aid in keeping the current constant in the heater-string branch circuit for the various modes of operation. The +39 volts is also divided up to provide +11 volts at the junction of R495 and R496 to power Channel 1 and 2 Input Amplifiers. In addition, it is used for setting the grid potential of V464 and V474 in the Output Amplifers second stage. At the junction of R496 and R497 the + 5 volts available at this point is applied to the cathodes of protection diodes D122 and D222 in the base circuits of Q123 and Q223.

SECTION 5
MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

This section contains maintenance instructions for the Type 1A1. The main topics are preventive maintenance, corrective maintenance and troubleshooting information.

PREVENTIVE MAINTENANCE

General

Preventive maintenance consists of cleaning, visual inspection, lubrication and, if needed, recalibration. Preventive maintenance is generally more economical than corrective maintenance, since preventive maintenance can usually be done during idle periods at a time convenient to the user. The preventive maintence schedule established for the instrument should be based on the amount of use and the environment in which the instrument is used.

Cleaning

The Type 1A1 should be cleaned as often as operating conditions require. The oscilloscope side panels and air filter provide some protection against dust accumulating in the interior of the unit, but a small amount if dust is still brought in by the circulating air. Dust on the circuit components can cause component overheating. Clean the unit by loosening the accumulated dust with a dry soft paint brush. Remove the loosened dust by vacuum and/or dry, low-pressure compressed air (high-velocity air can damage some components). Hardened dirt and grease may be removed with a cotton-tipped swab or a soft cloth dampened with water and mild detergent solution (such as Kelite or Spray White). Abrasive cleaners should not be used.

CAUTION

Do not permit water to get inside controls or shaft bushings. Store the unit in a dust-tight covering when not in use.

To clean the contacts on the Amplifier cards, use a cotton tipped swab dipped in a solvent such as socal or fotocol. Do not use any solvent that might leave a residue. An ordinary pencil eraser, if used very lightly, is also useful for cleaning the contacts. Do not use an ink eraser or abrasive-type cleaners because of the possibility of removing the gold plating. If the copper coating under the gold plating is exposed, corrosion may result.

Lubrication

The life of rotary switches is lengthened if they are properly lubricated. Use a cleaning type lubricant (such as Cramoline) on shaft bushings, plug-in connector contacts, and switch contacts. Lubricate the switch detents with a heavier grease (Beacon grease No. 325 or equivalent). The necessary materials and instructions for proper lubrication of Tektronix instruments are contained in a component lubrication kit which may be ordered from Tektronix. Order Tektronix Part No. 003-0342-00.

Visual Inspection

After cleaning, the unit should be carefully inspected for such defects as poor connections, damaged parts, improperly seated tubes or transistors, The remedy for most visible defects is obvious; however, if heat-damaged parts are discovered, determine the case of overheating before the damaged parts are replaced. Otherwise, the damage may be repeated.

Tube and Transistor Checks

Periodic preventive maintenance checks consisting only of removing the tubes and transitors from the unit and testing them in a tester are not recommended. The circuits within the unit provide the only satisfactory means of checking tube and transistor performance. Defective tubes or transistors will usually be detected during recalibration of the unit. If the transistors are removed from their sockets, they should be returned to the same sockets. The transistor pairs in the plastic thermal covers should be oriented as originally found. The tab on the FET's should face the same direction as originally found (see Fig. 5-1). Details of in-circuit tube and transistor checks are given in the troubleshooting procedures later in this section.

Recalibration

To ensure accurate measurements, the calibration of the Type 1A1 should be checked after each 500 hours of operation or every six months if the unit is used intermittently. The performance check or calibration procedure is helpful in isolating major troubles in the unit. Moreover, minor troubles not apparent during regular operation are frequently revealed and can be corrected during recalibration. Complete performance check and calibration instructions are contained in Section 6 and 7 respectively.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and plug-in unit repairs. Special techniques or procedures

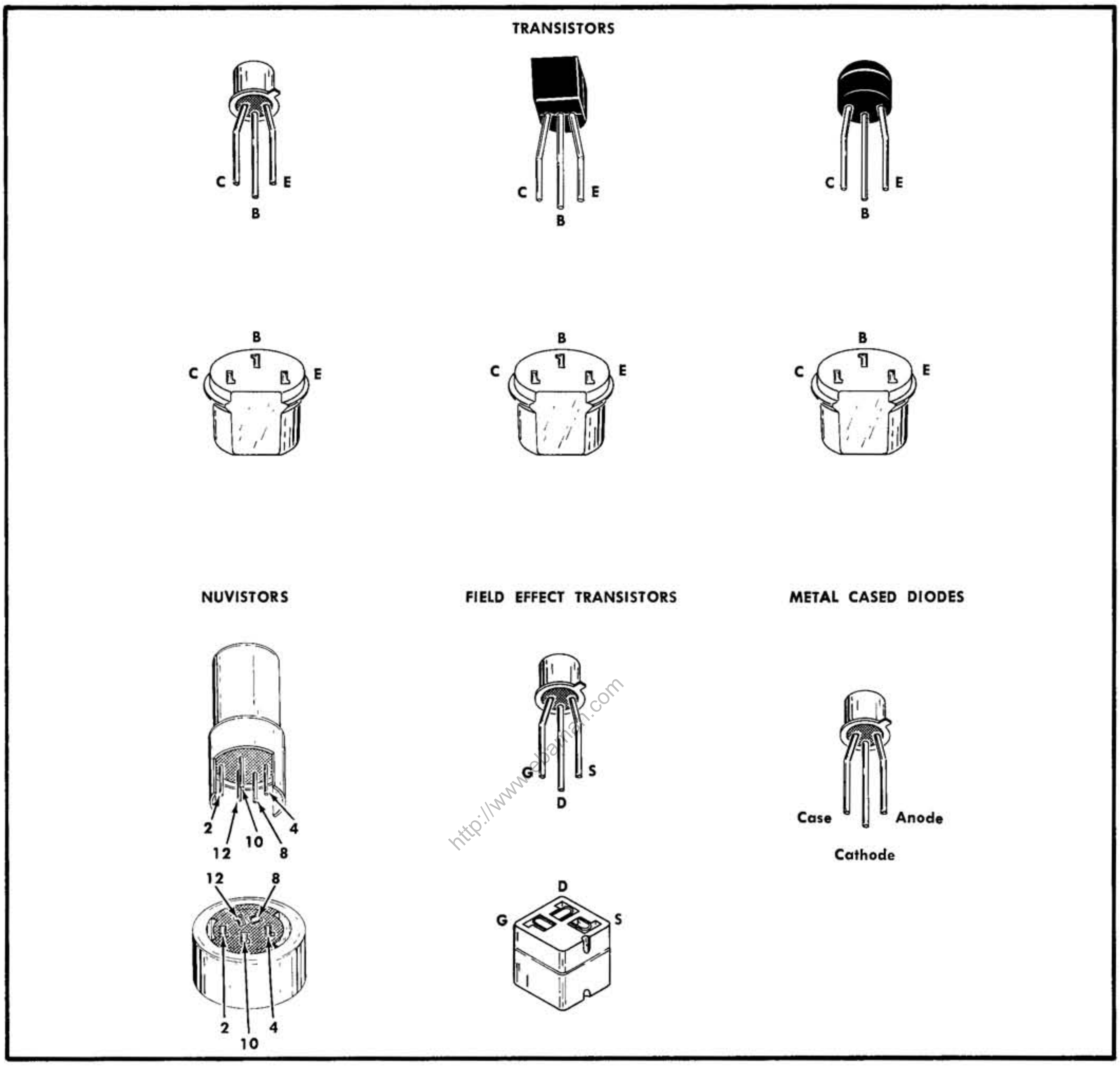


Fig. 5-1. Lead configuration for transistors, nuvistors, and metal cased diodes (D119 and D219).

required to replace certain components in the unit are described here.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part-replacements for the Type 1A1 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Electrical Parts List for value, tolerance and rating.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversley affect the Type 1A1 performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the Type 1A1. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the Part List by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your your Tektronix Field Office or representative.

Ordering Parts. When ordering replacement parts from Tektronix, include the following information:

1. Type 1A1 plug-in unit and serial number of the unit.

2. A description of the part (if electrical, include circuit number).

3. Tektronix Part Number.

Soldering Techniques

Replacing Components on the Circuit Cards.[1] Use ordinary electronic grade 60/40 solder and a 35- to 40-watt pencil soldering iron with a 1/8-inch wide chisel tip. The tip of the iron should be clean and properly tinned for rapid heat transfer to a soldered connection. Use of a higher wattage soldering iron increases the danger of ruining the bond between the etched wiring and base material by charring the glass epoxy laminate. Component replacement technique is as follows:

1. To remove a defective component, cut the leads near the body. This frees the leads for individual unsoldering.

2. Grip the lead with needle-nose pliers. Apply the tinned tip of the soldering iron to the lead between the pliers and the solder joint; then pull gently.

3. When the solder first begins to melt, the lead will come out, leaving a clean hole. If the hole is not clean, use the soldering iron and a toothpick or a piece of enamel wire to open the terminal hole. Do not attempt to drill the solder out since the plating inside the hole might be destroyed.

4. Clean the leads on the new component and bend them to the correct shape. Carefully insert the leads into the holes from which the defective component was removed.

5. Hold the leads of diodes with tweezers or needle-nose pliers to form a heat sink. Apply the iron for a short time at each connection on the side of the board opposite the component to properly seat the component.

6. Apply the iron and a little solder to the connections to finish the solder joint.

7. Clean the flux from the solder joint with a flux-remover solvent to maintain good environmental characteristics and appearance.

CAUTION

The etched wire (on the Channel 1 and Channel 2 input circuit board) that encircles the gate terminal of Q122 (or Q222) must never be soldered to the gate terminal of the FET.

[1]**A card is essentially a circuit board that can be plugged into a socket; the socket is used to make circuit connections to the card. A circuit board, on the other hand, is fastened with screws to a permanent mount; connections to a circuit board are made by pin connectors and/or soldered leads to the board.**

Soldering to Metal Terminals. When soldering to metal terminals (e.g., switch terminals, potentiometers, etc), ordinary 60/40 solder can be used. The soldering iron should have a 40- to 75-watt rating with a 1/8-inch wide channel-shaped tip.

Observe the following precautions when soldering to metal terminals.

1. Apply only enough heat to make the solder flow freely.

2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.

3. If a wire extends beyond the solder point, clip off the excess.

4. Clean the flux from the solder joint as previously described.

Removing And Installing Circuit Cards

The circuit cards are the plug-in type and can be removed easily as follows:

1. Unplug the ground lead and the leads which individually plug into the card.

To remove the Channel 1 and Channel 2 card, move the spring clip out of the notch in the side of the card to permit removal of the card. To remove the Output Amplifier card, remove the securing rod by removing the knob first.

3. Unplug the card and lift it out.

4. To install the card, plug it into the connector. Plug the leads into the card. For the Channel 1 and 2 card, check that the spring clip drops into the notch; for the Output Amplifier card, check that the securing rod is properly installed.

Removing And Installing The Input Circuit Boards

The Channel 1 and Channel 2 Input Circuit boards can be removed from the plug-in unit using the procedures given here and referring to the illustrations of the boards provided later in this section.

1. Remove the quick disconnects by the two transistors in the plastic cover located on the amplifier card.

2. Unsolder the three leads on the upper side of the input circuit board.

3. Unscrew the two hold-down screws that hold the board in place. Note the sequence of washers and spacer on the hold-down screws.

4. Grasp the board and tip the outer edge upward, exposing the connections on the underside.

5. Remove the quick disconnects on the underside of the board.

6. Lift the board from the plug-in unit.

7. To install the board make the connections to the underside of the board first. Mount the board in place and secure it with the hold-down screws. Resolder the connections on

the top of the board and fasten the quick disconnects by the two transistors in the plastic case.

Removing And Replacing Switches

If the INPUT SELECTOR switch is defective, remove and replace the switch. Use normal care in disconnecting and reconnecting the leads.

Single wafers or mechanical parts on rotary switches are not normally replaced. If the switch is defective, the entire switch should be replaced. The VOLTS/CM and MODE switches can be ordered through your Tektronix Field Office either unwired or wired, as desired. Refer to the Electrical Parts List to find the unwired and wired switch part numbers.

CAUTION

When disconnecting the leads to a wafer-type switch, do not let solder flow around and beyond the rivet on the switch terminal. Excessive solder can destroy the spring tension of the contact.

Circuit Board Replacement

If a circuit board is damaged beyond repair it is recommended that a circuit board completely wired with components mounted be obtained using the normal ordering procedure. If desired a circuit board without components is also available. Refer to the Mechanical Parts List for the part number of either board.

The circuit boards can be removed and installed using the procedures given in this section.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting the Type 1A1. Information contained in other sections of this manual should be used in conjunction with the following information to aid in locating the defective component or other cause of trouble.

Troubleshooting Aids

Diagrams. Circuit diagrams are shown on foldout pages in Section 10. The circuit number and electrical value of each component in this unit are indicated on the diagrams. Important voltages and waveforms are also shown.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to actual switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or the rear of the wafer is used to perform the particular switching function. For example, 2R of the VOLTS/CM switch is the second wafer when counting back from the detent section, and R is the rear side of the wafer.

Wiring Color Code

All insulated wire used in the Type 1A1 is color coded to facilitate circuit tracing. The widest color stripe identifies the first color of the code. Power-supply voltages can be identified by three color stripes and the following background color code; white, positive voltage; tan, negative voltage. Table 5-1 shows the wiring color code for the power-supply voltages used in the Type 1A1. The remainder of the wiring in the Type 1A1 is color coded with two or less stripes, or has a solid background with no stripes. The color coding helps to trace a wire from one point in the instrument to another.

TABLE 5-1

Supply	Background	1st Stripe	2nd Stripe	3rd Stripe
—150 volt	Tan	Red	Brown	Red
+ 75 volt	White	Brown	Brown	Green
+100 volt	White	Black	Violet	Green
+225 volt	White	Brown	Brown	Black

Resistor Color Code

A number of precision metal-film resistors are used in this instrument. These resistors can be identified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it will be color-coded according to the EIA standard resistor color code. It has a value indicated by four significant figures and a multiplier, the value will be printed on the body of the resistor. For example, a 333-kΩ resistor will be color-coded, but a 333.5-kΩ resistor will have its value printed on the body. The color-code sequence is shown in Fig. 5-2.

Troubleshooting Techniques

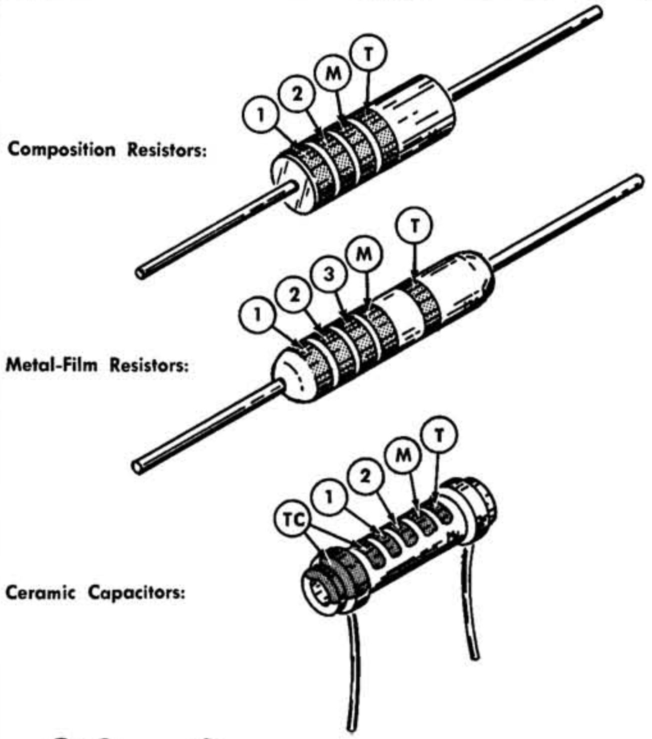
This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with more detailed troubleshooting. The first few checks assure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in isolating the trouble to a particular circuit; then the circuit must be checked to locate the defect in the circuit. When the defect is located, the repair should be made using the information previously provided in the Corrective Maintenance portion of this section.

Check Front-Panel Control Settings

Incorrect control settings can indicate a trouble that does not exist. For example, an incorrect setting of the VARIABLE control for one channel appears as incorrect gain. If there is any question about the correct function or operation of any control, see the Operating Instructions section for the Type 1A1 or the associated oscilloscope.

Isolate Trouble to Type 1A1 or Oscilloscope

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 1A1 is op-



(1) (2) and (3) —1st, 2nd and 3rd significant figures;
(M) —multiplier; (T) —tolerance;
(TC) —temperature coefficient.

Resistor and Capacitor Color Code

Color	Significant Figures	Multiplier: Resistors	Multiplier: Capacitors	Tolerance: Resistors	Tolerance: Capacitors
Silver	---	10^{-2}	---	±10%	---
Gold	---	10^{-1}	---	±5%	---
Black	0	1	1	---	±20% or 2 pF*
Brown	1	10	10	±1%	±1% or 0.1 pF*
Red	2	10^2	10^2	±2%	±2%
Orange	3	10^3	10^3	±3%	±3%
Yellow	4	10^4	10^4	±4%	+100% −0%
Green	5	10^5	10^5	±0.5%	±5% or 0.5 pF*
Blue	6	10^6	10^6	---	---
Violet	7	---	---	---	---
Gray	8	---	10^{-2}	---	+80% −20% or 0.25 pF*
White	9	---	10^{-1}	---	±10% or 1 pF*
(none)	---	---	---	±20%	±10% or 1 pF*

***For capacitance of 10 pF or less.**

NOTE: (T) and/or (TC) color code for capacitors depends upon manufacturer and capacitor type. May not be present in some cases.

Fig. 5-2. Color code for resistors and ceramic capacitors.

erating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 1A1.

Troubles occurring in the oscilloscope can usually be detected by substituting another plug-in unit for the Type 1A1—preferably another Type 1A1 or a Type 1A4 which is working normally. Then, such troubles as loss of alternate trace sync pulses, improper chopped blanking or loss of the slave pulse can be readily isolated to either the plug-in unit or the oscilloscope. If a substitute unit is not available, multi-trace troubles can be isolated by using another oscilloscope as a test oscilloscope for signal-tracing the Type 1A1.

NOTE

The power input to the oscilloscope used with the Type 1A1 must be within voltage and harmonic-distortion limits. This ensures that the oscilloscope low-voltage power supplies will regulate properly.

Test Equipment

Following is a list of equipment useful in troubleshooting the Type 1A1.

1. Transistor tester. Tektronix Type 575 Transistor-Curve Tracer to test transistors and diodes used in the Type 1A1.

2. VOM or VTVM. VOM DC sensitivity should be at least 20,000 ohms per volt; DC voltage accuracy for either the VOM or VTM should be within 3% for precision and general purpose use—can also be used to check transistors and diodes if used with care. Not recommended as a substitute for a good transistor and diode tester.

3. 0 to 2 milliameter for determining full-scale current delivered by the VOM or VTVM on ohmmeter ranges used for semiconductor testing.

4. Test oscilloscope with a 10× attenuator probe: Bandwidth, DC to about 300 kHz or better. Calibrated vertical deflection factors down to 5 mV/cm without a 10× probe (50 mV/cm and an input resistance of 10 MΩ with a 10× probe). An external trigger input connector on the test oscilloscope is desirable. Used for low-frequency signal tracing and to check DC levels in each amplifier stage. Can be used to signal trace the switching circuits if bandwidth limitation is considered.

5. Wide-bandwidth test oscilloscope with a 10× attenuator probe: Bandwidth, DC to 10 MHz or better. Calibrated vertical deflection factors down to 0.1 volt/cm without a 10× probe (1 volt/cm with a 10× probe). Used to signal trace the switching circuits. If the deflection factor of this wide-band test oscilloscope is as low as 5 mV/cm, use it in place of item 4.

6. Autotransformer with an output voltage variable between 103 and 127 volts (or 206 and 254 volts if oscilloscope used with the Type 1A1 is wired to operate within this range). Minimum rating depends on current drawn by the oscilloscope with its plug-in unit(s). Used to apply design-center line voltage to the oscilloscope/Type 1A1 combination.

7. RMS-calibrated AC voltmeter capable of indicating the voltage output of the autotransformer (item 6).

8. 30-inch long flexible cable plug-in extension. Permits operating the Type 1A1 out of the plug-in compartment so that all sides of the unit are accessible for servicing. Tektronix Part No. 012-0028-00.

9. Circuit extender card complete with four signal extension leads and two ground extension leads attached to the card. Permits operating the circuit partially out of the unit for troubleshooting. Tektronix Part No. 012-0100-00.

10. Adapter with BNC and UHF connector fittings. Fits BNC plug and UHF jack connectors. Used if test oscilloscope (item 4 and 5) external trigger connector is a UHF jack type connector. For use in a low-frequency signal-tracing setup to check phase relationship of calibrator signal at output of each amplifier stage in the Type 1A1. (Signal tracing setup includes items 4 through 12.) Tektronix Part No. 103-0015-00.

11. BNC T used in a low-frequency signal-tracing setup for connecting to the two BNC coaxial cables (item 12) and to the calibrator output connector on the oscilloscope used with the Type 1A1. Tektronix Part No. 103-0030-00.

12. Two coaxial cables equipped with BNC connectors on each end. Used in low-frequency signal-tracing setup to apply the calibrator signal to the Type 1A1 and to the test oscilloscope external trigger input connector. Tektronix Part No. 012-0057-00.

13. Miscellaneous: Replacement tubes, transistors, and diodes.

Interconnecting-Plug Resistance Checks

Table 5-2 lists the approximate resistance measured between the interconnecting-plug pins and ground of the 16-pin plug located on the rear panel of the Type 1A1. These measurements were taken with the Type 1A1 disconnected from the associated oscilloscope. The measurements are particularly useful for locating a possible short circuit or low-resistance path in the unit, if such trouble should occur.

The resistance measurements vary considerably since semiconductors are used in the circuitry. In addition, the readings can vary as much as 50% due to the type of ohmmeter in use. Therefore, empty columns are provided in the table for logging your own measurements, and the type of meter used, for future reference.

Significant differences between ohmmeter types are: (1) the amount of internal voltage used; (2) the currents delivered for full-scale deflection in each range; and (3) the scale readings on the meter itself. If ohmmeters differed less in these respects, the resistance measurements given in the table would be more typical.

Troubleshooting Table

Table 5-3 is a list of typical symptoms, their possible causes and the probable circuit at fault. Since it is impossible to list every kind of symptom that might happen, those that are included here may give you a clue to the most likely area to check.

To locate the exact cause of a trouble when it is not listed in the table, use the conventional method of troubleshooting; i.e. signal tracing, voltage and resistance checks, and parts substitution. To reduce the parts substitution method of troubleshooting to minimum, use the conventional method of troubleshooting first. In addition, use the information provided on the schematics and in other portions of this manual as an aid to isolating the trouble.

Isolating DC Imbalance

For free-running traces to appear within the usable viewing area of the CRT screen, the DC voltage as measured between pins 1 and 3 of the interconnecting plug to the oscilloscope must be less than ± 0.3 volt. A voltage difference which exceeds ± 0.3 volt between these two points may position the trace more than ± 3 cm from the oscilloscope vertical-amplifier electrical center, thus positioning the trace above or below the range of visibility.

To find the oscilloscope vertical-amplifier electrical center, short pins 1 and 3 together momentarily and note the position of the trace. The position of the trace is the electrical center. When shorting the pins, use care to avoid shorting to other pins or to ground.

The DC voltages at pins 1 and 3 of the interconnecting plug depend on the DC balance of all amplifier stages in both channels. Since all the amplifier stages are DC coupled, any excessive imbalance between input and output can unbalance the output and cause the trace to deflect out to the viewing area.

Fig. 5-3 shows the voltage difference limits between each stage. If the voltage limits are exceeded in one stage, the limits will be exceeded in the following stages (looking toward the output) and the trace will deflect off the screen. For example, if the voltage between the collectors of Q124 and Q144 in the Channel 1 Input Amplifier stage reads $+0.8$ volt, the voltage between the collectors of Q404 and Q414 in the Output Amplifier first stage will read $+0.6$ volt, and the voltage at pins 1 and 3 of the interconnecting plug will also read $+0.6$ volt, causing the trace to be deflected upward and off the CRT.

One quick method for isolating DC imbalance either to one of the Channels or to the Output Amplifier second stage is to turn one channel on at a time to see if the trace for the channel can be normally positioned on the CRT. If the trace for one channel cannot be positioned onto the CRT, then the DC imbalance originates in that channel. If none of the traces appear on the CRT, then the trouble is probably in the Output Amplifier second stage. Also, consider the possibility that the trouble might be one of the diode switches (D421, D422, D423, or D424 in Channel 1; D451, D452, D453 or D454 in Channel 2) or in the Switching Multivibrator stage (Q305/Q315).

TABLE 5-2

Approximate Resistance Between the 16-pin Interconnecting Plug Pins and Ground

Type of Meter: VOM[1]	Type of Meter: ________
	Manufactured By: ________
	Model No.: ________
	Type 1A1 Serial No.: ________

Pin No.	MODE Switch Setting	Resistance Readings[2] +GND	Resistance Readings[2] −GND	Ohms Range Used	Resistance Readings +Gnd	Resistance Readings −Gnd	Ohms Range Used
1	Any	6.8 k	4.9 k	RX1K			
2	Any	0 (Gnd)		——			
3	Any	6.8 k	4.9 k	RX1K			
4	Any	0 (Gnd)		——			
5	Any	7 k	6.8 k	RX1K			
6	Any	Infinite (No connection)		——			
7	Any except ALT	0 (Gnd)		RX1K			
	ALT	Infinite					
8	Any	47 Ω	36 Ω	RX1			
9	Any	4.9 k	7.5 k	RX1K			
10	Any	4.9 k	2.9 k	RX1K			
11	Any	9.3 k	7.5 k	RX1K			
12 13 14	Any	Infinite (No connection)		——			
15	CH 1 or CH 2	640 Ω	590 Ω	RX100			
	ALT	640 Ω	590 Ω	RX100			
	CHOP	590 Ω	560 Ω	RX100			
	ADD	640 Ω	590 Ω	RX100			
16	CH 1, ADD, or CH 2	Infinite (No connection)		——			
	ALT	20 k	19.5 k	RX1K			
	CHOP	10 k	10 k	RX1K			

[1]VOM used to obtain these measurements was a 20,000 Ω/V DC meter with a mid-scale reading of 4.5 kΩ on the RX1K range. For this range the mid-scale deflection current is 160 μA; full scale current is 320 μA.

[2]Ohmmeter leads are first connected one way and then the other way to get the two readings.

TABLE 5-3

Trouble Isolation Procedure Checks to Make

Symptom	Some Possible Causes	Probable Circuit Area At Fault
1. No trace or wavefrom display, either channel. Trace deflected off the CRT.	Defective output amplifier tube or transistor (V464, V474, Q464, Q474). Open filament in one of the tubes. Defective interconnecting plug. Check these nominal supply voltages in the Type 1A1: +225 V, +100 V, +75 V, +39 V, +11 V, +5 V and —150 V. If any of these voltages are incorrect, find the trouble before going to the third column.	Check for DC imbalance in the Output Amplifier second stage. Refer to Fig. 5-3.
2. Trace but no waveform display, either channel.	R467 open.	Check Output Amplifier second stage.

TABLE 5-3 (Cont)

Trouble Isolation Procedure Checks to Make

Symptom	Some Possible Causes	Probable Circuit Area At Fault
3. No Channel 1 trace or waveform display.	Check for open series diode D421 or D424, Q122 or Q142 defective. Check that the Switching Multivibrator stage is working properly and Q315 should be cut off. D421 open. D452 open. D122 shorted. D424 open. D453 open.	Check for DC imbalance in Channel 1. Refer to Fig. 5-3.
4. No channel 2 trace or waveform display.	Check for open series diode D451 or D454, Q222 or Q242 defective. Check that the Switching Multivibrator stage is working properly. Q315 should be conducting and Q305 should be cut off. D422 open. D451 open. D222 shorted. D423 open. D454 open.	Check for DC imbalance in Channel 2. Refer to Figure 5-3.
5. Channel 1 trace but no waveform display.	Check for short or open circuit between Channel 1 INPUT connector and gate of Q122.	Signal trace Channel 1 to locate faulty circuit.
6. Channel 2 trace but no waveform display.	Check for short or open circuit between Channel 2 INPUT connector and gate of Q222.	Signal trace Channel 2 to locate faulty circuit.
7. No chopped or alternate mode of operation. One channel is on all the time.	Q305 defective. Q315 defective.	Troubleshoot Switching Multivibrator stage (Q305/Q315).
8. No alternate mode of operation. Chopped mode is normal.	Q330 defective. T330 open winding. D308 open } Channel 1 only D313 shorted } is on. D303 shorted } Channel 2 only D318 open } is on.	Check Alternate Trigger Blocking Oscillator stage (Q330).
9. No chopped mode of operation. Alternate mode is normal.	Defective contact on the MODE switch the CHOP position.	Troubleshoot Switching Multivibrator stage (Q305/Q315).
10. No chopped mode blanking. Alternate mode is normal.	Q343 defective. Q353 defective. D345 is open.	Check Blanking Multivibrator stage (343/Q353).
11. No signal or insufficient amplitude signal at CH 1 SIGNAL OUT or CH 1 TRIGGER OUT connectors. No internal triggering on Channel 1 only.	Q163, Q164, Q173 or Q174 defective.	Check Channel 1 Signal pickoff Emitter Follower and Amplifier stages.
12. No signal or insufficient amplitude signal at CH 1 TRIGGER OUT connector.	Q184 and Q194 defective.	Check Channel 1 Trigger Output Amplifier stage (Q184/Q194).

In-Circuit Diode Checks

In-circuit checks of diodes can be made quite easily by using a voltmeter to find out if the diode is functioning properly in the circuit. Use Table 5-4 to determine whether a particular diode should be forward biased or not during single-trace or dual-trace operation. Also, measure the voltage on each side of the diode during its quiescent state as given on the diagrams, then determine whether the difference between voltages is normal or not.

If you are in doubt whether a diode is defective, unsolder one end and check the forward-to-back resistance ratio. If the ohmmeter check proves unsatisfactory, replace the diode.

Circuit Cards and Boards

The Type 1A1 contains three compact plug-in circuit cards and two circuit boards. Figs. 5-5 and up show the circuit number of each component and its location. Fig. 5-4 labels the connector wiring for each card.

Signal Tracing

Signal Amplifier Stages. A method is described here for checking waveform amplitude and polarity at the test points shown on the Input Amplifier and Output Amplifier schematic diagrams. The technique is based on using a plug-in extension to operate the Type 1A1 outside the oscilloscope plug-in compartment. The plug-in extension permits access to the circuits in the Type 1A1 for detailed signal tracing and troubleshooting.

After the faulty stage is located and the trouble found and corrected, then it is easy to remove the extension, insert the plug-in in the oscilloscope and go directly to the Performance Check procedure in Section 6 to check frequency response and other performance requirements. If

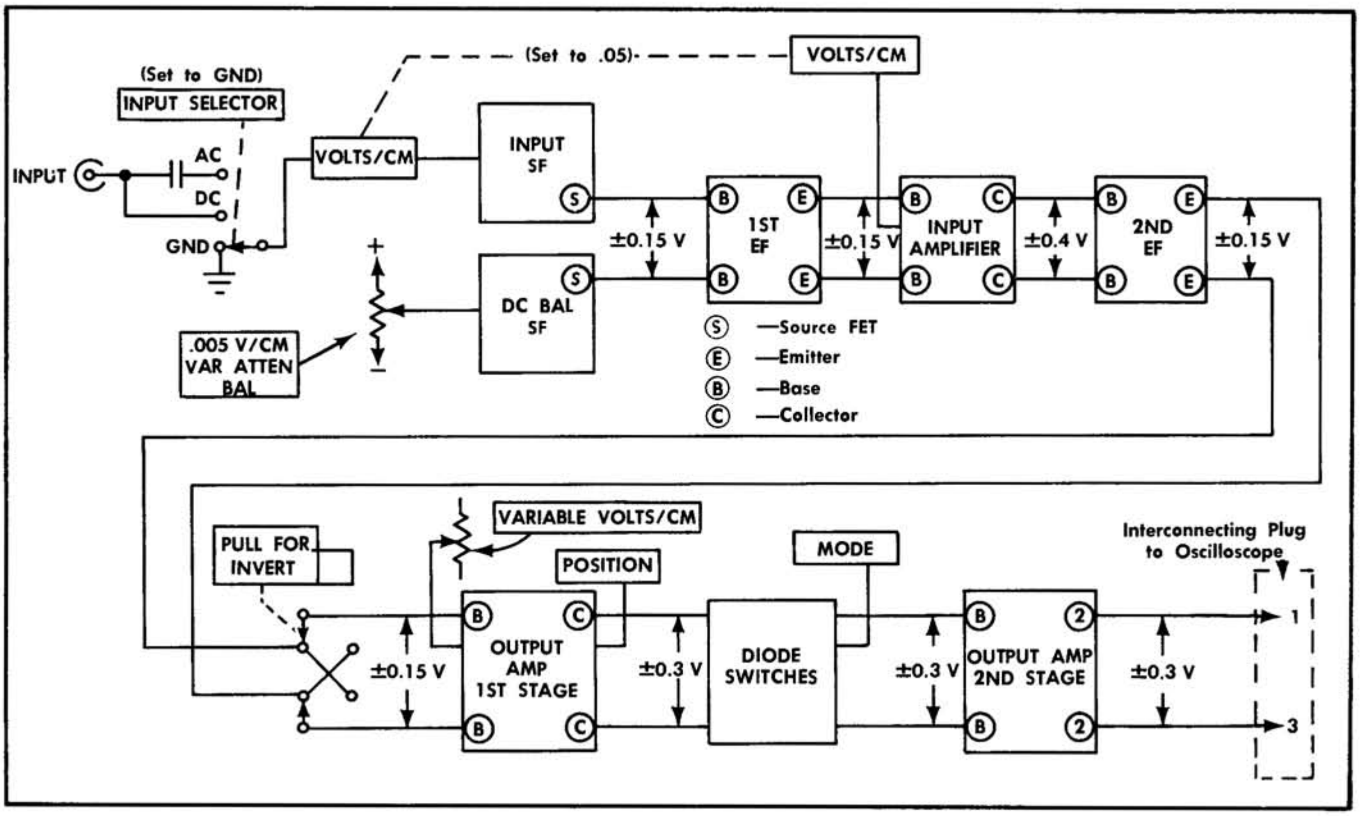


Fig. 5-3. DC balance voltage limits at each stage, which, if not exceeded, should position the trace on the CRT. The trace should appear within ±3 cm from the oscilloscope vertical-amplifier electrical center.

TABLE 5-4

Normal Diode Bias Conditions

Diode	Mode Switch Setting				
	CH 1	ALT[1]	CHOP	ADD	CH 2
D122	Reverse	Reverse	Reverse	Reverse	Reverse
D222	Reverse	Reverse	Reverse	Reverse	Reverse
D421	Forward			Forward	Reverse
D422	Reverse			Reverse	Forward
D423	Reverse			Reverse	Forward
D424	Forward			Forward	Reverse
D451	Reverse			Forward	Forward
D452	Forward			Reverse	Reverse
D453	Forward			Reverse	Reverse
D454	Reverse			Forward	Forward
D303	Forward	Reverse	Reverse	Forward	Reverse
D313	Reverse	Reverse	Reverse	Forward	Forward
D308	Reverse	Reverse[2]	Reverse	Reverse	Reverse
D318	Reverse	Reverse[2]	Reverse	Reverse	Reverse
D301	Forward	Forward	Reverse	Forward	Forward
D311	Forward	Forward	Reverse	Forward	Forward
D345	Forward	Forward	Reverse	Forward	Forward

[1]**Oscilloscope time base set for 1 μs/cm free-running sweep.**

[2]**Voltmeter shows a reverse-bias reading but does not indicate conduction of diode during positive-going sync pulse duration.**

preferred, the Calibration Procedure in Section 7 can be used. The advantage of using the Calibration Procedure is that the control setups provide convenient starting places when steps are performed out of sequence.

To signal trace the Type 1A1 amplifier stages, proceed as follows:

1. Connect an extender card between the Amplifier card and socket. Connect the interconnecting leads to complete the circuit interconnections.

NOTE

On the Channel 1 and Channel 2 circuit card, the yellow-on-white lead from the high-frequency compensation network on the VOLTS/CM switch has no connection on the circuit card extender. This lead is to be left unconnected while using the circuit card extender.

2. Connect a plug-in extension between the Type 1A1 and the associated oscilloscope.

CAUTION

If the Type 1A1 is used with a Type 544, 546, or 547 Oscilloscope, be sure to pull the oscilloscope plug-in sensing switch to its outward position before turning on the oscilloscope power.

3. Set the front-panel controls of the Type 1A1 to the same positions as listed in the IMPORTANT note located

on the inside portion of the Block Diagram pull-out page. Exception: If Channel 2 needs to be checked, set the MODE switch to select Channel 2.

4. Apply a 2 V peak to peak calibrator signal through a T connector and coaxial cables to the Type 1A1 Input connector of the selected channel and to the test oscilloscope (item 4 or 5 in Test Equipment list) External Trigger Input connector.

5. Set the test oscilloscope Input Coupling Switch to AC, and V/cm switch to 0.5, the Time/cm switch to 0.5 ms, and the triggering controls for +Ext triggering on the 2 V calibrator signal.

6. Touch the test oscilloscope probe tip to the soldered connection (wired end) of the Input connector center conductor for the channel to be checked.

7. Set the test oscilloscope Triggering Level control so the first half cycle of the waveform is positive going. The displayed waveform on the test oscilloscope should correspond to the waveform polarity and amplitude shown at the Input connector test point on the CH 1 Input Amplifier diagram. Disconnect the probe.

8. On the diagram locate the next test point where a waveform is shown. Set the test oscilloscope vertical deflection factor to correspond to the setting given at the left side of the diagram waveform.

9. Locate the same test point in the Type 1A1 that corresponds to the one on the diagram and connect the probe tip to this test point. Check the displayed waveform amplitude and polarity. Disconnect the probe.

10. Repeat steps 8 and 9 until a test point is found where an abnormal indication is definitely obtained. Then proceed with detailed troubleshooting checks between that stage and the preceding test point to isolate the trouble to the smallest possible area until the cause of the trouble is found. Detailed checks consist of signal tracing the circuits between the test points to determine where the signal becomes abnormal. Then voltage and resistance checks may have to be made; semiconductors (or tube) and other components may have to be substituted.

Switching Circuit. To signal trace the Switching Circuit, use the same technique as described for signal tracing the signal amplifier stages with the following exceptions:

1. Use a 10-MHz or higher bandwidth test oscilloscope.

2. Use AC input coupling to check the waveform amplitude.

3. Use DC input coupling and a suitable vertical deflection factor to check DC levels.

4. Use appropriate + and — Triggering Slope and Source switch positions for the waveform being checked.

Check Individual Components

The following procedures describe methods of checking the individual components in the Type 1A1. Components which are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurements due to the effects of surrounding circuitry.

1. Tube. The best check of tube operation is actual performance under operating conditions. If the tube is suspected of being defective, it can best be checked by substituting a new tube or one which has been previously checked. Turn off the oscilloscope power when substituting the tube.

2. Field Effect Transistors (FET). Best check is to make a temporary check by changing with an FET from another channel known to be good. Turn off the oscilloscope power when making the exchange. Turn on the oscilloscope and make the check. After making the check, be sure to return the FET to its original channel socket and check that it is properly oriented in the same direction as originally removed.

3. Transistors (excluding FET's). Defects in transistors usually take the form of the transistor opening, shorting, or developing excessive leakage. To check a transistor for these and other defects, use a transistor curve display instrument such as a Tektronix Type 575. However, if a good transistor checker is not readily available, a defective transistor can be found by signal tracing, by making in-circuit voltage checks, by measuring the transistor forward-to-back resistance using proper ohmmeter resistance ranges, or by using the substitution method. The location of all transistors is shown in the parts location illustrations provided later in this section.

To check transistors using a voltmeter, measure the emitter-to-base and emitter-to-collector voltages. Determine if the voltages are consistent with the normal resistances and currents in the circuit.

To check a transistor using an ohmmeter, know the ohmmeter ranges, the currents they deliver, and the internal battery voltage(s). If the ohmmeter does not have sufficient resistance in series with its internal voltage source, excessive current will flow through the transistor under test. Excessive current and/or high internal source voltage may damage the transistor.

NOTE

As a general rule, use the RX1k range where the current is usually limited to less than 2 mA and the internal voltage is usually 1.5 V. Current and voltage can be checked by inserting a multimeter between the ohmmeter leads and measuring the current and voltage for the range you intend to use.

When the ohmmeter ranges that will not harm the transistor are known, then those ranges should be used to measure resistances with the ohmmeter connected both ways as given in Table 5-5.

If there is doubt about whether the transistor is good, substitute a new transistor; but first, be certain the circuit voltages applied to the transistor are correct and turn the oscilloscope power off before making the substitution. If a transistor is substituted without first checking out the circuit, the new transistor may immediately be damaged by some defect in the circuit.

CAUTION

Use care when making measurements in an operating unit. The small size and high density of com-

TABLE 5-5

Transistor Resistance Checks

(excluding FET's)

Ohmmeter Connections[5]	Resistance Readings That Can Be Expected Using the RX1k Range
Emitter-Collector	High readings both ways (about 200 kΩ or higher.
Emitter-Base	High reading one way (about 200 kΩ or more). Low reading the other way (about 400 Ω to 5 kΩ).
Base-Collector	High reading one way (about 500 kΩ or more). Low reading the other way (about 400 Ω to 5 kΩ).

[5]Test prods from the ohmmeter are first connected one way to the transistor leads and then the test prods are reversed (connected the other way). Thus, the effects of the polarity reversal of the voltage applied from the ohmmeter to the transistor can be observed.

ponents used in the Type 1A1 result in close spacing. An inadvertent movement of the test prods, or the use of oversized prods may cause a short between circuits.

4. Diodes. In-circuit checks of diodes can be made quite easily by measuring the voltage drop across the diode using the voltages on the schematic diagrams as a guide. If there is doubt whether a diode is defective or not, turn off the oscilloscope power, unsolder one lead of the diode from the circuit and check the forward-to-back resistance ratio. Observe the same precautions as those described when checking transistors. If the ohmmeter checks prove unsatisfactory, use a good diode checker or replace the diode.

5. Resistors. Resistors can be checked with an ohmmeter. Check the Electrical Parts List for the tolerance of the resistors used in this unit. Resistors normally do not need to be replaced unless the measured value is in excess of the specified tolerance.

6. Capacitors. A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance readings should be high after the initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter or by checking whether the capacitor passes AC signals.

7. Repair and Recheck the Circuit. If any defective parts are located, follow the replacement procedures given earlier in the Corrective Maintenance portion of this section. Be sure to check the performance of any circuit that has been repaired or has had electrical components replaced.

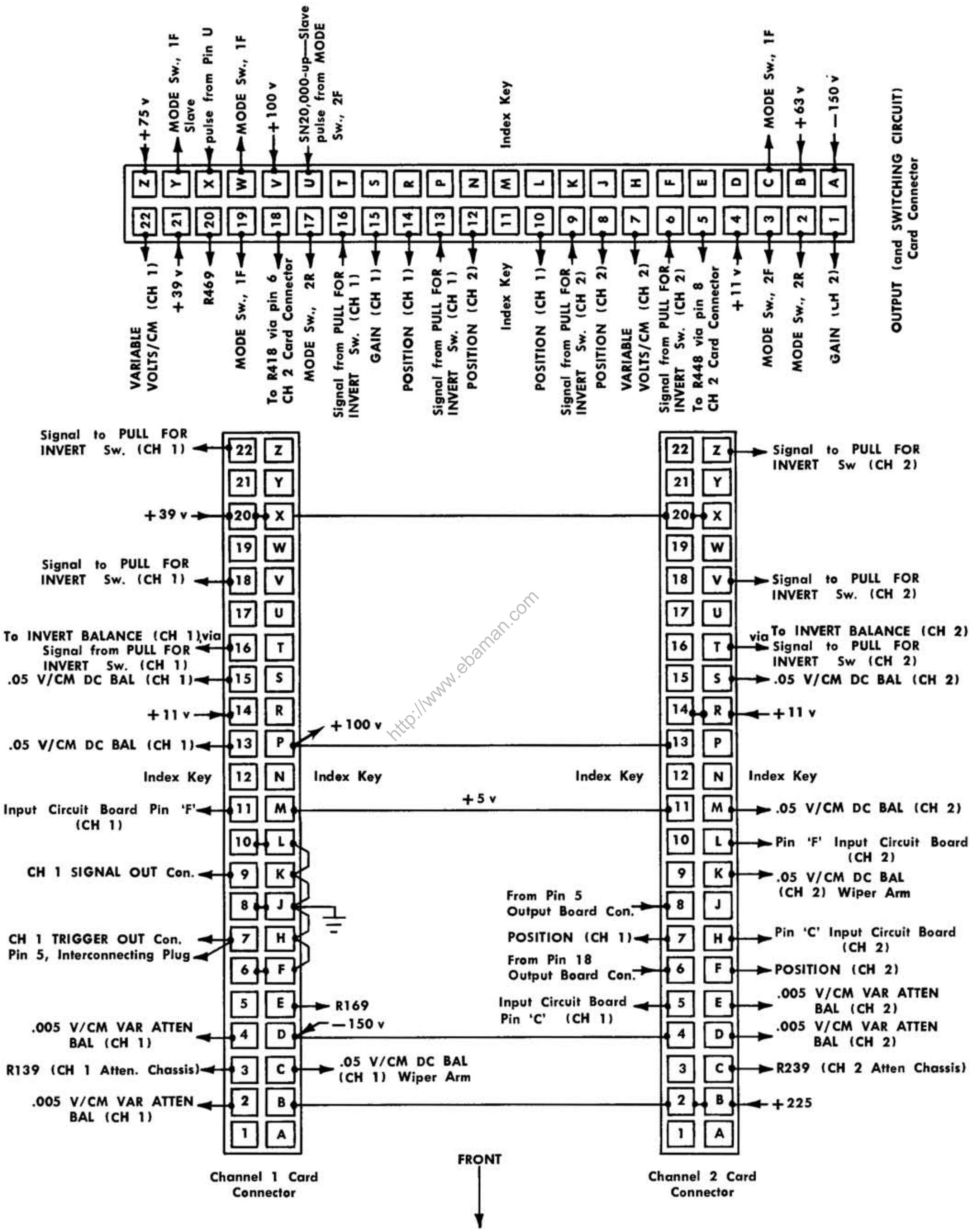


Fig. 5-4. Circuit card connector top view.

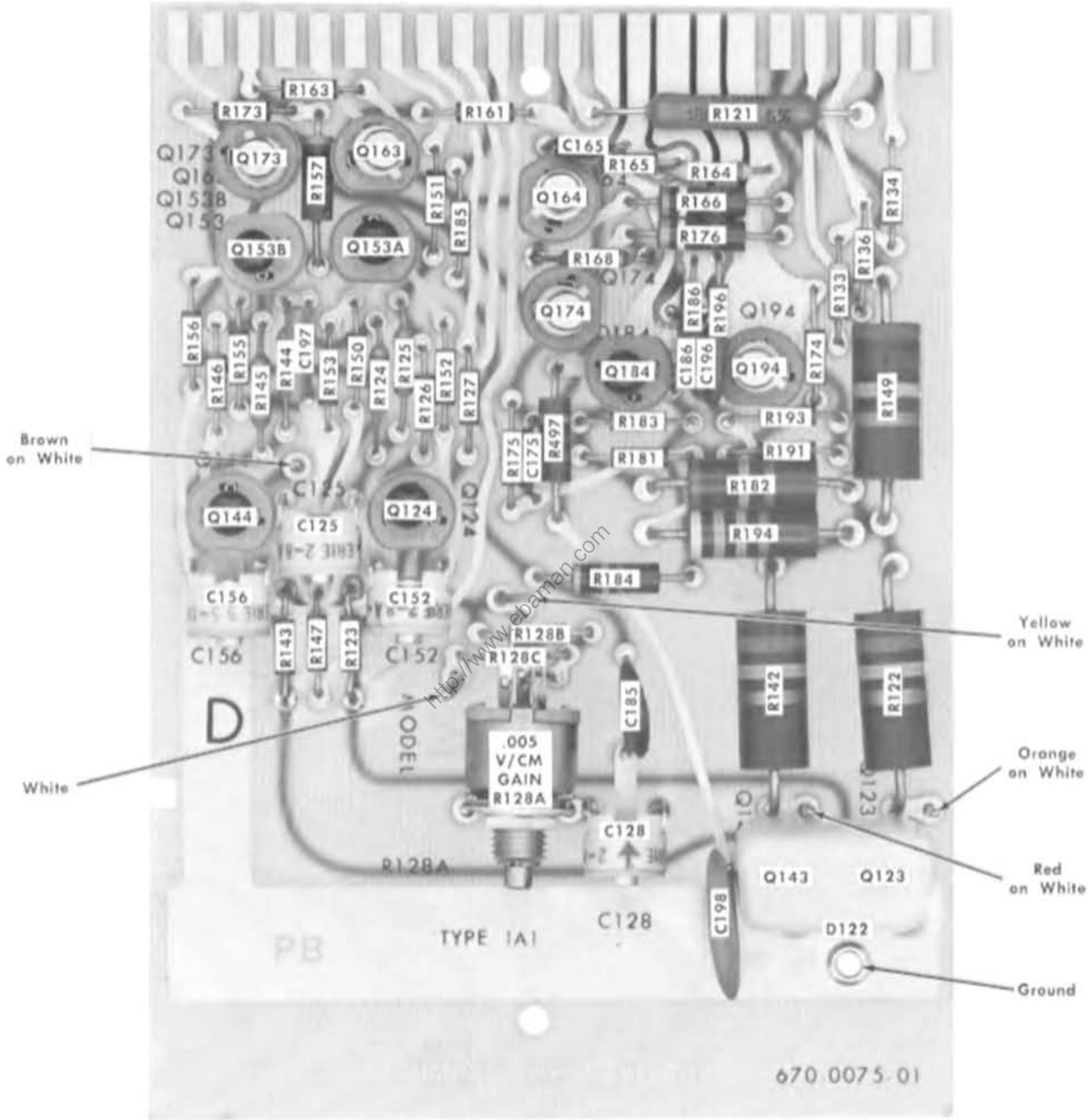


Fig. 5-5. Channel 1 Input Amplifier card.

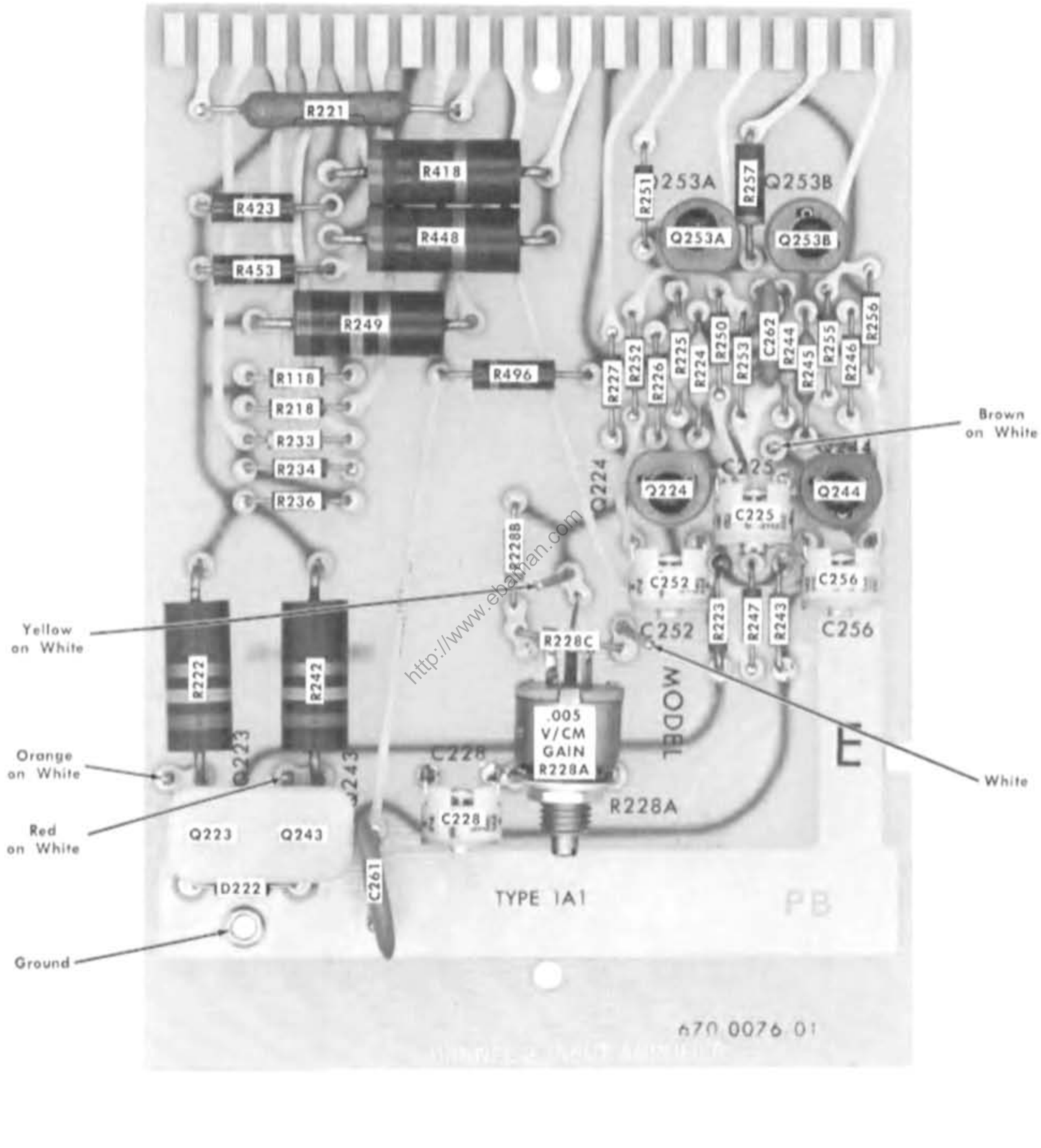


Fig. 5-6. Channel 2 Input Amplifier card.

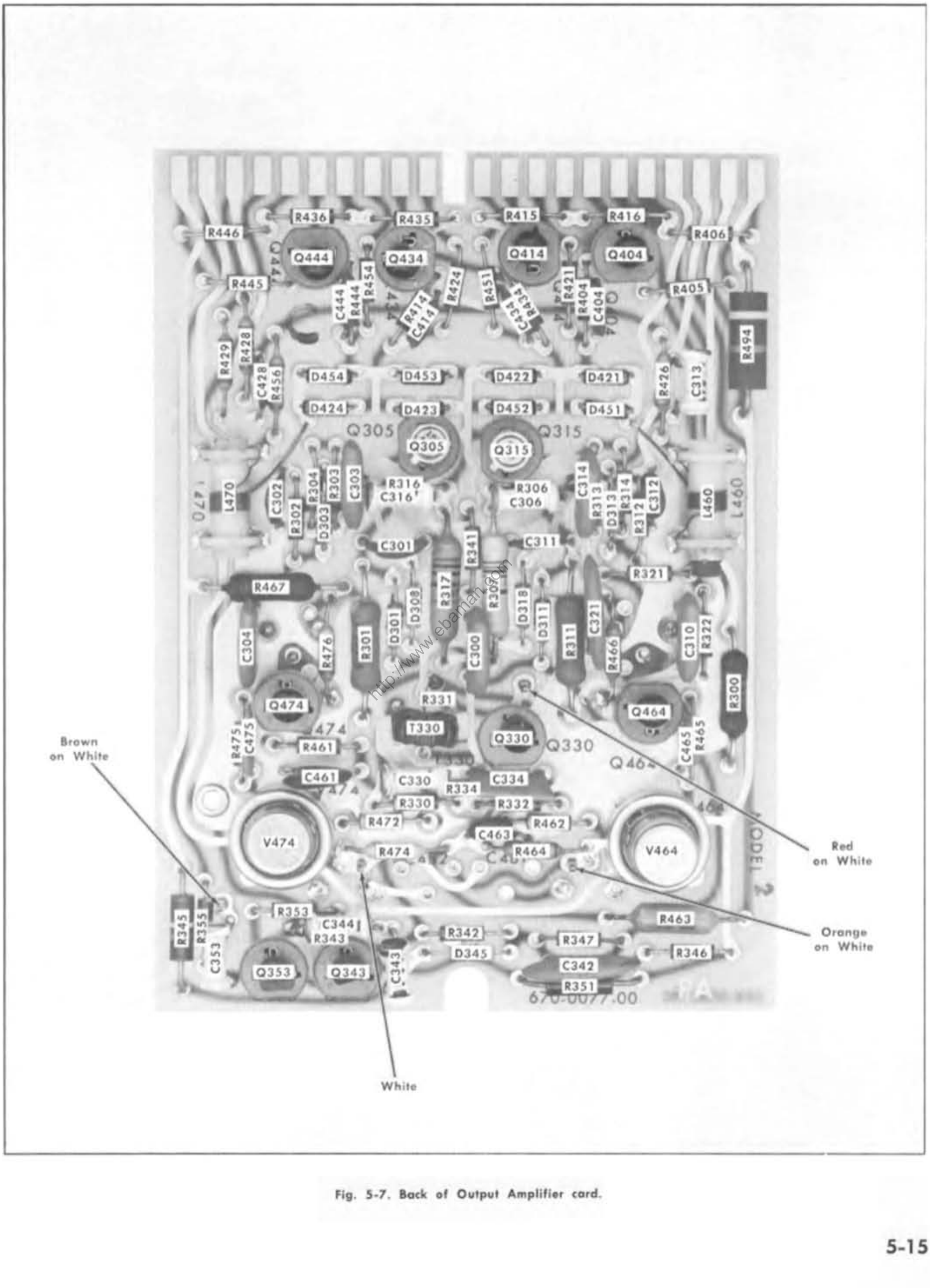


Fig. 5-7. Back of Output Amplifier card.

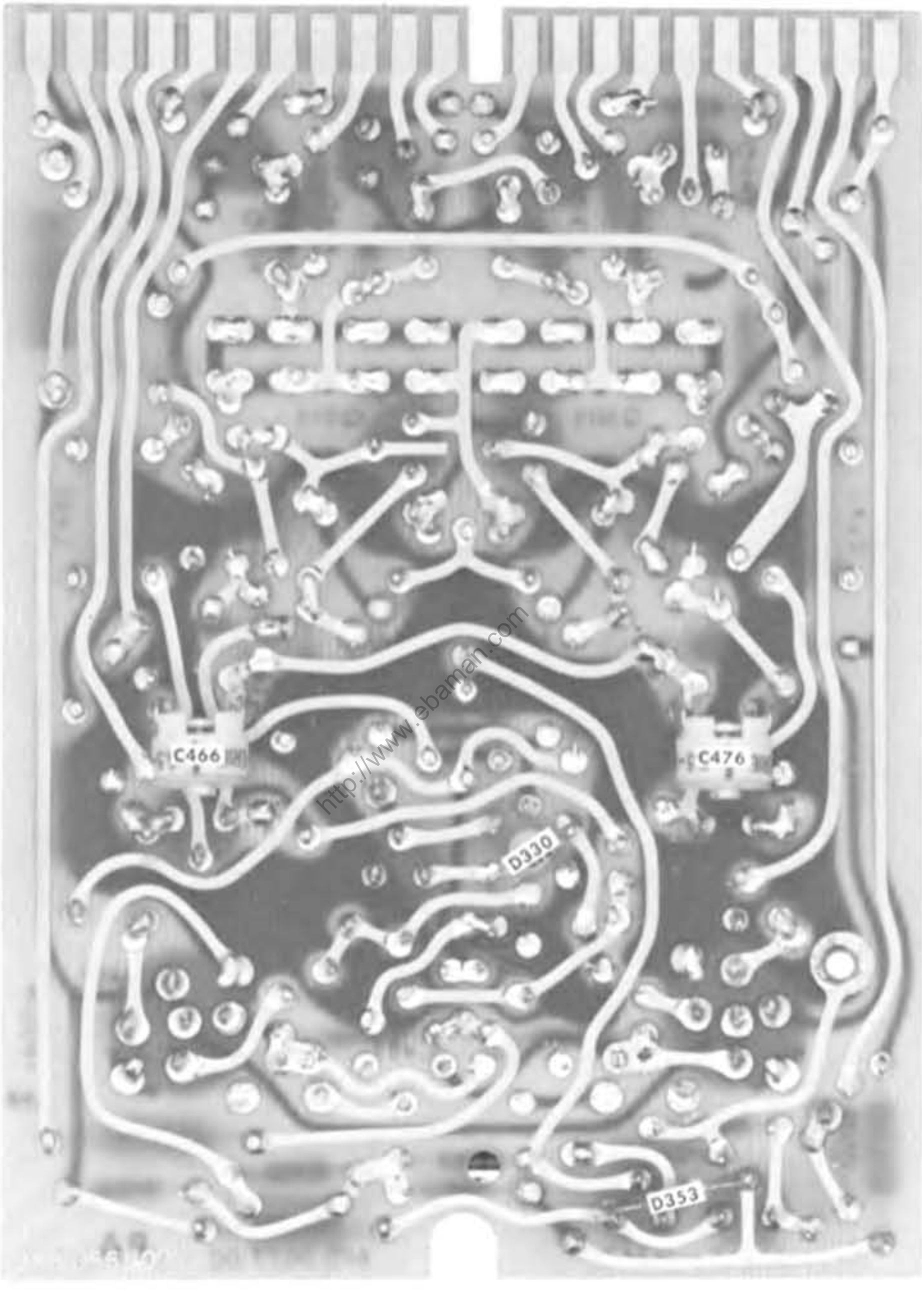


Fig. 5-8. Front of Output Amplifier card.

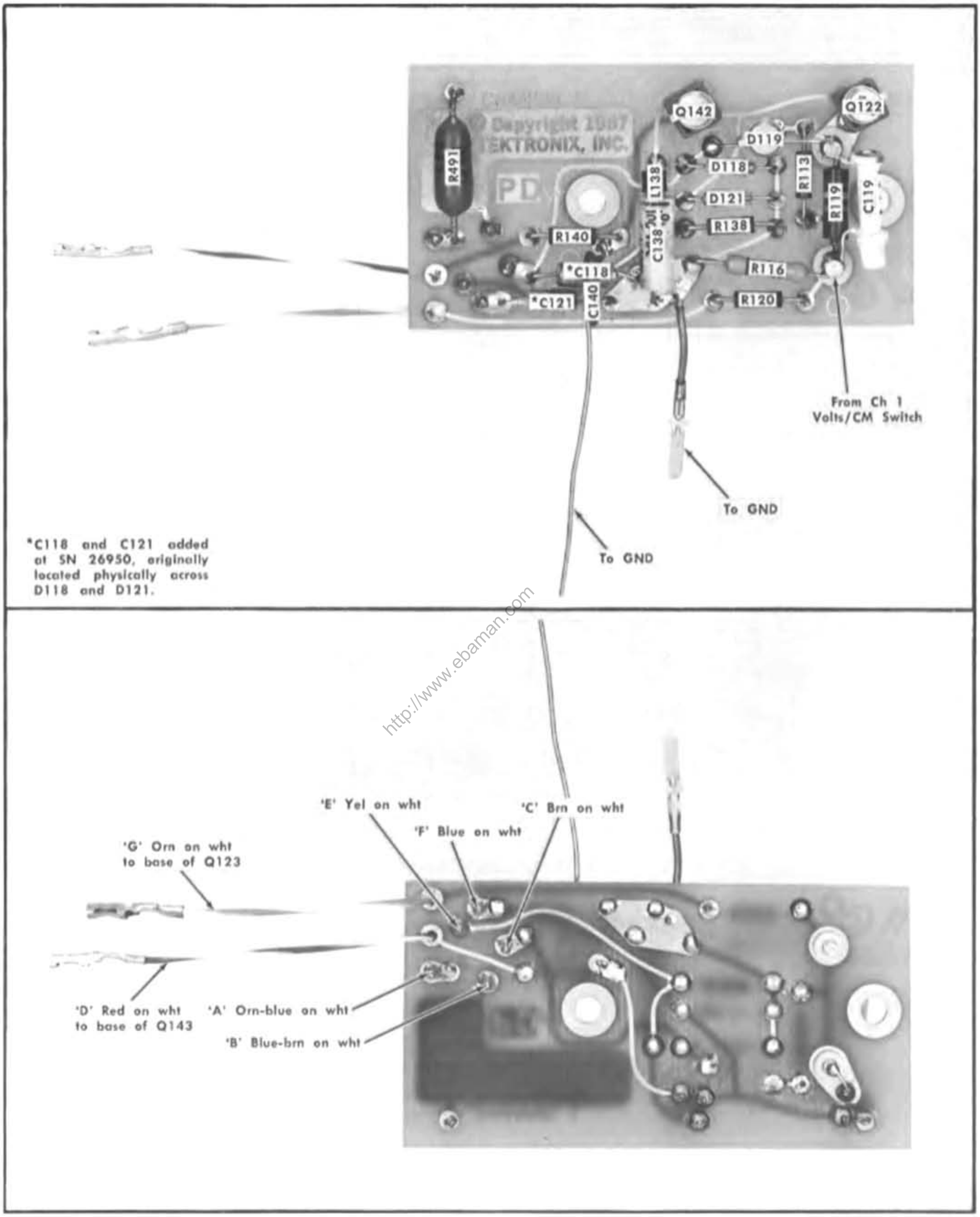


Fig. 5-9. Channel 1 Input FET board. Front and back view showing parts location and lead connections.

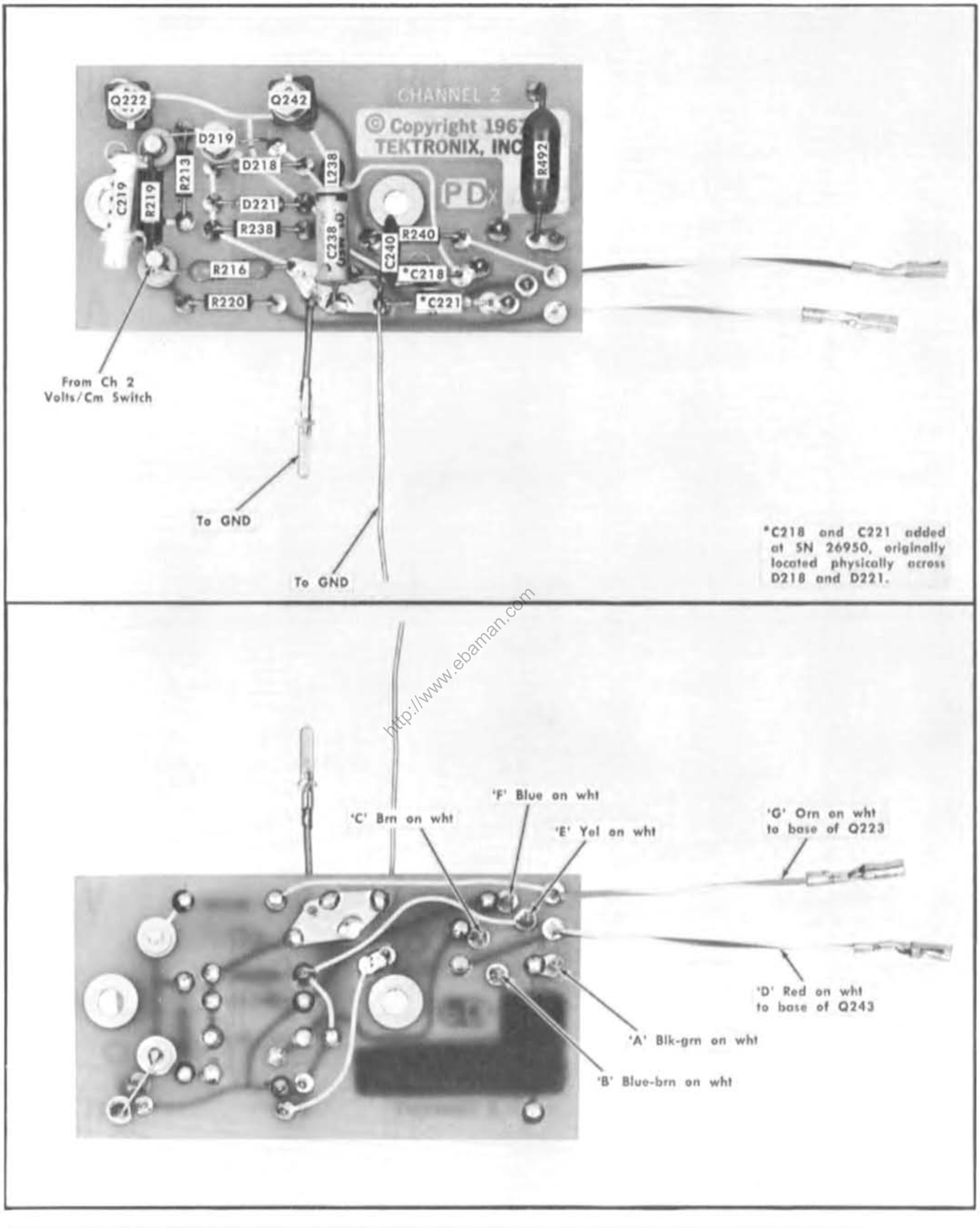


Fig. 5-10. Channel 2 Input FET board. Front and back view showing parts location and lead connections.

SECTION 6
PERFORMANCE CHECK

Change information, if any, affecting this section can be found at the rear of the manual.

Introduction

This performance check is provided to check the operation of the Type 1A1 without removing the side or bottom covers from the oscilloscope. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

Failure to meet the characteristics given in this procedure indicates that the unit requires internal checks and/or adjustments. See the Calibration section of this Instruction Manual.

TEST EQUIPMENT AND ACCESSORIES

General

The following equipment (items 1 through 4) is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate performance check, use the accessories (items 5 through 4) described in this list. The calibration fixtures that have a Tektronix part number are available from Tektronix, Inc. Order by description and part number from your local Tektronix Field Office or representative.

Test Equipment

1. Calibrated Type 544, 546, 547, or 556 Oscilloscope. For use with the Type 1A1 Plug-In Unit being checked: NOTE: The Type 547 was used when preparing this procedure.

2. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude 20 mV to 100 V; output signal, 1-kHz square wave. Tektronix calibration fixture No. 067-0502-00 recommended.

3. Square-wave generator. Frequency, 2.5 kHz and 100 kHz; risetime, 20 ns or faster from the high-amplitude output; 1 ns or faster from the fast-rise output. High-amplitude output; variable from 0.5 V to 12 V into a 50-ohm load, about 7 V to 120 V with no external load. Fast-rise output: variable from 50 mV to 500 mV into a 50-ohm load. Tektronix Type 106 Square-Wave Generator recommended.

4. Constant amplitude sine-wave generator. Frequency, 50 kHz, and 50 MHz; output amplitude, 20 mV to 300 mV peak to peak into a 50-ohm load. Amplitude accuracy within ±3% at 50 MHz using the amplitude at 50 kHz for a reference. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

Accessories

5. Input capacitance normalizer. Time constant, 1 megohm × 15 pF; attenuator 2×; connectors, BNC. Tektronix Part No. 067-0537-00.

6. In-line termination. Impedance, 50 ohm; accuracy, within ±3%; connectors, GR input with BNC male output. Tektronix Part No. 017-0083-00. (Supplied with items 3 and 4).

7. 10× attenuator. Impedance, 50 ohms; accuracy, within ±3%; connectors, GR-Type. Tektronix Part No. 017-0079-00.

8. Adapter, GR to BNC male. Tektronix Part No. 017-0064-00.

9. BNC T connector. Tektronix Part No. 103-0030-00.

10. Coaxial cable. Impedance, 50 ohms; Type RG8/213; length, five nanoseconds; connectors, GR874. Tektronix Part No. 017-0502-00. Supplied with items 3 and 4.

11. Coaxial cable. Impedance, 50 ohms; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-01.

12. Coaxial cable. Impedance, 50 ohms; length 18 inches; connectors, BNC. Tektronix Part No. 012-0076-00.

13. Patch cord. Red; BNC male connector on one end, banana plug on other end; 18 inches long. Tektronix Part No. 012-0091-00.

14. Small screwdriver with a 1/8 inch wide tip to fit screwdriver-adjust potentiometers.

PERFORMANCE CHECK PROCEDURE

General

In the following procedure, test equipment connections or control settings should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information.

The following procedure used the equipment listed under Recommended Equipment and Calibration Fixtures. If substitute equipment and accessories are used, control settings or setup must be altered to meet the requirements of the equipment used.

Preliminary Procedure

Insert the Type 1A1 into the test oscilloscope. Connect the power cord of the oscilloscope to the proper operating voltage and turn on the power switch. Allow a 15-minute warm-up time before proceeding with the performance check to allow the unit to stabilize. Preset the front-panel controls as follows:

Control Settings

Type 547 Oscilloscope[4]

Horizontal Display	B
Sweep Magnifier	×1 Off
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated
Brightness[5] (547)	Fully clockwise
Horizontal Position	Midrange
Vernier[5] (Horizontal Position)	Midrange
CRT Cathode Selector[5]	CRT Cathode
Amplitude Calibrator	Off

Type 1A1

MODE	CH 1
POSITION (both channels)	Midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	.005
INPUT SELECTOR (both channels)	GND

1. Check .005 V/CM and .05 V/CM DC Balance

a. Requirement—Equal to or less than 1-cm trace shift as the VARIABLE (V/CM) control is rotated through its range. Adjusted for no trace shift.

b. Set the oscilloscope Intensity control for normal trace brightness. Adjust the Astigmatism and Focus controls to obtain a well defined trace. (If trace is not on screen go to step 1d).

[4]The Type 547 Main Time Base B front-panel controls are used throughout this procedure.

[5]Not included in subsequent lists of control settings.

NOTE

From this point on in the Performance Check procedure, use the Intensity, Focus, and Astigmatism controls as needed to obtain sharply focused trace of the desired intensity. Time-Base controls are used unless otherwise specified.

c. CHECK—Rotate Channel 1 VARIABLE through its range and check for trace shift.

d. If there is a trace shift or the trace is not on the screen, adjust the .005 V/CM VAR ATTEN BAL to meet the desired requirement.

e. Position the trace to start at left side of graticule.

f. Set the V/CM switch to .05.

g. CHECK—Rotate Channel 1 VARIABLE through its range and check for trace shift.

h. Return the V/CM switch to .005 and the VARIABLE (V/CM) to CALIB position.

i. Set the MODE switch to CH 2. Repeat this check on Channel 2.

2. Check Normal-Invert DC Balance

a. Requirement—Trace shift should be less than 1 cm when the PULL FOR INVERT switch is actuated.

b. Using the Channel 2 POSITION control, position the trace to graticule center.

c. Pull the front-panel Channel 2 PULL FOR INVERT knob to its outward position.

d. CHECK—Trace should be located within 1 cm or less of graticule center.

e. Push the Channel 2 PULL FOR INVERT knob to its inward position.

f. Change the MODE switch to CH 1.

g. Repeat this check on Channel 1.

3. Check Gate Current (Q122 and Q222)

a. Requirement—1 nA or less gate current.

b. Connect a 50 Ω termination to INPUT 1 BNC connector.

c. Using the Channel 1 POSITION control, position the trace to graticule center.

d. Change the Channel 1 INPUT SELECTOR to AC.

e. CHECK—That the trace shift does not exceed 2 mm.

f. Move the 50 Ω termination to INPUT 2 BNC connector and set the MODE switch to CH 2.

g. Repeat steps 3c through 3e substituting Channel 2 controls for Channel 1 controls.

h. Remove the 50 Ω termination and set both INPUT SELECTOR switches to GND position.

4. Check Alternate Mode Operation

a. Requirement—Proper alternation of channels and trace slaving to the Type 547 Oscilloscope time bases.

b. Set the MODE switch to ALT, then position Channel 1 trace 1 cm above the graticule centerline, and Channel 2 trace 1 cm below the graticule centerline by means of the POSITION controls.

c. CHECK—The sequence of alternation one step at a time for all settings of the Time Base B Time/Cm switch. (The Intensity control for the test oscilloscope will have to be adjusted as the sweep rate is changed, brighter for the faster sweep rates and reduced for the slow rates.)

d. Set the Time Base Time/Cm switch to 10 μs.

NOTE

Perform the remainder of Step 4 only if the Type 1A1 is used in conjunction with an oscilloscope which has provisions for alternate slave operation (e.g., Type 547).

e. Requirement—Two trace display. Channel 1 slaved to Time Base A and Channel 2 slaved to Time Base B.

f. Set the Type 547 oscilloscope controls as follows:

Time Base controls

A Time/Cm	.5 mSEC
B Time/Cm	10 μSec

A Triggering controls

Set the same as B Triggering controls.

Other controls

Horizontal Display	A/ALT/B
Intensity	Both traces visible

NOTE

With the Time Base controls set as above, the dimmer trace identifies Time Base B due to its faster sweep rate setting.

g. CHECK—Rotate the Channel 1 POSITION control. This should change the position of Time Base A trace. Rotate the Channel 2 POSITION control. This should change the position of Time Base B trace.

h. Set the Time Base B Time/Cm switch to .1 Sec and check for alternate trace.

i. Set Time Base B Time/Cm switch to .5 μSec and the Horizontal Display switch to B.

5. Check Chopped Mode Blanking

a. Requirement—Blanking of between-channel switching transients.

b. Set controls as follows:

Type 1A1

MODE	CHOP

Type 547 Oscilloscope

Triggering Level	Near 0 and knob pushed in
Time/Cm	.5 μSec
Horizontal Display	B

c. Using the Type 1A1 POSITION controls, position Channel 1 segmented trace about 1.0 cm above graticule center. Position the trace for the other channel about 1.0 cm below the graticule center. Use the oscilloscope Triggering Level control to obtain a stable display (See Fig. 6-1A).

d. CHECK—That the display is set for normal viewing intensity. Set the oscilloscope CRT Cathode Selector switch to the Chopped Blanking position.

e. Switch transients between channels should be blanked out (see Fig. 6-1B).

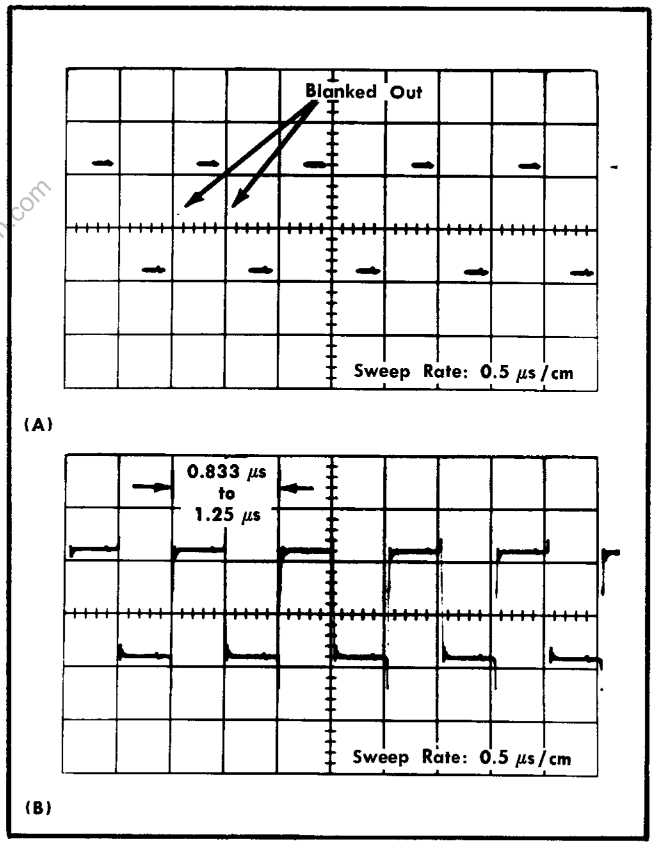


Fig. 6-1. (A) Blanked chopped-mode waveform; and (B) unblanked chopped-mode waveform.

f. Change the Time Base B Time/Cm switch to .2 μs and check the waveform distortion. It must have a flat top with no more than 2 mm of slope. (Disregard wrinkles that may be on the flat top.) Return the CRT Cathode Selector switch to CRT Cathode position and the Time Base B Time/Cm switch to .5 μs.

6. Check Chopped Mode Repetition Rate

a. Requirement—Chopped mode repetition rate, 1 MHz, ± 20%.

b. CHECK—The time duration of one cycle should be 0.833 μs to 1.25 μs (See Fig. 6-1B).

7. Check Front Panel Gain Adjustment

a. Requirement—Vertical deflection within ±3% of VOLTS/CM switch indication.

b. Set the controls as follows:

Type 1A1

INPUT SELECTOR (both channels)	DC
MODE	CH 1
VOLTS/CM (both channels)	.05

Type 547 Oscilloscope

Triggering Level	Fully clockwise and knob pushed in
Time/Cm	.5 mSec

Standard Amplitude Calibrator

Amplitude	.2 Volts
Mode	Square Wave
Mixed	Up
× 100 Amplifier	Not Applicable
Power	On

c. Connect the .2-Volt signal from the Standard Amplitude Calibrator output connector through a 42-inch 50-ohm cable to the Type 1A1 Channel 1 Input connector.

d. Use the Channel 1 POSITION control to center the display.

e. CHECK—CRT display for exactly 4 cm of vertical deflection (see Fig. 6-2).

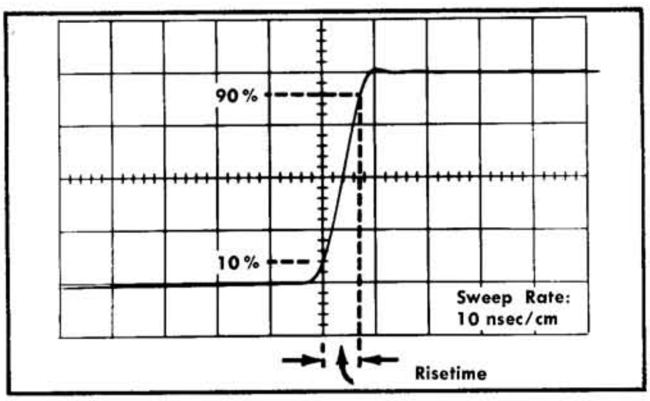


Fig. 6-2. Typical display showing correct gain adjustment.

f. If necessary, adjust the front-panel V/CM GAIN adjustment for exactly 4 cm of deflection.

g. Turn the MODE switch to CH 2 and apply the Standard Amplitude Calibrator signal to Channel 2 INPUT.

h. Repeat the above procedure for Channel 2.

8. Check Variable Volts/Cm Range

a. Requirement—At least 2.5:1 reduction in deflection when VARIABLE control is set fully counterclockwise.

b. Rotate the Channel 2 VARIABLE VOLTS/CM control to its fully counterclockwise position and note the vertical deflection amplitude.

c. Rotate the Channel 2 VARIABLE VOLTS/CM control in a clockwise direction until maximum deflection is obtained. Note the amplitude.

d. CHECK—The smaller amplitude noted in (b) divided into the larger amplitude obtained in (c) will be the attenuation ratio. Ratio must be no less than 2.5:1.

e. Return the VARIABLE VOLTS/CM control to the CALIB position.

f. Set the MODE switch to Channel 1 and apply the Standard Amplitude Calibrator signal to Channel 1 INPUT.

g. Repeat the above procedure to check Channel 1 VARIABLE VOLTS/CM control.

9. Check Volts/Cm Deflection Accuracy

a. Requirement—Vertical deflection within ±3% of VOLTS/CM switch indication.

b. Check both VARIABLE VOLTS/CM controls to insure they are in the CALIB detent.

c. CHECK—The attenuator accuracy by means of Table 6-1.

TABLE 6-1

Attenuator Accuracy Check

Type 1A1 VOLTS/CM Switch	Standard Amplitude Calibrator	Display Amplitude in Centimeters	Allowable Error in Millimeters
.005	20 m Volts	4	1.2
.01	50 m Volts	5	1.5
.02	.1 Volts	5	1.5
.05	.2 Volts	4	0.0 (Was adjusted during step 7.)
.1	.5 Volts	5	1.5
.2	1 Volt	5	1.5
.5	2 Volts	4	1.2
1	5 Volts	5	1.5
2	10 Volts	5	1.5
5	20 Volts	4	1.2
10	50 Volts	5	1.5
20	100 Volts	5	1.5

(Adjust the channel POSITION control to position the waveform for most accurate measurements).

d. Return the Standard Amplitude Calibrator output signal to 20 mVolts and connect its output signal to Channel 2 INPUT connector.

e. Set the MODE switch to CH 2 and repeat the check for Channel 2 VOLTS/CM attenuator.

10. Check AC Coupling

a. Requirement—DC-coupled displayed waveform should shift to its average AC level when the AC-GND-DC switch is set from DC to AC.

b. Apply a 0.1-volt signal from the Standard Amplitude Calibrator to Channel 2 INPUT.

c. Set both VOLTS/CM switches to .05.

d. Position the bottom portion of the 2-cm display to the centerline of the graticule by means of the Channel 2 POSITION control.

e. Switch the Channel 2 INPUT SELECTOR switch from DC to AC and note the shift of the display.

f. CHECK—The waveform should shift downward about one cm to its average voltage level.

g. Return the INPUT SELECTOR switch to DC and change the PULL FOR INVERT switch to invert.

h. Repeat the procedure to check the trace shift when the INPUT SELECTOR is changed from DC to AC. The trace should shift up about 1 cm. Amount of shift depends on symmetry of calibrator signal.

i. Return the PULL FOR INVERT switch to normal and the INPUT SELECTOR switch to GND. Display should now appear as a straight line.

j. Return the Channel 2 INPUT SELECTOR switch to DC.

k. Connect the Standard Amplitude Calibrator to Channel 1 INPUT connector.

l. Set the MODE SWITCH to CH 1 and repeat the above procedure to check the INPUT SELECTOR switch for Channel 2.

11. Check Added Operation and Common Mode Rejection

a. Requirement—The accuracy of added mode operation is within ±3%. Common mode rejection is 20:1.

b. Remove the 50-ohm coaxial cable from Channel 1 INPUT and install a BNC T connector to the Channel 1 INPUT.

c. Connect the Channel 2 INPUT connector through a 50 Ω coaxial cable to one side of the T connector and the Standard Amplitude Calibrator to the other branch of the BNC T connector.

d. Set the MODE switch to ADD.

e. CHECK—With both VOLTS/CM switches set at .05 and the Standard Amplitude Calibrator output at 0.1 volt, the display amplitude must be 4 cm, ±1.2 mm.

f. Change Channel 1 (or Channel 2) PULL FOR INVERT switch to invert.

g. Set the output of the Standard Amplitude Calibrator to 1 volt.

h. CHECK—Display amplitude should be 0.5 cm (20:1 ratio) or less.

i. Set the Standard Amplitude Calibrator output to 20 mVolts.

j. Remove the BNC T connector. Disconnect the coaxial cable from the Channel 2 INPUT connector. Use the remaining coaxial cable to connect the Standard Amplitude Calibrator signal to the Channel 1 INPUT connector.

k. Set the MODE switch to CH 1. Return the PULL FOR INVERT switch used in step f to the normal position.

12. Check Channel 1 Trigger Out Amplifier Gain

a. Requirement—Trigger Out Amplifier gain of 10 (±20%).

b. Set the Type 1A1 MODE switch to CH 2.

c. Set Channel 2 INPUT SELECTOR switch to AC.

d. Check that the Standard Amplitude Calibrator is set to 20 mVolts.

e. Connect a 50-ohm coaxial cable from the CH 1 TRIGGER OUT connector to the Channel 2 INPUT connector.

f. CHECK—The amplitude of the display should be 3.2 to 4.8 cm (gain of 10 ±20%).

NOTE

When the VOLTS/CM switch of Channel 1 is set to .005 the gain is then 100.

13. Check Channel 1 Signal Out Amplifier

a. Requirement—Channel 1 Signal Out Amplifier gain of 1 (±10%).

b. Move the coaxial cable from the CH 1 TRIGGER OUT connector to the CH 1 SIGNAL OUT connector.

c. Set the Standard Amplitude Calibrator for 0.2 volts output.

d. CHECK—The display amplitude should be 4 cm (±10%).

e. Disconnect the Standard Amplitude Calibrator signal and remove the coaxial cable from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector. Turn off the Standard Amplitude Calibrator and disconnect the coaxial cables.

NOTE

When the VOLTS/CM switch on Channel 1 and Channel 2 are set to .005 the Channel 1 Signal Out Amplifier gain is then 10 (±10%).

14. Check Input Capacitance Normalization and Attenuator Compensation

a. Requirement—Optimum response to a square wave. Rolloff or overshoot on the front corner should be no more than 3%.

b. Set the equipment controls as follows:

Type 1A1

MODE	CH 1
INPUT SELECTOR (both channels)	DC
VOLTS/CM (both channels)	.05
VARIABLE (VOLTS/CM) (both channels)	CALIB

Type 106 Square-Wave Generator

MODE	CH 1
INPUT SELECTOR (both channels)	DC
VOLTS/CM (both channels)	.05
VARIABLE VOLTS/CM) (both channels)	CALIB

Type 106 Square-Wave Generator

Repetition Rate Range	1 kHz
Multiplier	2.5
Symmetry	Midrange
Amplitude	Fully CCW
Hi Amplitude Fast Rise switch	Hi Amplitude
Fast Rise controls	Not Applicable
Power	On

c. Apply a 2.5 kHz signal from the Type 106 Square Wave Generator through a 10× attenuator, a 5 ns cable, a 50-ohm termination, and a 15-pF input capacitance normalizer to the Channel 1 INPUT connector.

d. Adjust the output of the Square Wave Generator for a 4 cm display.

e. Center the display with the Channel 1 POSITION control.

f. Check that the Time Base B Time/Cm switch is set to .5 mSec. Adjust the Time Base B Triggering Level control for a stable display.

g. CHECK—The attenuator compensation for rolloff or overshoot at all settings of the Channel 1 VOLTS/CM switch (See Fig. 6-3). Use .5 ms and .1 ms sweep rates to examine the waveform. (Adjust the output of the generator to maintain a 4 cm display except for the 20 VOLTS/CM switch position where the generator dirve is limited to about 3 cm. Refer to Table 6-2 for accessory use in checking compensation).

h. Rolloff or overshoot should not exceed ±3% (0.9 mm on a 3 cm display).

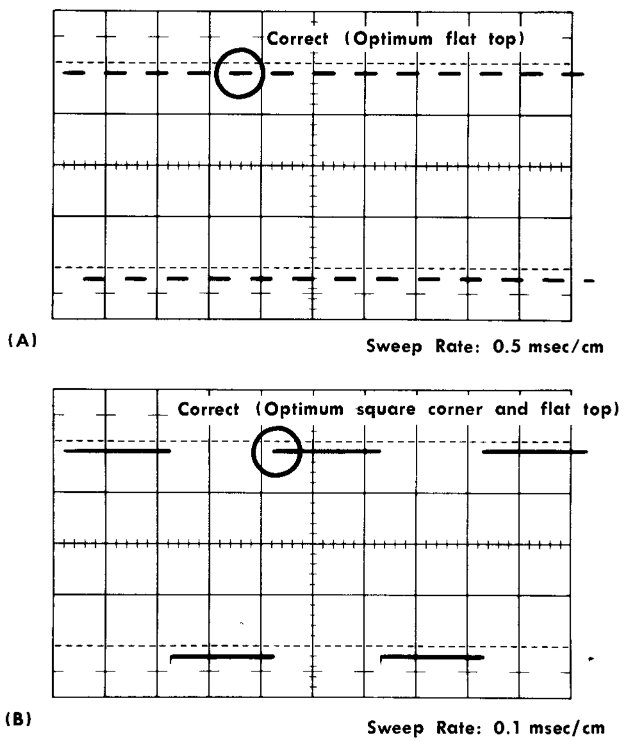


Fig. 6-3. Waveforms of a properly compensated attenuator.

i. Set the Type 106 for minimum output amplitude and disconnect the signal.

j. Apply the Type 106 signal through the 10× attenuator, 5-ns cable, 50-ohm in-line termination and 15-pF input capacitance normalizer to the Channel 2 INPUT connector.

k. Set the MODE switch to CH 2. Check that the Channel 2 VOLTS/CM switch is set to .05 and repeat this procedure to check Channel 2 input capacitance and attenuator compensation.

l. Reduce the output amplitude of the Type 106 to minimum and disconnect the signal.

TABLE 6-2

Accessory Use in Checking Attenuator Compensation

VOLTS/CM Switch Setting	Use 10× Atten	Use 50 Ω Term	Use GR-to-BNC Adapter	Use RC Norm
.05	X	X		X
.1	X	X		X
.2		X		X
.5		X		X
1		X		X
2			X	X
5			X	X
10			X	X
20			X	X

15. Check High-Frequency Compensation at .05 volts/cm (Both Channels)

a. Requirement—Optimum response to a fast-rise square-wave. Waveform must be flat with no more than 4% roll-off or overshoot.

b. Set the equipment controls as follows:

Control Settings

Type 1A1

MODE	CH 2
POSITION (both channels)	Near Midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE (VOLTS/CM)	CALIB
VOLTS/CM (both channels)	.05
INPUT SELECTOR (both channels)	DC

Type 547 Oscilloscope

Time/Cm	5 μSec

Type 106 Square-Wave Generator

Repetition Rate Range	100 kHz
Multiplier	1
Symmetry	Midrange
Amplitude	Not applicable
Hi Amplitude Fast Rise switch	Fast Rise
+ Transition Amplitude	Near minimum
— Transition Amplitude	Not applicable

c. Apply the 100 kHz fast-rise signal from the +Output connector on the Type 106 through a 5-ns cable and 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector.

d. Set the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. Set the Symmetry control to obtain a symmetrical waveform and, if necessary, adjust the Multiplier control to obtain the 100 kHz output repetition rate. Use the Type 1A1 Channel 1 POSITION control to center the display.

e. Set the oscilloscope Time/Cm switch to .1 μSec.

f. Use the oscilloscope Horizontal Position and Type 1A1 Channel 1 POSITION controls to move the waveform near the location shown in Fig. 6-4.

g. CHECK—Channel 1 CRT display for optimum square corner (see Fig. 6-4A). Ringing, rounding, overshoot and tilt should not be more than 1.6 mm (or 4%) peak to peak when a 4-cm positive-going square wave is displayed.

h. Disconnect the signal from Channel 1 INPUT connector and connect the signal to the Channel 2 INPUT connector. Set the MODE switch to CH 2.

i. CHECK—Channel 2 CRT display for optimum square corner ((see Fig. 6-4B). Ringing, rounding, overshoot and

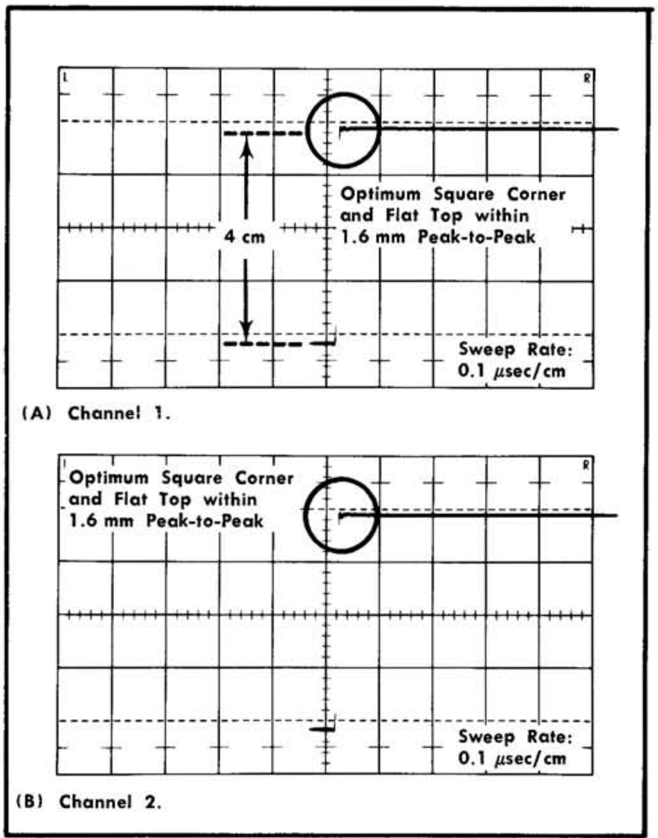


Fig. 6-4. Typical Channel 1 and Channel 2 waveforms of high-frequency response at a vertical deflection factor of 0.05 volts/cm.

tilt should not exceed 1.6 mm (or 4%) peak to peak for 4-cm amplitude display.

j. Set the MODE switch to CH 1 and connect the Type 106 Generator to the Channel 1 INPUT connector.

16. Check High-Frequency Compensation at .005 Volts/Cm (Both Channels)

a. Insert a 10× attenuator between the Type 106 +Output connector and the 5-ns cable. Set the Type 1A1 Channel 1 VOLTS/CM switch to .005.

b. If necessary, set the Type 106 +Transition Amplitude control to obtain a 4-cm display. Check that the waveform is positioned near the location shown in Fig. 6-5a.

c. CHECK—Channel 1 CRT display for optimum square corner (see Fig. 6-5A). Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm amplitude display.

d. Disconnect the signal from the Channel 1 INPUT connector.

e. Set the MODE switch to CH 2 and the Channel 2 VOLTS/CM switch to .005.

f. Check that the waveform is 4 cm in amplitude and positioned to the same location as described for the previous channel.

g. CHECK—Channel 2 CRT display for optimum square corner (see Fig. 6-5B). Ringing, rounding, overshoot and tilt

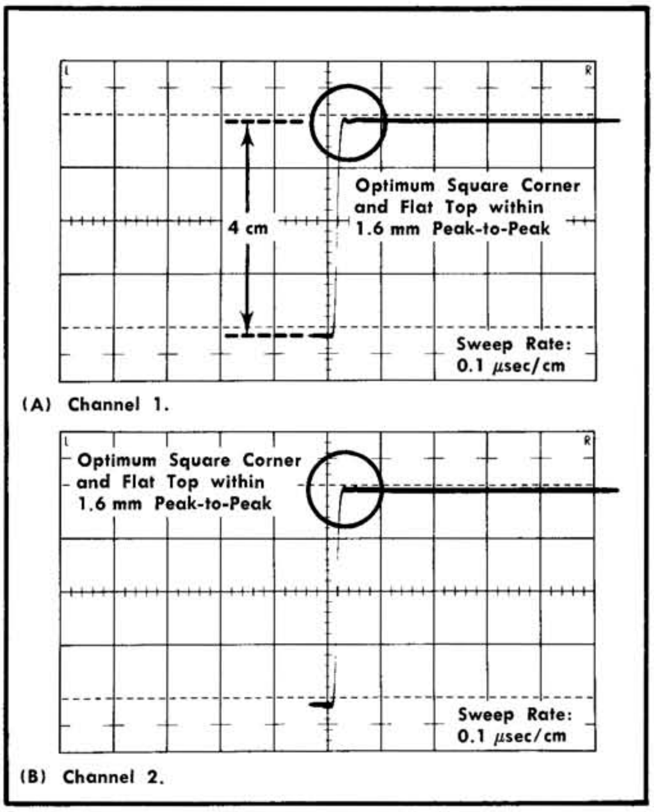


Fig. 6-5. Typical Channel 1 and Channel 2 waveforms of high-frequency response at a vertical deflection factor of 0.005 volts/cm.

should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm amplitude display.

h. Remove the 10× attenuator. Apply the 100 kHz fast-rise signal from the +Output connector on the Type 106 through the 5-ns cable and 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector.

17. Check Trigger Out Amplifier Risetime

a. Requirement—Risetime of the Trigger Out Amplifier waveform not to exceed 70-ns.

b. Set Channel 1 VOLTS/CM switch to .05, Channel 2 VOLTS/CM switch to .5, and the Channel 2 INPUT SELECTOR switch to AC.

c. Connect a 50-ohm coaxial cable from the CH 1 TRIGGER OUT connector to the CH 2 INPUT connector.

d. Check that the MODE switch is set to CH 2. Set the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. Use the Channel 2 POSITION control to center the display. Set the oscilloscope Sweep Magnifier switch to ×5.

e. CHECK—Risetime of the trigger out waveform must be equal to or less than 70-ns (see Fig. 6-6).

f. Disconnect the Type 106 signal from the Channel 1 and turn off the generator. Remove the 50-ohm coaxial cable from the CH 1 TRIGGER OUT and Channel 2 INPUT connectors.

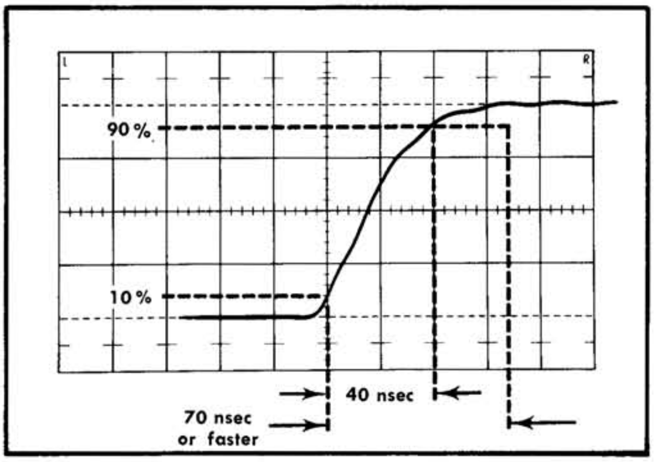


Fig. 6-6. Measuring the ristime of the CH 1 TRIGGER OUT waveform. Risetime should be 70 ns or less; waveform shown above has a risetime of 40 ns.. Sweep rate: 20 nsec/cm.

18. Check Upper Bandwidth Limit (Both Channels)

a. Requirement—50 MHz or greater at the 3 dB down point. (See Table 6-3 if oscilloscope is not a Type 547.)

b. Set the equipment controls as follows:

Type 1A1

MODE	CH 1
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	.05
INPUT SELECTOR (channel 2)	DC

Type 547

B Time/cm	.5 mSec
Sweep Magnifier	×1 Off
Triggering Level	Fully clockwise
Horizontal Position	Trace positioned to start at left of graticule line

Type 191 Constant Amplitude Signal Generator

Frequency dial	45 MHz
Frequency Range	50 kHz Only
Amplitude	20
Variable	Cal
Amplitude Range	50-500 mV
Power	On

c. Apply the 50-kHz reference signal from the Type 191 Output connector through a 5-ns cable and a 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector.

TABLE 6-3

Type 1A1 Bandwidth[1] and Risetime[2]

(Load Impedance: 50 ohms)

System (Instrument Types)	√ VOLTS/CM Switch Positions				
	.005		.05		
	Bandwidth	Risetime	Bandwidth	Risetime	
544, 546, 547, 556	Dc to 28 MHz	12.5 ns	DC to 50 MHz	7 ns	
581, 581A, 585, 585A	DC to 28 MHz	12.5 ns	DC to 50 MHz	7 ns	Using Type 81A Adapter
581, 581A, 585, 585A	DC to 23 MHz	15 ns	DC to 33 MHz	10.5 ns	Using Type 81A Adapter
541A, 543B, 545B	DC to 23 MHz	15 ns	DC to 33 MHz	10.5 ns	
551, 555	DC to 21 MHz	16.5 ns	DC to 27 MHz	13 ns	
531A, 533A, 535A	DC to 14 MHz	25 ns	DC to 15 MHz	23 ns	
536	DC to 10.5 MHz	33 ns	DC to 11 MHz	31 ns	

[1]Upper bandwidth measured at the 3 dB down point

[2]Risetime calculated from this formula: $\text{Risetime} = \frac{.35}{\text{*Frequency}}$

*Use upper bandwidth limit stated for the system.

d. Adjust the Type 191 Variable controls so the display is exactly 4 cm in amplitude. This is the reference amplitude (see Fig. 6-7A).

e. Set the Type 191 Frequency Range switch to 42-100.

f. Without changing the Type 191 output amplitude, increase the output frequency until the vertical deflection is reduced to 2.8 cm (see Fig. 6-7B). This is the 30% down voltage point (equivalent to —3 dB).

g. CHECK—Channel 1 upper bandwidth limit at a vertical deflection factor of 0.05 volts/cm should be 50 MHz or higher.

NOTE

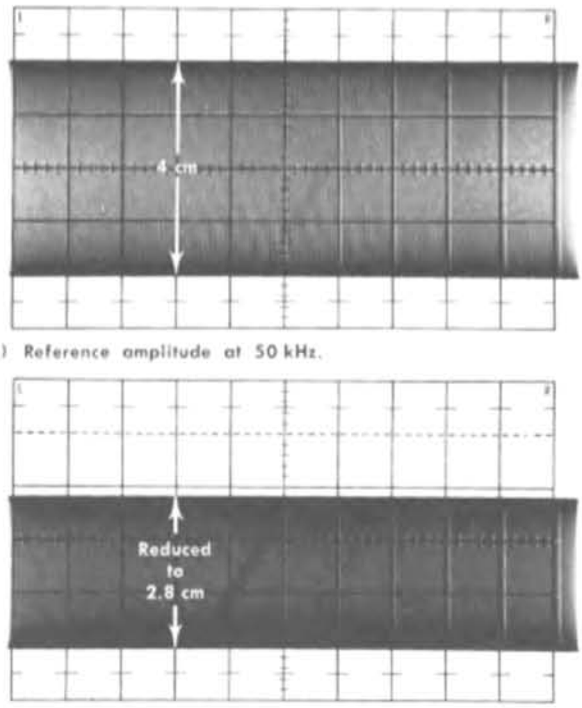
If the 3 dB down point is slightly less than 50 MHz consider that the accuracy of the Type 191 is within ±2% of the selected frequency, within ±4% of indicated amplitude using the 0.5-5 V range and ±5% of indicated amplitude using the 5-50 mV range into a 50-ohm ±1% termination. In addition, consider that the high-frequency response of the oscilloscope vertical amplifier must meet its requirements.

NOTE

Risetime may be calculated using the formula given below Table 6-3.

h. Set the Type 191 Frequency dial to 45 MHz and the Frequency Range switch to 50 kHz Only.

i. Disconnect the signal from the Channel 1 INPUT connector and connect it to the Channel 2 INPUT connector.



(A) Reference amplitude at 50 kHz.

(B) Upper bandwidth limit 3-dB down point.

Fig. 6-7. Typical CRT displays obtained when checking the upper bandwidth limit. Sweep rate: 0.5 msec/cm free running.

j. Set the MODE switch to CH 2.

k. CHECK—Using steps 18d through 18g as a guide, check Channel 2 upper bandwidth for a limit of 50 MHz or higher.

l. Set the Type 191 Frequency dial to 25 MHz, and the Frequency Range switch to 50 kHz ONLY, and the Amplitude Range switch to 5-50 mV.

m. Set the Channel 2 VOLTS/CM switch to .005.

n. If necessary, adjust the Type 191 Variable controls so the display is exactly 4 cm in amplitude. This is the reference amplitude (see Fig. 6-7A).

o. Set the Type 191 Frequency Range switch to 18-42.

p. Without changing the Type 191 output amplitude, increase the output frequency until the vertical deflection is reduced to 2.8 cm (see Fig. 6-7B).

q. CHECK—Channel 2 upper bandwidth limit at a vertical deflection factor of 0.005 volts/cm should be 28 MHz or higher.

r. Disconnect the signal from the Channel 2 INPUT connector and connect it to the Channel 1 INPUT connector.

s. Set the MODE switch to CH 1 and set the Channel 1 VOLTS/CM switch to .005.

t. Set the Type 191 Frequency dial to 25 MHz and the Frequency Range switch to 50 kHz ONLY.

u. CHECK—Using steps 18n through 18q as a guide, check Channel 1 upper bandwidth for a limit of 28 MHz or higher.

19. Check Upper Bandwidth Limit of Channel 1 Signal Out Amplifier

a. Requirement—Upper bandwidth limit should be equal to or greater than 35 MHz at the 3 dB down point.

b. Set the controls as follows:

Type 1A1

MODE	CH 2
INPUT SELECTOR (channel 2)	AC
VOLTS/CM (both channels)	.05

Type 191

Frequency dial	35 MHz
Frequency Range	50 kHz ONLY
Amplitude	20
Amplitude Range	50-500 mV

c. Connect an 18-inch 50-ohm cable from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector.

d. Adjust the Type 191 Amplitude controls so the display is exactly 4 cm in amplitude.

e. Disconnect the end of the 18-inch cable that connects to Channel 2 INPUT connector.

f. Disconnect the signal from the Channel 1 INPUT connector and connect it to the Channel 2 INPUT connector. Note the exact amount of vertical deflection.

g. Set the Type 191 Frequency Range switch to 18-42. Check that the Frequency dial is set to 35 MHz.

h. Adjust the Type 191 Amplitude controls to obtain the same vertical deflection as that noted in step 18f.

i. Disconnect the signal from the Channel 2 INPUT connector and reconnect it to the Channel 1 INPUT connector.

j. Reconnect the 18-inch cable to the Channel 2 INPUT connector. Check that the signal is applied from the CH 1 SIGNAL OUT connector to Channel 2.

k. CHECK—The CRT display should be 2.8 cm in amplitude or more. This indicates the upper bandwidth limit for the Channel 1 Signal Out Amplifier is 35 MHz or higher.

NOTE

Steps 19f through 19h in the procedure use a technique that eliminates Channel 2 and the oscilloscope as factors when determining the upper bandwidth limit for the Signal Out Amplifier alone.

l. Disconnect the signal from the Channel 1 INPUT connector and turn off the Type 191 Constant Amplitude Signal Generator. Remove the coaxial cable from CH 1 SIGNAL OUT connector to Channel 2 INPUT connector.

20. Check—AC Coupled Low Frequency Response

a. REQUIREMENT—The —3 dB response point is less than 2 hertz.

b. Set both Channel 1 and 2 VOLTS/CM switches to 5, INPUT SELECTORS to AC, and the MODE switch to CH 1.

c. Set the Time Base B Time/Cm switch to .1 sec and turn the Time Base B Triggering Level control fully clockwise.

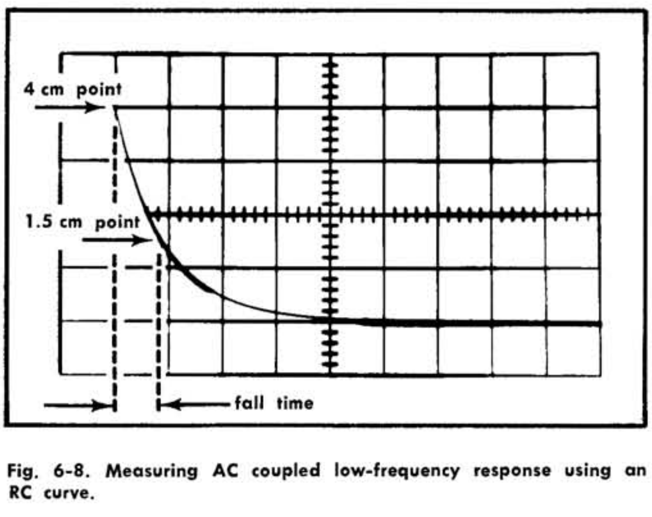


Fig. 6-8. Measuring AC coupled low-frequency response using an RC curve.

d. Connect a patch cord between Channel 1 INPUT and the Time Base B + Gate Out connector.

e. Turn the test oscilloscope Intensity control counterclockwise to reduce the intensity to normal brilliance to avoid burning the CRT. The display obtained should be a falling RC curve as shown in Fig. 6-8.

f. Adjust the Channel 1 VARIABLE VOLTS/CM control for a display amplitude of 4 cm.

g. Position the display to the center of the graticule area and measure the time it takes the waveform to fall from 4 cm to 1.5 cm (see Fig. 6-8). It should be more time than 0.008 sec (less than 2 hertz).

h. Change the patch cord to Channel 2 INPUT and set the MODE switch to CH 2.

i. Repeat the procedure to check the Channel 2 low-frequency response.

j. Remove the patch cord. This completes the performance checkout procedure for the Type 1A1 Dual-Trace Plug-In Unit. If the instrument has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

SECTION 7
CALIBRATION

Change information, if any, affecting this section can be found at the rear of the manual.

Introduction

Complete calibration information for the Type 1A1 is given in this section. This procedure calibrates the unit to the performance requirements listed in the Characteristcis section. The Type 1A1 can be returned to original performance standards by completion of each step in this procedure. If it is desired to merely touch up the calibration, perform only those steps entitled "Adjust . . . . ". A short-form calibration procedure is also provided in this section for the convenience of the experienced calibrator.

Type 1A1 should be checked, and recalibrated if necessary, after each 500 hours of operation, or every six months if used infrequently, to ensure correct operation and accuracy. The Performance Check section of this manual provides a complete check of instrument performance without making internal adjustments. Use the performance check procedure to verify the calibration of the Type 1A1 and determine if recalibration is required.

TEST EQUIPMENT, ACCESSORIES AND TOOLS

General

The following test equipment (items 1 through 4; see Fig. 7-1) or its equivalent, is required for complete calibration of the Type 1A1. Specifications given are the minimum necessary for accurate calibration of this unit. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted it must meet or exceed the specifications of the recommended equipment.

Items 5 through 15 are the accessories that are used in this procedure. All accessories except item 13 have a Tektronix part number and can be ordered through your local Tektronix Field Office or representative. Item 13 is a standard item that can be purchased locally.

Test Equipment

1. Calibrated Type 544, 546, 547 or 556 Oscilloscope. For use with the Type 1A1 Plug-In Unit being calibrated. NOTE: The Type 547 was used when performing this procedure.

2. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude 20 mV to 100 V; output signal, 1-kHz square wave. Tektronix calibration fixture No. 067-0502-00 recommended.

3. Square-wave generator. Frequency 2.5 kHz and 100 kHz; risetime, 20 ns or faster from high-amplitude; 1 ns or faster from fast-rise output. High-amplitude output: variable from 0.5 V to 12 V into a 50-ohm load, about 7 V to 120 V with no external load. Fast-rise output: variable from 50 mV to 500 mV into a 50-ohm load. Tektronix Type 106 Square-Wave Generator recommended.

4. Constant amplitude sine-wave generator. Frequency 50 kHz, 28 MHz, 35 MHz, and 50 MHz; output amplitude, 20 mV to 200 mV into a 50-ohm load. Amplitude accuracy, within ±3% at 28 MHz, 35 MHz, and 50 MHz using the amplitude at 50 kHz for a reference. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

Accessories

5. Input capacitance normalizer. Time constant, 1 megohm × 15 pF; attenuator 2×; connectors, BNC. Tektronix Part No. 067-0537-00.

6. In-line termination. Impedance, 50 ohm; accuracy, within ±3%; connectors, GR input with BNC male output. Tektronix Part No. 017-0083-00. (Supplied with items 3 and 4).

7. 10× attenuator. Impedance, 50 ohms; accuracy, within ±3%; connectors, GR-Type. Tektronix Part No. 017-0078-00.

8. Adapter, GR to BNC male. Tektronix Part No. 017-0064-00.

9. BNC T connector. Tektronix Part No. 103-0030-00.

10. Coaxial cable. Impedance, 50 ohms; Type RG8/213; length, five nanoseconds; connectors, GR874. Tektronix Part No. 017-0502-00. Supplied with items 3 and 4.

11. Coaxial cable. Impedance, 50 ohms; length, 42 inches; connectors, BNC. Tektronix Part No. 012-0057-01.

12. Coaxial cable. Impedance, 50 ohms; length, 18 inches; connectors, BNC. Tektronix Part No. 012-0076-00.

Adjustment Tools

13. Small screwdriver with a 1/8-inch wide tip to fit screwdriver-adjust potentiometers.

14. Insulated low-capacitance screwdriver, Jaco No. 125, 1 1/2-inch shank. 1/8-inch wide metal tip. Tektronix Part No. 003-0000-00.

15. Low-capacitance alignment tool consisting of a handle (Part No. 003-0307-00), a 5/64-inch hexagonal wrench insert (Part No. 003-0310-00) and a nylon insert with a wire pin (Part No. 003-0308-00).

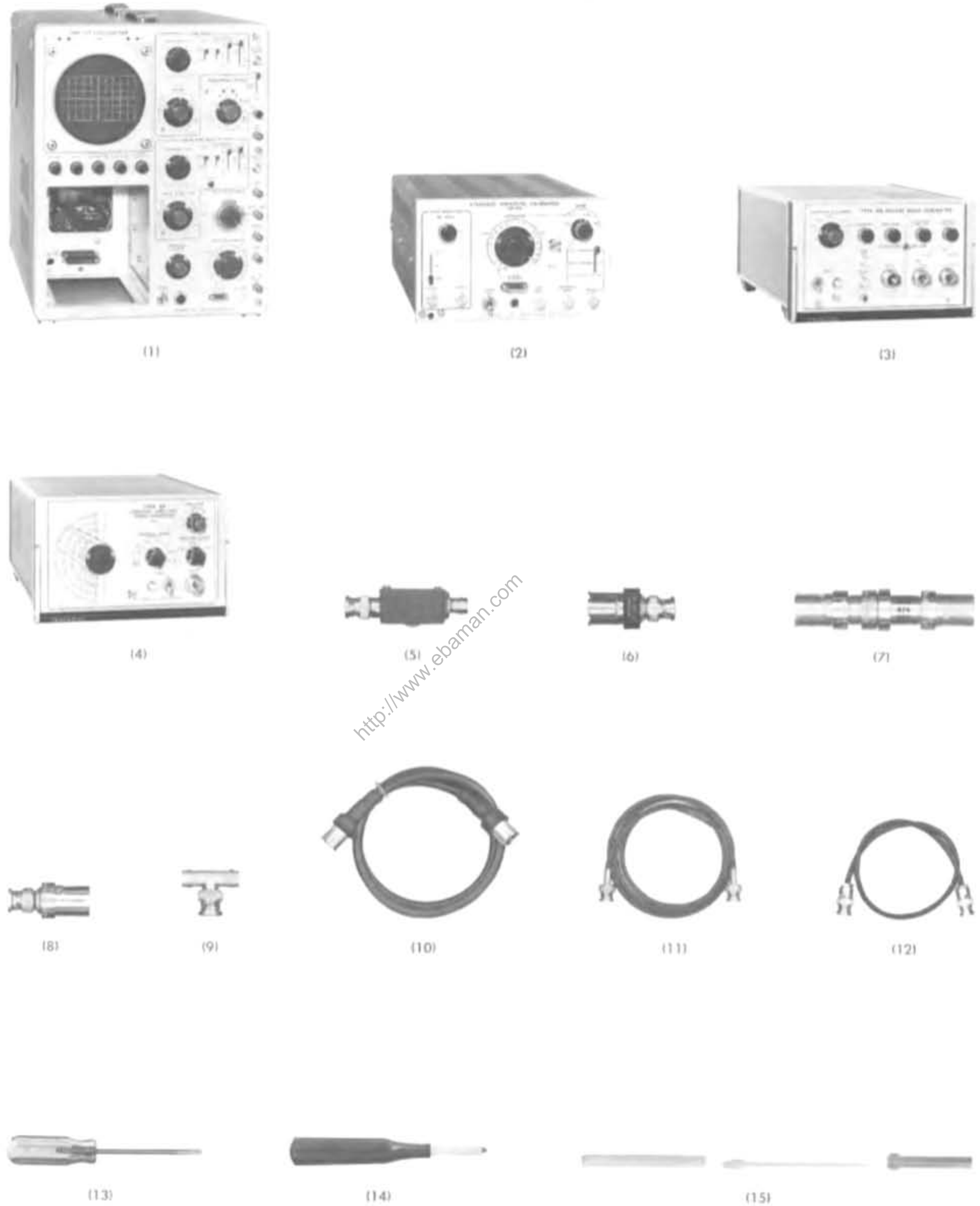


Fig. 7-1. Test equipment, accessories and tools recommended for complete calibration of the Type 1A1.

CALIBRATION RECORD AND INDEX

This short-form calibration procedure is provided to aid in checking the operation of the Type 1A1. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristics section.

Type 1A1, Serial No. ______________________

Calibration Date ______________________

Calibration Technician ______________________

☐ 1. Adjust Channel 1 .005 V/CM VAR ATTEN BAL (R130) (page 7-6)

No trace shift as VARIABLE VOLTS/CM is rotated.

☐ 2. Adjust Channel 1 .05 VOLTS DC BAL (R148) (page 7-7)

Trace must coincide with graticule center line.

☐ 3. Adjust Channel 2 .005 V/CM VAR ATTEN BAL (R230) (page 7-7)

No trace shift as VARIABLE VOLTS/CM is rotated.

☐ 4. Adjust Channel 2 .05 VOLTS DC BAL (R248) (page 7-8)

Trace must coincide with graticule centerline.

☐ 5. Adjust Channel 2 .05 V/CM GAIN (R439) (page 7-9)

4 cm high display with 200 mV peak-to-peak calibrator signal.

☐ 6. Check Channel 2 VARIABLE VOLTS/CM control (page 7-10)

Control must be able to attenuate the display by 2.5 times, when rotated to its fully counterclockwise position.

☐ 7. Adjust Channel 1 .05 V/CM GAIN (R409) (page 7-10)

4 cm high display with 200 mV peak-to-peak calibrator signal.

☐ 8. Check Channel 1 VARIABLE VOLTS/CM control (page 7-10)

Control must be able to attenuate the display by 2.5 times, when rotated to its fully counterclockwise position.

☐ 9. Adjust Channel 1 .005 V/CM GAIN (R128A) (page 7-11)

4 cm high display with 20 mV peak-to-peak calibrator signal.

☐ 10. Adjust Channel 2 .005 V/CM GAIN (R228A) (page 7-11)

4 cm high display with 20 mV peak-to-peak calibrator signal.

☐ 11. Check Gate Current for Channel 2 (page 7-12)

Trace shift should not exceed 2 mm as INPUT SELECTOR switch is changed from GND to AC.

☐ 12. Check Gate Current for Channel 1 (page 7-12)

Trace Shift should not exceed 2 mm as INPUT SELECTOR switch is changed from GND to AC.

☐ 13. Adjust Channel 1 INV BAL (R152) (page 7-13)

No trace shift as PULL FOR INVERT switch is changed from normal to invert.

☐ 14. Adjust Channel 2 INV BAL (R252) (page 7-13)

No trace shift as PULL FOR INVERT switch is changed from normal to invert.

☐ 15. Check Chopped-Mode Operation (page 7-13)

Repetition rate of waveform should be 1 MHz ±20%. Switching transients of waveform must be blanked out (become dim) when oscilloscope CRT Cathode Selector is set to Chopped Blanking and trace thickness of waveform is 2 mm or less at normal display brightness.

☐ 16. Check Alternate-Mode Operation (page 7-14)

Alternating two trace display at all sweep rates.

☐ 17. Check Add Mode Operation (page 7-16)

A 2 cm display for each channel must produce a 4 cm high display when MODE switch is set to ADD.

☐ 18. Check Channel 1 Signal Out Amplifier Gain (page 7-18)

Gain of 10 times ±10%.

☐ 19. Check Channel 1 Trigger Out Amplifier Gain (page 7-19)

Gain of 100 times ±20%.

☐ 20. Check VOLTS/CM Attenuation Ratios (Both Channels) (page 7-20)

VOLTS/CM Switch Setting	Standard Amplitude Calibrator Output (peak to peak)	Vertical Deflection in Centimeters
.005	20 mVolts	4[1]
.01	50 mVolts	5
.02	.1 Volt	5
.05	.2 Volt	4[1]
.1	.5 Volt	5
.2	1 Volt	5
.5	2 Volts	4
1	10 Volts	5
2	20 Volts	4
5	20 Volts	4
10	50 Volts	5
20	100 Volts	5

[1]This switch position has been previously adjusted.

☐ 21. Adjust Input Capacitance and Attenuator (page 7-22) Compensation (Both Channels)

	Channel 1		Channel 2	
VOLTS/CM Switch Setting	Input Shunt Capacitor	[3]Frequency Compen-sating Capacitor	[2]Input Shunt Capacitor	[3]Frequency Compen-sating Capacitor
.05	C104	None	C204	None
.1	C105B	C105C	C205B	C205C
.2	C106B	C106C	C206B	C206C
.5	C107B	C107C	C207B	C207C
1	C108B	C108C	C208B	C208C
2	C109B	C109C	C209B	C209C
5	C110B	C110C	C210B	C210C
10	C111B	C111C	C211B	C211C
20	C112B	C112C	C212B	C212C

[2]Use a 0.5 ms/cm sweep rate and adjust for optimum flat top.

[3]Use a 0.1 ms/cm sweep rate and adjust for optimum leading corner (minimum fast rolloff or spike).

☐ 22. Adjust High-Frequency Compensation at (page 7-25) .05 Volts/Cm (Both Channels)

Adjust high frequency compensation controls for optimum response to a square wave. Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm display.

☐ 23. Adjust High-Frequency Compensation at (page 7-27) .005 Volts/Cm (Both Channels)

Adjust C129D in Channel 1 and C229D in Channel 2 for optimum response to a square wave. Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or ±4%) peak to peak for a 4-cm display.

☐ 24. Check Upper Bandwidth Limit (Both (page 7-29) Channels)

With VOLTS/CM switches set to .05: 50 MHz or higher at the 3 dB down point.

With VOLTS/CM switches set to .005: 28 MHz or higher at the 3 dB down point.

☐ 25. Check Upper Bandwidth Limit of Chan- (page 7-30) nel 1 Signal Out Amplifier

35 MHz or higher at the 3 dB point. Channel 1 VOLTS/CM switch set to .05.

☐ 26. Check Channel 1 Trigger Out Amplifier (page 7-33) Risetime

Risetime should be 70 ns or faster with Channel 1 VOLTS/CM switch set to .05.

CALIBRATION PROCEDURE

General

The following procedure is arranged in a sequence which allows the Type 1A1 to be calibrated with the least interaction of adjustments if the complete procedure is followed. However, if steps out of sequence are performed, some adjustments will affect the calibration of other circuits within the unit. In this case, it will be necessary to check the operation of those circuits that are affected. When a step interacts with others, the steps which need to be checked are noted under "INTERACTION . . . . ".

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using normal troubleshooting techniques.

The steps titled "Adjust . . . . ◐" in the following procedure provide a check of instrument performance, whenever possible, before the adjustment is made. The symbol ◐ is used to identify the steps in which an adjustment is made. To prevent recalibration of other circuits when performing a partial calibration, readjust only if the listed tolerance is not met. However, when performing a complete calibration, best overall performance will be provided if each adjustment is made to the exact setting, even if the "CHECK— . . . . " is within the allowable tolerance.

In the following procedure, a test equipment setup picture is shown for each major group of adjustments and checks. Following each setup picture is a complete list of front-panel control settings for the Type 1A1 and a guide list for setting pertinent controls on the oscilloscope, particularly Time Base and Triggering Controls.

To aid in locating individual controls which have been changed during complete calibration, these control names are printed in BOLD type. If only a partial calibration is performed, start with the nearest setup proceding the desired portion. Type 1A1 front-panel and internal control titles referred to in this procedure are capitalized to match the lettering used in the unit. Any additional clarifying information for the title is usually given in initial capitals; e.g., Channel 1 VOLTS/CM.

The following procedure uses the equipment and fixtures previously listed in this section of the manual. If equipment and fixtures are substituted, control settings or test equipment setup may need to be altered to meet the requirements of the equipment used.

NOTE

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera system. Projected graticules were used. Each major division on the graticule illustrations represents one cm.

Preliminary Procedure

1. Remove the panels from the test oscilloscope to expose the left side and bottom of the vertical plug-in compartment.

2. Lay the oscilloscope on its right side for access to the bottom side of the Type 1A1.

3. Install the Type 1A1 in the oscilloscope vertical plug-in compartment.

4. Connect the power cord of the oscilloscope to the design-center operating voltage for which the oscilloscope is wired.

5. Turn on the oscilloscope and allow 15 minutes for warm up and stabilization. While the oscilloscope is warming up, preset the controls to the position given in the list that precedes step 1.

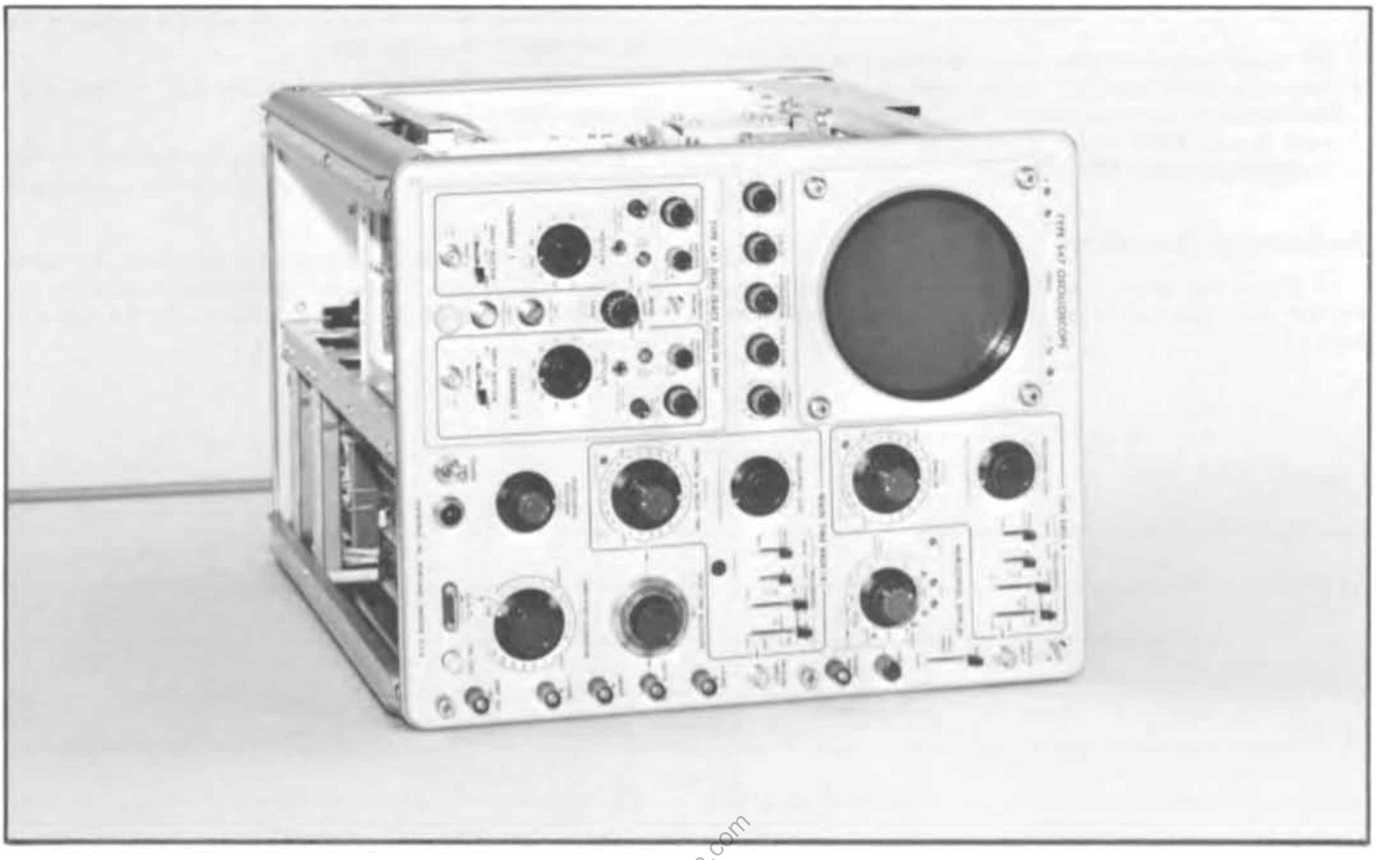


Fig. 7-2. Equipment setup for steps 1 through 4.

Control Settings

Type 547 Oscilloscope[4]

Horizontal Display	B
Sweep Magnifier	× 1 Off
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated
Brightness[5] (547)	Fully clockwise
Horizontal Position	Midrange
Vernier[5] (Horizontal Position)	Midrange
CRT Cathode Selector[5]	CRT Cathode
Amplitude Calibrator	Off

Type 1A1

MODE	CH 1
POSITION (both channels)	Midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	.005
INPUT SELECTOR (both channels)	GND

[4]The Type 547 Main Time Base B front-panel controls are used throughout this procedure.

[5]Not included in subsequent lists of control settings.

1. Adjust Channel 1 .005 V/CM VAR ATTEN BAL (R130)

a. Equipment setup is shown in Fig. 7-2.

b. CHECK—That a free running trace is present near the center of the screen. The trace does not shift as the Channel 1 VARIABLE VOLTS/CM control is rotated back and forth. If the trace is not present and/or trace-shift occurs, adjust the Channel 1 .005 V/CM VAR ATTEN BAL control (see Fig. 7-3) to vertically position the trace onto the screen.

c. ADJUST—Channel 1 .005 V/CM VAR ATTEN BAL control for no trace shift while rotating the Channel 1 VARIABLE VOLTS/CM control back and forth.

d. Using the Channel 1 POSITION control, position the trace to coincide with graticule center. Leave the control at this setting until completing the next step.

e. INTERACTION—Interacts with step 2.

Ⓓ

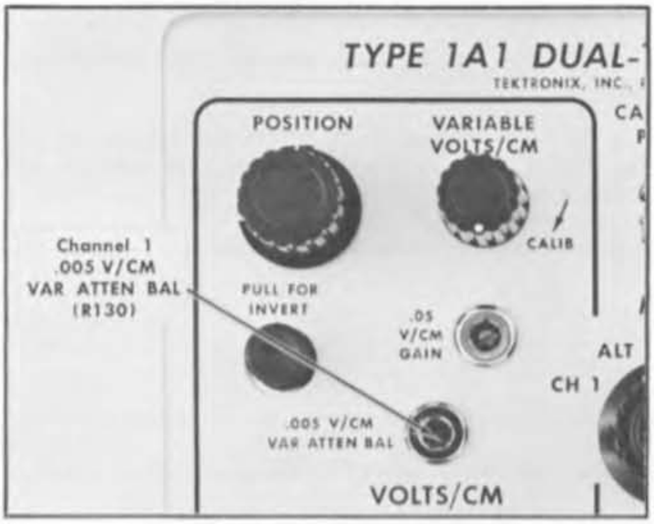


Fig. 7-3. Step 1 adjustment location.

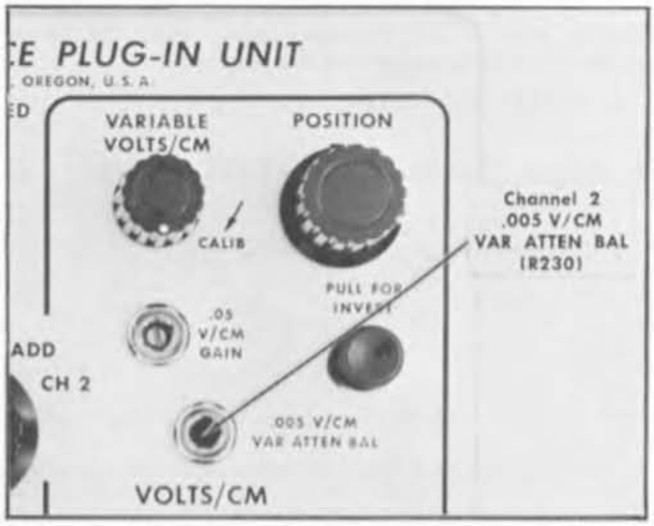


Fig. 7-5. Step 3 adjustment location.

2. Adjust Channel 1 .05 VOLTS DC BAL (R148)

a. Equipment setup is shown in Fig. 7-2.

b. Set the Channel 1 VOLTS/CM switch to .05.

c. CHECK—That the trace coincides with graticule center.

d. ADJUST—Channel 1 .05 VOLTS DC BAL control (see Fig. 7-4) to vertically position the trace to coincide with graticule center.

e. INTERACTION—Interacts with step 1.

3. Adjust Channel 2 .005 V/CM VAR ATTEN (R230)

a. Equipment setup is shown in Fig. 7-2.

b. Set the MODE switch to CH 2.

c. CHECK—That a free-running trace is present near the center of the screen. The trace does not shift as the Channel 2 VARIABLE VOLTS/CM control is rotated back and forth. If the trace is not present and/or trace-shift occurs, adjust the Channel 2 .005 V/CM VAR ATTEN BAL control (see Fig. 7-5) to vertically position the trace onto the screen.

d. ADJUST—Channel 2 .005 V/CM VAR ATTEN BAL control for no trace shift while rotating the Channel 2 VARIABLE VOLTS/CM control back and forth.

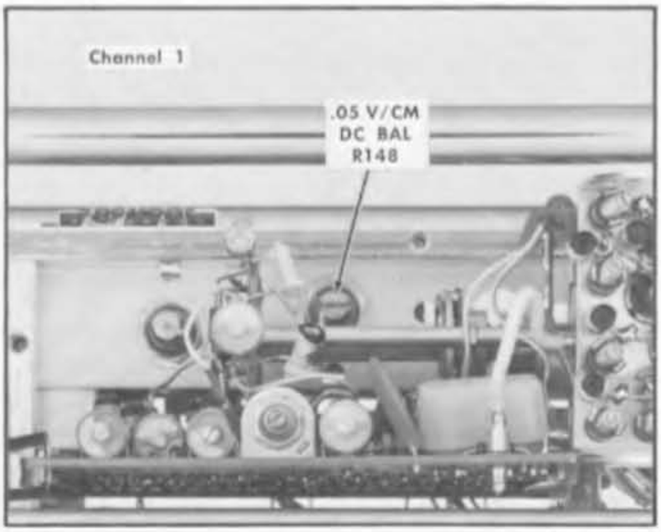


Fig. 7-4. Step 2 adjustment location.

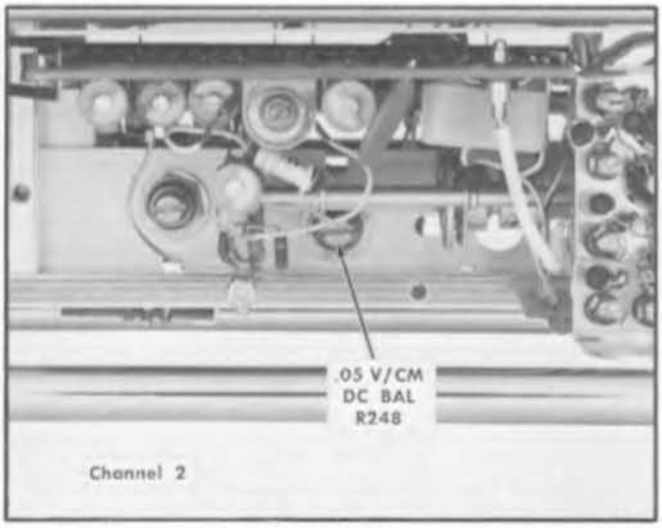


Fig. 7-6. Step 4 adjustment location.

e. Using the Channel 2 POSITION control, position the trace to coincide with graticule center. Leave the control at this setting until completing the next step.

f. INTERACTION—Interacts with step 4.

4. Adjust Channel 2 .05 VOLTS DC BAL (R248)

a. Equipment setup is shown in Fig. 7-2.

b. Set the Channel 2 VOLTS/CM switch to .05.

c. CHECK—That the trace coincides with graticule center.

d. ADJUST—Channel 2 .05 VOLTS DC BAL control (see Fig. 7-6) to vertically position the trace to coincide with graticule center.

e. INTERACTION—Interacts with step 3.

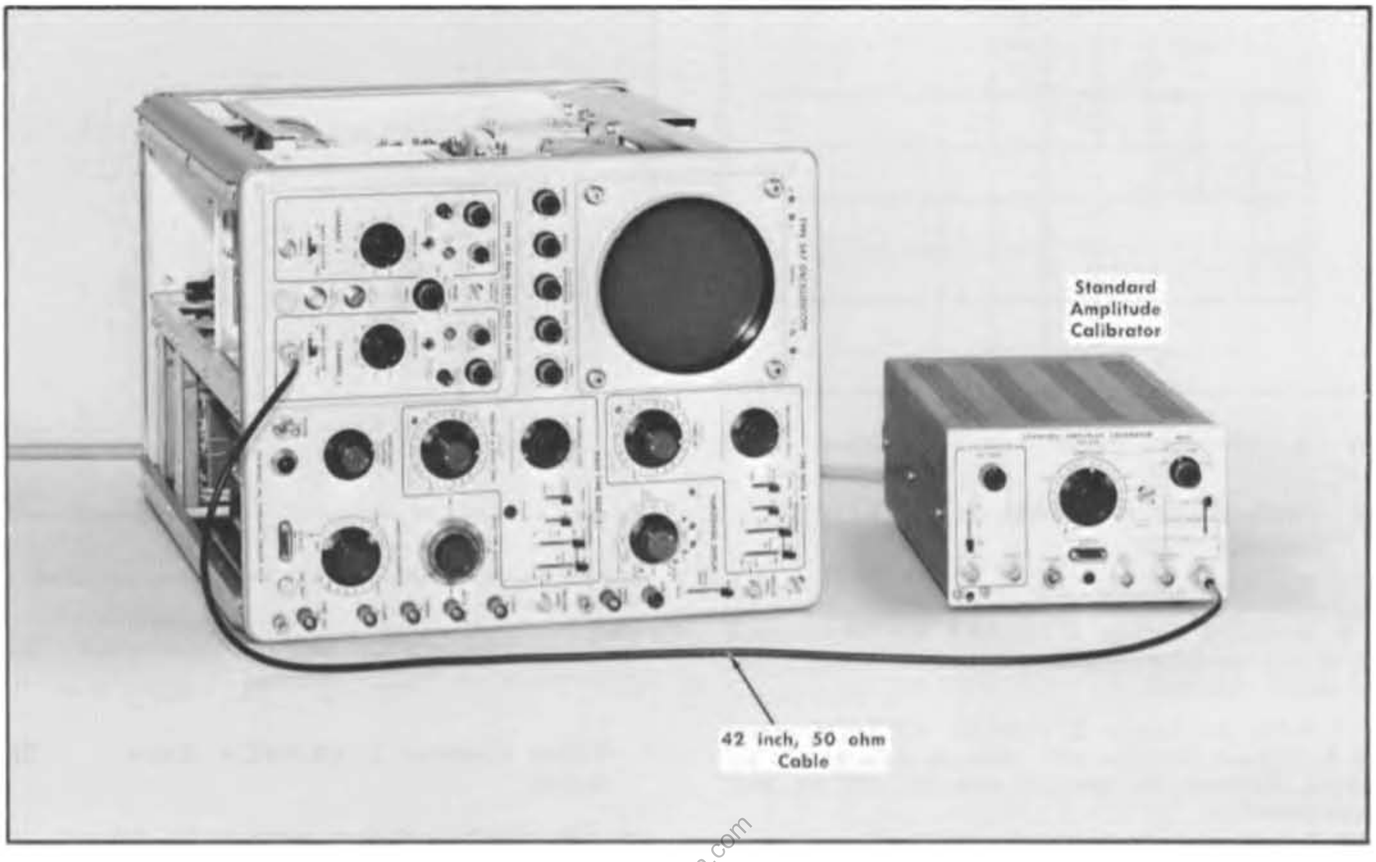


Fig. 7-7. Test equipment setup for steps 5 through 10.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	X1 Off
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line
Amplitude Calibrator	Off

Type 1A1

MODE	CH 2
POSITION (Channel 1)	At or near midrange
POSITION (Channel 2)	Trace positioned to graticule center
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	.05
INPUT SELECTOR (both channels)	DC

Standard Amplitude Calibrator

Amplitude	.2 Volt
Mode	Square Wave
Mixed	Up
X100 Amplifier	Not Applicable
Power	On

5. Adjust Channel 2 .05 V/CM GAIN (R439)

a. Test equipment setup, with connections made at completion of step 5b, is shown in Fig. 7-7.

b. Apply a 200-mV peak-to-peak signal from the Standard Amplitude Calibrator Output connector through a 50-ohm coaxial cable to the Channel 2 INPUT connector.

c. Using the Channel 2 POSITION control, center the free-running display in the graticule viewing area.

d. CHECK—For a display 4 cm in amplitude (see Fig. 7-8).

e. ADJUST—Channel 2 .05 V/CM GAIN control (see Fig. 7-9 for a vertical deflection of exactly 4 cm.

f. INTERACTION—Interacts with step 10.

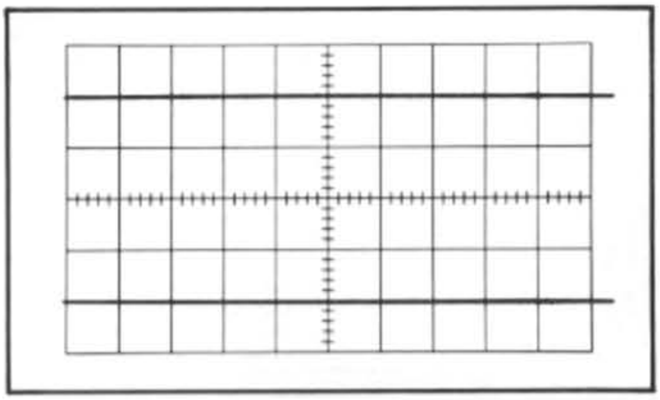


Fig. 7-8. Typical display showing correct gain adjustment.

6. Check Channel 2 VARIABLE VOLTS/CM Control

a. Test equipment setup is shown in Fig. 7-7.

b. Rotate the Channel 2 VARIABLE VOLTS/CM control to its fully counterclockwise position and note the amplitude of vertical deflection.

c. Rotate the Channel 2 VARIABLE VOLTS/CM control in a clockwise direction until maximum deflection is obtained. Compare the maximum deflection with the minimum deflection.

d. CHECK—That the ratio is at least 2.5:1. For example, if the maximum deflection is 4.6 cm and minimum is 1.8 cm, then, 4.6 divided by 1.8 is a ratio of 2.55:1.

e. Rotate the control from the 4-cm deflection amplitude to minimum and check for smooth electrical operation.

NOTE

If rotation of the VARIABLE VOLTS/CM control through the minimum to 4-cm amplitude range causes erratic jumping of the trace, replace the control.

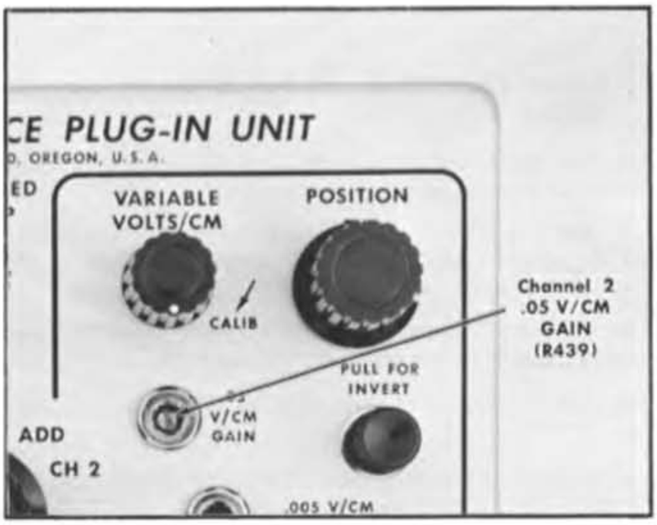


Fig. 7-9. Location of Channel 2 .05 V/CM GAIN adjustment.

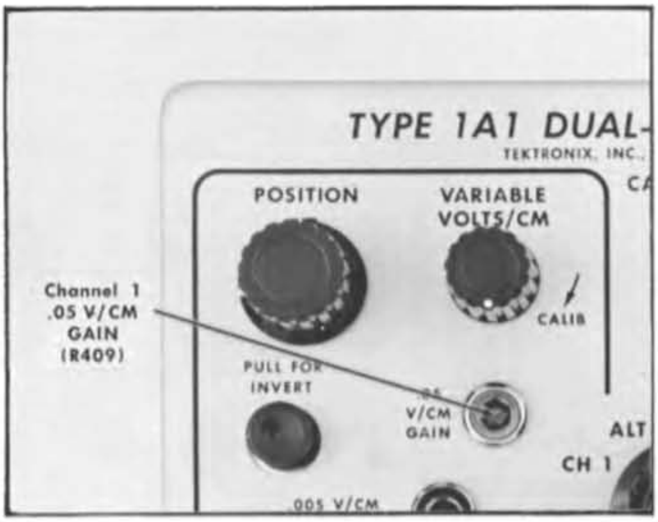


Fig. 7-10. Location of Channel 1 .05 V/CM GAIN adjustment.

f. Set the Channel 2 VARIABLE VOLTS/CM control to the CALIB position.

7. Adjust Channel 1 .05 V/CM GAIN (R409)

a. Test equipment setup is shown in Fig. 7-7.

b. Apply the 200 mV peak-to-peak calibrator signal to the Channel 1 INPUT connector.

c. Set the MODE switch to CH 1.

d. Check that the Channel 1 INPUT SELECTOR switch is set to DC, the VARIABLE VOLTS/CM control is set to CALIB.

e. CHECK—That display amplitude is exactly 4 cm (see Fig. 7-8). Use the Channel 1 POSITION control to align the display with the graticule lines for measuring purposes.

f. ADJUST—Channel 1 .05 V/CM GAIN control (see Fig. 7-10) for proper amplitude.

g. INTERACTION—Interacts with step 9.

8. Check Channel 1 VARIABLE VOLTS/CM Control

a. Test equipment setup is shown in Fig. 7-7. This is the same setup as shown except Channel 1 connector and controls are used for this step.

b. Rotate Channel 1 VARIABLE VOLTS/CM control to its fully counterclockwise position and note the amplitude of vertical deflection.

c. Rotate Channel 1 VARIABLE VOLTS/CM control in a clockwise direction until maximum deflection is obtained. Compare the maximum deflection with the minimum deflection.

d. CHECK—That the ratio is at least 2.5:1.

e. Rotate the control from the 4-cm deflection amplitude to minimum and check for smooth electrical operation.

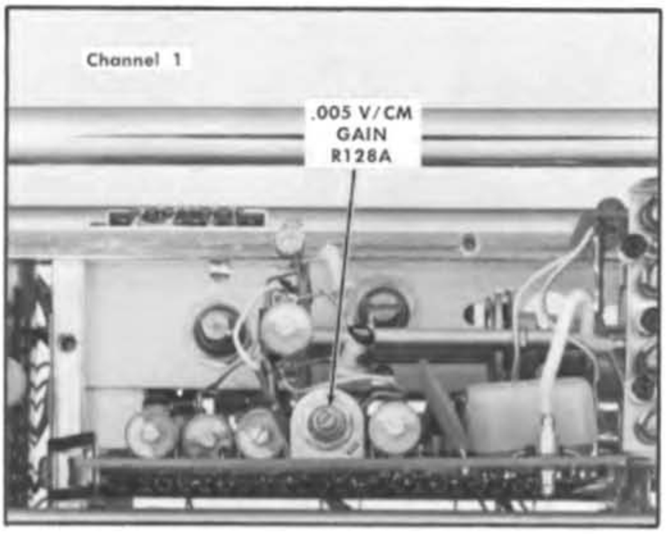


Fig. 7-11. Location of Channel 1 .005 V/CM GAIN adjustment.

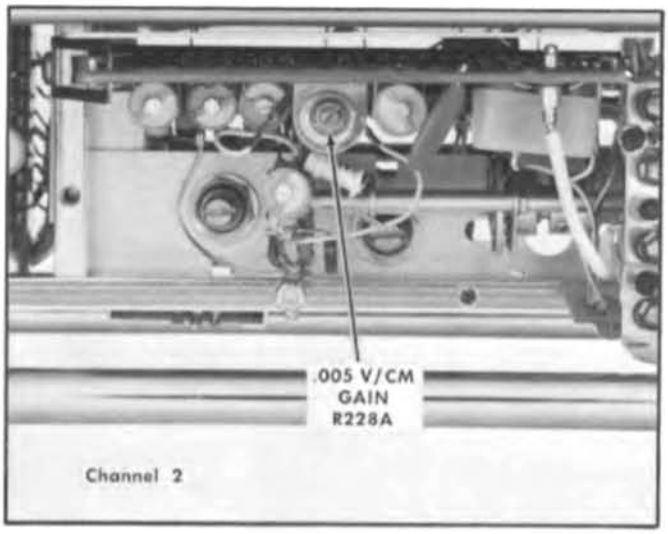


Fig. 7-12. Location of Channel 2 .05 V/CM GAIN adjustment.

NOTE

If rotation of the VARIABLE VOLTS/CM control through the minimum to 4-cm amplitude range causes erratic jumping of the trace, replace the control.

f. Set the Channel 1 VARIABLE VOLTS/CM control to the CALIB position.

9. Adjust Channel 1 .005 V/CM GAIN (R128A)

a. Test equipment setup is shown in Fig. 7-7. (The signal is applied to Channel 1 for this step.)

b. Set the Standard Amplitude Calibrator for an output of 20 mV.

c. Set the Channel 1 VOLTS/CM switch to .005.

d. CHECK—That the display is exactly 4 cm in amplitude (see Fig. 7-8).

e. ADJUST—Channel 1 .005 V/CM Gain control (see Fig. 7-11) to obtain the correct amplitude display.

f. INTERACTION—Interacts with step 7.

10. Adjust Channel 2 .005 V/CM GAIN (R228A)

a. Test equipment setup is shown in Fig. 7-7.

b. Apply the 20-mV calibrator signal to Channel 2 INPUT connector.

c. Set Channel 2 VOLTS/CM switch to .005, and MODE switch to CH 2.

d. CHECK—That the display is exactly 4 cm in amplitude (see Fig. 6-8).

e. ADJUST—Channel 2 .005 V/CM GAIN control (see Fig. 7-12) to obtain a display of correct amplitude.

f. Disconnect the Standard Amplitude Calibrator signal.

g. INTERACTION—Interacts with step 5.

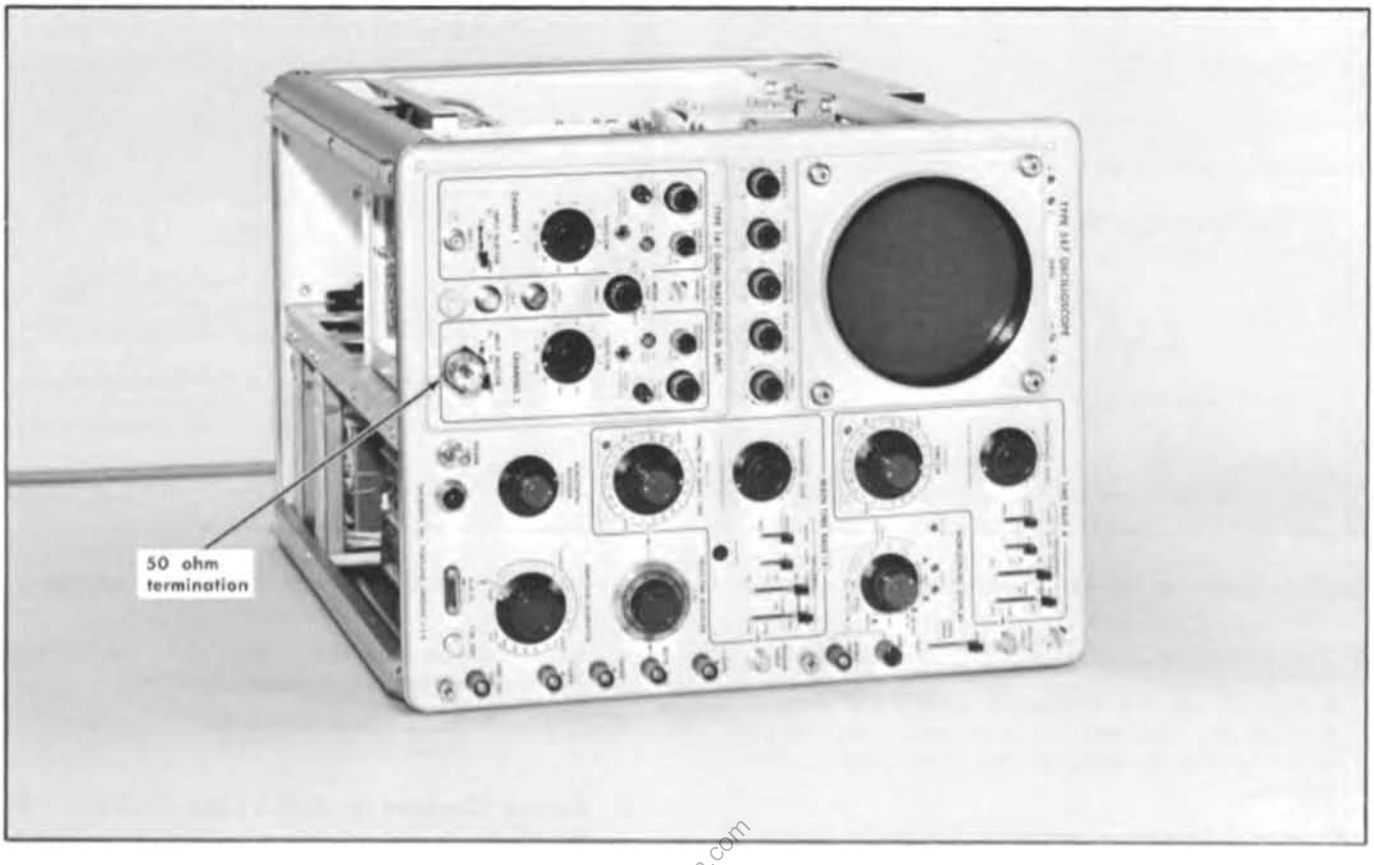


Fig. 7-13. Equipment setup for steps 11 through 16.

Control Settings

TYPE 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	X1 Off
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Trigger Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line
Amplitude Calibrator	Off

Type 1A1

MODE	CH 2
POSITION (Channel 1)	At or near midrange
POSITION (Channel 2)	**Trace positioned to graticule center**
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	**.005**
INPUT SELECTOR (both channels)	**GND**

11. Check Gate Current for Channel 2

a. Equipment setup is shown in Fig. 7-13.

b. Connect a 50-ohm termination to the Channel 2 INPUT connector.

c. Check that the Channel 2 VOLTS/CM switch is set to .005 and the trace is positioned to the horizontal centerline.

d. CHECK—Set the Channel 2 INPUT SELECTOR switch to AC and note the amount of trace shift; should not exceed 2 mm.

12. Check Gate Current for Channel 1

a. Equipment setup is shown in Fig. 7-13.

b. Move the 50-ohm termination from the Channel 2 INPUT connector to the Channel 1 INPUT connector.

c. Set MODE switch to CH 1 and check that the Channel 1 VOLTS/CM switch is set to .005.

d. Position the trace to the horizontal centerline with the Channel 1 POSITION control.

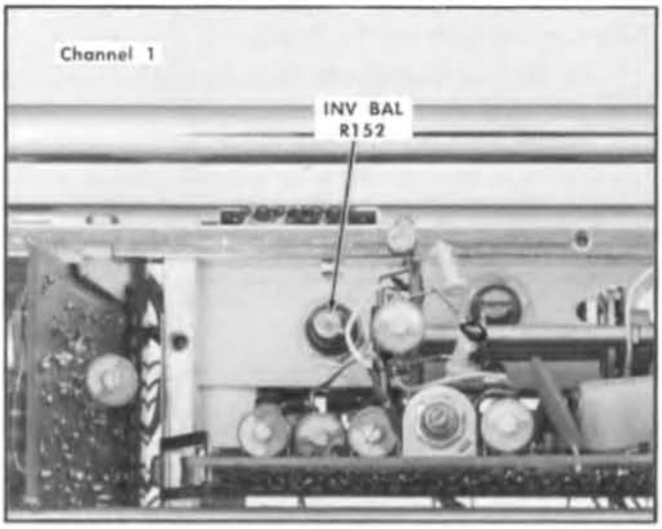


Fig. 7-14. Location of Channel 1 INV BAL adjustment.

e. CHECK—Set the Channel 1 INPUT SELECTOR switch to AC and note the amount of trace shift; should not exceed 2 mm.

f. Disconnect the 50-ohm termination.

13. Adjust Channel 1 INV BAL (R152)

a. Equipment setup is shown in Fig. 7-13. (The 50-ohm termination is not used.)

b. Set Channel 1 INPUT SELECTOR switch to GND and check that the VOLTS/CM switch is set to .005.

c. Check that the trace is positioned to the horizontal centerline. Note the trace position.

d. Set the Channel 1 PULL FOR INVERT switch to invert.

e. CHECK—That there is no trace shift when switching to the invert position. If there is, leave the switch in the invert position.

f. ADJUST—Channel 1 INV BAL control (see Fig. 7-14) to vertically position the trace to the point noted in step c.

NOTE

To check on the accuracy of your adjustment, set Channel 1 PULL FOR INVERT switch to normal. Then repeat steps d and e and readjust, if necessary, the Channel 1 INV BAL control for no trace shift.

h. Set Channel 2 PULL FOR INVERT switch to normal.

i. INTERACTION—Dependent on proper adjustments performed in steps 1 and 2.

14. Adjust Channel 2 INV BAL (R252)

a. Equipment setup is shown in Fig. 7-13. (The 50-ohm termination is not used.)

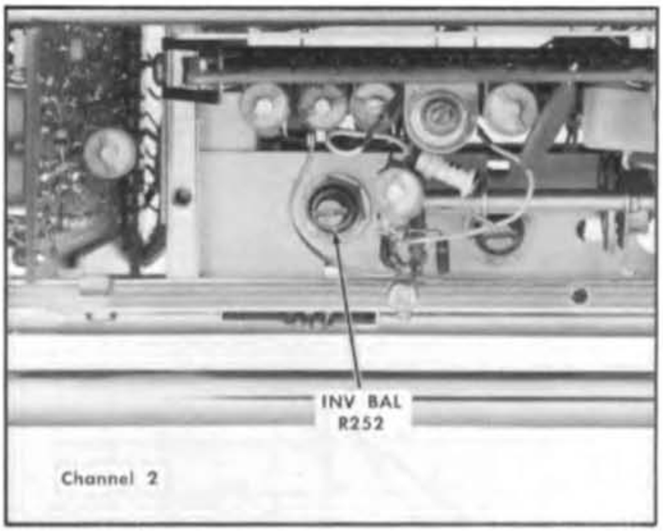


Fig. 7-15. Location of Channel 2 INV BAL adjustment.

b. Set the Channel 2 INPUT SELECTOR switch to GND and the MODE switch to CH 2. Check that the Channel 2 VOLTS/CM switch is set to .005.

c. Check that the trace is positioned to the horizontal centerline. Note the position of the trace.

d. Set the Channel 2 PULL FOR INVERT switch to invert.

e. CHECK—That there is no trace shift when switching to the invert position. If there is, leave the switch in the invert position.

g. ADJUST—Channel 2 INV BAL control (see Fig. 7-15) to vertically position the trace to the point noted in step c.

NOTE

To check on the accuracy of your adjustment, set Channel 2 PULL FOR INVERT switch to normal. Then repeat steps d and e and readjust, if necessary, the Channel 2 INV BAL control for no trace shift.

h. Set Channel 2 PULL FOR INVERT switch to normal.

i. INTERACTION—Dependent on proper adjustments performed in steps 3 and 4.

15. Check Chopped-Mode Operation

a. Equipment setup is shown in Fig. 7-13. (The 50-ohm termination is not used).

b. Set the MODE switch to CHOP. Two free-running traces should be displayed.

c. Check that both VOLTS/CM switches are set to .005 and the INPUT SELECTOR switches are set to GND.

d. Using the Channel 1 and 2 POSITION controls, position the Channel 1 trace above the Channel 2 trace. Separate the traces so they are about two cm apart and the display is centered on the CRT.

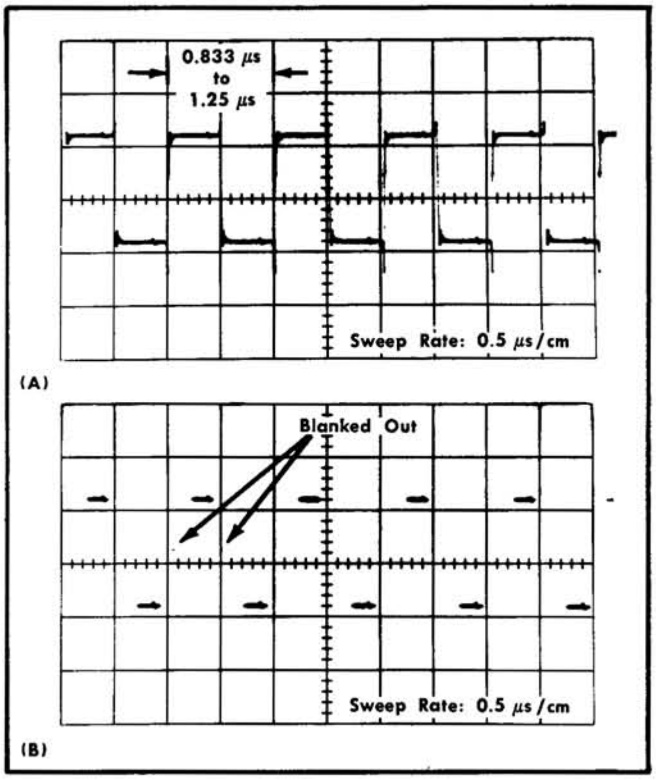


Fig. 7-16. (A) Unblanked chopped-mode waveform; and (B) switching portion of waveform blanked out.

e. Set the oscilloscope Time/Cm switch to 0.5 µsec and adjust the Triggering Level control to obtain a stable display.

f. Horizontally position the display so the display starts near the left side of the graticule.

g. CHECK—The repetition rate of the displayed waveform. The repetition rate should be 1 MHz, within a tolerance of ±20%. This is equal to a time duration of 0.833 µs to 1.25 µs for one cycle (see Fig. 7-16A).

h. Set the oscilloscope CRT Cathode Selector switch to the Chopped Blanking position.

i. CHECK—That the switching portion of the trace from one channel to the next blanks out (becomes dim) at normal intensity. This indicates that the Type 1A1 blanking pulses are blanking the beam during the switching-time interval between channels (see Fig. 7-16B).

j. Set the oscilloscope Time/Cm switch to .1 msec and free run the time base.

k. CHECK—That at normal intensity, the width (thickness) of the traces is about 2 mm or less.

NOTE

If the trace for one channel is too wide because of excessive tilting or distortion of the trace segments, a defective series (Channel 1, D421 or D424; Channel 2, D451 or D454) or shunt (Channel 1, D422 or D423, Channel 2, D452 or D453) diode could cause the trouble.

l. Set the CRT Cathode Selector Switch to the Ext CRT Cathode position.

16. Check Alternate-Mode Operation

a. Set the MODE switch to the ALT position.

b. Check that the oscilloscope Triggering Level control is set fully clockwise to free run the time base.

c. CHECK—For a two-trace display on the CRT.

d. Set the test oscilloscope Time/Cm switch to various sweep rates. At the slower sweep rates check that the traces run alternately across the face of the CRT; at the faster sweep rates check that a two-trace display is obtained.

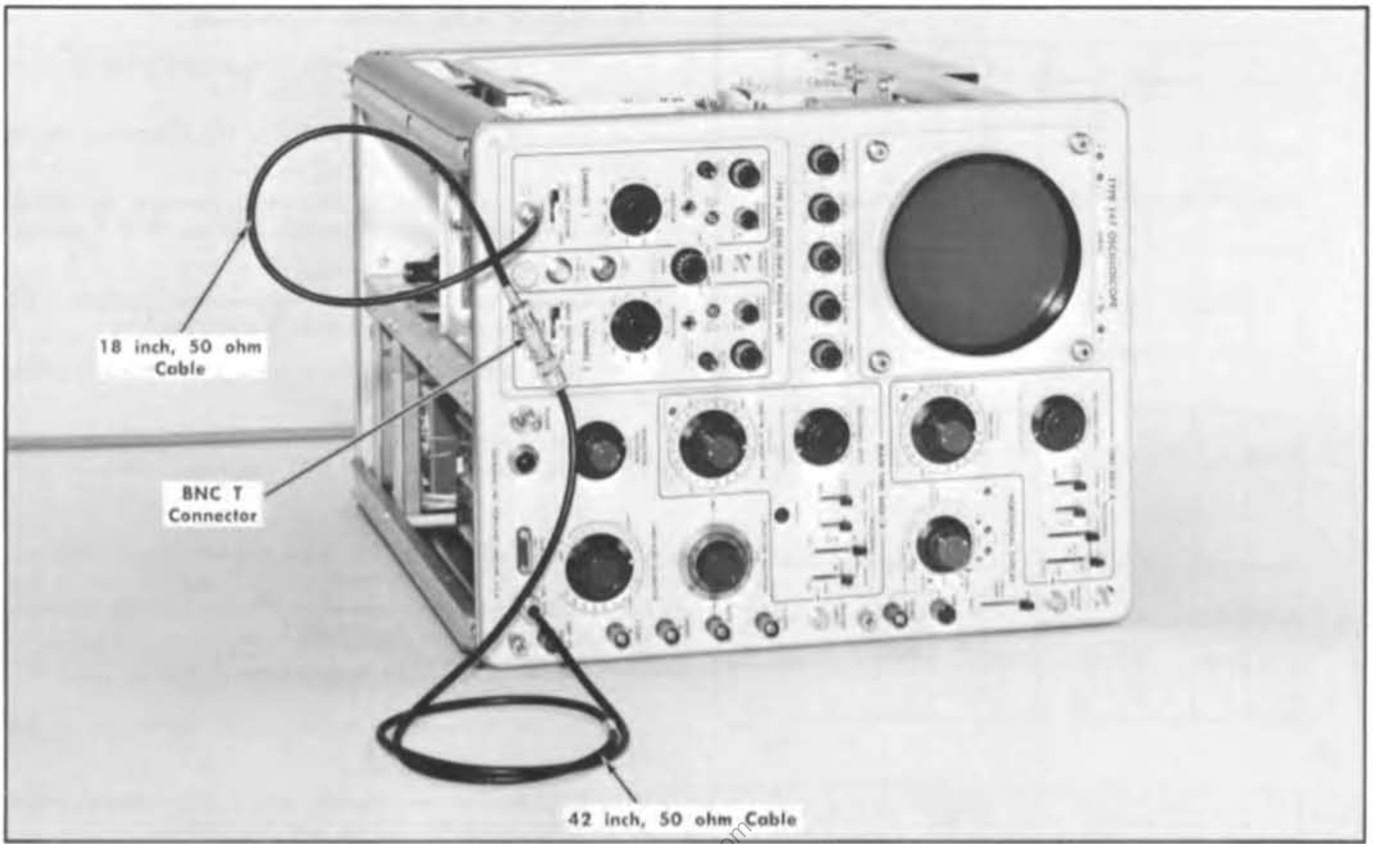


Fig. 7-17. Equipment setup for step 17.

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	×1 Off
Single Sweep Switch	Normal
Triggering Level	Fully clockwise and pushed in
Triggering Source	**Plug-In Int**
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	**.5 msec**
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line

Amplitude Calibrator **.1 Volt**

Type 1A1

MODE	ALT
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	**.05**
INPUT SELECTOR (both channels)	**AC**

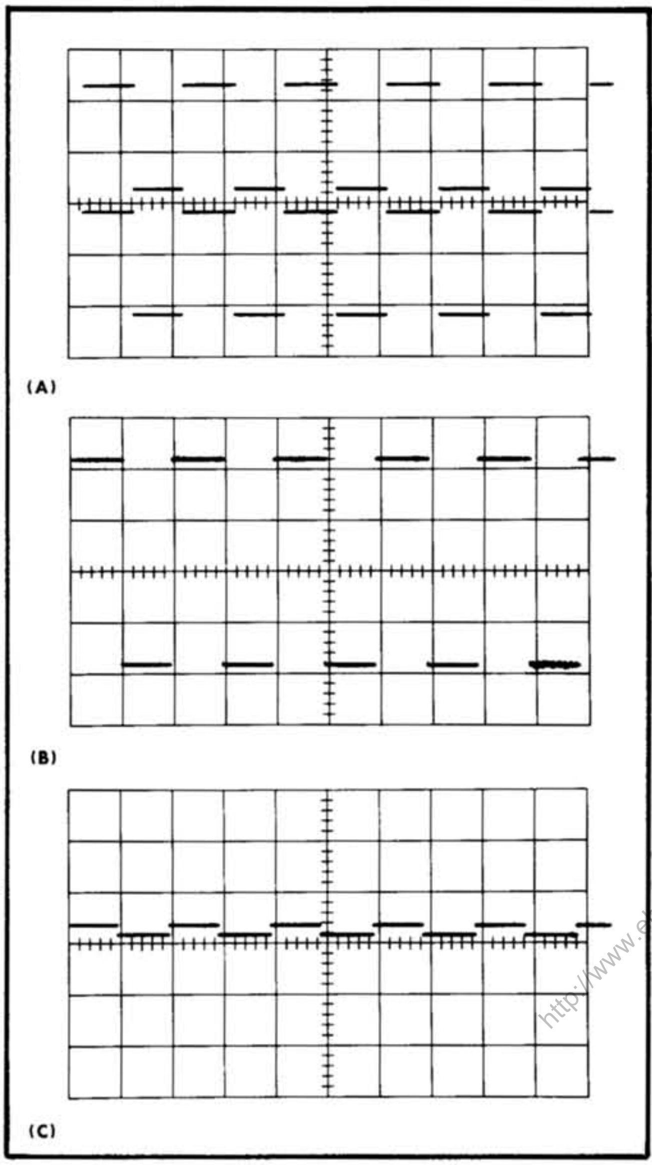


Fig. 7-18. Waveform displays obtained when checking Add Mode of operation (step 17).

17. Check Add Mode Operation

a. Test equipment setup with connections made at completion of step 17d, is shown in Fig. 7-17.

b. Connect a BNC T connector to the Channel 2 INPUT connector.

c. Connect a 42-inch 50-ohm cable between the oscilloscope Calibrator Output connector and the BNC T connector.

d. Connect an 18-inch 50-ohm cable from Channel 2 INPUT connector to Channel 1 INPUT connector.

e. Adjust the Triggering Level control to obtain a stable display.

f. CHECK—For two calibrator waveforms, each two cm in amplitude, displayed on the CRT (see Fig. 7-18A).

g. Set the MODE switch to ADD.

h. CHECK—That with the same amount of calibrator signal applied to both channels of the Type 1A1 as in step 17f, a single calibrator waveform display four cm in amplitude is obtained (see Fig. 7-18B).

i. Set Channel 1 PULL FOR INVERT switch to invert.

j. Set the oscilloscope calibrator for an output of 0.5 volt.

k. CHECK—The two signals should differentially cancel each other out within 0.5 cm (see Fig. 7-18C).

NOTE

If the cancellation just described takes place, set Channel 1 PULL FOR INVERT switch to normal and Channel 2 PULL FOR INVERT switch to invert. Now check for proper cancellation. The Type 1A1 is operating satisfactorily if either condition will permit proper cancellation of the signals.

l. Disconnect the BNC T connector and the 50-ohm coaxial cables.

m. Set the oscilloscope Amplitude Calibrator switch to Off.

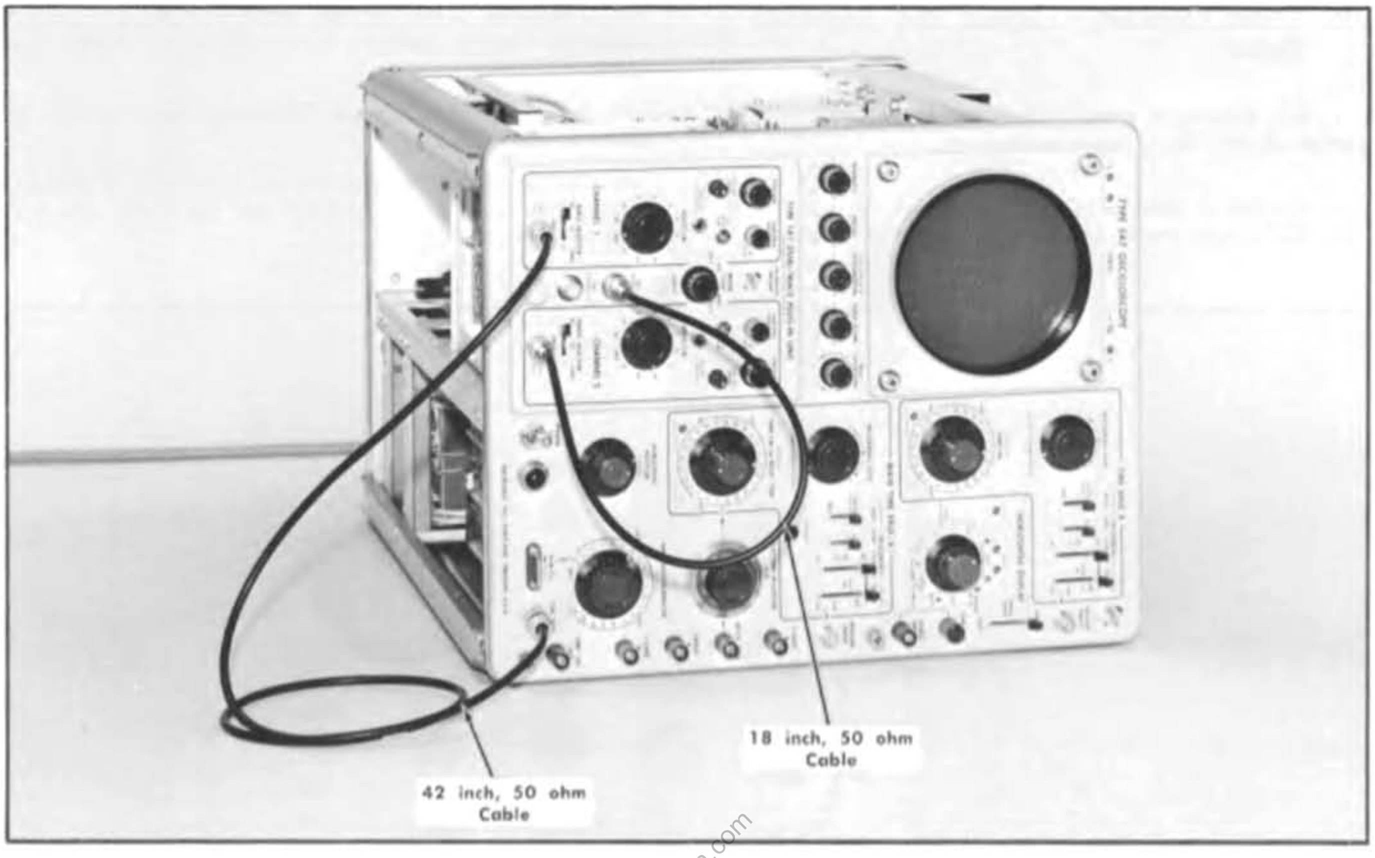


Fig. 7-19. Equipment setup for step 18.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	×1 Off
Single Sweep Switch	Normal
Triggering Level	**Fully clockwise** and pushed in
Triggering Source	**Norm Int**
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line
Amplitude Calibrator	**10 mVolts**

Type 1A1

MODE	**CH 2**
POSITION (both channels)	Near Midrange
PULL FOR INVERT (Channel 1)	Normal or in
PULL FOR INVERT (Channel 2)	**Normal or in**
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (Channel 1)	**.005**
VOLTS/CM (Channel 2)	.05
INPUT SELECTOR (both channels)	AC

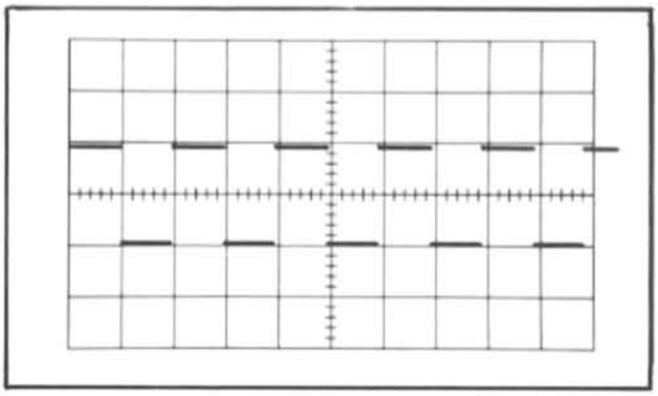


Fig. 7-20. Channel 1 signal out amplifier waveform.

18. Check Channel 1 Signal Out Amplifier Gain

a. Test equipment setup, with connections made at completion of step 18d, is shown in Fig. 7-19.

b. Connect a 18-inch 50-ohm cable from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector.

c. Connect a 42-inch 50-ohm cable from the oscilloscope Calibrator Output connector to the Channel 1 INPUT connector.

d. Adjust the oscilloscope Triggering Level control to obtain a stable display.

e. CHECK—That the peak-to-peak amplitude of the display is two cm (100 mV), ±2 mm (see Fig. 7-20). This is a gain of 10×, ±10%.

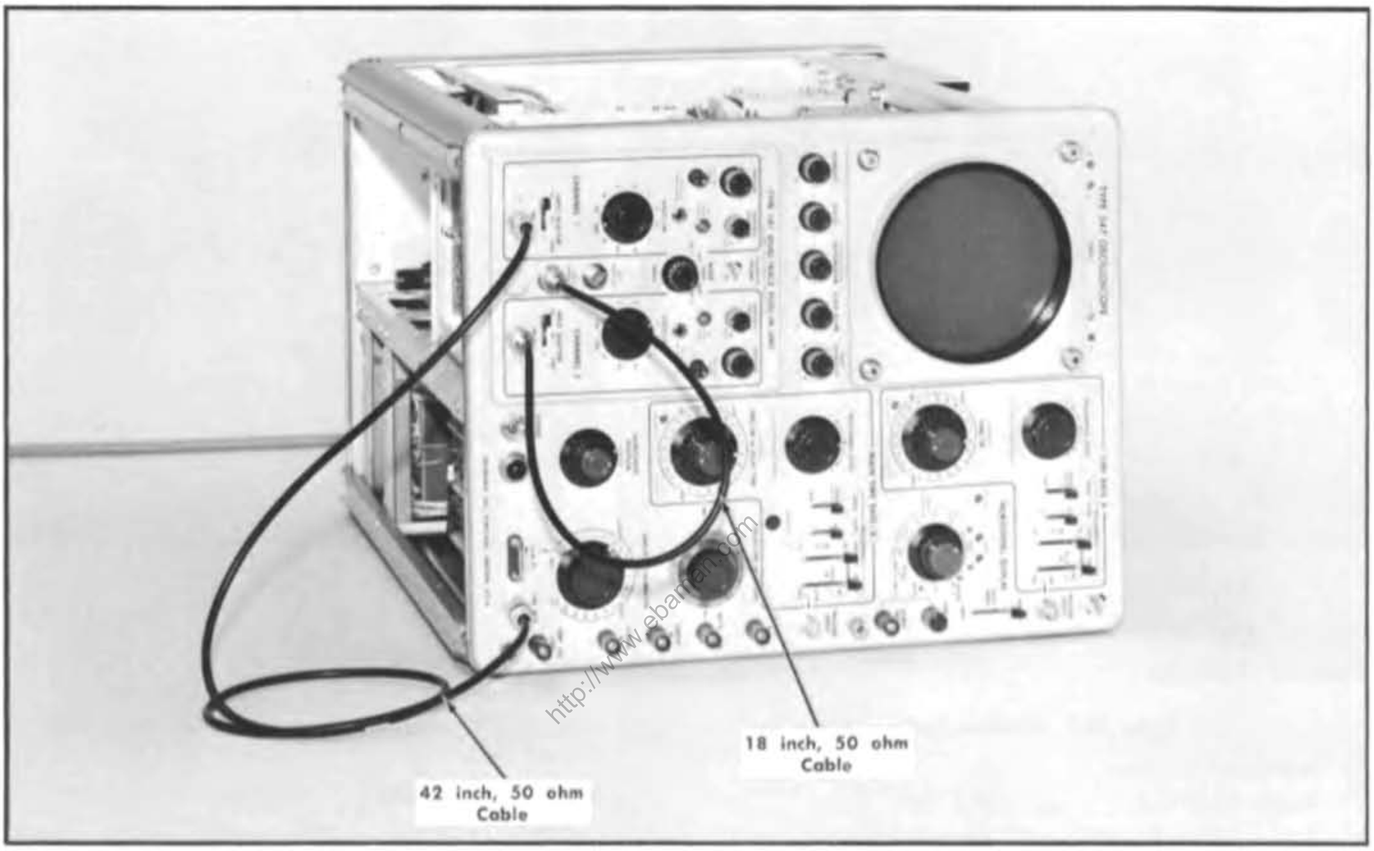


Fig. 7-21. Equipment setup for step 19.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	×1 Off
Single Sweep Switch	Normal
Triggering Level	Near 0 and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line
Amplitude Calibrator	10 mVolts

Type 1A1

MODE	CH 2
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (Channel 1)	.005
VOLTS/CM (Channel 2)	**.5**
INPUT SELECTOR (both channels)	AC

19. Check Channel 1 Trigger Out Amplifier Gain

a. Test equipment setup, with connections made at completion of step 19b, is shown in Fig. 7-21.

b. Disconnect the 18-inch cable from the CH 1 SIGNAL OUT connector and connect it to the CH 1 TRIGGER OUT connector. (The Channel 1 trigger output signal should now be applied to Channel 2 INPUT.)

c. CHECK—That the peak-to-peak amplitude of the display is two cm (1 V) ±4 mm (see Fig. 7-22). This is a gain of 100×, ±20%.

d. Disconnect the two 50-ohm coaxial cables.

e. Set the oscilloscope Amplitude Calibrator switch to Off.

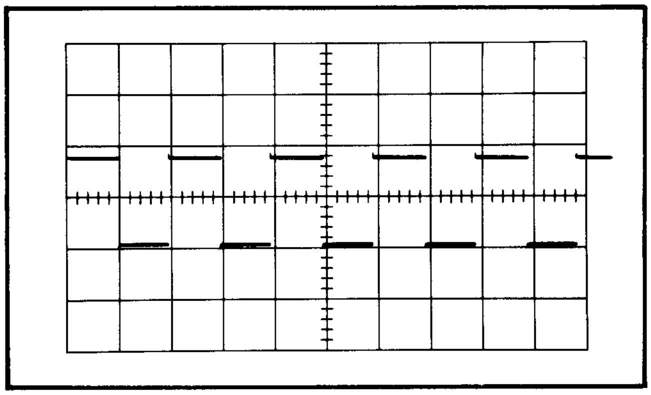


Fig. 7-22. Channel 1 trigger output amplifier gain.

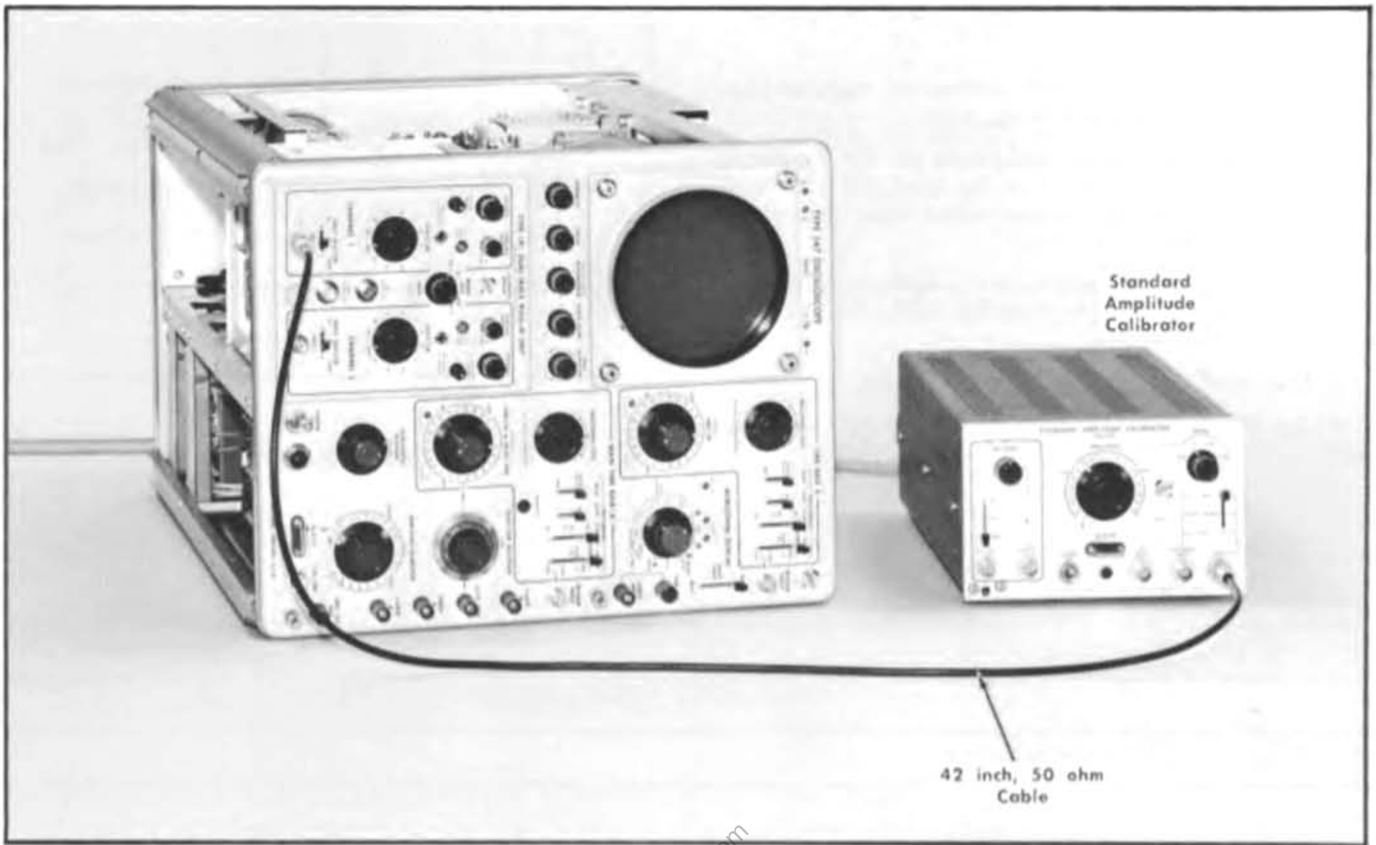


Fig. 7-23. Test equipment setup for step 20.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	×1 Off
Single Sweep Switch	Normal
Triggering Level	Near 0 and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Variable (Time/Cm)	Calibrated
Horizontal Position	Trace positioned to start at left graticule line
Amplitude Calibrator	Off

Type 1A1

MODE	**CH 1**
POSITION (both channels)	Midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM Channel 1)	.005
VOLTS/CM (Channel 2)	**.005**
INPUT SELECTOR (both channels)	**DC**

Standard Amplitude Calibrator

Amplitude	**20 mVolts**
Mode	Square
Mixed	Up
×100 Amplifer	Not Applicable
Power	On

20. Check VOLTS/CM Attenuation Ratios (Both Channels)

a. Test equipment setup, with connections made at completion of step 20b, is shown in Fig. 7-23.

b. Connect a 42-inch 50-ohm cable from Channel 1 INPUT connector to the Standard Amplitude Calibrator output connector.

c. Check that the Standard Amplitude Calibrator is set for an output of 20 mV.

d. Adjust the oscilloscope Triggering Level control to obtain a stable display.

e. Using the Channel 1 POSITION control, align the display with the graticule lines so the amplitude can be measured easily.

f. CHECK—For proper vertical deflection at each Channel 1 VOLTS/CM switch position by using Table 7-1 as a con-convenient guide. Accuracy is ±3% for the .01, .02 and .1 through 20 switch positions when the gain is accurately set at the .005 and .05 positions.

g. After checking the attenuation ratios of the Channel 1 VOLTS/CM switch, set the Standard Amplitude Calibrator for a 20 mV output.

h. Apply the calibrator signal to the Channel 2 INPUT connector.

i. Set the MODE switch to CH 2.

j. CHECK—For proper vertical deflection at each Channel 2 VOLT/CM switch position. Use Table 7-1 as a guide.

k. After completing the previous step, turn off the Standard Amplitude Calibrator and disconnect the 50-ohm coaxial cable.

TABLE 7-1

VOLTS/CM Switch Setting	Standard Amplitude Calibrator Output (peak to peak) Vertical	Vertical Deflection in cm	Maximum Error for ±3% Accuracy
.005	20 mVolts	4	Adjusted[G]
.01	50 mVolts	5	±1.5 mm
.02	.1 Volts	5	±1.5 mm
.05	.2 Volt	4	Adjusted[G]
.1	.5 Volt	5	±1.5 mm
.2	1 Volt	5	±1.5 mm
.5	2 Volts	4	±1.2 mm
1	5 Volts	5	±1.5 mm
2	10 Volts	5	±1.5 mm
5	20 Volts	4	±1.2 mm
10	50 Volts	5	±1.5 mm
20	100 Volts	5	±1.5 mm

[G]The amplifier gain for these switch positions has been previously adjusted for exact amplitude. See steps 5, 7, 9 and 10.

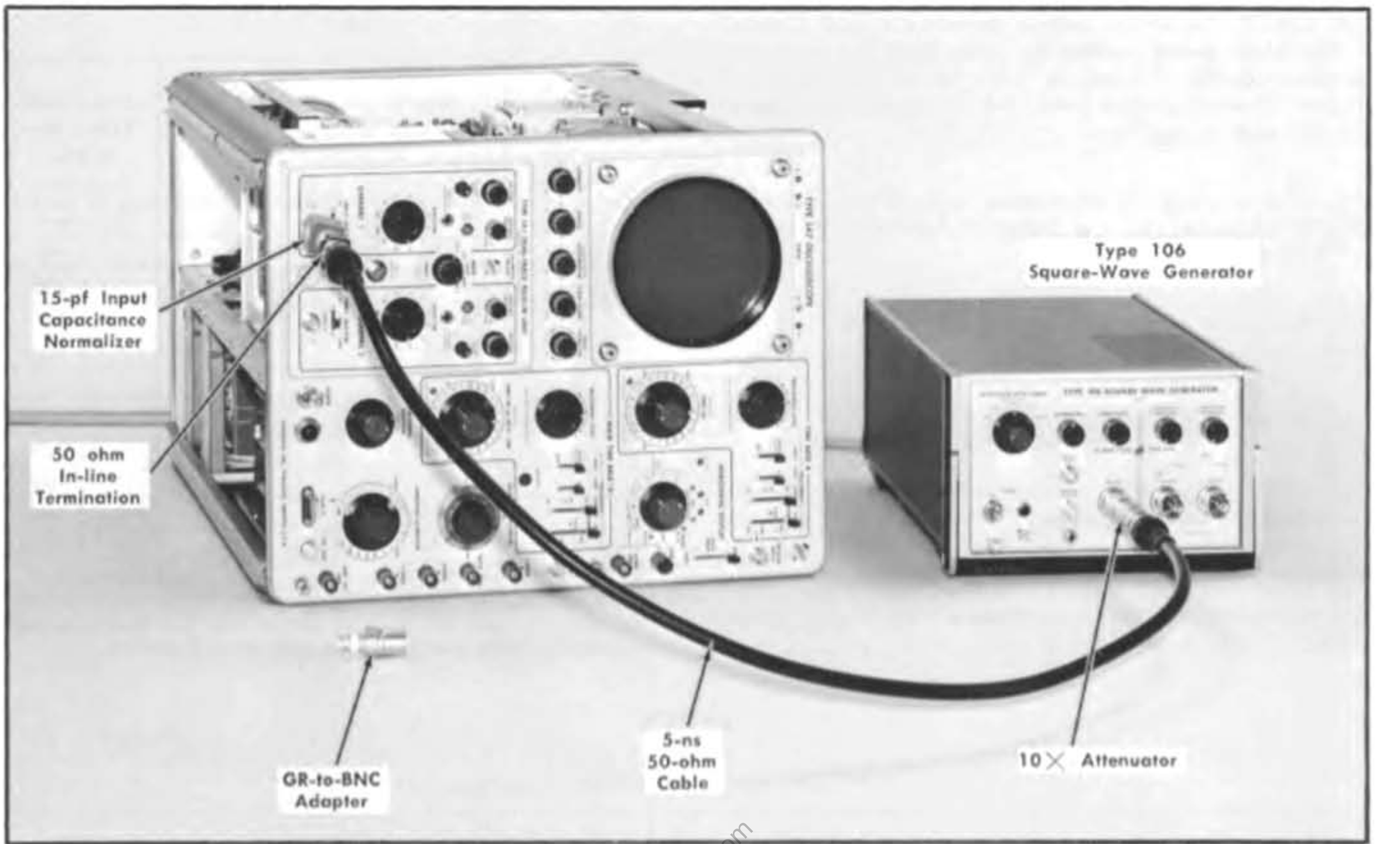


Fig. 7-24. Test equipment setup for step 21.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	× Off
Single Sweep Switch	Normal
Triggering Level	Near 0 and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	.5 msec
Horizontal Position	Trace positioned to start near left graticule line
Amplitude Calibrator	Off

Type 1A1

MODE	**CH 1**
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	**.05**
INPUT SELECTOR (both channels)	DC

Type 106 Square-Wave Generator

Repetition Rate Range	1 kHz
Multiplier	2.5
Symmetry	Midrange
Amplitude	Fully CCW
Hi Amplitude Fast Rise switch	Hi Amplitude
Fast Rise controls	Not applicable
Power	On

21. Adjust Input Capacitance and Attenuator Compensation (Both Channels) ⓘ

a. Test equipment setup, with connections made at completion of step 21c, is shown in Fig. 7-24.

b. Set the Type 106 Square-Wave Generator control to the positions given in the list that precedes step 21.

c. Apply the 2.5 kHz signal from the Type 106 high amplitude output connector through a 10× attenuator, 5-ns 50-ohm cable, 50-ohm in-line termination and a 15-pF input capacitance normalizer to the Channel 1 INPUT connector on the Type 1A1 (see Fig. 7-24).

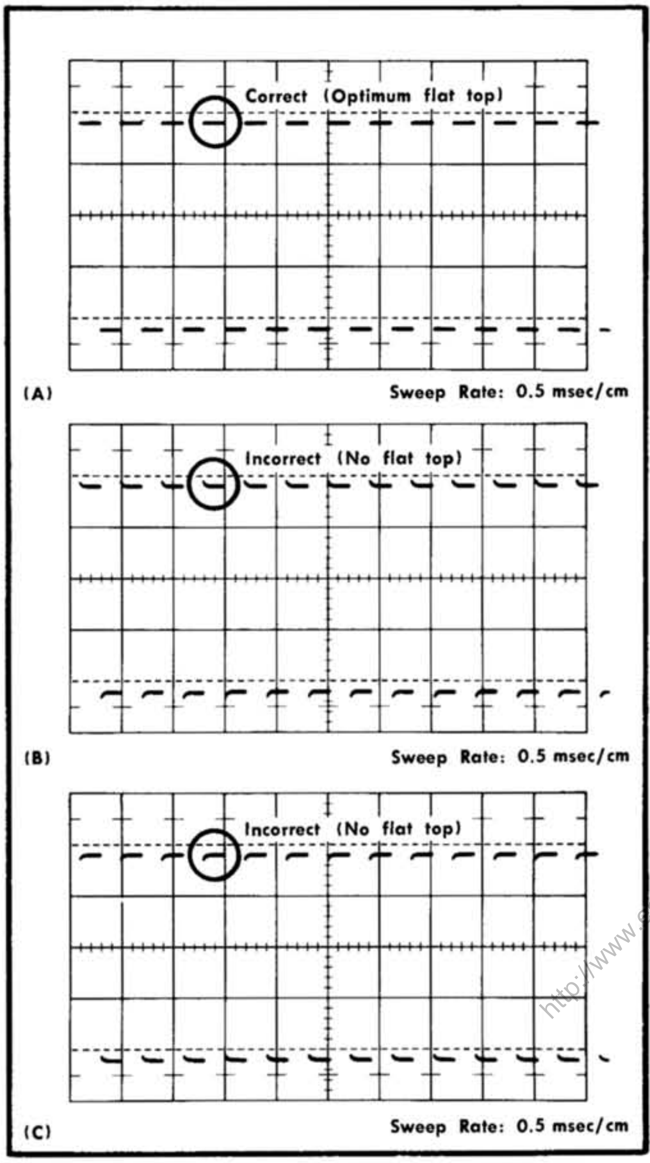


Fig. 7-25. (A) Correct waveform obtained when normalizing the input capacitance of the Type 1A1; square-wave repetition rate is 2.5 kHz. (B) and (C) show incorrect waveforms.

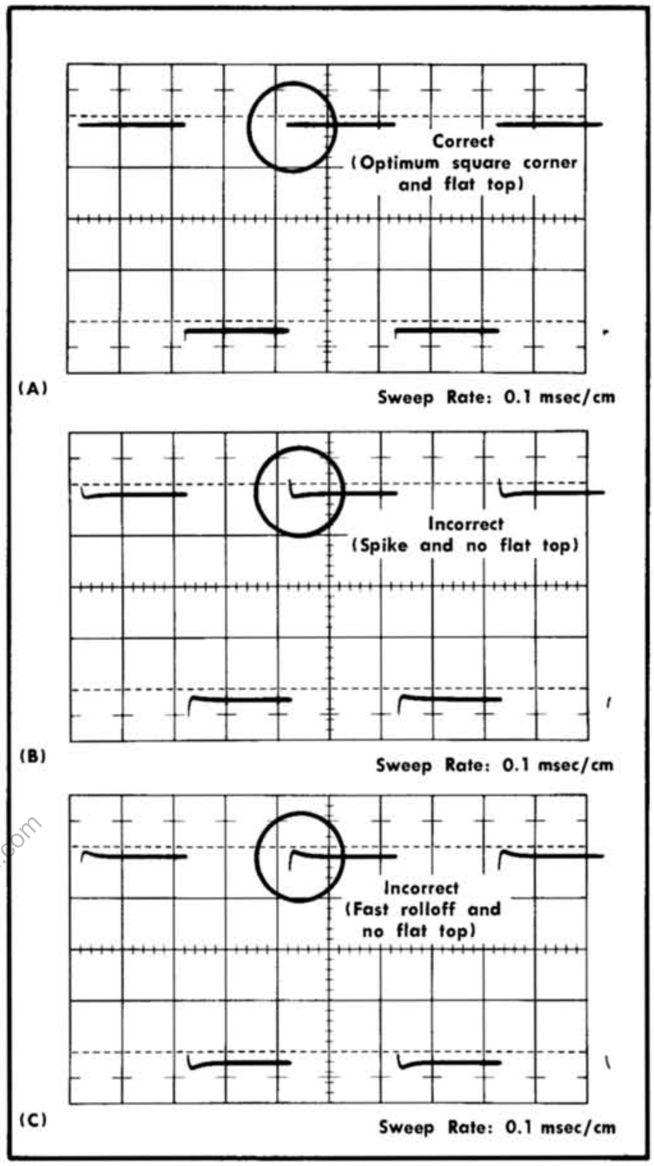


Fig. 7-26. Waveform (A) shows the desired result obtained when an attenuator frequency-compensating capacitor is adjusted correctly. Waveforms (B) and (C) show effect obtained when both the shunt and frequency-compensating capacitors are misadjusted. Square-wave repetition rate is 2.5 kHz.

d. Set the Type 106 Amplitude control to produce a display 4 cm in amplitude.

e. Set the oscilloscope Triggering Level control to obtain a stable display and use the Type 1A1 Channel 1 POSITION control to center the display.

f. Set the Type 106 Symmetry control to obtain a symmetrical waveform display. If necessary, adjust the Multiplier control to obtain the 2.5 kHz output repetition rate.

g. CHECK—The waveform should have a flat top similar to the illustration shown in Fig. 7-25A. Overshoot or rolloff on the top front corner of each cycle of the waveform should not exceed 3% peak to peak or 0.9 mm on a 3-cm waveform. Using Table 7-2 as a guide, check for a square corner and flat top on the top front corner of the waveform in all the other listed VOLTS/CM switch positions. Maintain a 4 cm display amplitude except for the 20 VOLTS/CM position.

h. ADJUST—Using Table 7-2 as a guide adjust Channel 1 input capacitance and frequency compensation capacitors (see Fig. 7-27) for optimum flat top and square corner (see Figs. 7-25A and 7-26A). Maintain a 4 cm display (except on the 20 VOLTS/CM switch setting where approximately 3 cm is the maximum obtainable amplitude). Use the calibration accessories where indicated in Table 7-2.

Waveforms shown in Figs. 7-25B and 7-25C shows the effects obtained when an input shunt capacitor such as C104 or C105B is misadjusted. Waveforms shown in Figs. 7-26B and 7-26C show two effects obtained when an at-

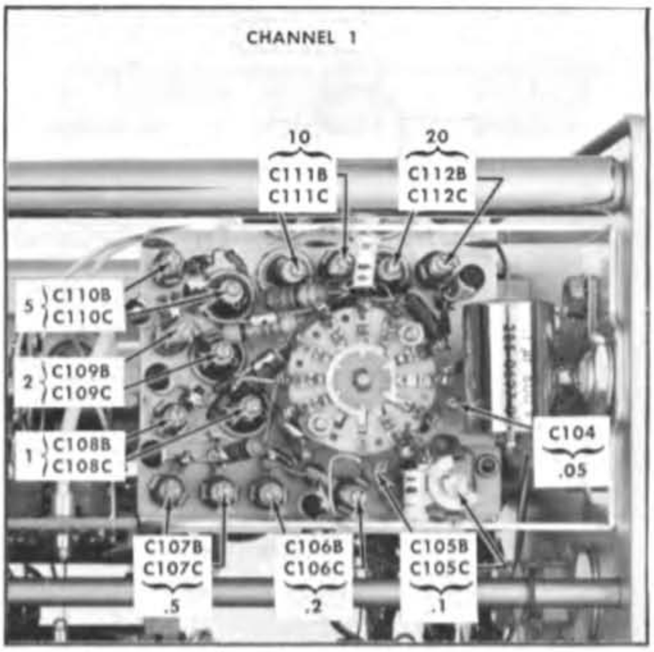


Fig. 7-27. Location of Channel 1 input shunt capacitance and attenuator adjustments associated with the VOLTS/CM switch position.

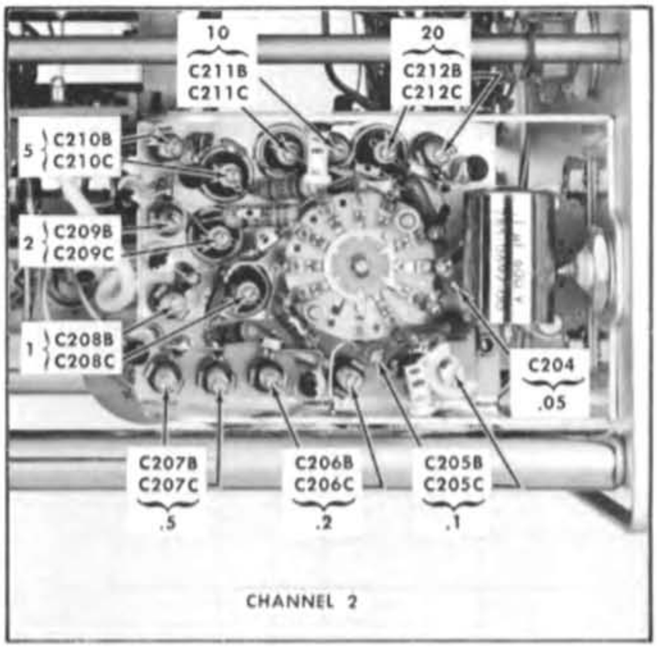


Fig. 7-28. Location of Channel 2 input shunt capacitance and attenuator adjustments associated with the VOLTS/CM switch position.

tenuator frequency-compensating capacitor such as C105C is misadjusted.

i. After completing the check and adjustment procedure for Channel 1, set the Type 106 for minimum output amplitude and disconnect the signal.

j. Set the MODE switch to CH 2.

k. Apply the 2.5 kHz signal from the Type 106 to the Channel 2 INPUT connector. The setup is similar to the illustration shown in Fig. 7-24 and described in step 21c.

l. Using Table 7-2 and steps 21g through 21i as a guide, check and adjust, if necessary, the input shunt capacitance and the attenuator compensation adjustments for Channel 2. Fig. 7-28 shows the physical location of each Channel 2 adjustment.

m. After completing the Channel 2 adjustments, check that the Type 106 is set for minimum output amplitude and is disconnected from the Channel 2 INPUT connector.

TABLE 7-2

Input Capacitance Normalization and Frequency Compensation

VOLTS/CM Switch Setting	Use 10X Atten	Use 50 Ω Term	Use GR-to-BNC Adapter	Use RC Norm	Channel 1		Channel 2	
					[6]Input Shunt Cap	[7]Freq Comp Cap	[6]Input Shunt Cap	[7]Freq Comp Cap
.05	X	X		X	C104	None	C204	None
.1	X	X		X	C105B	C105C	C205B	C205C
.2		X		X	C106B	C106C	C206B	C206C
.5		X		X	C107B	C107C	C207B	C207C
1		X		X	C108B	C108C	C208B	C208C
2			X	X	C109B	C109C	C209B	C209C
5			X	X	C110B	C110C	C210B	C210C
10			X	X	C111B	C111C	C211B	C211C
20			X	X	C112B	C112C	C212B	C212C

[6]Use a 0.5 ms/cm sweep rate and adjust for optimum flat top.

[7]Use a 0.1 ms/cm sweep rate and adjust for optimum leading corner (minimum fast rolloff or spike).

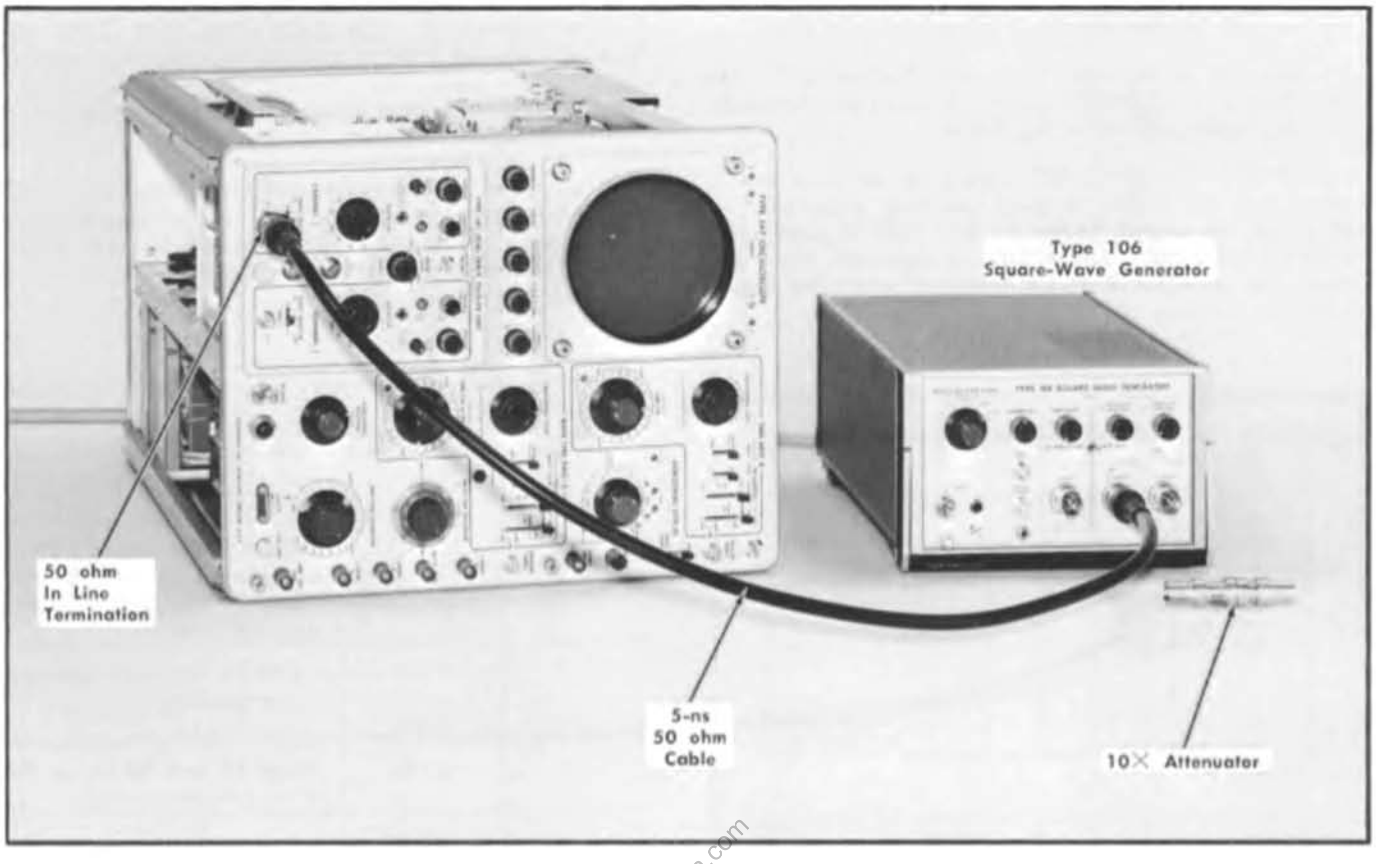


Fig. 7-29. Test equipment setup for steps 22 and 23.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	X1 Off
Single Sweep Switch	Normal
Triggering Level	Near 0 and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	**5 μSec**
Variable (Time/Cm)	Calibrated
Horizontal Position	**Trace positioned to start at left graticule line**
Amplitude Calibrator	Off

Type 1A1

MODE	**CH 1**
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	**.05**
INPUT SELECTOR (both channels)	DC

Type 106 Square-Wave Generator

Repetition Rate Range	**100 kHz**
Multiplier	**1**
Symmetry	Midrange
Amplitude	Not applicable
Hi Amplitude Fast Rise switch	**Fast Rise**
+Transition Amplitude	**Near minimum**
—Transition Amplitude	Not applicable
Power	On

22. Adjust High-Frequency Compensation at .05 Volts/Cm (Both Channels)

a. Test equipment, with connections made at completion of step 22c, is shown in Fig. 7-29.

b. Check that the controls are set as given in the list that precedes step 22.

c. Apply the 100-kHz fast-rise signal from the +Output connector on the Type 106 through a 5-ns cable and 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector (see Fig. 7-29).

d. Set the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. Set the Symmetry control to obtain a symmetrical waveform and, if necessary, adjust the Multiplier control to obtain the 100 kHz output repetition rate. Use the Type 1A1 Channel 1 position control to center the display.

e. Set the oscilloscope Time/Cm switch to .1 μSec.

f. Use the oscilloscope Horizontal Position and Type 1A1 Channel 1 POSITION controls to move the waveform near the location shown in Fig. 7-30A.

g. CHECK—Channel 1 CRT display for optimum square corner (see Fig. 7-30A). Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak when a 4-cm positive-going square wave is displayed. Fig. 7-30B shows the appearance of the waveform when the Sweep Magnifier switch is set to X5.

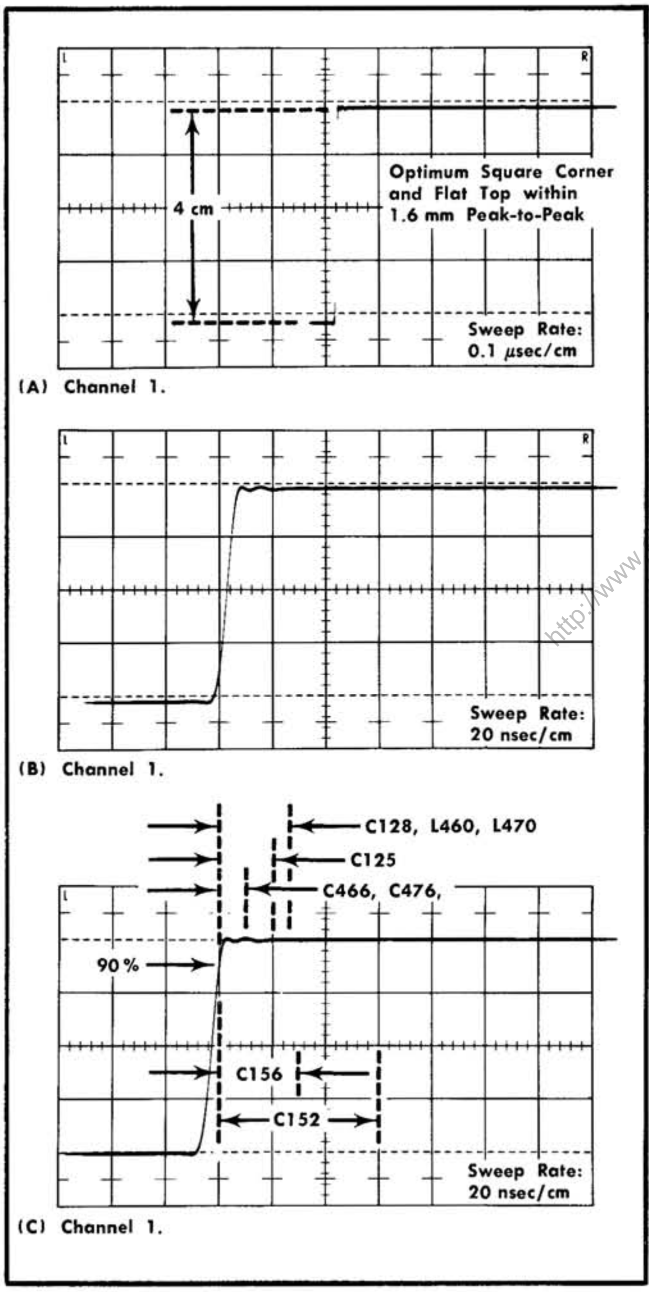


Fig. 7-30. Typical Channel 1 waveforms obtained when the high-frequency compensating adjustments are set properly at a vertical deflection factor of 0.05 volts/cm. Waveforms (C) shows the approximate time domain affected by each adjustment.

h. ADJUST—C125, C128, C152, C156, C466, C476, L460 and L470 (see Fig. 7-31) for optimum high-frequency response to a square wave. The resulting waveform may have a slightly overpeaked front corner and a slight dip that follows the corner within specification limits.

A suggested procedure for performing these adjustments is provided in Table 7-3. Fig. 7-30C shows the approximate time domain on the waveform affected by each adjustment. Time reference is the 90% amplitude level on the rising portion of the waveform.

TABLE 7-3

Adjusting Sequence	Adjustment	Procedure[8]
1	L460	Turn so bottom of slug is flush with bottom of coil form.
	L470	Turn so bottom of slug is flush with bottom of coil form and then turn slug 3 turns clockwise into coil.
2	C466 and C476	Adjust for maximum top-front corner peaking.
3	C152	Adjust for best flat top in the 60-ns front corner region.
4	C156	Adjust for best flat top in the 30-ns front corner region.
5	C128	Adjust for maximum top-front corner peaking.
6	C125 and L460	Insert the hexagonal wrench in L460 slug. Work C125 and L460 together to obtain the fast risetime and optimum top-front corner in the 5-ns region.
7	C125 and L470	Using a similar technique as given for C125 and L460, work C125 and L470 together for fast risetime and optimum front corner.
8	C125, L460 and L470	Adjust in small increments to obtain a fast risetime and optimum front corner.
9	C156	Readjust C156, if necessary, to obtain best square corner.
	C125 and L470	Readjust, if necessary to obtain optimum top front corner.
	C156 and C125	Readjust, if necessary, to obtain optimum top front corner.
10	C152	Set the Sweep Magnifier switch to X1 Off. Readjust C152 for best long term overall flat-top characteristics.

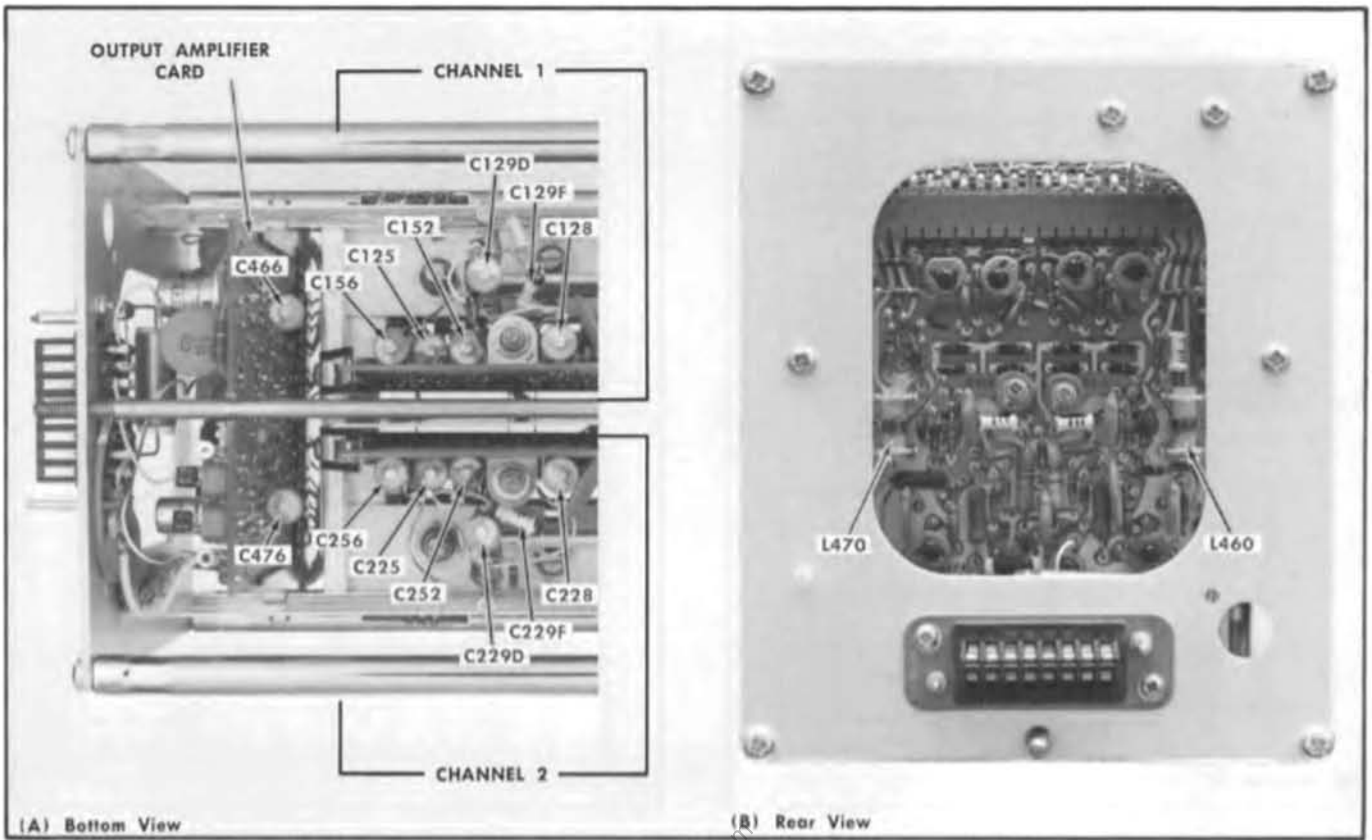


Fig. 7-31. (A) Bottom and (B) rear views of the Type 1A1 showing locations of high-frequency compensating adjustments.

11	C125, L460 or L470	If more peaking is desired, these adjustments can be re-adjusted for slight overshoot within specifications.

i. Disconnect the termination from the Channel 1 INPUT connector and connect it to the Channel 2 INPUT connector so the signal is applied to Channel 2. Set the MODE switch CH 2.

j. CHECK—Channel 2 CRT display for optimum square corner (see Fig. 7-32A). Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm amplitude display.

k. ADJUST—C252, C256, C228 and C225 (see Fig. 7-31A) for optimum top leading corner and flat top on the displayed waveform. Use the adjusting sequence as described for 5 through 13 in Table 7-3 as a guide for performing the Channel 2 adjustments. When adjusting C225, work C225 together with L460 and L470 for fast risetime and optimum front corner.

l. Apply the Type 106 signal to the Channel 1 INPUT connector, set the MODE switch to CH 1, recheck the Channel 1 waveform. If necessary, readjust C125 for optimum front corner.

NOTE

Through repeated adjustments of L460, L470, C125 (using Channel 1) and C225 (using Channel 2), achieve the best compromise setting to make the channel waveforms look similar to each other.

23. Adjust High-Frequency Compensation at .005 Volts/Cm (Both Channels)

a. Test equipment setup is similar to that shown in Fig. 7-29.

b. Check that the signal is applied to the Channel 1 INPUT connector and the MODE switch is set to CH 1.

c. Insert a 10× attenuator between Type 106 +Output connector and the 5-ns cable. Set the Type 1A1 Channel 1 VOLTS/CM switch to .005.

d. If necessary, set the Type 106 +Transition Amplitude control to obtain a 4-cm display. Check that the waveform is positioned near the location shown in Fig. 7-33A.

e. CHECK—Channel 1 CRT display for optimum square corner (see Fig. 7-33A). Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm amplitude display.

f. ADJUST—C129D (see Fig. 7-31A) for optimum top leading corner on the displayed waveform. If C129D has insufficient range, change shunt capacitor C129F (see Fig. 7-31A) to a value that permits proper adjustment range.

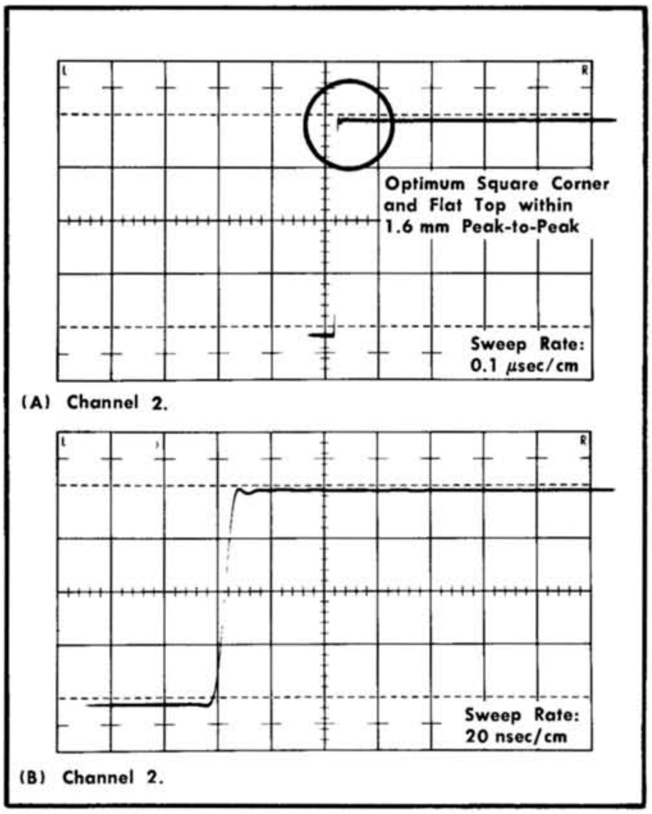


Fig. 7-32. Typical Channel 2 waveforms obtained when the high-frequency-compensating adjustments are set properly at a vertical deflection factor of 0.05 volts/cm.

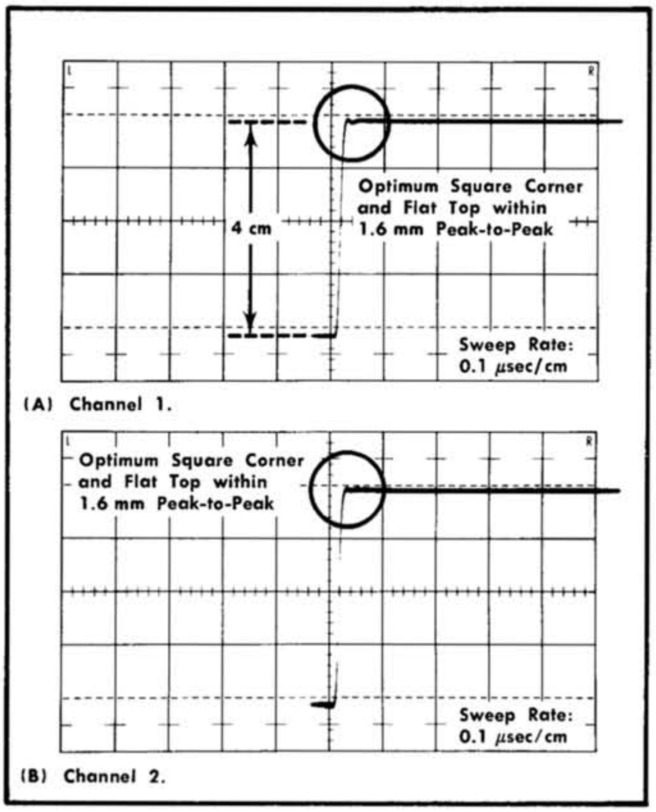


Fig. 7-33. Typical Channel 1 and 2 waveforms obtained when C129D and C229D are set properly at a vertical deflection factor of 0.005 volts/cm.

g. INTERACTION—If C129D is adjusted, check Channel 1 waveform at a vertical deflection factor of .05 volts/cm using step 22 as a guide for the setup. Adjust C128 if the top leading corner is not optimum.

h. Disconnect the signal from the Channel 1 INPUT connector and apply it to the Channel 2 INPUT connector.

i. Set the MODE switch to CH 2 and the Channel 2 VOLTS/CM switch to .005.

j. Check that the waveform is 4 cm in amplitude and positioned to the same location as described for the previous channel.

k. CHECK—Channel 2 CRT display for optimum square corner (see Fig. 7-33B). Ringing, rounding, overshoot and tilt should not exceed 1.6 mm (or 4%) peak to peak for a 4-cm amplitude display.

l. ADJUST—C229D (see Fig. 7-31A) for optimum top leading corner on the displayed waveform. If C229D has insufficient range, change shunt capacitor C229F (see Fig. 7-31A) to a value that permits proper adjustment range.

m. INTERACTION—If C229D is adjusted, check Channel 2 waveform at a vertical deflection factor of .05 volts/cm using step 22 as a guide for the setup. Adjust C228 if the top leading corner is not optimum.

n. Disconnect the Type 106 signal from the Type 1A1.

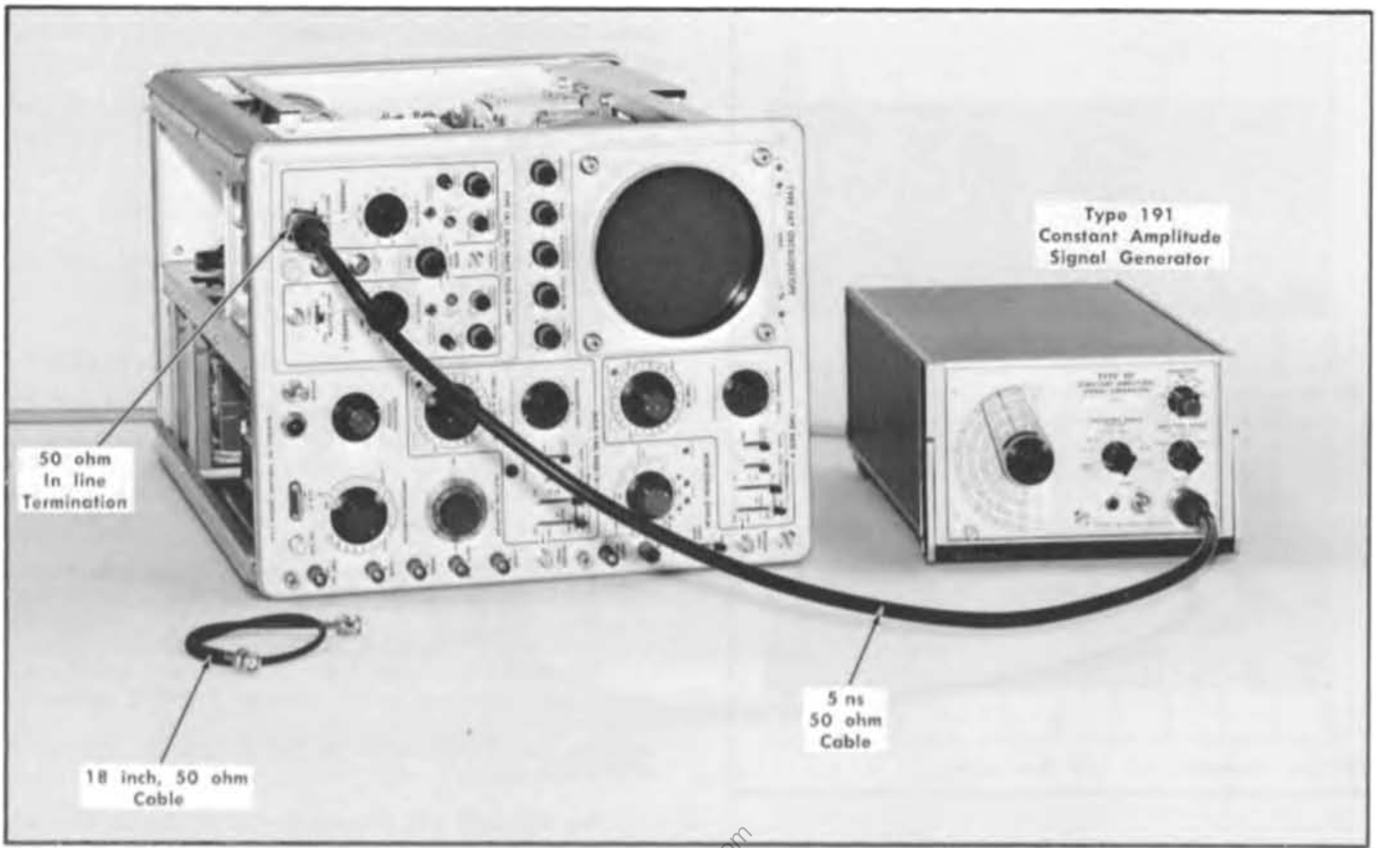


Fig. 7-34. Test equipment setup for steps 24 and 25.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Sweep Magnifier	X1 Off
Single Sweep Switch	Normal
Triggering Level	**Fully CW** and pushed in
Triggering Source	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	**.05 ms**
Variable (Time/Cm)	Calibrated
Horizontal Position	**Trace positioned to start at left graticule line**
Amplitude Calibrator	Off

Type 1A1

MODE	**CH 1**
POSITION (both channel)	**Midrange**
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (both channels)	**.05**
INPUT SELECTOR (both channels)	DC

Type 191 Constant Amplitude Signal Generator

Frequency dial	45 MHz
Frequency Range	50 kHz Only
Amplitude	20
Variable	Cal
Amplitude Range	50-500 mV
Power	On

24. Check Upper Bandwidth Limit (Both Channels)

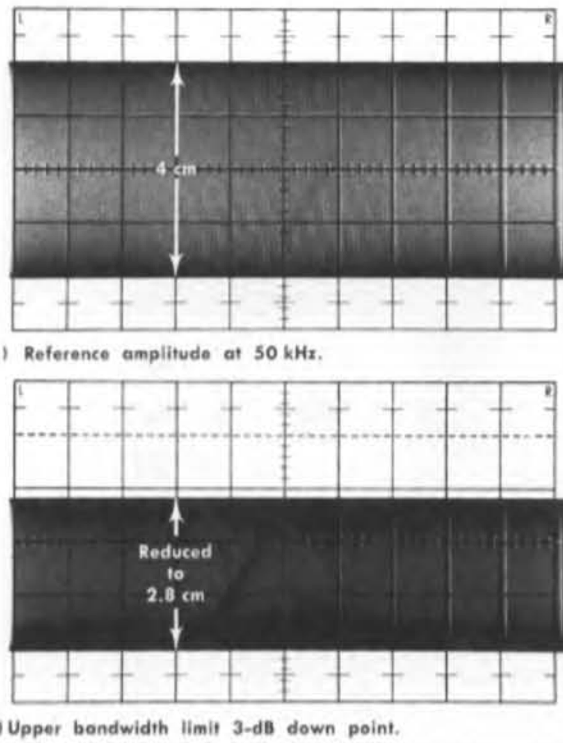
a. Test equipment setup, with connections made at completion of step 24c, is shown in Fig. 7-34.

b. Check that the controls are set as given in the list that precedes step 24.

c. Apply the 50-kHz reference signal from the Type 191 Output connector through a 5-ns cable and a 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector (see Fig. 7-34).

d. Adjust the Type 191 Amplitude controls so the display is exactly 4 cm in amplitude. This is the reference amplitude (see Fig. 7-35A).

e. Set the Type 191 Frequency Range switch to 42-100.



(A) Reference amplitude at 50 kHz.

(B) Upper bandwidth limit 3-dB down point.

Fig. 7-35. Typical CRT displays obtained when checking the upper bandwidth limit. Sweep rate: 0.5 msec/cm free running.

f. Without changing the Type 191 output amplitude, increase the output frequency until the vertical deflection is reduced to 2.8 cm (see Fig. 7-35B). This is the 30% down voltage point (equivalent to —3 dB). Use the Channel 1 POSITION control to position the display to permit accurate measurement of amplitude.

g. CHECK—Channel 1 upper bandwidth limit at a vertical deflection factor of 0.05 volts/cm should be 50 MHz or higher.

NOTE

If the 3-dB down point is slightly less than 50 MHz consider that the accuracy of the Type 191 is within ±2% of the selected frequency, within ±4% of indicated amplitude using the 50-500 mV range and ±5% of indicated amplitude using the 5-50 mV range into a 50-ohm ±1% termination. In addition, consider that the high-frequency response of the oscilloscope vertical amplifier must meet its requirements. Risetime may be calculated using the formula given in the characteristics section.

h. Set the Type 191 Frequency dial to 45 MHz and the Frequency Range switch to 50 kHz Only.

i. Disconnect the signal from the Channel 1 INPUT connector.

j. Set the MODE switch to CH 2.

k. CHECK—Using steps 24d through 24g as a guide, check Channel 2 upper bandwidth for a limit of 50 MHz or higher.

l. Set the Type 191 Frequency dial to 25 MHz, the Frequency Range switch to 50 kHz Only, and the Amplitude Range switch to 5-50 mV.

m. Set the Channel 2 VOLTS/CM switch to .005.

n. If necessary, adjust the Type 191 Amplitude controls so the display is exactly 4 cm in amplitude. This is the reference amplitude (see Fig. 7-35A).

o. Set the Type 191 Frequency Range switch to 18-42.

p. Without changing the Type 191 output amplitude, increase the output frequency until the vertical deflection is reduced to 2.8 cm (see Fig. 7-35B). Use the Channel 2 POSITION control to position the display to permit accurate measurement of amplitude.

q. CHECK—Channel 2 upper bandwidth limit at a vertical deflection factor of 0.005 volts/cm should be 28 MHz or higher.

r. Disconnect the signal from the Channel 2 INPUT connector and connect it to the Channel 1 INPUT connector.

s. Set the MODE switch to CH 1 and the Channel 1 VOLTS/CM switch to .005.

t. Set the Type 191 Frequency dial to 25 MHz and the Frequency Range switch to 50 kHz ONLY.

u. CHECK—Using steps 24n through 24q as a guide, check Channel 1 upper bandwidth for a limit of 28 MHz or higher.

25. Check Upper Bandwidth Limit of Channel 1 Signal Out Amplifier

a. Test equipment setup is similar to that shown in Fig. 7-34.

b. Place the oscilloscope in the upright position.

c. Set the controls as follows:

Type 1A1

MODE	CH 2
VOLTS/CM (both channels)	.05
INPUT SELECTOR (Channel 2)	AC

Type 191

Frequency dial	35 MHz
Frequency Range	50 kHz ONLY
Amplitude	20
Amplitude Range	50-500 mV

d. Connect an 18-inch 50-ohm cable from the CH 1 SIGNAL OUT connector to the Channel 2 INPUT connector.

e. Adjust the Type 191 Amplitude controls so the display is exactly 4 cm in amplitude (see Fig. 7-35A).

f. Disconnect the end of the 18-inch cable that connects to Channel 2 INPUT connector.

g. Disconnect the signal from the Channel 1 INPUT connector and connect it to the Channel 2 INPUT connector. Note the exact amount of vertical deflection.

h. Set the Type 191 Frequency Range switch to 18-42. Check that the Frequency dial is set to 35 MHz.

i. Adjust the Type 191 Amplitude controls to obtain the same vertical deflection as that noted in step 25g.

j. Disconnect the signal from the Channel 2 INPUT connector and reconnect it to the Channel 1 INPUT connector.

k. Reconnect the 18-inch cable to the Channel 2 INPUT connector. Check that the signal is applied from the CH 1 SIGNAL OUT connector to Channel 2.

l. CHECK—The CRT display should be 2.8 cm in amplitude or more. This indicates the upper bandwidth limit for the Channel 1 Signal Out Amplifier is 35 MHz or higher.

NOTE

Steps 25g through 25i in the procedure use a technique that eliminates Channel 2 and the oscilloscope as factors when determining the upper bandwidth limit for the Signal Out Amplifier alone.

m. Disconnect the signal from the Channel 1 INPUT connector and turn off the Type 191 Constant Amplitude Signal Generator. Leave the 18-inch cable connected as is.

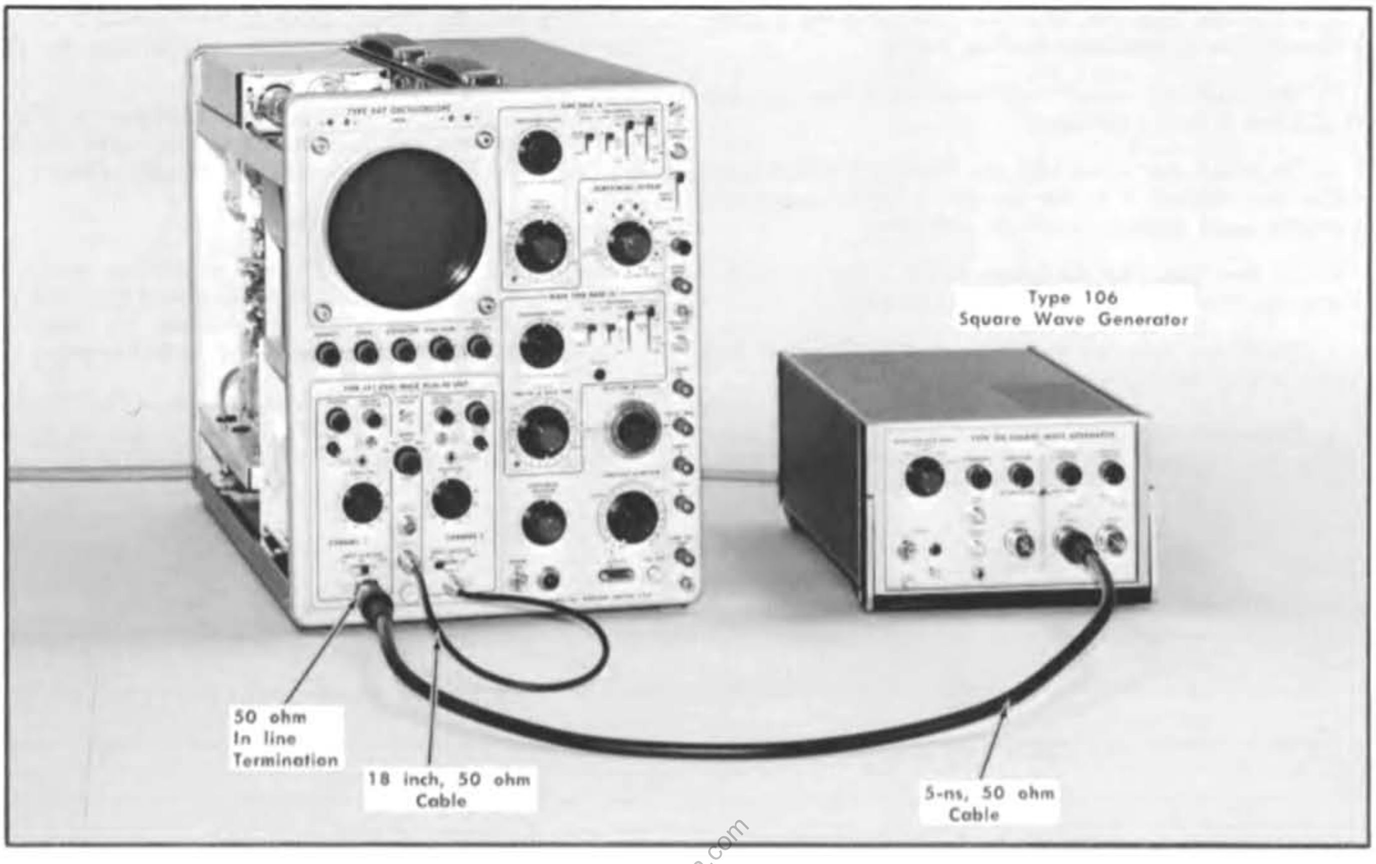


Fig. 7-36. Test equipment setup for step 26.

Control Settings

Type 547 Oscilloscope

Horizontal Display	B
Single Sweep Switch	X1 Off
Sweep Magnifier	Normal
Triggering Level	**Near 0** and pushed in
Triggering Soure	Norm Int
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto Stability
Time/Cm	**.1 μsec**
Variable (Time/Cm)	Calibrated
Horizontal Position	**Trace positioned to start near center graticule vertical line**
Amplitude Calibrator	Off

Type 1A1

MODE	CH 2
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in
VARIABLE VOLTS/CM (both channels)	CALIB
VOLTS/CM (Channel 1)	.05
VOLTS/CM (Channel 2)	**.5**
INPUT SELECTOR (Channel 1)	DC
INPUT SELECTOR (Channel 2)	AC

Type 106 Square-Wave Generator

Repetition Rate Range	100 kHz
Multiplier	1
Symmetry	Midrange
Amplitude	Not applicable
Hi Amplitude Fast Rise switch	Fast Rise
+Transition Amplitude	Near midrange
—Transition Amplitude	Not applicable
Power	On

26. Check Channel 1 Trigger Out Amplifier Risetime

a. Test equipment setup, with connections made to completion of step 26d, is shown in Fig. 7-36.

b. Check that the controls are set as given in the list that precedes step 26.

c. Apply the 100-kHz fast-rise signal from the +Output connector on the Type 106 through a 5-ns cable and a 50-ohm in-line termination to the Type 1A1 Channel 1 INPUT connector (see Fig. 7-36).

d. Disconnect the end of the 18-inch cable that connects to the CH 1 SIGNAL OUT connector and connect it to the CH 1 TRIGGER OUT connector. (The Channel 1 trigger output signal should now be applied to the Channel 2 INPUT.)

e. Set the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. Use the Type 1A1 Channel 2 POSITION control to center the display.

f. Set the oscilloscope Sweep Magnifier switch to X5 and position the waveform similar to the location shown in Fig. 7-37.

g. CHECK—Measure the risetime of the waveform from the 10% to 90% points. Check that the risetime is 70-ns or faster. The risetime of the waveform shown in Fig. 7-37 is 40 ns.

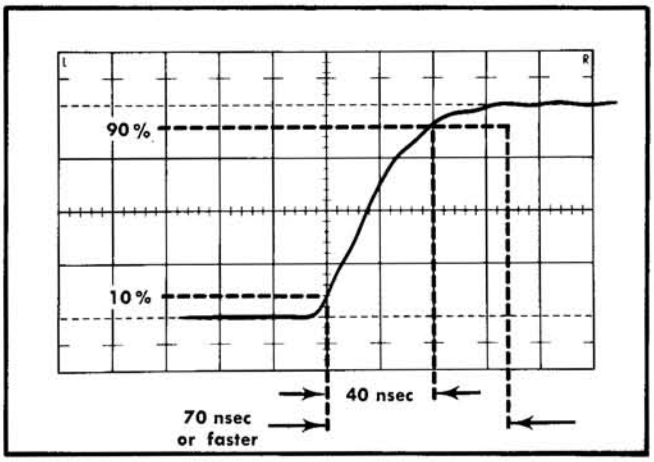


Fig. 7-37. Measuring the risetime at the CH 1 TRIGGER OUT waveform. Risetime should be 70 ns or faster; waveform shown above has a risetime of 40 ns. Sweep rate: 20 nsec/cm.

This completes the calibration procedure for the Type 1A1. Turn off the Type 106 Square-Wave Generator and disconnect it from the Type 1A1. Reinstall the left side and bottom covers on the oscilloscope. If the Type 1A1 has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Characteristics section of this Instruction Manual.

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	PHB	pan head brass
DE	double end	PHS	pan head steel
dia	diameter	plstc	plastic
div	division	PMC	paper, metal cased
elect.	electrolytic	poly	polystyrene
EMC	electrolytic, metal cased	prec	precision
EMT	electrolytic, metal tubular	PT	paper, tubular
ext	external	PTM	paper or plastic, tubular, molded
F & I	focus and intensity	RHB	round head brass
FHB	flat head brass	RHS	round head steel
FHS	flat head steel	SE	single end
Fil HB	fillister head brass	SN or S/N	serial number
Fil HS	fillister head steel	SW	switch
h	height or high	TC	temperature compensated
hex.	hexagonal	THB	truss head brass
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	var	variable
ID	inside diameter	w	wide or width
incd	incandescent	WW	wire-wound

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

×000	Part first added at this serial number
00×	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
◐	Screwdriver adjustment.
☐	Control, adjustment or connector.

SECTION 8
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
C102	*285-0751-00			0.1 μF	MT	600 V	
C103	281-0613-00			10 pF	Cer	200 V	10%
C104	281-0064-00			0.2-1.5 pF, Var	Tub.		
C105A	281-0537-00			0.68 pF		Selected (nominal value)	
C105B	281-0064-00			0.2-1.5 pF, Var	Tub.		
C105C	281-0081-00			1.8-13 pF, Var	Air		
C106B	281-0037-00			0.7-3 pF, Var	Tub.		
C106C	281-0027-00			0.7-3 pF, Var	Tub.		
C106D	281-0529-00			1.5 pF		Selected (nominal value)	
C107A	281-0547-00	20000	22709	2.7 pF		Selected (nominal value)	
C107A	281-0604-00	22710		2.2 pF	Cer	500 V	±0.25 pF
C107B	281-0037-00			0.7-3 pF, Var	Tub.		
C107C	281-0037-00			0.7-3 pF, Var	Tub.		
C108A	281-0547-00			2.7 pF		Selected (nominal value)	
C108B	281-0037-00			0.7-3 pF, Var	Tub.		
C108C }	281-0082-00			0.2-1.5 pF, Var	Tub.		
C108E }				15 pF	Mica		10%
C109A	281-0547-00	20000	22709	2.7 pF		Selected (nominal value)	
C109A	281-0604-00	22710		2.2 pF	Cer	500 V	±0.25 pF
C109B	281-0037-00			0.7-3 pF, Var	Tub.		
C109C }	281-0083-00			0.2-1.5 pF, Var	Tub.		
C109E }				50 pF	Mica		10%
C110A	281-0547-00			2.7 pF		Selected (nominal value)	
C110B	281-0037-00			0.7-3 pF, Var	Tub.		
C110C }	281-0084-00	20000	22509	0.2-1.5 pF, Var	Tub.		
C110E }				100 pF	Mica		10%
C110C }	281-0113-00	22510		0.2-1.5 pF, Var	Tub.		
C110E }				100 pF	Mica		10%
C111A	281-0547-00			2.7 pF		Selected (nominal value)	
C111B	281-0037-00			0.7-3 pF, Var	Tub.		
C111C }	281-0085-00			0.2-1.5 pF, Var	Tub.		
C111E }				200 pF	Mica		10%
C112A	281-0534-00			3.3 pF		Selected (nominal value)	
C112B	281-0037-00			0.7-3 pF, Var	Tub.		
C112C }	281-0086-00			0.2-1.5 pF, Var	Tub.		
C112E }				500 pF	Mica		10%
C118	290-0267-00	X26947		1 μF	EMT	35 V	
C119	281-0536-00	20000	22919	1000 pF	Cer	500 V	10%
C119	281-0614-00	22920		6800 pF	Cer	500 V	+80%—20%
C121	290-0246-00	X26947		3.3 μF	EMT	15 V	10%
C129D	281-0063-00			9-35 pF, Var	Cer		
C129E	281-0552-00			25 pF	Cer	500 V	
C129F	281-0519-00	20000	24819	47 pF		Selected (nominal value)	
C129F	281-0512-00	24820		27 pF		Selected (nominal value)	
C138	285-0598-00			0.01 μF	PTM	100 V	5%
C140	283-0001-00			0.005 μF	Cer	500 V	
C202	*285-0751-00			0.1 μF	MT	600 V	
C203	281-0613-00			10 pF	Cer	200 V	10%

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C204	281-0064-00			0.2-1.5 pF, Var	Tub.		
C205A	281-0537-00			0.68 pF		Selected (nominal value)	
C205B	281-0064-00			0.2-1.5 pF, Var	Tub.		
C205C	281-0081-00			1.8-13 pF, Var	Tub.		
C206B	281-0037-00			0.7-3 pF, Var	Tub.		
C206C	281-0027-00			0.7-3 pF, Var	Tub.		
C206D	281-0529-00			1.5 pF		Selected (nominal value)	
C207A	281-0547-00	20000	22709	2.7 pF		Selected (nominal value)	
C207A	281-0604-00	22710		2.2 pF	Cer	500 V	±0.25 pF
C207B	281-0037-00			0.7-3 pF, Var	Tub.		
C207C	281-0037-00			0.7-3 pF, Var	Tub.		
C208A	281-0547-00			2.7 pF		Selected (nominal value)	
C208B	281-0037-00			0.7-3 pF, Var	Tub.		
C208C }	281-0082-00			0.2-1.5 pF, Var	Tub.		
C208E }				15 pF	Mica		10%
C209A	281-0547-00	20000	22709	2.7 pF		Selected (nominal value)	
C209A	281-0604-00	22710		2.2 pF	Cer	500 V	±0.25 pF
C209B	281-0037-00			0.7-3 pF, Var	Tub.		
C209C }	281-0083-00			0.2-1.5 pF, Var	Tub.		
C209E }				50 pF	Mica		10%
C210A	281-0547-00			2.7 pF		Selected (nominal value)	
C210B	281-0037-00			0.7-3 pF, Var	Tub.		
C210C }	281-0084-00	20000	22509	0.2-1.5 pF, Var	Tub.		
C210E }				100 pF	Mica		10%
C210C }	281-0113-00	22510		0.2-1.5 pF, Var	Tub.		
C210E }				100 pF	Mica		10%
C211A	281-0547-00			2.7 pF		Selected (nominal value)	
C211B	281-0037-00			0.7-3 pF, Var	Tub.		
C211C }	281-0085-00			0.2-1.5 pF, Var	Tub.		
C211E }				200 pF	Mica		10%
C212A	281-0534-00			3.3 pF		Selected (nominal value)	
C212B	281-0037-00			0.7-3 pF, Var	Tub.		
C212C }	281-0086-00			0.2-1.5 pF, Var	Tub.		
C212E }				500 pF	Mica		10%
C218	290-0267-00	X26947		1 μF	EMT	35 V	
C219	281-0536-00	20000	22919	1000 pF	Cer	500 V	10%
C219	281-0614-00	22920		6800 pF	Cer	500 V	+80%—20%
C221	290-0246-00	X26947		3.3 μF	EMT	15 V	10%
C229D	281-0063-00			9-35 pF, Var	Cer		
C229E	281-0552-00			25 pF	Cer	500 V	
C229F	281-0519-00	20000	24819	47 pF		Selected (nominal value)	
C229	281-0512-00	24820		27 pF		Selected (nominal value)	
C238	285-0598-00			0.01 μF	PTM	100 V	5%
C240	283-0001-00			0.005 μF	Cer	500 V	
C263	283-0002-00			0.01 μF	Cer	500 V	
C492	290-0149-00			5 μF	Elect.	150 V	
C494	283-0057-00			0.1 μF	Cer	200 V	

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Eff	Disc	Description		
D118	152-0304-00			Zener	1N968B	0.4 W, 20 V, 5%
D119	*152-0367-00			Silicon	Tek Spec	
D121	152-0149-00			Zener	1N961B	0.4 W, 10 V, 5%
D218	152-0304-00			Zener	1N968B	0.4 W, 20 V, 5%
D219	*152-0367-00			Silicon	Tek Spec	
D221	152-0149-00			Zener	1N961B	0.4 W, 10 V, 5%

Connectors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
J101	*131-0342-01			BNC, female, 1 contact
J201	*131-0342-01			BNC, female, 1 contact

Inductors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
L138	276-0507-00			Core, Ferramic Suppressor	
L238	276-0507-00			Core, Ferramic Suppressor	
LR105A	*108-0270-00			0.25 μH	(wound on a 62 Ω resistor)
LR105B	*108-0270-00	X22710		0.25 μH	(wound on a 62 Ω resitsor)
LR106A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR106A	*108-0513-00	22710		0.4 μH	(wound on a 1 kΩ resistor)
LR106B	*108-0270-00	20000	22709	0.25 μH	(wound on a 62 Ω resistor)
LR106B	*108-0331-00	22710		0.75 μH	(wound on a 120 Ω resistor)
LR107A	*108-0349-00	20000	22709	0.6 μH	(wound to a 150 Ω resistor)
LR107A	*108-0516-00	22710		0.4 μH	(wound on a 1 kΩ resistor)
LR107B	*108-0511-00	X22710		1 μH	(wound on a 180 Ω resistor)
LR108A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR108A	*108-0515-00	22710		0.4 μH	(wound on a 180 Ω resistor)
LR108B	*108-0271-00	20000	22709	0.25 μH	(wound on a 51 Ω resistor)
LR108B	*108-0512-00	22710		0.75 μH	(wound on a 91 Ω resistor)
LR109A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR109A	*108-0514-00	22710		0.4 μH	(wound on a 82 Ω resistor)
LR110A	*108-0268-00			0.1 μH	(wound on a 36 Ω resistor)
LR111A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR111A	*108-0517-00	22710		0.1 μH	(wound on a 430 Ω resistor)
LR205A	*108-0270-00			0.25 μH	(wound on a 62 Ω resistor)
LR205B	*108-0270-00	X22710		0.25 μH	(wound on a 62 Ω resitsor)
LR206A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR206A	*108-0513-00	22710		0.4 μH	(wound on a 1 kΩ resistor)
LR206B	*108-0270-00	20000	22709	0.25 μH	(wound on a 62 Ω resistor)
LR206B	*108-0331-00	22710		0.75 μH	(wound on a 120 Ω resistor)
LR207A	*108-0349-00	20000	22709	0.6 μH	(wound to a 150 Ω resistor)
LR207A	*108-0516-00	22710		0.4 μH	(wound on a 1 kΩ resistor)
LR207B	*108-0511-00	X22710		1 μH	(wound on a 180 Ω resistor)
LR208A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR208A	*108-0515-00	22710		0.4 μH	(wound on a 180 Ω resistor)
LR208B	*108-0271-00	20000	22709	0.25 μH	(wound on a 51 Ω resistor)
LR208B	*108-0512-00	22710		0.75 μH	(wound on a 91 Ω resistor)
LR209A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR209A	*108-0514-00	22710		0.4 μH	(wound on a 82 Ω resistor)
LR210A	*108-0268-00			0.1 μH	(wound on a 36 Ω resistor)
LR211A	*108-0286-00	20000	22709	0.17 μH	(wound on a 36 Ω resistor)
LR211A	*108-0517-00	22710		0.1 μH	(wound on a 430 Ω resistor)

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
Q122 } Q142 }	*153-0561-00			FET (matched pair)
Q222 } Q242 }	*153-0561-00			FET (matched pair)

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R103	317-0560-00			56 Ω	1/8 W		5%
R104	317-0560-00			56 Ω	1/8 W		5%
R105C	322-0610-01			500 kΩ	1/4 W	Prec	1/2%
R105E	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R106C	322-0469-01			750 kΩ	1/4 W	Prec	1/2%
R106E	321-0628-01			333 kΩ	1/8 W	Prec	1/2%
R107C	322-0621-01			900 kΩ	1/4 W	Prec	1/2%
R107E	321-1389-01			111 kΩ	1/8 W	Prec	1/2%
R108C	322-0622-01			950 kΩ	1/4 W	Prec	1/2%
R108E	321-0616-01			52.6 kΩ	1/8 W	Prec	1/2%
R109C	322-0623-01			975 kΩ	1/4 W	Prec	1/2%
R109E	321-0627-01			25.6 kΩ	1/8 W	Prec	1/2%
R109G	317-0560-00			56 Ω	1/8 W		5%
R110C	322-0624-01			990 kΩ	1/4 W	Prec	1/2%
R110E	321-1289-01			10.1 kΩ	1/8 W	Prec	1/2%
R110G	317-0151-00			150 Ω	1/8 W		5%
R111C	322-0625-01			995 kΩ	1/4 W	Prec	1/2%
R111E	321-0613-01			5.03 kΩ	1/8 W	Prec	1/2%
R111G	317-0201-00			200 Ω	1/8 W		5%
R112A	317-0560-00			56 Ω	1/8 W		5%
R112C	322-0626-01			997.5 kΩ	1/4 W	Prec	1/2%
R112E	321-0626-01			2.51 kΩ	1/8 W	Prec	1/2%
R112G	317-0101-00			100 Ω	1/8 W		5%
R113	316-0102-00			1 kΩ	1/4 W		
R116	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R119	302-0564-00			560 kΩ	1/2 W		
R120	315-0151-00			150 kΩ	1/4 W		5%
R129A	321-0607-00			80 Ω	1/8 W	Prec	1%
R129B	321-0134-00			243 Ω	1/8 W	Prec	1%
R129C	321-0181-00			750 Ω	1/8 W	Prec	1%
R129E	315-0152-00			1.5 kΩ	1/4 W		5%
R130	311-0459-00			2 X 500 kΩ, Var			
R138	315-0222-00			2.2 kΩ	1/4 W		5%
R140	315-0151-00			150 Ω	1/4 W		5%
R148	311-0117-00			5 kΩ, Var			
R152	311-0183-00			500 kΩ, Var			
R169	308-0008-00			10 kΩ	5 W	WW	5%
R203	317-0560-00			56 Ω	1/8 W		5%
R204	317-0560-00			56 Ω	1/8 W		5%
R205C	322-0610-01			500 kΩ	1/4 W	Prec	1/2%
R205E	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R206C	322-0469-01			750 kΩ	1/4 W	Prec	1/2%
R206E	321-0628-01			333 kΩ	1/8 W	Prec	1/2%
R207C	322-0621-01			900 kΩ	1/4 W	Prec	1/2%
R207E	321-1389-01			111 kΩ	1/8 W	Prec	1/2%
R208C	322-0622-01			950 kΩ	1/4 W	Prec	1/2%
R208E	321-0616-01			52.6 kΩ	1/8 W	Prec	1/2%
R209C	322-0623-01			975 kΩ	1/4 W	Prec	1/2%
R209E	321-0627-01			25.6 kΩ	1/8 W	Prec	1/2%
R209G	317-0560-00			56 Ω	1/8 W		5%

Resistors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R210C	322-0624-01			990 kΩ	¼ W	Prec	½%
R210E	321-1289-01			10.1 kΩ	⅛ W	Prec	½%
R210G	317-0151-00			150 Ω	⅛ W		5%
R211C	322-0625-01			995 kΩ	¼ W	Prec	½%
R211E	321-0613-01			5.03 kΩ	⅛ W	Prec	½%
R211G	317-0201-00			200 Ω	⅛ W		5%
R212A	317-0560-00			56 Ω	⅛ W		5%
R212C	322-0626-01			997.5 kΩ	¼ W	Prec	½%
R212E	321-0626-01			2.51 kΩ	⅛ W	Prec	½%
R212G	317-0101-00			100 Ω	⅛ W		5%
R213	316-0102-00			1 kΩ	¼ W		
R216	322-0481-01			1 MΩ	¼ W	Prec	½%
R219	302-0564-00			560 kΩ	½ W		
R220	315-0151-00			150 kΩ	¼ W		5%
R229A	321-0607-00			80 Ω	⅛ W	Prec	1%
R229B	321-0134-00			243 Ω	⅛ W	Prec	1%
R229C	321-0181-00			750 Ω	⅛ W	Prec	1%
R229E	315-0152-00			1.5 kΩ	¼ W		5%
R230	311-0459-00			2 X 500 kΩ, Var			
R238	315-0222-00			2.2 kΩ	¼ W		5%
R240	315-0151-00			150 Ω	¼ W		5%
R248	311-0117-00			5 kΩ, Var			
R252	311-0183-00			500 kΩ, Var			
R310	315-0123-00			12 kΩ	¼ W		5%
R360	302-0275-00			2.7 MΩ	½ W		
R408[1]	311-0630-00			500 Ω, Var			
R409	311-0574-00			100 Ω, Var			
R422	311-0575-00			2 X 100 kΩ, Var			
R438[2]	311-0630-00			500 Ω, Var			
R439	311-0574-00			100 Ω, Var			
R452	311-0575-00			2 X 100 kΩ, Var			
R469	315-0101-00			100 Ω	¼ W		5%
R490	302-0183-00			18 kΩ	½ W		
R491	308-0451-00			91 Ω	3 W	WW	5%
R492	308-0451-00			91 Ω	3 W	WW	5%
R493	315-0183-00			18 kΩ	¼ W		5%
R495	308-0274-00			470 Ω	5 W	WW	5%
R499	315-0363-00			36 kΩ	¼ W		5%

Switches

Ckt. No.	Unwired or Wired	Eff	Disc	Description	
SW101 } SW105 }	Wired *262-0693-02	20000	22709	Lever	CHANNEL 1 INPUT SELECTOR
				Rotary	CHANNEL 1 VOLTS/CM (Front)
SW101 } SW105 }	Wired *262-0693-04	22710		Lever	CHANNEL 1 INPUT SELECTOR
				Rotary	CHANNEL 1 VOLTS/CM (Front)
SW101	260-0621-00			Lever	CHANNEL 1 INPUT SELECTOR
SW105	260-0673-02			Rotary	CHANNEL 1 VOLTS/CM (Front)
SW129	Wired *262-0716-00			Rotary	CHANNEL 1 VOLTS/CM (Rear)

[1]Furnished as a unit with SW409.

[2]Furnished as a unit with SW439.

Switches *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
SW129	260-0560-00			Rotary	CHANNEL 1 VOLTS/CM (Rear)
SW201 }	Wired *262-0693-02	20000	22709	Lever	CHANNEL 2 INPUT SELECTOR
SW205 }				Rotary	CHANNEL 2 VOLTS/CM (Front)
SW201 }	Wired *262-0693-04	22710		Lever	CHANNEL 2 INPUT SELECTOR
SW205 }				Rotary	CHANNEL 2 VOLTS/CM (Front)
SW201	260-0621-00			Lever	CHANNEL 2 INPUT SELECTOR
SW205	260-0673-02			Rotary	CHANNEL 2 VOLTS/CM (Front)
SW229	Wired *262-0717-00			Rotary	CHANNEL 2 VOLTS/CM (Rear)
SW229	260-0560-00			Rotary	CHANNEL 2 VOLTS/CM (Rear)
SW320	Wired *262-0579-00			Rotary	MODE
SW320	260-0561-00			Rotary	MODE
SW405	260-0767-00			Slide	PULL FOR INVERT
SW409[3]	311-0630-00				
SW435	260-0767-00			Slide	PULL FOR INVERT
SW439[4]	311-0630-00				

CHANNEL 1 INPUT AMPLIFIER CARD Series D

	*670-0075-01	Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

C125	281-0089-00	2-8 pF, Var	Cer	
C128	281-0089-00	2-8 pF, Var	Cer	
C152	281-0089-00	2-8 pF, Var	Cer	
C156	281-0096-00	5.5-18 pF, Var	Air	
C165	283-0000-00	0.001 μF	Cer	500 V
C175	283-0000-00	0.001 μF	Cer	500 V
C185	283-0002-00	0.01 μF	Cer	500 V
C186	283-0003-00	0.01 μF	Cer	150 V
C196	283-0003-00	0.01 μF	Cer	150 V
C197	283-0059-00	1 μF	Cer	25 V
C198	283-0081-00	0.1 μF	Cer	25 V

Semiconductor Device, Diode

D122	*152-0153-00	Silicon	Replaceable by 1N4244

Transistors

Q123	151-0220-00	Silicon	2N4122
Q124	151-0225-00	Silicon	2N3563
Q143	151-0220-00	Silicon	2N4122
Q144	151-0225-00	Silicon	2N3563
Q153A	151-0225-00	Silicon	2N3563

[3]Furnished as a unit with R408.

[4]Furnished as a unit with R438.

CHANNEL 1 INPUT AMPLIFIER CARD Series D *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Transistors *(cont)*			
Q153B	151-0225-00			Silicon	2N3563		
Q163	151-0131-00			Germanium	2N964		
Q164	151-0131-00			Germanium	2N964		
Q173	151-0131-00			Germanium	2N964		
Q174	151-0131-00			Germanium	2N964		
Q184	151-0224-00			Silicon	2N3692		
Q194	151-0131-00			Germanium	2N964		

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R121	308-0400-00			18 kΩ	5 W	WW	5%
R122	305-0563-00			56 kΩ	2 W		5%
R123	315-0183-00			18 kΩ	1/4 W		5%
R124	321-0127-00			205 Ω	1/8 W	Prec	1%
R125	321-0127-00			205 Ω	1/8 W	Prec	1%
R126	315-0561-00			560 Ω	1/4 W		5%
R127	315-0682-00			6.8 kΩ	1/4 W		5%
R128A	311-0258-00			100 Ω, Var			
R128B	315-0470-00			47 Ω	1/4 W		5%
R128C	315-0390-00			39 Ω	1/4 W		5%
R133	316-0475-00			4.7 MΩ	1/4 W		
R134	316-0474-00			470 kΩ	1/4 W		
R136	316-0185-00			1.8 MΩ	1/4 W		
R142	305-0563-00			56 kΩ	2 W		5%
R143	315-0183-00			18 kΩ	1/4 W		5%
R144	321-0127-00			205 Ω	1/8 W	Prec	1%
R145	321-0127-00			205 Ω	1/8 W	Prec	1%
R146	315-0621-00			620 Ω	1/4 W		5%
R147	315-0682-00			6.8 kΩ	1/4 W		5%
R149	305-0123-00			12 kΩ	2 W		5%
R150	315-0510-00			51 Ω	1/4 W		5%
R151	316-0564-00			560 kΩ	1/4 W		
R153	315-0202-00			2 kΩ	1/4 W		5%
R154	315-0152-00			1.5 kΩ	1/4 W		5%
R155	315-0202-00			2 kΩ	1/4 W		5%
R156	315-0101-00			100 Ω	1/4 W		5%
R157	301-0302-00			3 kΩ	1/2 W		5%
R161	315-0681-00			680 Ω	1/4 W		5%
R163	315-0682-00			6.8 kΩ	1/4 W		5%
R164	321-0068-00			49.9 Ω	1/8 W	Prec	1%

CHANNEL 1 INPUT AMPLIFIER CARD Series D *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Resistors *(cont)*
R165	315-0471-00			470 Ω ¼ W 5%
R166	301-0392-00			3.9 kΩ ½ W 5%
R168	321-0058-00			39.2 Ω ⅛ W Prec 1%
R173	315-0682-00			6.8 kΩ ¼ W 5%
R174	315-0221-00			220 Ω ¼ W 5%
R175	315-0361-00			360 Ω ¼ W 5%
R176	301-0392-00			3.9 kΩ ½ W 5%
R181	315-0102-00			1 kΩ ¼ W 5%
R182	303-0623-00			62 kΩ 1 W 5%
R183	315-0332-00			3.3 kΩ ¼ W 5%
R184	301-0303-00			30 kΩ ½ W 5%
R185	315-0101-00			100 Ω ¼ W 5%
R186	315-0103-00			10 kΩ ¼ W 5%
R191	315-0102-00			1 kΩ ¼ W 5%
R193	315-0332-00			3.3 kΩ ¼ W 5%
R194	303-0433-00			43 kΩ 1 W 5%
R196	315-0103-00			10 kΩ ¼ W 5%
R497	301-0131-00			130 Ω ½ W 5%

CHANNEL 2 INPUT AMPLIFIER CARD Series E

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-0076-01			Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
C225	281-0089-00			2-8 pF, Var Cer
C228	281-0089-00			2-8 pF, Var Cer
C252	281-0089-00			2-8 pF, Var Cer
C256	281-0096-00			5.5-18 pF, Var Air
C261	283-0081-00			0.1 μF Cer 25 V
C262	283-0059-00			1 μF Cer 25 V

Semiconductor Device, Diode

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
D222	*152-0153-00			Silicon Replaceable by 1N4244

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
Q223	151-0220-00			Silicon 2N4122
Q224	151-0225-00			Silicon 2N3563
Q243	151-0220-00			Silicon 2N4122
Q244	151-0225-00			Silicon 2N3563
Q253A	151-0225-00			Silicon 2N3563
Q253B	151-0225-00			Silicon 2N3563

CHANNEL 2 INPUT AMPLIFIER CARD Series E *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Value	Power	Type	Tolerance
R118	316-0154-00			150 kΩ	¼ W		
R218	316-0154-00			150 kΩ	¼ W		
R221	308-0400-00			18 kΩ	5 W	WW	5%
R222	305-0563-00			56 kΩ	2 W		5%
R223	315-0183-00			18 kΩ	¼ W		5%
R224	321-0127-00			205 Ω	⅛ W	Prec	1%
R225	321-0127-00			205 Ω	⅛ W	Prec	1%
R226	315-0561-00			560 Ω	¼ W		5%
R227	315-0682-00			6.8 kΩ	¼ W		5%
R228A	311-0258-00			100 Ω, Var			
R228B	315-0470-00			47 Ω	¼ W		5%
R228C	315-0390-00			39 kΩ	¼ W		5%
R233	316-0475-00			4.7 MΩ	¼ W		
R234	316-0474-00			470 kΩ	¼ W		
R236	316-0185-00			1.8 MΩ	¼ W		
R242	305-0563-00			56 kΩ	2 W		5%
R243	315-0183-00			18 kΩ	¼ W		5%
R244	321-0127-00			205 Ω	⅛ W	Prec	1%
R245	321-0127-00			205 Ω	⅛ W	Prec	1%
R246	315-0621-00			620 Ω	¼ W		5%
R247	315-0682-00			6.8 kΩ	¼ W		5%
R249	305-0123-00			12 kΩ	2 W		5%
R250	315-0510-00			51 Ω	¼ W		5%
R251	316-0564-00			560 kΩ	¼ W		
R253	315-0202-00			2 kΩ	¼ W		5%
R254	315-0152-00			1.5 kΩ	¼ W		5%
R255	315-0202-00			2 kΩ	¼ W		5%
R256	315-0101-00			100 Ω	¼ W		5%
R257	301-0302-00			3 kΩ	½ W		5%
R418	305-0622-00			6.2 kΩ	2 W		5%
R423	301-0123-00			12 kΩ	½ W		5%
R448	305-0622-00			6.2 kΩ	2 W		5%
R453	301-0123-00			12 kΩ	½ W		5%
R496	301-0131-00			130 Ω	½ W		5%

OUTPUT AMPLIFIER CARD Series F

Ckt. No.	Tektronix Part No.	Eff	Disc	Description
	*670-0077-01			Complete Card

Capacitors

Tolerance ±20% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Value	Type	Voltage	Tolerance
C300	283-0010-00			0.05 μF	Cer	25 V	
C301	283-0051-00			0.0033 μF	Cer	100 V	5%

OUTPUT AMPLIFIER CARD Series F *(cont)*

Capacitors *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C302	283-0000-00			0.001 μF	Cer	500 V	
C303	283-0010-00			0.05 μF	Cer	50 V	
C304	283-0010-00			0.05 μF	Cer	50 V	
C306	281-0518-00			47 pF	Cer	500 V	
C310	283-0010-00			0.05 μF	Cer	50 V	
C311	283-0051-00			0.0033 μF	Cer	100 V	5%
C312	283-0000-00			0.001 μF	Cer	500 V	
C313	281-0525-00			470 pF	Cer	500 V	
C314	283-0010-00			0.05 μF	Cer	50 V	
C316	281-0518-00			47 pF	Cer	500 V	
C321	283-0081-00			0.1 μF	Cer	25 V	
C330	281-0524-00			150 pF	Cer	500 V	
C334	283-0026-00			0.2 μF	Cer	25 V	
C342	283-0081-00			0.1 μF	Cer	25 V	
C343	281-0540-00			51 pF	Cer	500 V	5%
C344	281-0524-00	1	2X	150 pF	Cer	500 V	
C353	281-0536-00			0.001 μF	Cer	500 V	10%
C404	283-0051-00			0.0033 μF	Cer	100 V	5%
C414	283-0051-00			0.0033 μF	Cer	100 V	5%
C428	283-0000-00			0.001 μF	Cer	500 V	
C434	283-0051-00			0.0033 μF	Cer	100 V	5%
C444	283-0051-00			0.0033 μF	Cer	100 V	5%
C461	283-0001-00			0.005 μF	Cer	500 V	
C463	283-0000-00			0.001 μF	Cer	500 V	
C465	283-0028-00			0.0022 μF	Cer	50 V	
C466	281-0096-00			5.5-18 pF, Var	Air		
C467	281-0504-00			10 pF	Cer	500 V	10%
C475	283-0028-00			0.0022 μF	Cer		500 V
C476	281-0096-00			5.5-18 pF, Var	Air		

Semiconductor Device, Diodes

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D301	*152-0075-00			Germanium	Tek Spec
D303	152-0141-00	1	3	Silicon	1N4152
D303	152-0141-02	4		Silicon	1N4152
D308	*152-0075-00			Germanium	Tek Spec
D311	*152-0075-00			Germanium	Tek Spec
D313	*152-0075-00			Germanium	Tek Spec
D318	*152-0075-00			Germanium	Tek Spec
D330	*152-0075-00			Germanium	Tek Spec
D345	*152-0075-00			Germanium	Tek Spec
D353	152-0141-00	1	3	Silicon	1N4152
D353	152-0141-02	4		Silicon	1N4152
D421	*152-0153-00			Silicon	Replaceable by 1N4244

Semiconductor Device, Diodes *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
D422	*152-0153-00			Silicon	Replaceable by 1N4244
D423	*152-0153-00			Silicon	Replaceable by 1N4244
D424	*152-0153-00			Silicon	Replaceable by 1N4244
D451	*152-0153-00			Silicon	Replaceable by 1N4244
D452	*152-0153-00			Silicon	Replaceable by 1N4244
D453	*152-0153-00			Silicon	Replaceable by 1N4244
D454	*152-0153-00			Silicon	Replaceable by 1N4244

Inductors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
L460	*114-0159-00	1		0.7-1.5 μH, Var	core 276-0506-00
L460	*114-0277-00	2		0.7-1.5 μH, Var	core 276-0506-00
L470	*114-0159-00	1		0.7-1.5 μH, Var	core 276-0506-00
L470	*114-0276-00	2		0.7-1.5 μH, Var	core 276-0506-00

Transistors

Ckt. No.	Tektronix Part No.	Eff	Disc	Description	
Q305	151-0188-00			Silicon	2N3906
Q315	151-0188-00			Silicon	2N3906
Q330	151-0224-00			Silicon	2N3692
Q343	151-0164-00			Silicon	2N3702
Q353	151-0164-00			Silicon	2N3702
Q404	151-0221-00	1	4	Silicon	2N4258
Q404	151-0199-00	5		Silicon	MOT MPS-3640
Q414	151-0221-00	1	4	Silicon	2N4258
Q414	151-0199-00	5		Silicon	MOT MPS-3640
Q434	151-0221-00	1	4	Silicon	2N4258
Q434	151-0199-00	5		Silicon	MOT MPS-3640
Q444	151-0221-00	1	4	Silicon	2N4258
Q444	151-0199-00	5		Silicon	MOT MPS-3640
Q464	151-0225-00			Silicon	2N3653
Q474	151-0225-00			Silicon	2N3653

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

Ckt. No.	Tektronix Part No.	Eff	Disc	Description			
R300	308-0303-00			750 Ω	3 W	WW	1%
R301	308-0304-00			1.5 kΩ	3 W	WW	1%
R302	315-0101-00			100 Ω	¼ W		5%
R303	315-0123-00			12 kΩ	¼ W		5%
R304	315-0303-00			30 kΩ	¼ W		5%
R306	315-0332-00			3.3 kΩ	¼ W		5%
R307	323-0126-00			200 Ω	½ W	Prec	1%
R311	308-0304-00			1.5 kΩ	3 W	WW	1%
R312	315-0101-00			100 Ω	¼ W		5%
R313	315-0123-00			12 kΩ	¼ W		5%
R314	315-0303-00			30 kΩ	¼ W		5%
R316	315-0332-00			3.3 kΩ	¼ W		5%
R317	323-0126-00			200 Ω	½ W	Prec	1%
R321	315-0100-00			10 Ω	¼ W		5%
R322	315-0101-00			100 Ω	¼ W		5%

OUTPUT AMPLIFIER CARD Series F *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
				Resistors *(cont)*			
R330	315-0472-00			4.7 kΩ	¼ W		5%
R331	315-0470-00			47 Ω	¼ W		5%
R332	315-0102-00			1 kΩ	¼ W		5%
R334	315-0272-00			2.7 kΩ	¼ W		5%
R341	315-0102-00			1 kΩ	¼ W		5%
R342	315-0102-00			1 kΩ	¼ W		5%
R343	315-0122-00			1.2 kΩ	¼ W		5%
R345	301-0154-00			150 kΩ	½ W		5%
R346	315-0512-00			5.1 kΩ	¼ W		5%
R347	315-0332-00			3.3 kΩ	¼ W		5%
R351	301-0272-00			2.7 kΩ	½ W		5%
R353	315-0122-00			1.2 kΩ	¼ W		5%
R355	315-0103-00			10 kΩ	¼ W		5%
R404	315-0221-00			220 Ω	¼ W		5%
R405	315-0111-00			110 Ω	¼ W		5%
R406	315-0512-00			5.1 kΩ	¼ W		5%
R414	315-0221-00			220 Ω	¼ W		5%
R415	315-0111-00			110 Ω	¼ W		5%
R416	315-0512-00			5.1 kΩ	¼ W		5%
R421	315-0823-00			82 kΩ	¼ W		5%
R424	315-0823-00			82 kΩ	¼ W		5%
R426	321-0141-00			289 Ω	⅛ W	Prec	1%
R428	321-0097-00			100 Ω	⅛ W	Prec	1%
R429	321-0136-00			255 Ω	⅛ W	Prec	1%
R434	315-0221-00			220 Ω	¼ W		5%
R435	315-0111-00			110 Ω	¼ W		5%
R436	315-0512-00			5.1 kΩ	¼ W		5%
R444	315-0221-00			220 Ω	¼ W		5%
R445	315-0111-00			110 Ω	¼ W		5%
R446	315-0512-00			5.1 kΩ	¼ W		5%
R451	315-0823-00			82 kΩ	¼ W		5%
R454	315-0823-00			82 kΩ	¼ W		5%
R456	321-0141-00			287 Ω	⅛ W	Prec	1%
R461	315-0103-00			10 kΩ	¼ W		5%
R462	315-0470-00			47 Ω	¼ W		5%
R463	308-0300-00			1.75 kΩ	3 W	WW	1%
R464	321-0077-00			61.9 Ω	⅛ W	Prec	1%
R465	315-0331-00			330 Ω	¼ W		5%
R466	321-0065-00			46.4 Ω	⅛ W	Prec	1%
R467	308-0301-00			10 kΩ	3 W	WW	1%
R472	315-0470-00			47 Ω	¼ W		5%
R474	321-0077-00			61.9 Ω	⅛ W	Prec	1%
R475	315-0331-00			330 Ω	¼ W		5%
R476	321-0065-00			46.4 Ω	⅛ W	Prec	1%
R494	303-0242-00			2.4 kΩ	1 W		5%

OUTPUT AMPLIFIER CARD Series F *(cont)*

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
				Transformer
T330	*120-0161-00			Toroid 12 turns, quintifilar
				Electron Tubes
V464	*157-0121-00			7586, checked
V474	*157-0121-00			7586, checked

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
  Detail Part of Assembly and/or Component
  mounting hardware for Detail Part
    Parts of Detail Part
    mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise specificed.

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS

(Located behind diagrams)

SECTION 9
MECHANICAL PARTS LIST

FIG. 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-1	366-0220-00			2	KNOB, charcoal—POSITION
	- - - - - -			-	each knob includes:
	213-0020-00			1	SCREW, set, 6-32 x $^{1}/_{8}$ inch, HSS
	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	Mounting hardware for each: (not included w/resistor)
	210-0013-00			1	LOCKWASHER, internal, $^{3}/_{8}$ ID x $^{11}/_{16}$ OD
	210-0840-00			1	WASHER, flat, 0.390 ID x $^{9}/_{16}$ inch OD
	210-0590-00			1	NUT, hex., $^{3}/_{8}$-32 x $^{7}/_{16}$ inch
-2	366-0153-00			2	KNOB, charcoal—VARIABLE VOLTS/CM
	- - - - - -			-	each knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
-3	358-0229-00			2	BUSHING, plastic, shaft
-4	131-0352-01			2	CONNECTOR, coaxial, 1 contact, BNC
-5	366-0125-00			1	KNOB, plug-in securing
	- - - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
-6	210-0984-00			1	WASHER, plastic, 0.190 ID x $^{7}/_{16}$ inch OD
-7	366-0215-01			2	KNOB, charcoal—INPUT SELECTOR
-8	366-0145-00	2000	23059	2	KNOB, charcoal—VOLTS/CM
	366-1089-00	23060		2	KNOB, charcoal—VOLTS/CM
	- - - - - -			-	each knob includes:
	213-0004-00	2000	23059	1	SCREW, set, 6-32 x $^{3}/_{16}$ inch, HSS
	213-0153-00	23060		2	SCREW, set, 5-40 x 0.125 inch, HSS
-9	262-0693-02	20000	22709	2	SWITCH, wired—VOLTS/CM (Channel 1, front; Channel 2, front)
	262-0693-04	22710		2	SWITCH, wired—VOLTS/CM (Channel 1, front; Channel 2, front)
	- - - - - -			-	each switch includes:
	260-0673-02			1	SWITCH, attenuator
-10	337-0673-00			1	SHIELD, attenuator
-11	260-0621-00			1	SWITCH, lever—INPUT SELECTOR
	- - - - - -			-	Mounting hardware: (not included w/switch)
	211-0105-00			2	SCREW, 4-40 x $^{3}/_{16}$ inch, 80° csk, FHS
	210-0586-00			2	NUT, keps, 4-40 x $^{1}/_{4}$ inch
-12	134-0015-00			1	PLUG, banana
-13	426-0201-00			1	FRAME, attenuator
	- - - - - -			-	mounting hardware: (not included w/frame)
-14	211-0007-00			2	SCREW, 4-40 x $^{3}/_{16}$ inch, PHS
	- - - - - -			-	mounting hardware for each: (not included w/switch)
-15	358-0029-00			1	BUSHING, hex., $^{3}/_{8}$-32 x $^{1}/_{2}$ x $^{1}/_{2}$ inch long

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
1-16	262-0717-00			1	SWITCH, wired—VOLTS/CM (Channel 2, rear)
	- - - - - -			-	switch includes:
	260-0560-00			1	SWITCH, unwired
-17	210-0963-00			1	WASHER, plastic, 0.254 ID x 0.500 inch OD
-18	214-0274-00			2	BALL, stainless steel
-19	214-0385-00			1	SPRING, index
-20	214-0379-00			2	HUB, driver
	- - - - - -			-	each hub includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-21	384-0295-00			1	ROD, shaft
-22	387-0827-00			1	PLATE, flange
-23	131-0371-00			3	CONNECTOR, single contact, (female)
-24	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-25	214-0272-00			4	GEAR, miter
	- - - - - -			-	each gear includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-26	262-0716-00			1	SWITCH, wired—VOLTS/CM (Channel 1, rear)
	- - - - - -			-	switch includes:
	260-0560-00			1	SWITCH, unwired
-27	210-0963-00			1	WASHER, plastic, 0.254 ID x 0.500 inch OD
-28	214-0274-00			2	BALL, stainless steel
-29	214-0385-00			1	SPRING, index
-30	214-0379-00			2	HUB, driver
	- - - - - -			-	each hub includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-31	384-0295-00			1	ROD, shaft
-32	387-0827-00			1	PLATE, flange
-33	131-0371-00			3	CONNECTOR, single contact, (female)
-34	348-0031-00			2	GROMMET, plastic, 3/32 inch diameter
-35	358-0054-00			1	BUSHING, banana jack
	- - - - - -			-	mounting hardware: (not included w/bushing)
	210-0223-00			1	LUG, solder, 1/4 ID x 7/16 inch OD, SE
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
-36	358-0054-00			1	BUSHING, banana jack
	- - - - - -			-	mounting hardware: (not included w/bushing)
	210-0465-00			1	NUT, hex., 1/4-32 x 3/8 inch
-37	366-0173-00	20000	23059	1	KNOB, charcoal—MODE
	366-1088-00	23060		1	KNOB, charcoal—MODE
	- - - - - -			-	knob includes:
	213-0004-00	20000	23059	1	SCREW, set, 6-32 x 3/16 inch, HSS
	213-0153-00	23060		2	SCREW, set, 5-40 x 0.125 inch, HSS
-38	262-0579-00			1	SWITCH, wired—MODE
	- - - - - -			-	switch includes:
	260-0561-00			1	SWITCH, unwired
	- - - - - -			-	mounting hardware: (not included w/switch)
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-39	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch
-40	333-0918-00			1	PANEL, front
-41	131-0276-00			2	CONNECTOR, coaxial, 1 contact, BNC
-42	384-0510-00			1	ROD, plug-in securing
	- - - - - -			-	rod includes:
-43	354-0025-00			1	RING, retaining

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Serial/Model No. Disc	Qty	Description 1 2 3 4 5
1-44	387-0792-01			1	PLATE, sub-panel
-45	- - - - - -			2	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
-46	220-0420-00			1	NUT, hex., adapter, 1/4-32 x 3/8-32 x 1/2 x 1.250 inches long
-47	358-0054-00			1	BUSHING, banana jack
-48	260-0786-00			1	ASSEMBLY, switch, unwired—PULL FOR INVERT (Channel 1)
	- - - - - -			-	assembly includes:
	260-0767-00			1	SWITCH, unwired
-49	210-0001-00			2	LOCKWASHER, internal, #2
-50	211-0062-00			2	SCREW, 2-56 x 5/16 inch, RHS
-51	214-0649-00			1	PLATE, detent spring
-52	214-0650-00			2	CLIP, detent spring
-53	214-0651-00			1	BALL, switch detent
-54	384-0383-00			1	ROD, extension, w/knob—PULL FOR INVERT (Channel 1)
-55	384-0646-00			1	POST, switch support
	- - - - - -			-	mounting hardware: (not included w/assembly)
	211-0513-00			1	SCREW, 6-32 x 5/8 inch, PHS
-56	260-0878-00			1	ASSEMBLY, switch, unwired—PULL FOR INVERT (Channel 2)
	- - - - - -			-	assembly includes:
	260-0767-00			1	SWITCH, unwired
-57	210-0001-00			2	LOCKWASHER, internal #2
-58	211-0062-00			2	SCREW, 2-56 x 5/16 inch, RHS
-59	214-0649-00			1	PLATE, detent spring
-60	214-0650-00			2	CLIP, detent spring
-61	214-0651-00			1	BALL, switch detent
-62	384-0383-00			1	ROD, extension, w/knob—PULL FOR INVERT (Channel 2)
-63	384-0646-00			1	POST, switch support
	- - - - - -			-	mounting hardware: (not included w/assembly)
	211-0513-00			1	SCREW, 6-32 x 5/8 inch, PHS
	670-0266-00	20000	22919	1	ASSEMBLY, circuit board—INPUT (Channel 2)
	670-0266-01	22920		1	ASSEMBLY, circuit board—INPUT (Channel 2)
	- - - - - -			-	assembly includes:
-64	388-0996-00			1	BOARD, circuit
-65	214-0506-00			5	PIN, connector, straight (male)
-66	131-0371-00			2	CONNECTOR, single contact (female)
-67	131-0374-00			2	CONNECTOR, single contact (male)
-68	136-0220-00			2	SOCKET, transistor, 3 pin
-69	131-0183-00			2	CONNECTOR, terminal, feed thru
	- - - - - -			-	mounting hardware for each: (not included w/connector)
	358-0136-00			1	BUSHING, plastic
	- - - - - -			-	mounting hardware: (not included w/assembly)
-70	211-0017-00	20000	24819	2	SCREW, 4-40 x 3/4 inch, PHS
	210-0054-00	20000	24819	2	LOCKWASHER, internal, #4, split
	210-0994-00	20000	24819	2	WASHER, flat, #4
-71	166-0026-00	20000	24819	2	TUBE, spacer, 3/16 OD x 3/8 inch long
	129-0236-00	24820		2	POST, 0.375 inch long
	211-0116-00	24820		2	SCREW, sems, 4-40 x 5/16 inch, PHS

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
1-	670-0265-00	20000	22919	1	ASSEMBLY, circuit board—INPUT (Channel 1)
	670-0265-01	22920		1	ASSEMBLY, circuit board—INPUT (Channel 1)
	- - - - - -			-	assembly includes:
-72	388-0995-00			1	BOARD, circuit
-73	214-0506-00			5	PIN, connector, straight (male)
-74	131-0371-00			2	CONNECTOR, single contact (female)
-75	131-0374-00			2	CONNECTOR, single contact (male)
-76	136-0220-00			2	SOCKET, transistor, 3 pin
-77	131-0183-00			2	CONNECTOR terminal feed-thru
	- - - - - -			-	mounting hardware for each: (not included w/connector)
	358-0136-00			1	BUSHING, plastic
	- - - - - -			-	mounting hardware: (not included w/assembly)
-78	211-0017-00			2	SCREW, 4-40 x $^3/_{16}$ inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0994-00			2	WASHER, flat, #4
-79	166-0026-00			2	TUBE, spacer, $^3/_{16}$ OD x $^3/_8$ inch long

FIG. 2 REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-1	337-0577-00			1	SHIELD
	- - - - - -			-	mounting hardware: (not included w/shield)
-2	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-3	384-0644-03			1	ROD, support, right
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0559-00			1	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
-4	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-5	385-0171-01			1	ROD, support, front
	- - - - - -			-	mounting hardware: (not included w/rod)
-6	211-0559-00	20000	20219	2	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	211-0512-00	20220		2	SCREW, 6-32 x 1/2 inch, 100° csk, FHS
-7	351-0059-00			6	GUIDE, circuit card
	- - - - - -			-	mounting hardware for each: (not included w/guide)
-8	211-0510-00			1	SCREW, 6-32 x 3/8 inch, PHS
-9	344-0101-00			2	CLIP, retainer
-10	385-0171-00			1	ROD, support, rear
	- - - - - -			-	mounting hardware: (not included w/rod)
-11	211-0559-00	20000	20219	2	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
	211-0512-00	20220		2	SCREW, 6-32 x 1/2 inch, 100° csk, FHS
-12	384-0644-04			1	ROD, support, left
	- - - - - -			-	mounting hardware: (not included w/rod)
	211-0559-00			1	SCREW, 6-32 x 3/8 inch, 100° csk, FHS
-13	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-14	441-0658-00			1	CHASSIS, right
	- - - - - -			-	mounting hardware: (not included w/chassis)
-15	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-16	- - - - - -			4	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0013-00	X20540		1	LOCKWASHER, internal, 3/8 ID x 11/16 inch OD
-17	210-0840-00			1	WASHER, flat, 0.390 ID x 9/16 inch OD
-18	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-19	441-0658-03			1	CHASSIS, left
	- - - - - -			-	mounting hardware: (not included w/chassis)
-20	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-21	136-0156-01			2	SOCKET, circuit card, 44 pin
	- - - - - -			-	mounting hardware for each: (not included w/socket)
-22	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
	210-0801-00			1	WASHER, flat, 0.140 ID x 9/32 inch OD

FIG. 2 REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-23	136-0156-01			2	SOCKET, circuit card, 44 pin
	- - - - - -			-	mounting hardware: (not included w/socket)
-24	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-25	179-0746-02			1	CABLE HARNESS
-26	384-0282-00			2	ROD, extension
-27	376-0051-00			2	COUPLING, flexible
	- - - - - -			-	each coupling includes:
	213-0048-00			4	SCREW, set, 4-40 x 3/16 inch, HSS
-28	376-0049-00			1	COUPLING, plastic
-29	354-0251-00			2	RING, coupling
-30	- - - - - -			-	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-31	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-32	- - - - - -			3	RESISTOR, variable
	- - - - - -			-	mounting hardware for each: (not included w/resistor)
	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-33	384-0284-00			2	ROD, extension
-34	376-0051-00			2	COUPLING, flexible
	- - - - - -			-	each coupling includes:
	213-0048-00			4	SCREW, set, 4-40 x 3/16 inch, HSS
	376-0049-00			1	COUPLING, plastic
	354-0251-00			2	RING, retaining
-35	406-0931-01			1	BRACKET, mounting
	- - - - - -			-	mounting hardware: (not included w/bracket)
-36	211-0507-00			2	SCREW, 6-32 x 5/16 inch, PHS
-37	384-0631-00			4	ROD, frame
	- - - - - -			-	mounting hardware for each: (not included w/rod)
-38	212-0044-00			1	SCREW, 8-32 x 1/2 inch, RHS
-39	387-0793-00			1	PLATE, rear
-40	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS
	210-0478-00			1	NUT, hex., resistor mounting
	210-0202-00			1	LUG, solder, SE #6
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS

FIG. 2 REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	Description 1 2 3 4 5
2-41	- - - - - -			1	RESISTOR
	- - - - - -			-	mounting hardware: (not included w/resistor)
	211-0544-00			1	SCREW, 6-32 x 3/4 inch, THS
	210-0478-00			1	NUT, hex., resistor mounting
	211-0507-00			1	SCREW, 6-32 x 5/16 inch, PHS
-42	131-0017-00			1	CONNECTOR, 16 contact
	- - - - - -			-	mounting hardware: (not included w/connector)
	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0201-00			2	LUG, solder, SE #4
	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch
-43	343-0088-00			1	CLAMP, cable, plastic
-44	131-0371-00			4	CONNECTOR, single contact
-45	134-0015-00			1	PLUG, banana

FIG. 3 CIRCUIT CARDS & STANDARD ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Qty	1 2 3 4 5 Description
3-1	670-0075-01			1	ASSEMBLY, circuit card—INPUT CHANNEL 1
	- - - - - -			-	assembly includes:
	388-0560-01			1	CARD, circuit
-2	214-0506-00			3	PIN, connector, straight, male
-3	214-0507-00			2	PIN, connector, 45°, male
-4	136-0183-00			12	SOCKET, transistor, 3 pin
-5	387-0794-00			1	PLATE, variable resistor
-6	210-0696-00			1	EYELET, 0.121 ID x 0.200 inch OD
-7	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-8	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-9	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-10	670-0076-01			1	ASSEMBLY, circuit card—INPUT CHANNEL 2
	- - - - - -			-	assembly includes:
	388-0559-01			1	CARD, circuit
-11	214-0506-00			3	PIN, connector, straight, male
-12	214-0507-00			2	PIN, connector, 45°, male
-13	136-0183-00			6	SOCKET, transistor, 3 pin
-14	387-0794-00			1	PLATE, variable resistor
-15	210-0696-00			1	EYELET, 0.121 ID x 0.200 inch OD
-16	- - - - - -			1	RESISTOR, variable
	- - - - - -			-	mounting hardware: (not included w/resistor)
-17	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-18	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-19	670-0077-01			1	ASSEMBLY, circuit card—OUTPUT AMPLIFIER
	- - - - - -			-	assembly includes:
	388-0561-01			1	CARD, circuit
-20	214-0506-00			4	PIN, connector, straight, male
-21	136-0183-00			1	SOCKET, transistor, 3 pin
-22	136-0125-00			1	SOCKET, nuvistor, 5 pin
	200-0658-00			2	COVER, plastic (not shown)
-23	210-0696-00			1	EYELET, 0.121 ID x 0.200 inch OD
-24	426-0121-00			1	MOUNT, toroid
	- - - - - -			-	mounting hardware: (not included w/mount)
-25	361-0007-00			1	SPACER, plastic, 0.188 inch long
					STANDARD ACCESSORIES
-26	012-0076-00			1	CABLE, 50 Ω BNC to BNC
	070-0885-00			2	MANUAL, instruction

Ⓕ

IMPORTANT

VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages were measured with a 20,000 Ω/V DC VOM. All readings are in volts. Voltages were measured with respect to ground unless otherwise indicated.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera equipped with a projected graticule. Each division of the graticule represents one centimeter.

Voltages and waveforms (shown in blue) on the diagrams are not absolute and may vary between Type 1A1 units. A 30-inch flexible cable plug-in extension (012-0038-00) was used to operate the Type 1A1 outside the oscilloscope plug-in opening and a rigid extender card (012-0100-00) was used for access to the Channel 1 and Output Amplifier cards test points. Any apparent differences between voltages measured with the voltmeter and the DC levels shown at the right side of the waveforms are due to differences in circuit loading, operating mode, and measurement resolution.

NOTE

Waveforms for Channel 2 are the same as for Channel 1 except that Channel 1 has a TRIGGER OUT amplifier and a CH 1 SIGNAL OUT amplifier.

The waveforms were obtained using a test oscilloscope with a 10X probe. The system characteristics are as follows: Minimum vertical deflection factor of 0.05 V/cm with the probe 10X attenuation factor included, frequency response of DC to 10 MHz. The procedure for obtaining the time related waveforms and DC levels is described in the Maintenance section.

CAUTION

If the Type 1A1 is used with the Type 544, 546 or 547 Oscilloscope and the plug-in extension is used, be sure to pull the Oscilloscope plug-in sensing switch to its outward position before turning on the oscilloscope power. The switch connects the +75-V supply to pin 15 of the 16-pin interconnecting plug. Use care when obtaining voltage and waveform measurements in an operating unit. An inadvertant movement of the test prods or probe may cause a short between circuits and seriously damage circuit components, such as solid state devices.

Control Settings

Type 1A1

(See individual diagrams for remaining control settings.)

VOLTS/CM	.5
VARIABLE (VOLTS/CM)	CALIB
POSITION (both channels)	Near midrange
PULL FOR INVERT (both channels)	Normal or in

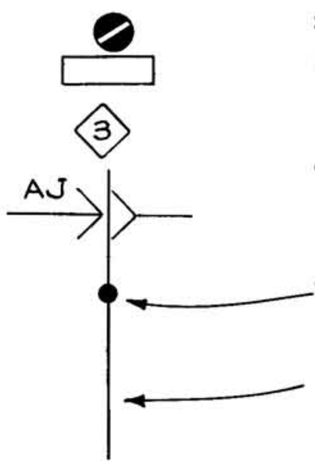
Type 547 Oscilloscope with 1A1

Triggering controls	
Triggering Level	Near 0 and knob pushed for all voltages and waveforms except ALT and CHOP waveforms. Fully CW to free run sweep for ALT and CHOP waveforms on switching Circuit 5
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Normal Int
Time Base Controls	
Time/Cm	.5 mSec to display 1-kHz calibrator signal (Diagrams 2 and 4) 1 μSec for Diagram 5
Variable (Time/Cm)	Calibrated
Other controls	
Amplitude Calibrator	2 volts
Sweep Magnifier	X1 (Off)
Power	On

Test Oscilloscope (for signal tracing)

External Trigger signal applied to Trigger Input connector	2-V peak-to-peak 1-kHz calibrator signal (from Type 547 with 1A1) to obtain time-related waveforms on diagrams 2 and 4.
Internal Trigger	Waveform photographs for ALT and CHOP modes on diagram 5 are not time-related.
Time/Cm	See waveforms
V/Cm	See waveforms
Input Coupling	AC, to photograph waveforms. DC, to obtain DC levels (when shown) at right side of waveforms. Use appropriate V/Cm setting (not given).

SCHEMATIC SYMBOLS



Screwdriver adjustment

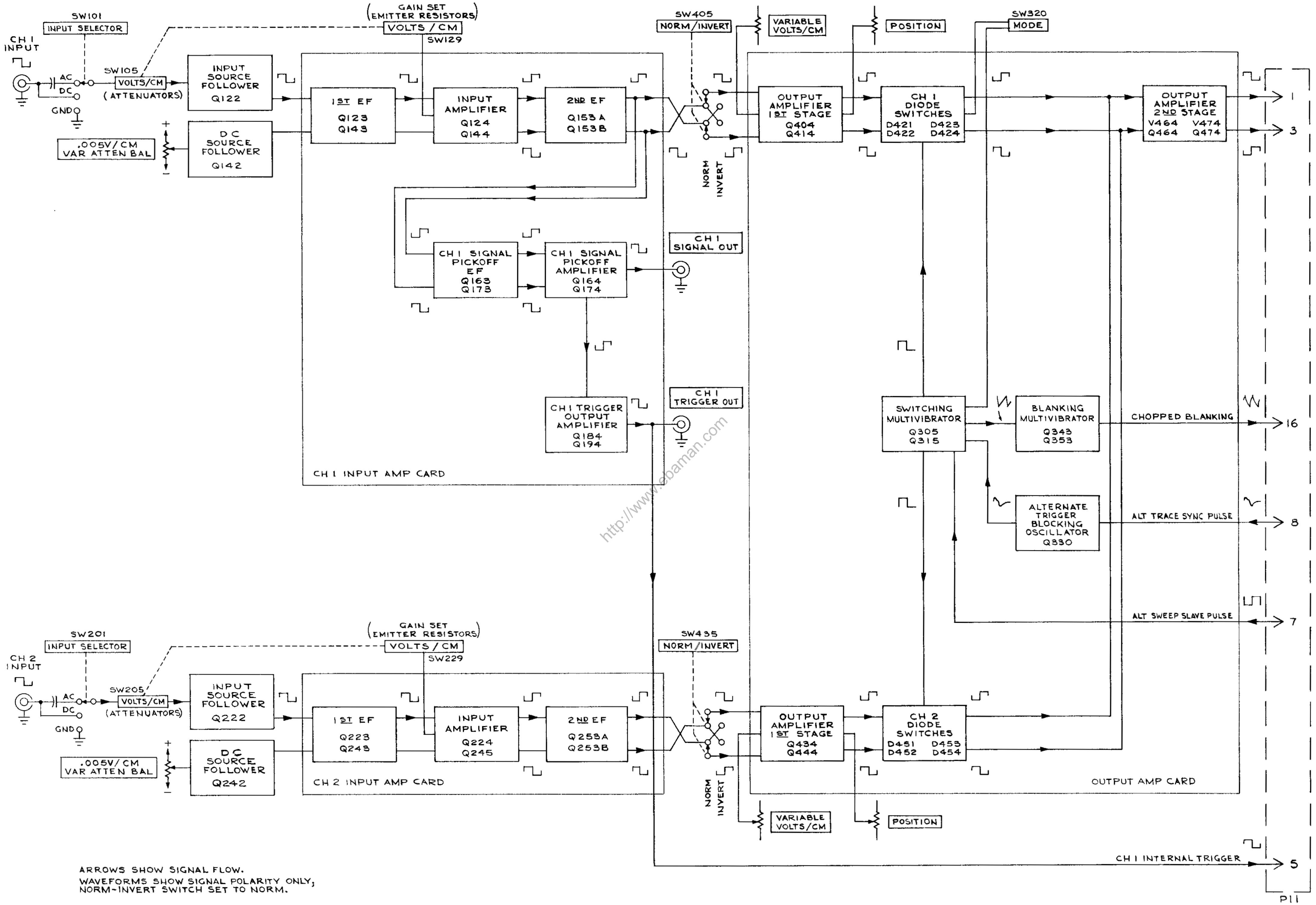
Front or rear control

Refer to indicated diagram

Connection to circuit board mode with pin connector at indicated pin.

Connection soldered to etched-wiring board.

Blue line encloses components located on etched-wiring card or board.

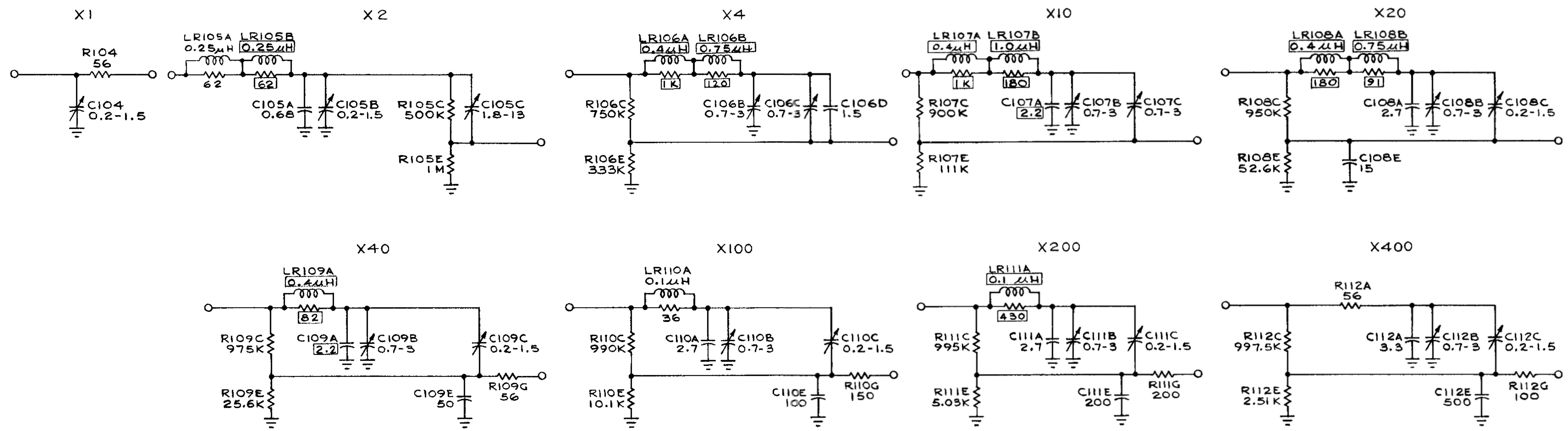


ARROWS SHOW SIGNAL FLOW.
WAVEFORMS SHOW SIGNAL POLARITY ONLY; NORM-INVERT SWITCH SET TO NORM.

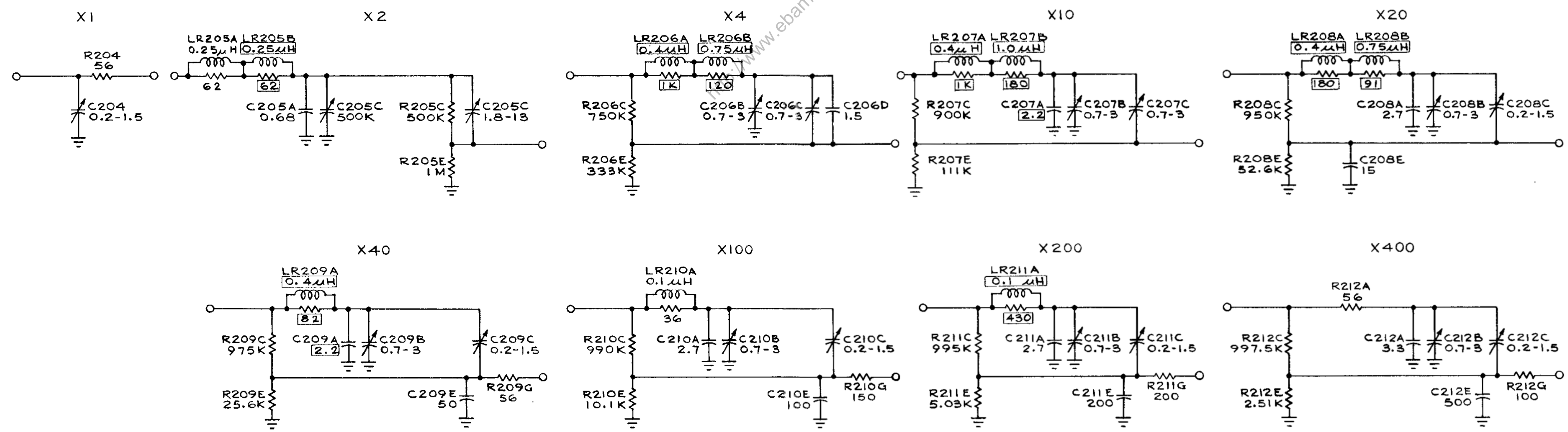
SEE IMPORTANT NOTE FOR VOLTAGE AND WAVEFORM CONDITIONS

S/N 20,000 - UP
BLOCK DIAGRAM

MRH 368

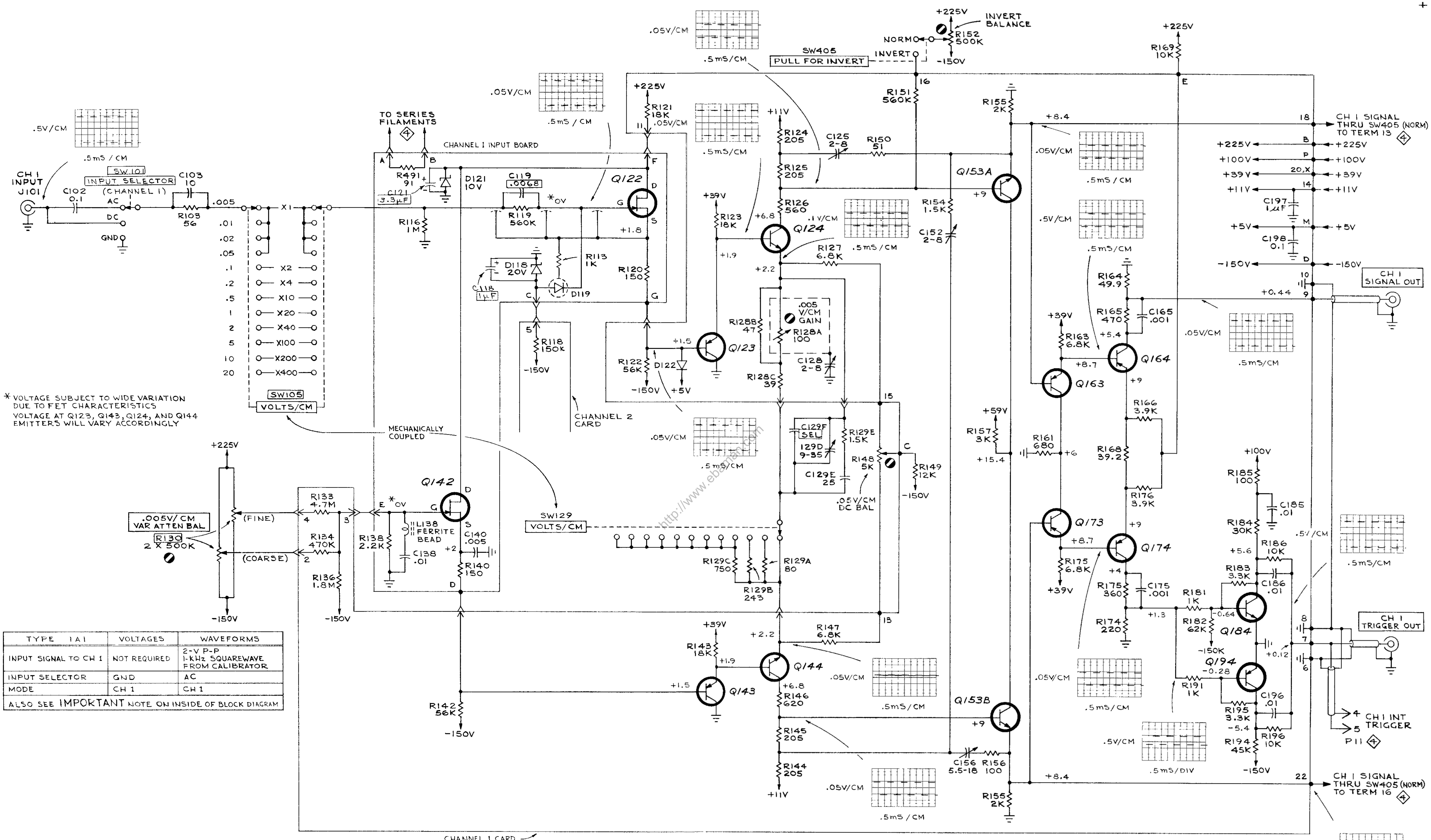


CHANNEL 1



CHANNEL 2

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

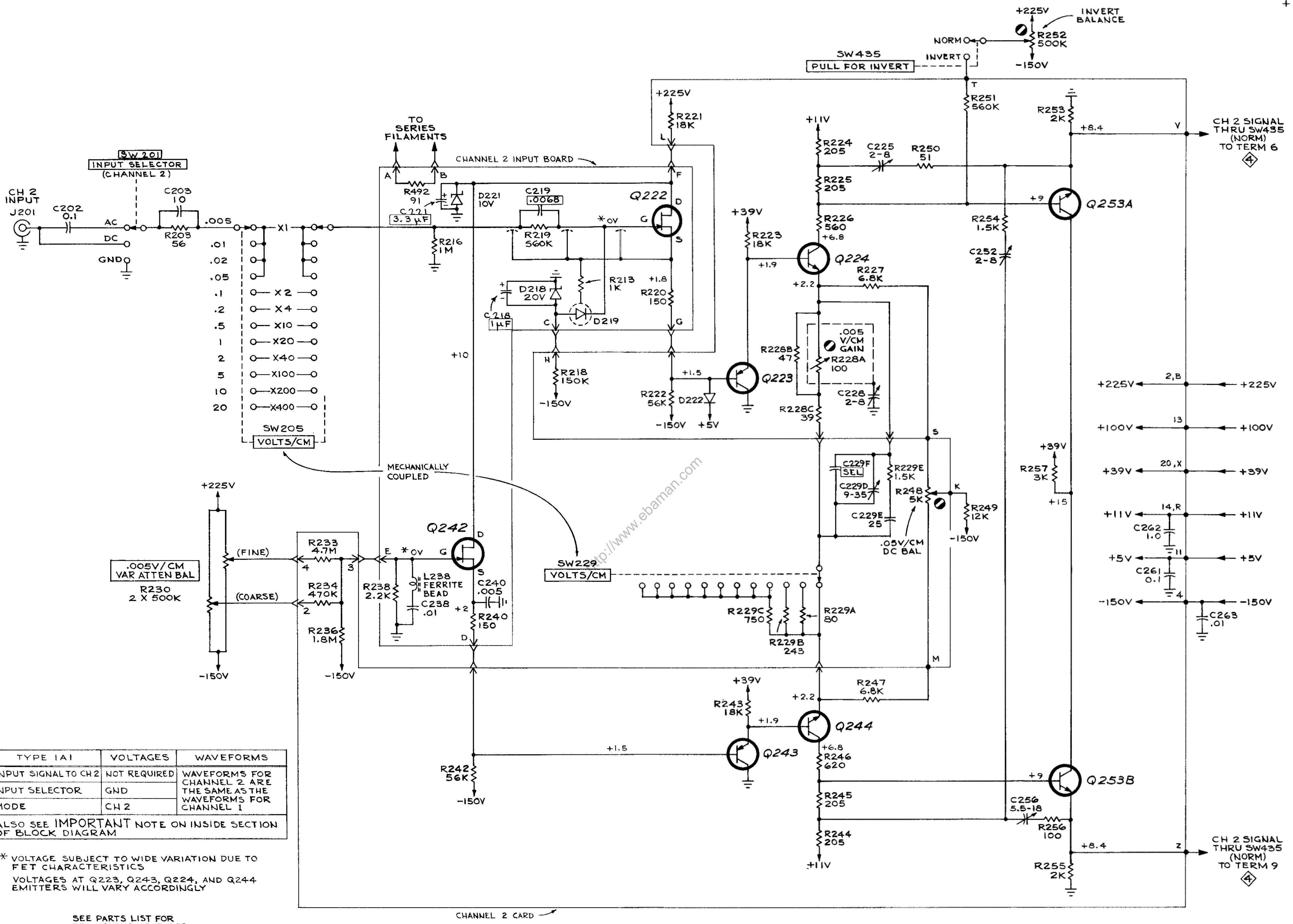


TYPE 1A1	VOLTAGES	WAVEFORMS
INPUT SIGNAL TO CH 1	NOT REQUIRED	2-V P-P 1-kHz SQUAREWAVE FROM CALIBRATOR
INPUT SELECTOR	GND	AC
MODE	CH 1	CH 1
ALSO SEE IMPORTANT NOTE ON INSIDE OF BLOCK DIAGRAM		

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAM:
④ OUTPUT AMPLIFIER

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



TYPE 1A1	VOLTAGES	WAVEFORMS
INPUT SIGNAL TO CH 2	NOT REQUIRED	WAVEFORMS FOR CHANNEL 2 ARE THE SAME AS THE WAVEFORMS FOR CHANNEL 1
INPUT SELECTOR	GND	
MODE	CH 2	

ALSO SEE IMPORTANT NOTE ON INSIDE SECTION OF BLOCK DIAGRAM

* VOLTAGE SUBJECT TO WIDE VARIATION DUE TO FET CHARACTERISTICS

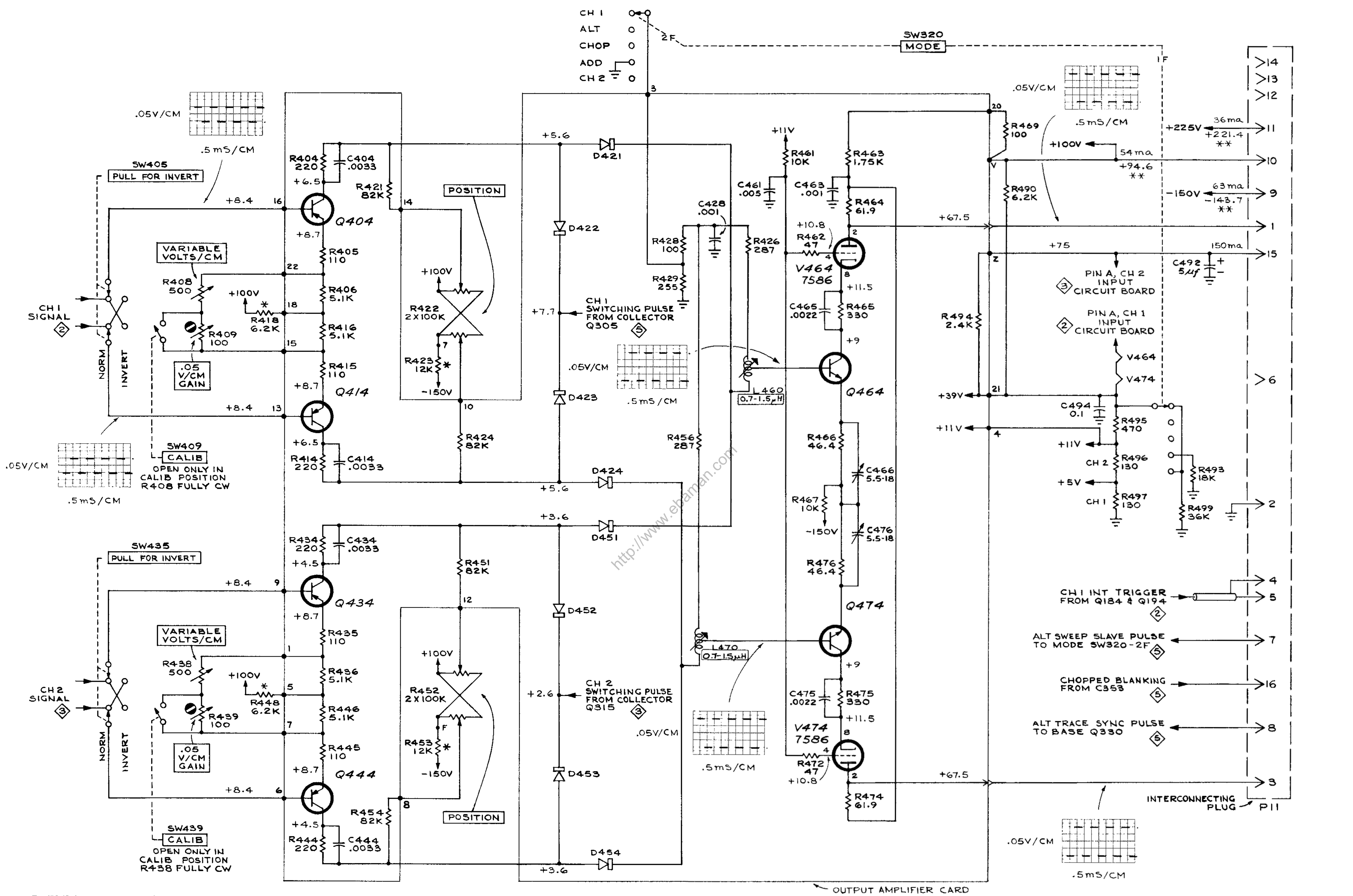
VOLTAGES AT Q223, Q243, Q224, AND Q244 EMITTERS WILL VARY ACCORDINGLY

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

④ OUTPUT AMPLIFIER

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.



REFERENCE DRAWINGS:

(2) CH 1 INPUT AMPLIFIER
(3) CH 2 INPUT AMPLIFIER
(5) SWITCHING CIRCUIT

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

* ON CH 2 CARD

TYPE 1A1	VOLTAGES	WAVEFORMS
INPUT SIGNAL TO CH 1	NOT REQUIRED	2-V P-P 1-kHz SQUAREWAVE FROM CALIBRATOR
INPUT SELECTOR	GND	AC
MODE	CH 1	CH 1
ALSO SEE IMPORTANT NOTE ON INSIDE SECTION OF BLOCK DIAGRAM		

B1

** DECOUPLED SUPPLY VOLTAGES

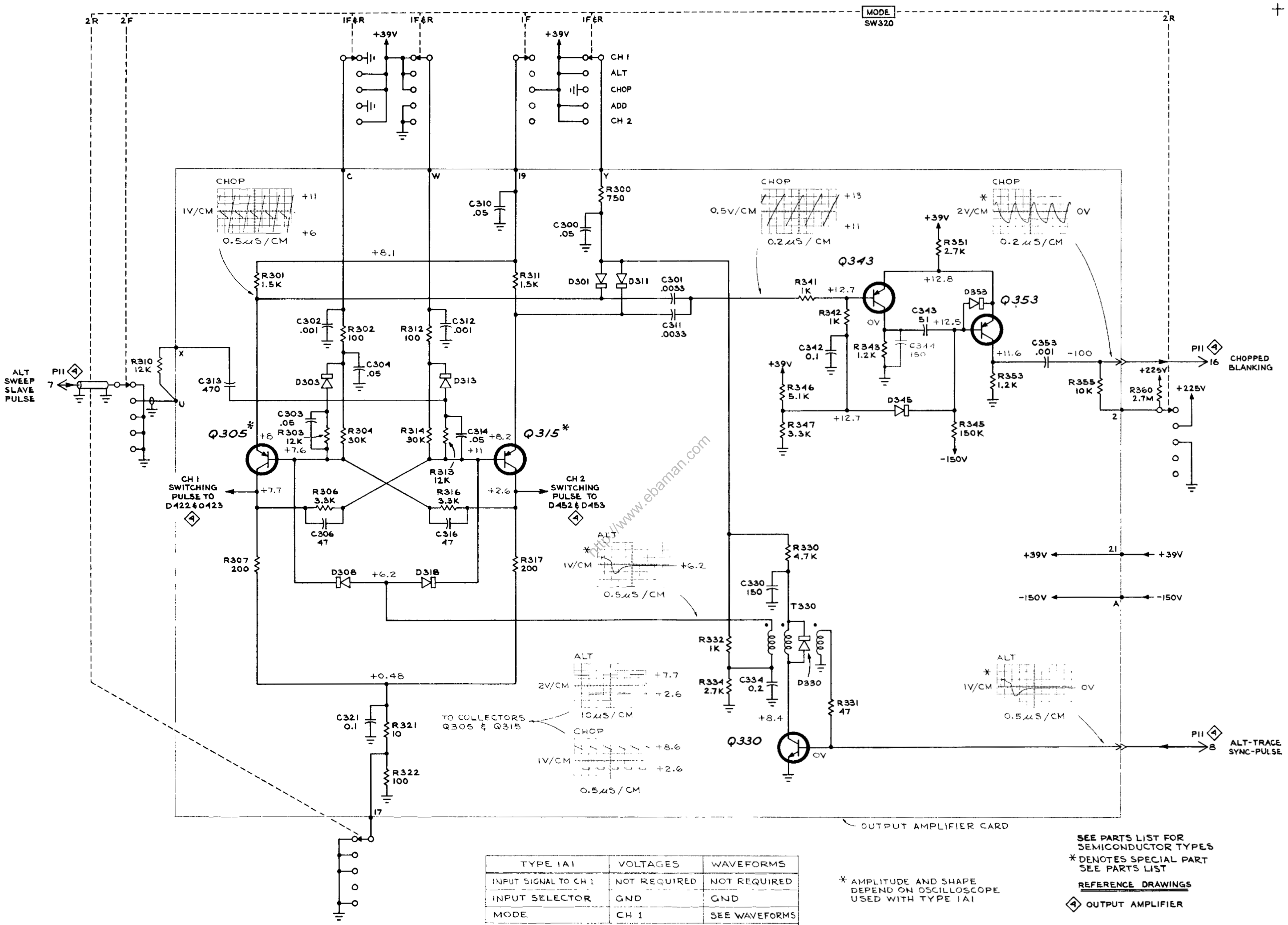
NOTE:
ON SOME PLUG-INS THERE MAY BE A DIFFERENCE IN WAVEFORM AMPLITUDES AT PINS 1 AND 3 OF P11. (ALSO AN AMPLITUDE DIFFERENCE MAY EXIST BETWEEN THE TWO SIDES OF PREVIOUS AMPLIFIERS). THIS IS NOT AN ABNORMAL CONDITION FOR THE AMPLIFIERS INVOLVED.

TYPE 1A1 PLUG-IN

S/N 20,000-UP

OUTPUT AMPLIFIER (4)

MRH 668



TYPE 1A1	VOLTAGES	WAVEFORMS
INPUT SIGNAL TO CH 1	NOT REQUIRED	NOT REQUIRED
INPUT SELECTOR	GND	GND
MODE	CH 1	SEE WAVEFORMS
ALSO SEE IMPORTANT NOTE ON INSIDE SECTION OF BLOCK DIAGRAM		

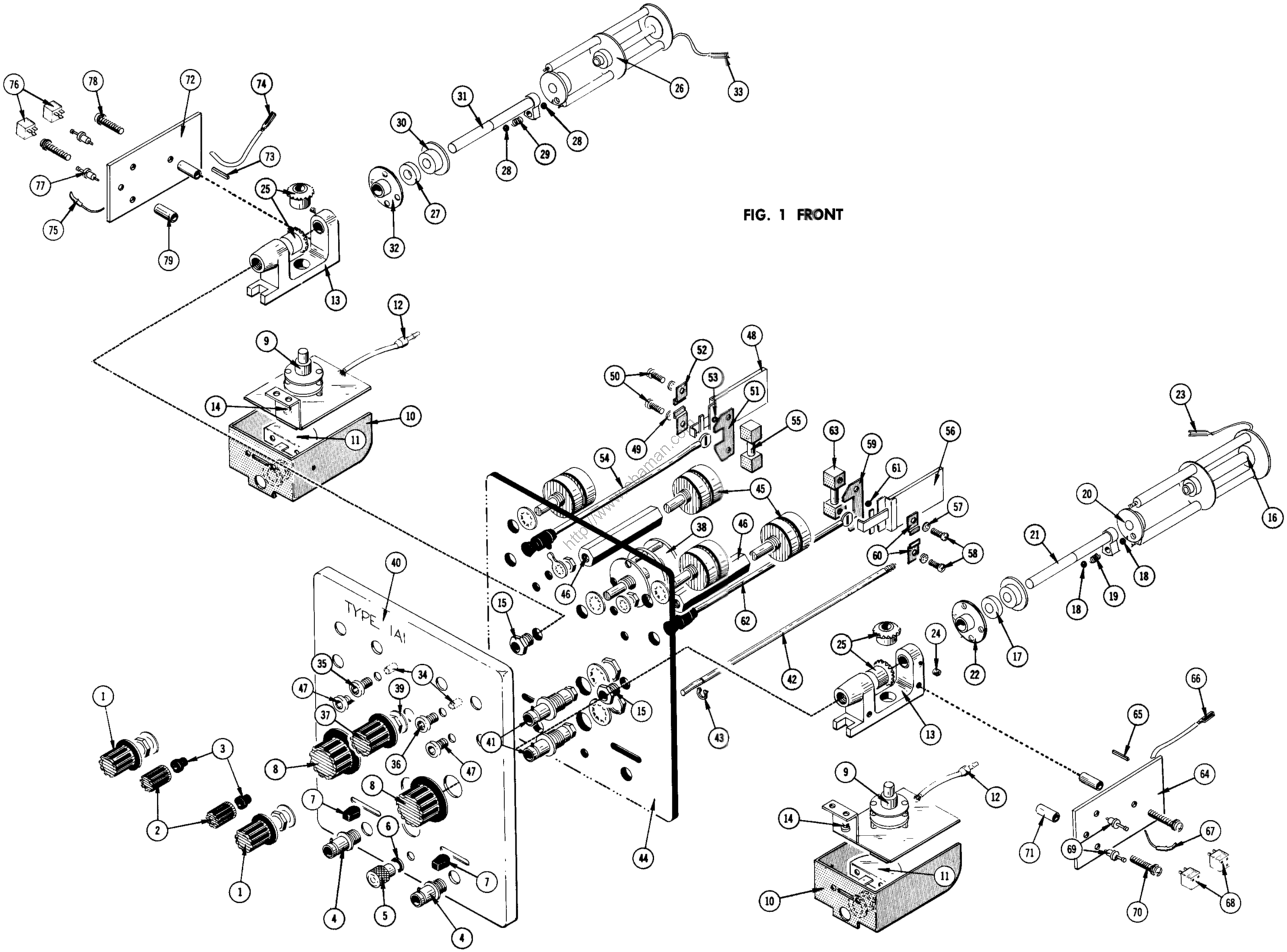
* AMPLITUDE AND SHAPE DEPEND ON OSCILLOSCOPE USED WITH TYPE 1A1

SEE PARTS LIST FOR SEMICONDUCTOR TYPES
* DENOTES SPECIAL PART SEE PARTS LIST

REFERENCE DRAWINGS

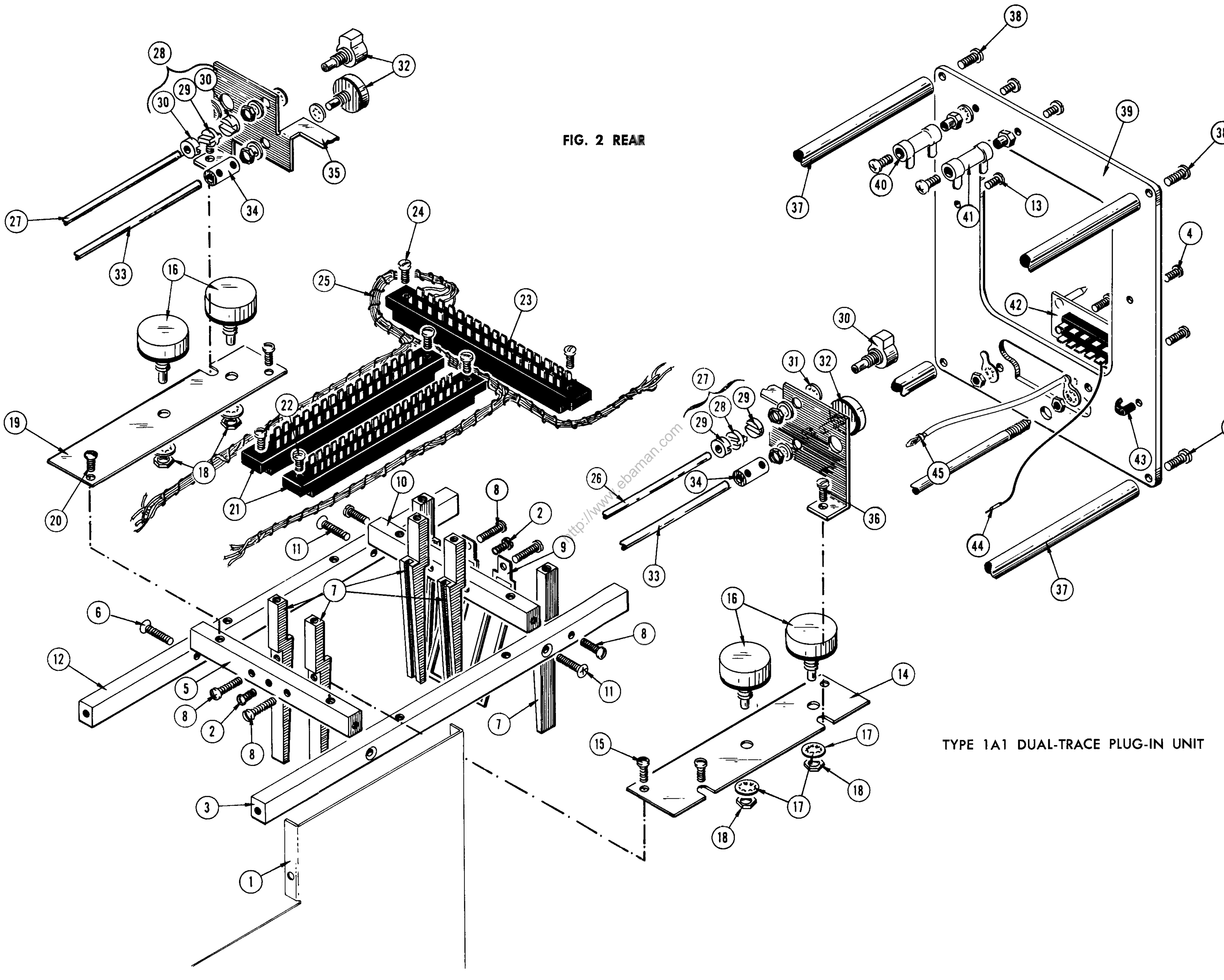
(4) OUTPUT AMPLIFIER

FIG. 1 FRONT



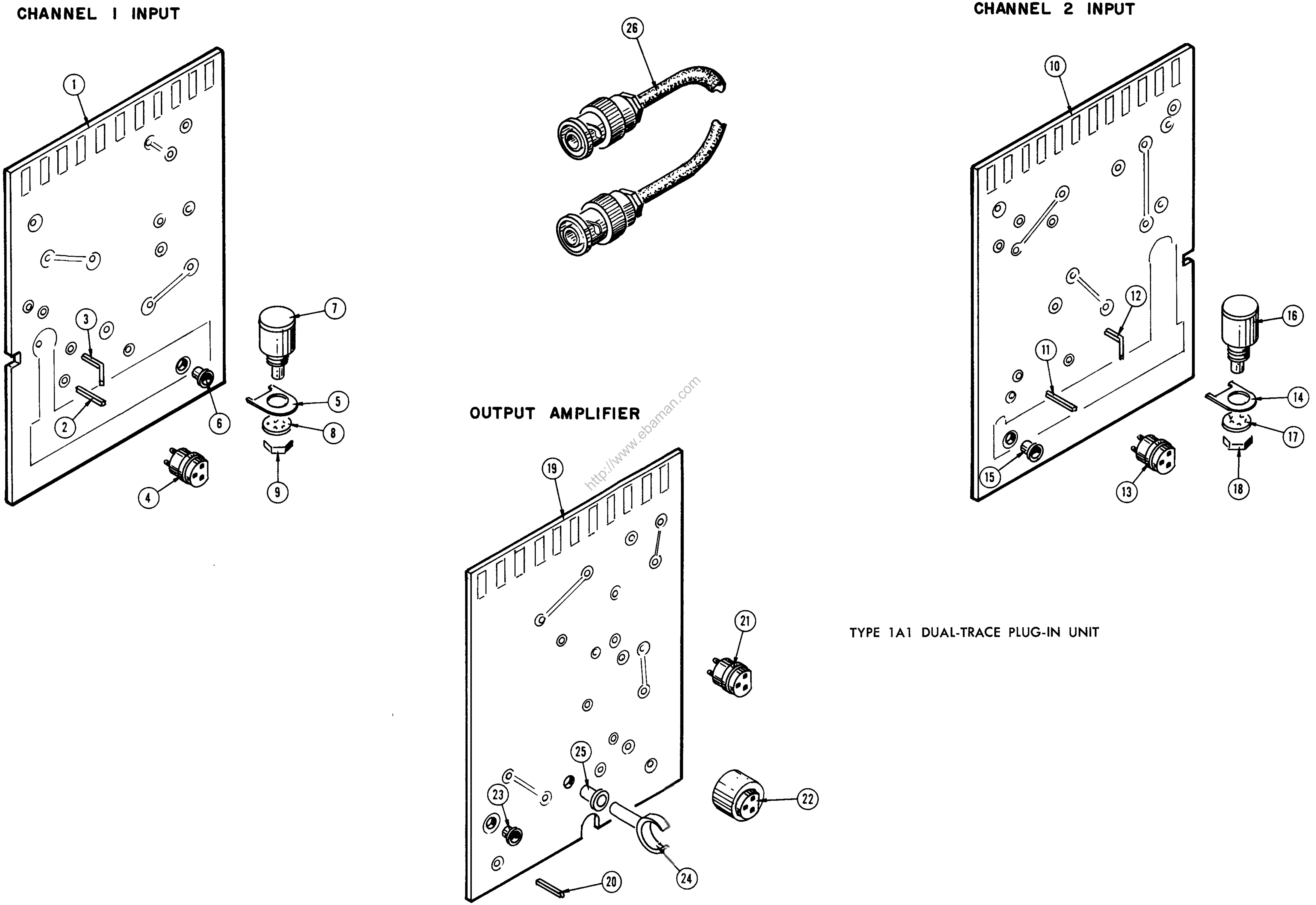
TYPE 1A1 DUAL-TRACE PLUG-IN UNIT

FIG. 2 REAR



TYPE 1A1 DUAL-TRACE PLUG-IN UNIT

FIG. 3 CIRCUIT CARDS & ACCESSORIES



TYPE 1A1 DUAL-TRACE PLUG-IN UNIT

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

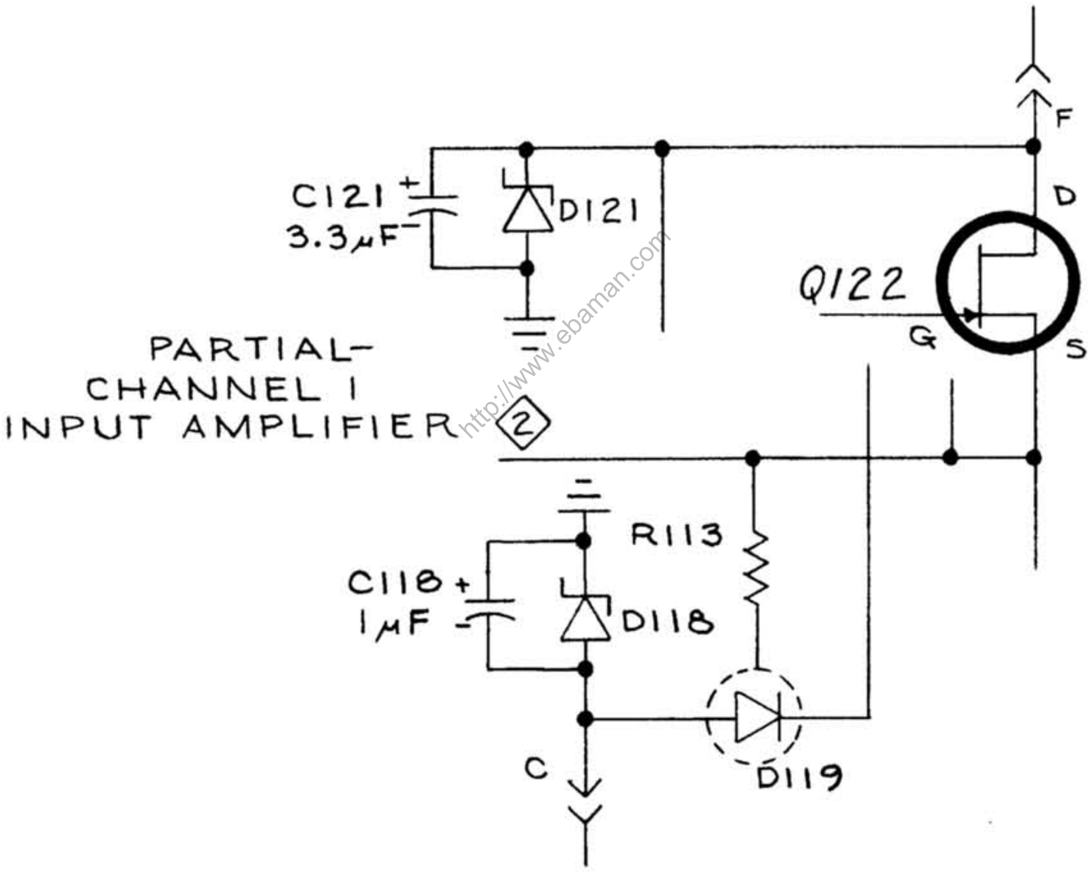
Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

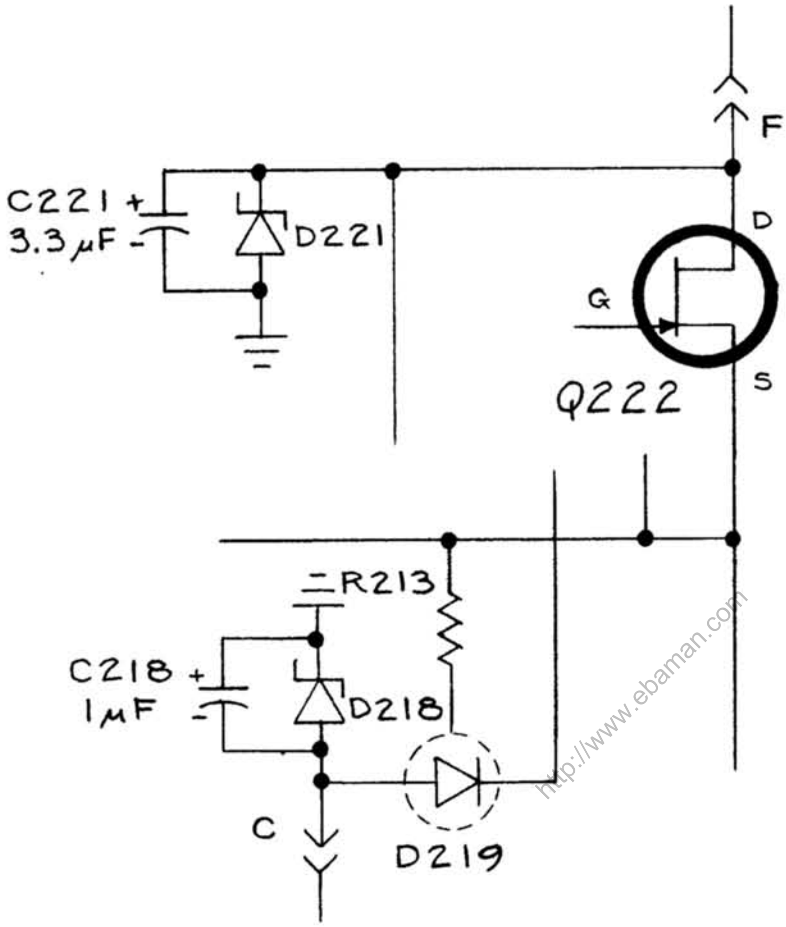
A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.

ELECTRICAL PARTS LIST AND SCHEMATIC ADDITIONS

ADD:

C118	290-0267-00	1 μF	EMT	35 V
C121	290-0246-00	3.3 μF	EMT	10 V
C218	290-0267-00	1 μF	EMT	35 V
C221	290-0246-00	3.3 μF	EMT	10 V





PARTIAL-
CHANNEL 2
INPUT AMPLIFIER 3

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

CHANGE TO:

R300	308-0314-00	680 Ω	3 W	WW	5%

TYPE 1A1 TENT SN 27890

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

J101	131-0955-01	BNC, female
J201	131-0955-01	BNC, female

M16,334/470

ELECTRICAL PARTS LIST CORRECTION

CHANGE TO:

R408[1]	311-0422-00	500 Ω, Var
R438[2]	311-0422-00	500 Ω, Var
SW409[3]	311-0422-00	
SW439[4]	311-0422-00	

[1]Furnished as a unit with SW409.

[2]Furnished as a unit with SW439.

[3]Furnished as a unit with R408.

[4]Furnished as a unit with R438.