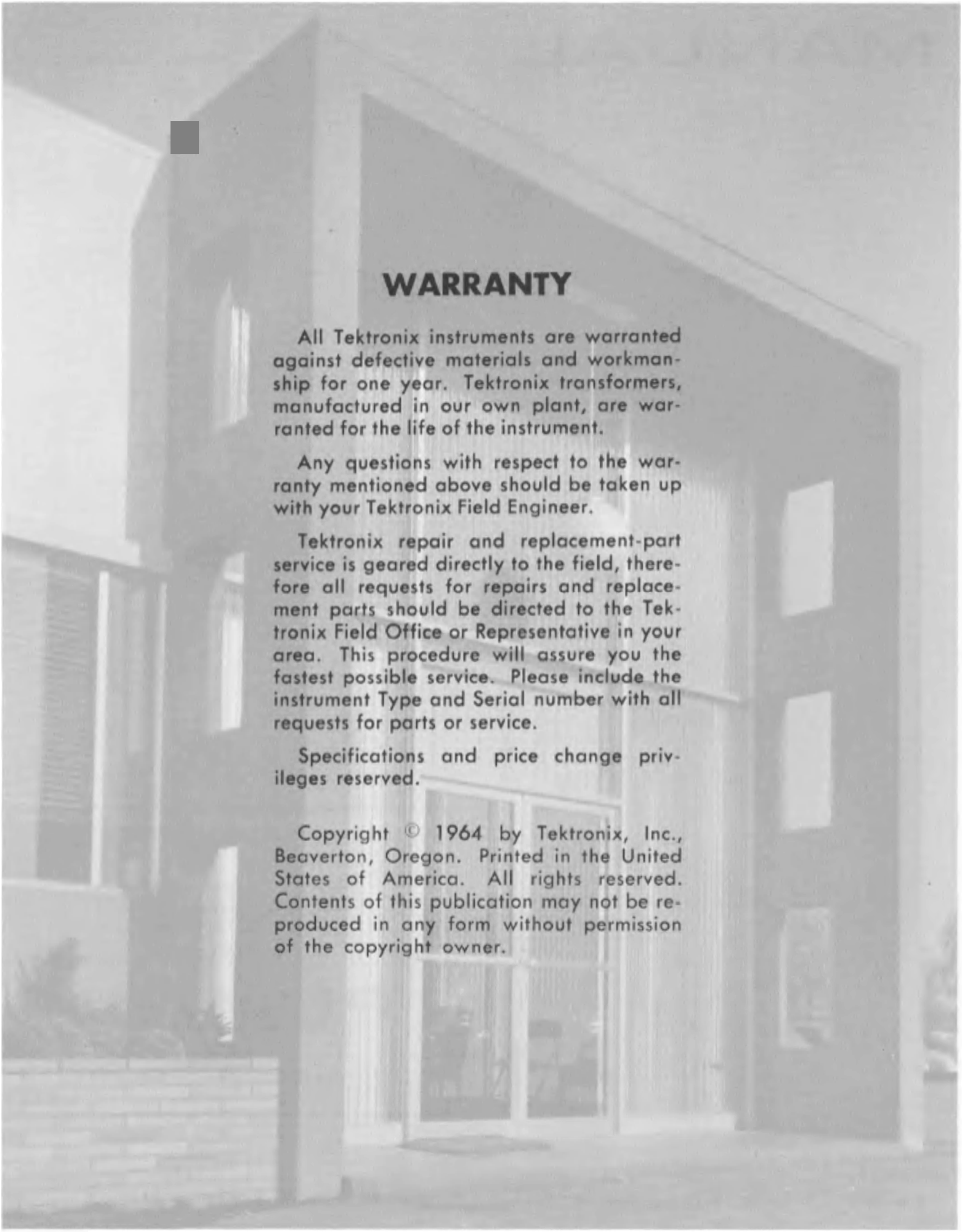
INSTRUCTION MANUAL

Serial Number ____________

TYPE 1A1 PLUG-IN

Tektronix, Inc.
S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix

070-378



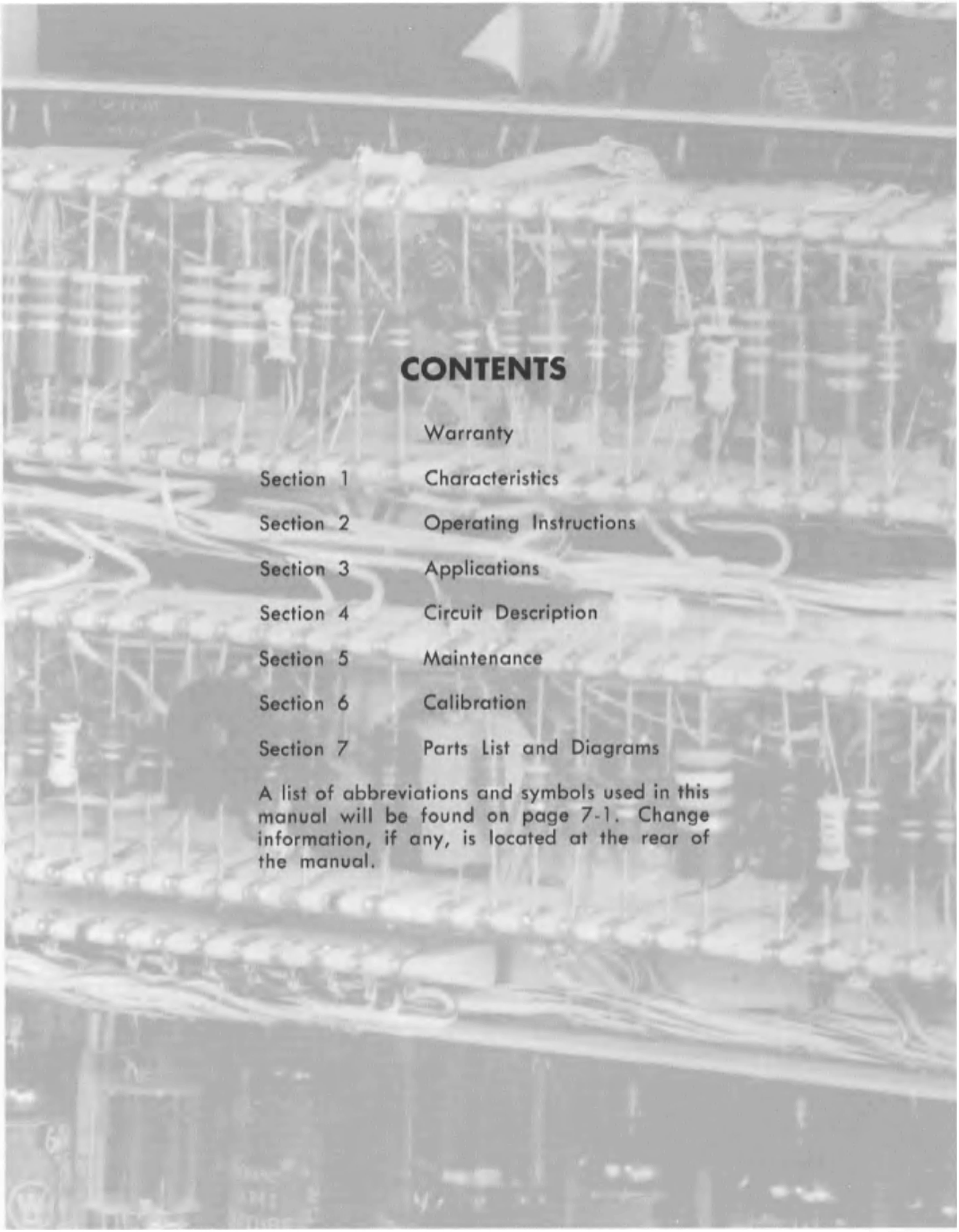
WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own 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 number with all requests for parts or service.

Specifications and price change privileges reserved.



CONTENTS

A list of abbreviations and symbols used in this manual will be found on page 7-1. Change information, if any, is located at the rear of the manual.

Type 1A1 Dual-Trace Plug-In Unit

SECTION 1
CHARACTERISTICS

General Information

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 which enables the display to be adjusted for optimum viewing and information.

In dual-trace operation there is a choice of two operating modes, chopped or alternate. In the chopped mode, an internal multivibrator switches the channels at a free-running rate of about 1 mc. In the alternate mode, the oscilloscope time-base generator internally switches the channels 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 10× (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 Type 580-Series Oscilloscopes in conjunction with the Type 81 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.

Risetime and Bandwidth

Your Type 1A1 was adjusted at the factory for optimum transient response. Table 1-1 summarizes the approximate risetime and bandwidth capabilities when the Type 1A1 is used with various Tektronix oscilloscopes in any operating mode except ADD. In the ADD mode, when the Type 1A1 is used with the fastest risetime oscilloscopes, the system risetime is somewhat slower and high-frequency response is less than that indicated in Table 1-1 and Fig. 1-1.

Vertical Deflection Factors

Twelve calibrated steps are provided for each channel .005, .01, .02, .05, .1, .2, .5, 1, 2, 5, 10 and 20 volts/cm. Variable controls for each channel permit continuous (uncalibrated) adjustment from 0.005 volt/cm to 50 volts/cm.

Calibration Accuracy

Front-panel and internal adjustments set the gain of each channel. When these adjustments are accurately set with

TABLE 1-1

Approx. Risetime and Bandwidth[1]
(Load impedance: 50 ohms)

System (Instrument Types)	VOLTS/CM Switch Position			
	.005[2]		.05 through 20	
	Risetime	Bandwidth	Risetime	Bandwidth
Type 1A1 with 544 546 or 547	12.5 nsec	dc to 28 mc	7 nsec	dc to 50 mc (Also, see Fig. 1-1)
Type 1A1 with 581 or 585[3]	15 nsec	dc to 23 mc	10 nsec	dc to 35 mc
Type 1A1 with 541, 541A, 543, 543A, 545, 545A, or 555	15 nsec	dc to 23 mc	10 nsec	dc to 35 mc
Type 1A1 with 551	16.7 nsec	dc to 21 mc	13 nsec	dc to 27 mc
Type 1A1 with 531, 531A, 533, 533A, 535 or 535A	25 nsec	dc to 14 mc	23 nsec	dc to 15 mc
Type 1A1 with 536	33 nsec	dc to 10.5 mc	31 nsec	dc to 11 mc

[1]Bandwidth dc to 3-db down point.

[2]Risetime and bandwidth values for the .01 and .02 VOLTS/CM switch positions are betweeen the .005 and the .05 through 20 values.

[3]Type 81 Plug-In Adapter must be used.

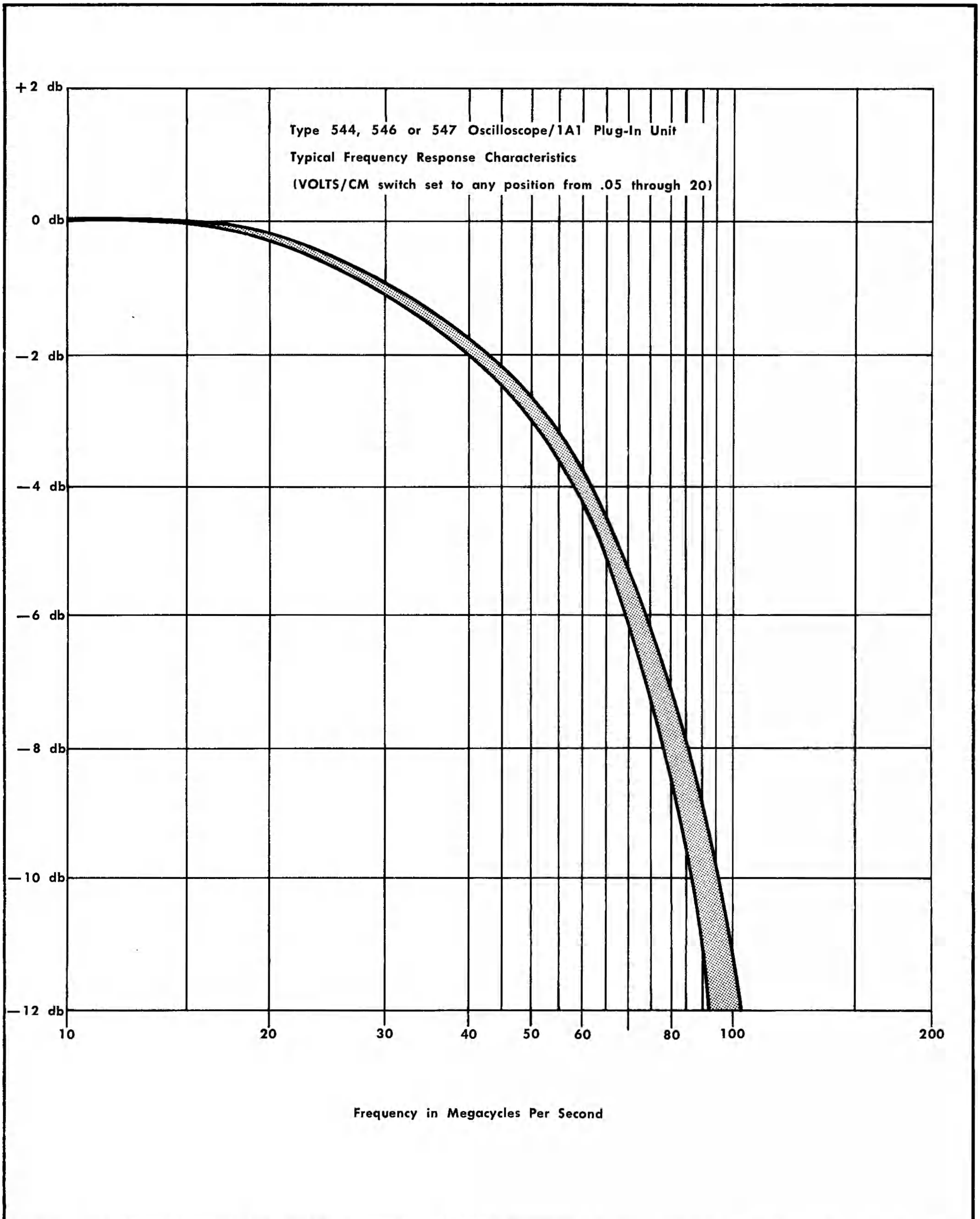


Fig. 1-1. Typical frequency response characteristic curve of the Type 1A1 when used in conjunction with the Type 544, 546, or 547 Oscilloscopes. A 25-ohm resistive source (50-ohm cable terminated in 50 ohms) was used to drive the Type 1A1.

the VOLTS/CM switch in the appropriate .005 and .05 position, the vertical deflection factor for the other switch positions will be within 3% of the panel markings.

Input Impedance

1 megohm ±1% paralleled by approximately 15 pf.

Input Coupling

Choice of ac or dc coupling. In the AC position the low-frequency response is limited to about 2 cps (3-db down) directly, or 0.2 cps (3-db down) when using a 10× atteunator probe.

Maximum Allowable Input Voltage Rating

600 volts combined dc and peak ac; 600 volts (not 1200 volts) peak-to-peak ac.

Noise

Approximately 200 μvolts internal noise or less, peak-to-peak, in any position of the INPUT SELECTOR switch.

Drift

Typically less than 5 mv/hour (after warmup), referred to the input, VOLTS/CM switch set to .005.

Channel 1 Outputs

Signal—Output Voltage and Gain—With Channel 1 set for a deflection factor of 0.005 v/cm, output signal voltage is about 50 mv/cm or a gain of approximately 10.

Deflection Factor—Channel 1 signal can be ac coupled (Channel 2 INPUT SELECTOR switch set to AC) into Channel 2 to obtain an overall deflection factor of approximately 500 μv/cm; 3-db down bandwidth is 2 cps to 15 mc, providing the input signal into Channel 1 is dc coupled.

Bandwidth (measured at the CH 1 SIGNAL OUT connector)—

Channel 1 VOLTS/CM switch set to .005: dc to 24 mc.

Channel 1 VOLTS/CM switch set to .05: dc to 35 mc.

Output Dc Level—0.45 volt, ±10%. Not affected by Channel 1 POSITION control.

Output Impedance—50 ohms.

Trigger— Output Voltage and Gain—With Channel 1 set for deflection factor of 0.005 v/cm, output trigger voltage is approximately 0.5 v/cm or a gain of 100, ±20%.

Bandwidth of trigger voltage at the CH 1 TRIGGER OUT connector—Sufficient to obtain stable triggering on a 50-mc waveform which is two centimeters or more in displayed amplitude.

Output Dc Level—0 volts, ±1 volt. Not affected by Channel 1 POSITION control.

Output Impedance—Approximately 100 ohms.

Operating Modes

Channel 1 Only

Channel 2 Only

Chopped—Free-running electronic switching of channels at about a 1-mc rate. The sweep trace for each channel is chopped into segments. Each trace segment has an "on" time (or display time) duration of about 0.5 μsec; "off" time between segments is about 0.5 μsec.

Alternate—Triggered electronic switching of channels at the end of each sweep, during the retrace interval.

Add—Both channels are combined at the output, adding or subtracting according to the settings of the polarity switches. When subtracting, common-mode rejection ratio is at least 20-to-1 for 1 kc common-mode signals up to 10 cm in amplitude.

Polarity Inversion

Polarity of either channel can be inverted for comparison of signals 180° out of phase.

Mechanical

Construction: Aluminum-alloy chassis with three plug-in etched-wiring cards.

Finish: Photo-etched, anodized front panel.

Net Weight: 5 lbs, 6 oz.

Accessories Supplied

	Tektronix Part Number
Jumper Coax Cable, 20" long, equipped with BNC plug connectors on each end.	012-076
Adapter, fitted with BNC-jack and UHF-plug connectors.	103-015
2 Instruction Manuals.	070-378

SECTION 2
OPERATING INSTRUCTIONS

FUNCTIONS OF CONTROLS AND CONNECTORS

The function of all 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.
NORM-INVERT	A two position switch that presents the input signal in a normal or inverted polarity with respect to the applied signal.
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	A screwdriver adjustment that sets the basic deflection factor of the channel at 0.05 v/cm.
.005 V/CM VAR ATTEN BAL	A 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.
Input Connector	Signal input connector for the channel.
MODE	A 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-mc 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 a modified Type 555 Oscilloscope (S/N 7000 and up) with the Types 21 and 22 instead of Type 21A and 22A Time-Base Units, +87 volts from the Types 21 and 22 is applied to pin 5 of the Type 1A1 interconnecting plug, to the associated circuits, and to the front-panel CH 1 TRIGGER OUT connector. This voltage may not damage any components in the Type 1A1 Channel 1 Trigger Output Amplifier stage, but it will cause the circuit to be inoperative. In addition, the +87 volts at the connector is hazardous. For proper Type 1A1 operation, remove the +87 volts by disconnecting the lead that goes from pin 19 of the Types 21 and 22 interconnecting plug to the ceramic terminal strip within the units. (Type 21A and 22A Time-Base Units are compatible with the Type 1A1 and need not be modified).

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 msec/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
NORM-INVERT	NORM
POSITION	Centered
MODE	CH 1

4. Position the trace about one centimeter above the graticule centerline with the Channel 1 POSITION control.
5. Place the MODE switch to CH 2 and position the trace one centimeter below the graticule center line 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 msec. 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 μsec and adjust the oscilloscope trigger controls to obtain a stable display. Notice that each trace is composed of many

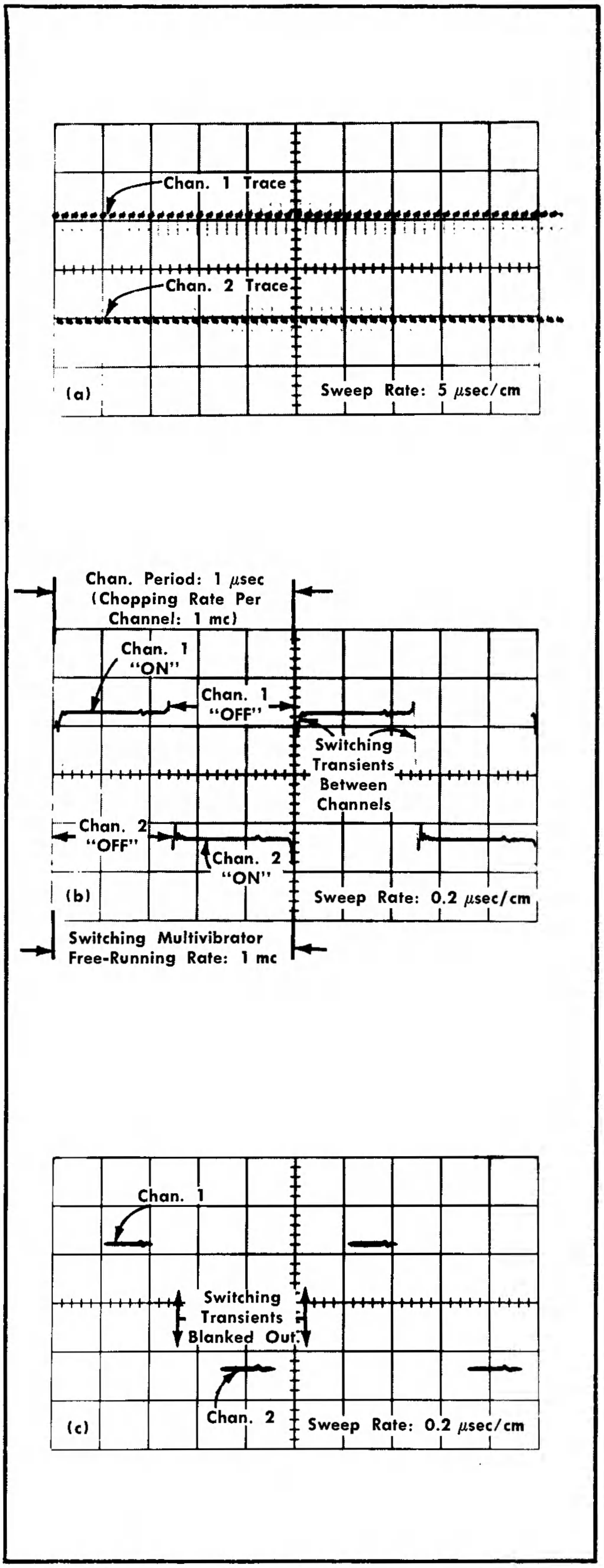


Fig. 2-1. Chopped-mode waveforms: (a) trace broken up into segments, (b) chopped-mode switching action from channel to channel, and (c) switching transients blanked out.

short-duration bits or segments with visible switching transients existing between channels (see Fig. 2-1a).

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

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. 2-1c).

12. Set the oscilloscope Time/Cm switch to 0.5 msec. Using coaxial cables, a "T" connector connected to Channel 1 and 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 jumper coaxial cable from the CH 1 TRIGGER OUT connector through a connector adapter, if required, 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 NORM-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 .2. Adjust the oscilloscope triggering controls to obtain a stable display. A calibrator waveform two centimeters or more in amplitude should be displayed. This indicates that Channel 1 has

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amplified the calibrator signal 10× or more before the signal reached the Channel 2 input connector (10 x 20 mv = 200 mv or 0.2 volt).

20. Disconnect the cable connected between the CH 1 SIGNAL OUT and Channel 2 input connectors.

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 oscillscope 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
NORM-INVERT	NORM
POSITION	Centered
VARIABLE VOLTS/CM	CALIB
MODE	CH 1

2. Set the oscilloscope sweep rate and triggering controls for a 0.1 msec/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 two preamplifer channels can be used independently by setting the MODE switch to CH 1 or CH 2 and connecting the signal to be observed to the appropriate input. Table 2-1 lists several input systems suitable to the Type 1A1 input. Fig. 2-2 shows a block diagram of the input when using the system outlined in Method 7 of Table 2-1. Fig. 2-3 shows the input X_c and R curves for the Type 1A1.

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 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 multipy the observed amplitude by the probe attenuation.

To assure the accuracy of 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 the 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. 2-4.

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

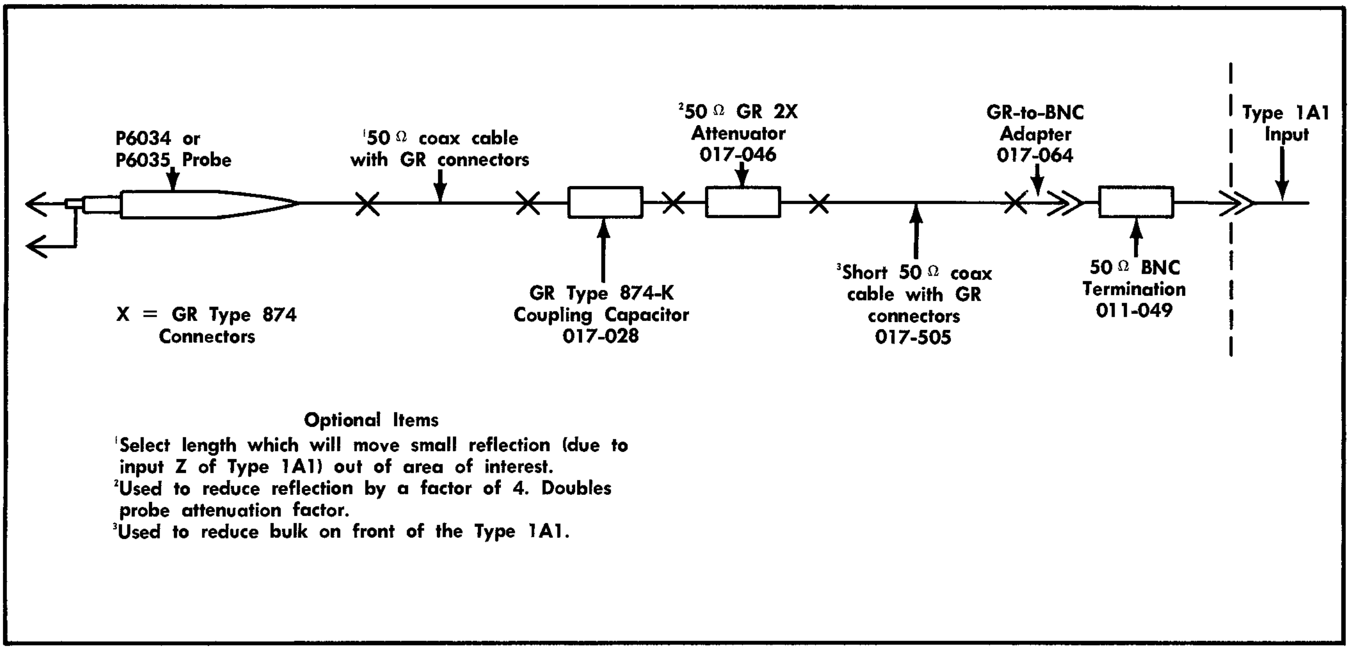

Fig. 2-2. Using the P6034 or P6035 Probe with the Type 1A1.

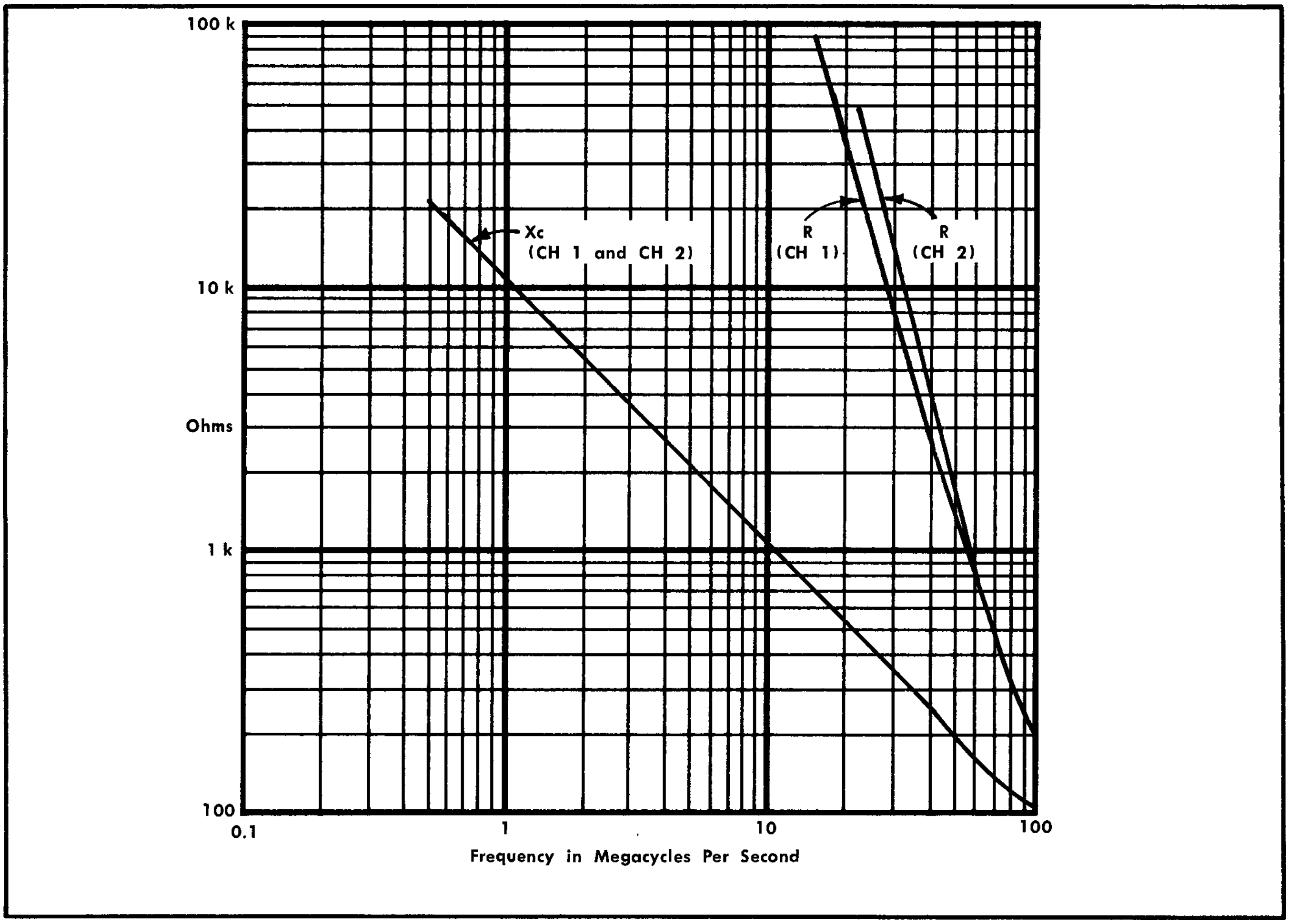

Fig. 2-3. Type 1A1 nominal input resistance and capacitive reactance vs frequency at any position of the VOLTS/CM switch.

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 (103-003). Two test leads.	1 Meg Ω and 15 pf at at input, plus test leads.	Stray pickup and spurious oscillations.
2. Unterminated coax cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coax cable with BNC connector(s).	1 Meg Ω and 15 pf plus cable capacitance.	High capacitive loading.
3. Terminated coax 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 coax. May need blocking capacitor to prevent dc loading or damage to termination.	Coax cable with BNC connector(s). R_o termination at Type 1A1 input. (BNC 50 Ω Termination, 011-049).	R_o plus 15 pf at Type 1A1 end of coax can cause reflections.	Reflection from 15 pf at input. Dc and ac loading on test point. Power limit of termination.
4. Same as 3, 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.
5. Tap into terminated coax system. (BNC Tee: UG-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 Tee and BNC connectors on signal cables.	1 Meg Ω and 15 pf at tap point.	Reflections from 15 pf input.
6. 10×, 10 Meg Ω Probe. 100×, 9.1 Meg Ω Probe. 1000×, 100 Meg Ω Probe.	Reduced resistive and and capacitive loading, nearly full Type 1A1/Oscilloscope bandwidth.	×0.1 sensitivity. ×0.01 sensitivity. ×0.001 sensitivity.	P6006, P6008 are 10×; P6007, P6009 are 100×; P6015 is 1000×.	P6006*: ≈7 pf, 10 Meg Ω P6007: less than 2 pf, 10 Meg Ω P6008: ≈7.5 pf, 10 Meg Ω P6009: ≈2.5 pf, 10 Meg Ω P6015: ≈3 pf, 100 Meg Ω	Check probe frequency compensation. Use square-wave frequency less than 5 kc, preferably 1 kc.
7. 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. ×0.1 or ×0.01 sensitivity. May need blocking capacitor to prevent dc loading or damage to termination. Limited low frequency response when ac coupled: 70 kc for P6034; 7 kc for P6035.	P6034 — 10× P6035 — 100× Items in Fig. 2-2.	P6034: 500 Ω, 0.7 pf P6035: 5 KΩ, 0.6 pf	Dc and ac loading. Voltage rating of probe.
8. Current transformer. Terminated in 50 Ω at Type 1A1. Upper Bandwidth is that of Type 1A1/Oscilloscope.	Current xfmr can be permanent part of test circuit. Less than 2.2 pf to test circuit chassis. Measure signal currents in transistor circuits. CT-1: 20 amps pk. CT-2: 100 amps pk.	Rms current rating: CT-1: 0.5 amp CT-2: 2.5 amps Sensitivity: CT-1: 5 mv/ma. CT-2: 1 mv/ma.	CT-1: Coax adapter and BNC termination. CT-2: nothing extra. (Perhaps additional coax 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 kc. CT-2: low frequency limit about 1.2 kc, and is 1/5th as sensitive as the CT-1.

* P6006 Probe has less input capacitance than P6008, but P6008 has wider bandwidth.

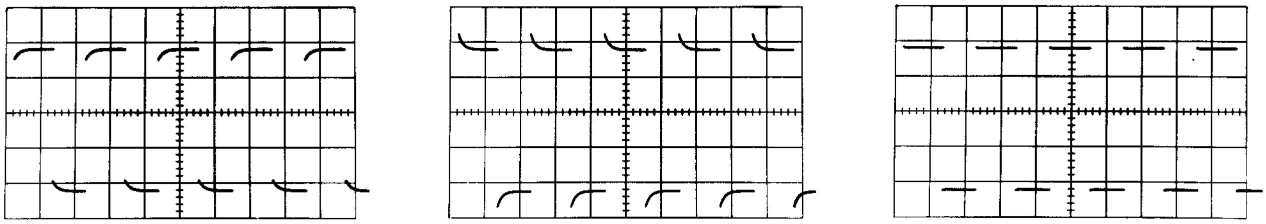

Fig. 2-4. Probe compensation waveforms using a 1-kc calibrator signal.

5 kc. 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 AC-DC-GND switch to DC; to display only the ac component of a signal, set the AC-DC-GND 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 response of the unit is about 2 cps at —3 db. Thus, some drop in duration response (droop) exists even when observing a symmetrical 60-cycle 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 cps; with a 100× probe, low-frequency response is about 2 cps.

Placing the AC-DC-GND switch to the GND position grounds the input circuit of the Type 1A1 to provide a dc zero reference, providing the GRID CURRENT ZERO control (see Calibration section) for the channel in use is properly adjusted. Proper adjustment of this control is particularly important at sensitivities greater than 0.05 volts/cm. When the AC-DC-GND 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.

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.

NORM-INVERT Switch

The NORM-INVERT switch may be used to invert the displayed waveform, particularly when using the dual-trace feature of the Type 1A1. The NORM-INVERT switch has two positions. In the NORM 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 INVERT 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 paragrpahs. 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-tace 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).

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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 Channel 1 input connector and apply the other signal to the Channel 2 input connector. Set the appropriate NORM-INVERT switch to NORM or INVERT, depending on whether you want to display the signals in a normal or inverted position, 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 μsec/cm for displaying two nonrepetitive signals occurring within the sweep-time interval set by the oscilloscope Time/Cm switch. Nonrepetitive signals are those signals 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 the 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 msec/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 Nonrepetitive or Low-Frequency (Below 10 Kc) Synchronous Signals. To show true time and phase relationship between two nonrepetitive or low-frequency synchronous signals, use chopped-mode operation. Transients as short as 0.1 msec can be well delineated or resolved. At 10 μsec/cm a 0.1-msec duration transient, for example, will contain about 100 "on" segments in its trace. If a higher sweep rate is used, the number of segments that make up each of 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 6) 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 coax jumper 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 mc).

Since the internal trigger from the oscilloscope vertical amplifier is a composite trigger during chopped mode of operation and the trigger contains a nonsynchronized 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 kc; set the Triggering Coupling switch to AC LF Reject or AC Fast for stable triggering and a bright display on signals above 1 kc. 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 reqirements of the oscilloscope.

If one displayed signal has a smaller amplitude than the other but is of adequate amplitude for internal triggering,

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. Other remarks.
(a) Two nonrepetitive signals or two low-frequency synchronous signals (below 10 kc). Apply reference signal to Channel 1.	CHOP	Plug-In* or Ext (connect jumper coax cable from CH 1 TRIGGER OUT connector to Trigger Input connector on oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject	Yes Use sweep rates up to 10 μsec/cm. Higher sweep rates reduce resolution.
(b) Two asynchronous signals, any frequency within full bandwidth of the system.	ALT	Norm Int or Int **	AC or AC Slow for frequencies below 1 kc. AC Fast or AC LF Reject for frequencies above 1 kc.	No
(c) Two synchronous signals, 250 cps and above.	ALT	Plug-In* or Ext (connect jumper coax cable from CH 1 TRIGGER OUT connector to Trigger Input connector on oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject	Yes Apply reference signal to Channel 1.
		Norm Int or Int **	AC Fast or AC LF Reject	No

*Plug In position is the Channel-1-only internal signal available at pin 5 of theT ype 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.

**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.

then 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 kc is more difficult to obtain and the jitter will be greater. If you are using sweep rates faster than 0.5 msec/cm, the effect of the dual-trace display becoming noticeably brighter as the waveforms are vertically positioned together and dimmer when they are positioned apart is more apparent. 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 square wave 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 two centimeters apart. Repetition rate of the switching waveform is one half 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 Cps and Above. To show true time and phase relationship between two synchronous signals, 250 cps and above, use alternate mode operation and trigger on Channel 1 only. In practice, for displaying signals between 250 cps and 10 kc you can choose either alternate- or chopped-mode operation since 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 (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 1 signal will remain stationary while 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 a 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 NORM-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 displayed 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 a wideband ac-coupled 10× preamplifier for Channel 2. To do this, connect a coaxial jumper 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 coax jumper cable (Tektronix Part No. 012-076) furnished with the unit. As an alternative method use a 3-inch jumper wire made from #18 solid tinned-copper wire.

Though it seems that you can use the CH 1 TRIGGER OUT signal (amplified 100×) for application to the Channel 2 input connector, the trigger signal is unusable because of its high noise level.

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 cps to about 15 mc (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 10× when the Channel 1 VOLTS/CM switch is set to .005; 5× when set to .01; 2½× when set to .02, and 1× when set to .05.

4. Use the Channel 1 preamplifier as an impedance transformer with or without voltage gain. With a 1 meg input and 50 ohms 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 jumper cable, the noise level can be reduced. For example, use a 400-cycle bandpass filter for observing low-level 400-cycle 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, NORM-INVERT and VARIABLE VOLTS/CM controls do not have any affect 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 10× 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 10× 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.

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, such 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 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):

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 coax 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 centimeters 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.

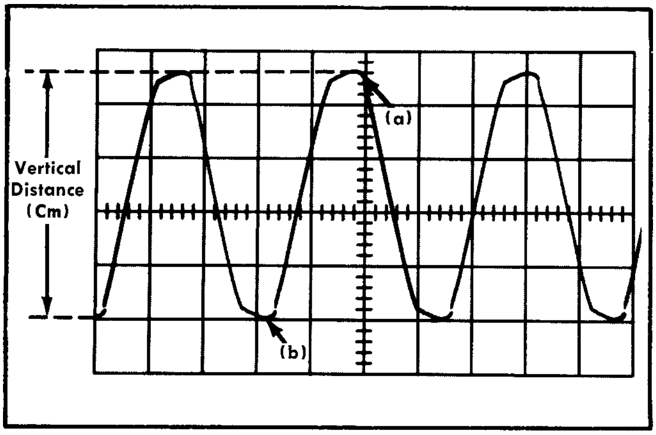

Fig. 3-1. Measuring the peak-to-peak voltage of a waveform.

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 10X probe with the VOLTS/CM switch set to .5. Substituting these values in the following formula:

Volts Peak-to-Peak = Vertical deflection in cm X VOLTS/CM switch setting X Probe attenuation factor

Then:

Volts Peak-to-Peak = 4.6 X .5 X 10 = 23 volts

Using Channel 1 as a 10X Preamplifier for Channel 2. This procedure describes a method for making low-level ac-component measurements with a 10X attenuator probe without having to consider the probe attenuation factor. The

10X attenuation of the probe is offset by the 10X amplification of Channel 1. Thus, the following is the correct formula:

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

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
NORM-INVERT (Channel 2)	NORM
VARIABLE VOLTS/CM (Channel 2)	CALIB
MODE	CH 2
VOLTS/CM (both channels)	.005
INPUT SELECTOR (both channels)	AC

NOTE

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

2. Connect a coax jumper cable from the CH 1 SIGNAL OUT connector to the Channel 2 input connector.

3. Connect another coax jumper 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, then 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 10X 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 Cal Out 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 Cal Out 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 10X probe with the Channel 1 VOLTS/CM switch set to .01. Substituting these values in the formula given at the beginning of this procedure:

Volts Peak-to-Peak = 3.5 X .01 = 0.035 volt or 35 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.

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

5. Apply the signal, preferably through a coax cable or a 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 centimeters 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 NORM-INVERT switch is set to NORM 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 NORM-INVERT switch is set to INVERT, the indicated polarities will be reversed.

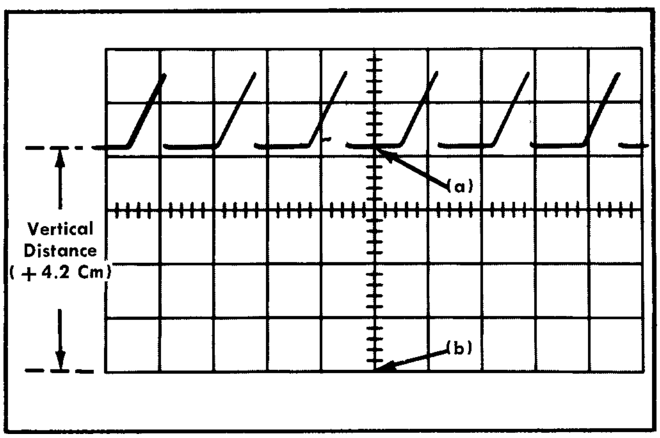

Fig. 3-2. Measuring instantaneous voltage with respect to some reference.

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 10X attenuator probe with the NORM-INVERT switch set to NORM and the VOLTS/CM switch set to 2. Substitute these values in the following formula:

Instantaneous Voltage (with respect to a ground reference) = Vertical deflection in cm and polarity X VOLTS/CM switch setting X Probe attenuation factor

Then:

Instantaneous Voltage (with respect to a ground reference) = +4.2 X 2 X 10 = +84 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 centimeters (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:

True Deflection Factor = (VOLTS/CM switch setting)(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:

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

True Deflection Factor = (5) (1.5) = 7.5 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 centimeters and determine the amplitude by using the following formula:

Signal Amplitude = Deflection Conversion Factor X Deflection in cm X VOLTS/CM switch setting

For example, assume the signal to be compared caused a vertical deflection of 4.5 cm at a VOLTS/CM switch setting of 10 and the VARIABLE VOLTS/CM control was 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:

Signal Amplitude (in volts) = (1.5)(4.5)(10) = 67.5 volts

Time-Difference Measurements

The calibrated sweep rate of the oscilloscope and the dual-trace feature of the Type 1A1 allow 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 NORM-INVERT switches to NORM.

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 coax jumper 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 10X 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 coax cables or probes having equal delay.

7. Set the oscilloscope Trigger Source 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).

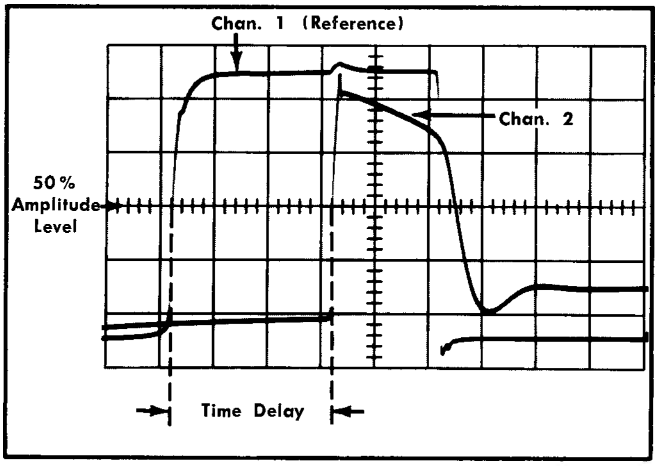

Fig. 3-3. Measuring time delay between pulse waveforms.

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:

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

For example, assume that the Time/Cm switch setting is 2 μsec, the Magnifier is set for 5X 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:

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

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."

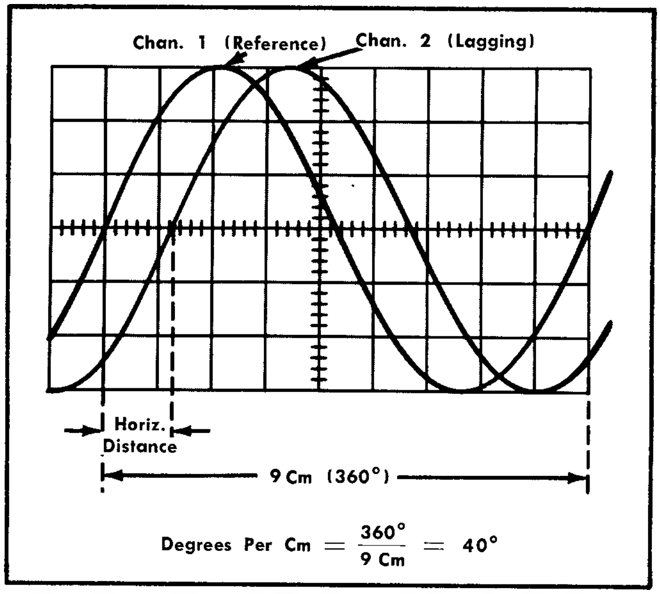

Fig. 3-4. Measuring phase shift between electrical waveforms.

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

3. Adjust the VARIABLE VOLTS/CM control 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

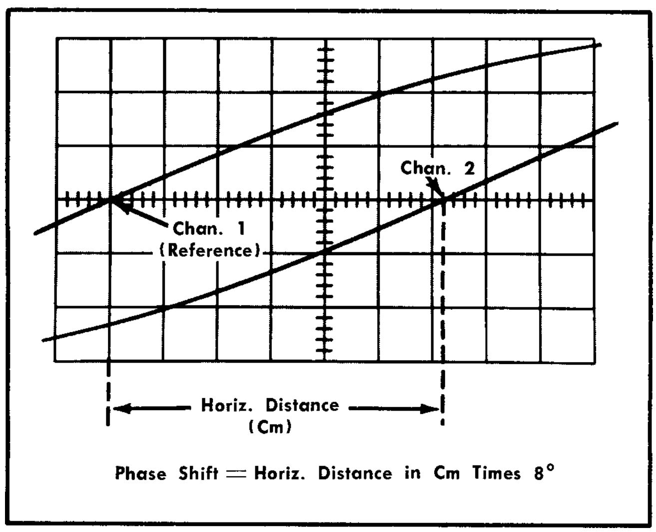

Fig. 3-5. Computing the phase shift when the oscilloscope sweep rate is increased 5X.

9 cm horizontally. Use the Trigger Slope and Triggering Level controls to trigger on the reference waveform at any 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.

SECTION 4
CIRCUIT DESCRIPTION

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 7.

Input Coupling

The signal to be displayed is applied to Input CF V123 via INPUT SELECTOR switch SW101 and VOLTS/CM switch SW105. In the DC position of the INPUT SELECTOR switch, input coupling capacitor C101 is bypassed so the input is dc coupled. In the AC position, the signal must pass through C101, which blocks the dc component. Capacitor C101 limits the low-frequency response to about 2 cps 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 grid circuit of Input CF V123; 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 CF V123. 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 grid circuit of Input CF V123 so the signal applied to the grid is always 0.05 volt for each centimeter of crt deflection; that is, 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:

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

Using the X2 attenuator as a specific example (see Fig. 4-1), the formula is:

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

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 X2 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-meg when using a 15-pf Input Time Constant Standardizer as a reference. Similarly, C104 provides a method for "standardizing" 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 megohm 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 regardless of the setting of the VOLTS/CM switch.

Input Cathode Follower V123

The Input CF V123 stage presents a high-impedance, low-capacitance load to the input circuit and isolates the input circuit from the succeeding stages. The cathode is connected through R122 to the —150-volt supply. The large value of R122 permits the stage to operate linearly.

Resistor R119 protects the grid circuit of V123. This resistor limits the dc grid current through V123 in the event a positive-going overload signal is applied to the input connector. Since R119 alone would deteriorate the high-frequency ac response of the stage, C119 is added to pass the high-frequency ac components around R119. To protect transistor Q123 from the same overload signal, diode D122 is provided. This diode conducts during the overload interval, thus limiting the reverse bias of Q123.

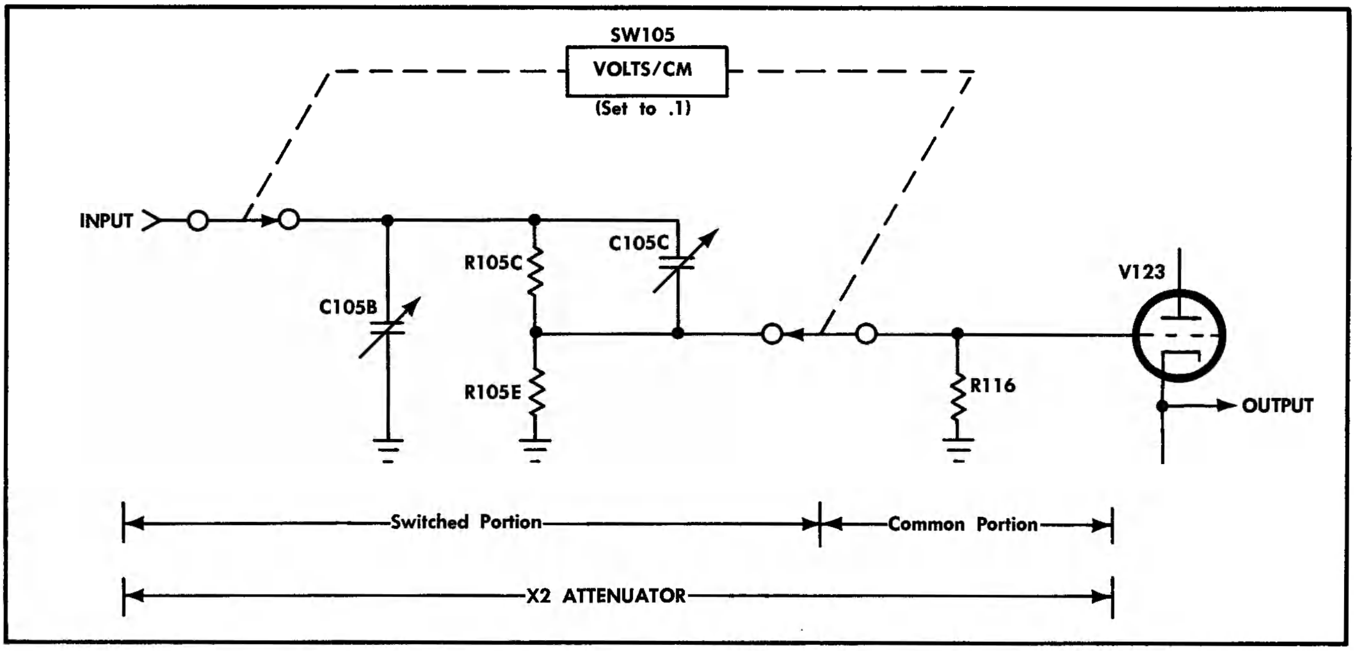

Fig. 4-1. Simplified circuit diagram showing the most important components involved when calculating the X2 attenuation factor.

Diode D121, connected between the plate of V123 and the +100-volt supply, is also a protection diode. During normal operation the diode is forward biased and clamps the plate at about +100 volts. A positive-going overload signal at the grid of V123 unclamps (reverse biases) the diode. R121 drops the plate voltage of V123 to protect the tube against excessive plate dissipation and cathode current.

Negative-going overload signals do not damage V123, which is protected by B119. If V123 goes more than —73 volts below cutoff, neon B119 ignites and then maintains a 55-volt difference voltage between the grid and cathode. The clamping action of B119 prevents the grid from going further negative and prevents grid-to-cathode arcing. Current through R122 is handled mostly by B119 and partly by transistor Q123 for the duration of the overload signal.

Channel 1 GRID CURRENT ZERO adjustment R117 applies a dc voltage to R116. When this control is set properly, the voltage taken off at the arm of R117 offsets any grid-current developed voltage across R116. This minimizes display shift and assures accurate dc measurements.

DC Balance Cathode Follower V143

The DC BAL CF V143, the Input CF V123, and EF Q123/Q143 stages constitute 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 balance circuit arrive in phase at the bases of the Input Amplifier Q124/Q144 stage and therefore cancel.

In the grid circuit of V143 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 voltage accurately and yet provide a wide range of coarse adjustment.

First Emitter Follower Q123/Q143

In addition to providing a means of balancing out power-supply fluctuations, as explained previously, the First EF Q123/Q143 stage provides a low impedance drive to the Input Amplifier Q124/Q144 stage. The signal at the cathode of V123 is coupled via one winding of T124 to the base of Q124.

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 posi-

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tion 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 EF Q153A/Q153B stage couples the push-pull signal from the Input Amplifier to the Output Amplifier first stage. In addition, the second EF stage provides the necessary low-impedance drive for the etched wiring card connectors, the NORM-INVERT switch SW405, and the interconnecting leads.

When the NORM-INVERT switch is set to the NORM position, the signal at the collector of Q153A is coupled via the switch contacts to the base of Q414 (Output Amp.) and the signal at the collector of Q153B is coupled via the switch contacts to the base of Q404 (Output Amp.). 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 INVERT BAL control R152 in the base circuit of Q153A dc balances the outputs of the second EF stage so there is no trace shift when the NORM-INVERT switch is changed from NORM 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 volts per side occurs at pins 1 and 3 of the interconnecting plug to the oscilloscope. This voltage range corresponds to about 12 centimeters positioning range at the crt.

Diode Switches

The push-pull signal from the Output Amp. 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 D424, or D422 and D423 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 diode 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 1 signal passes through these diodes to the Output Amp. 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 Amp. second stage. With the shunt 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 states. The Switching Multivibrator's cut-off 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 Amp. second stage. Simultaneously, Channel 2 series 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 Amp. 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 Amp. 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 Amp. 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 inphase current signals at the plate of the tubes. The signals at the plates are then applied through pins 1 and 3 of the inter-connecting 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 MODE switch set to NORM, 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 7 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. Network R481, C481, R482 and C482 are also high-frequency compensation adjustments.

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 EF Q153A/Q153B stage. This is the signal which is applied to the Channel 1 Signal Pickoff EF Q163/Q173 stage 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 Q153 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 form 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 NORM-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 Q174 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 B.O. (Blocking Oscillator) Q330, and the Blanking Multivibrator Q343/Q353.

Switching Multivibrator Q305/Q315

The Switching Multivibrator Q305/Q315 stage 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-conductting (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 the transistors in each of their states.

With Q305 conducting, its collector rests at +7.7 volts; the collector voltage of Q315 during cut off 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 reversed 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 diodes switches to connect Channel 2 to the Output Ampilifer.

(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 intial 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 cut off. 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 Amp. Board connector to the Alt. Trig. B.O. 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 Alt (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 be-

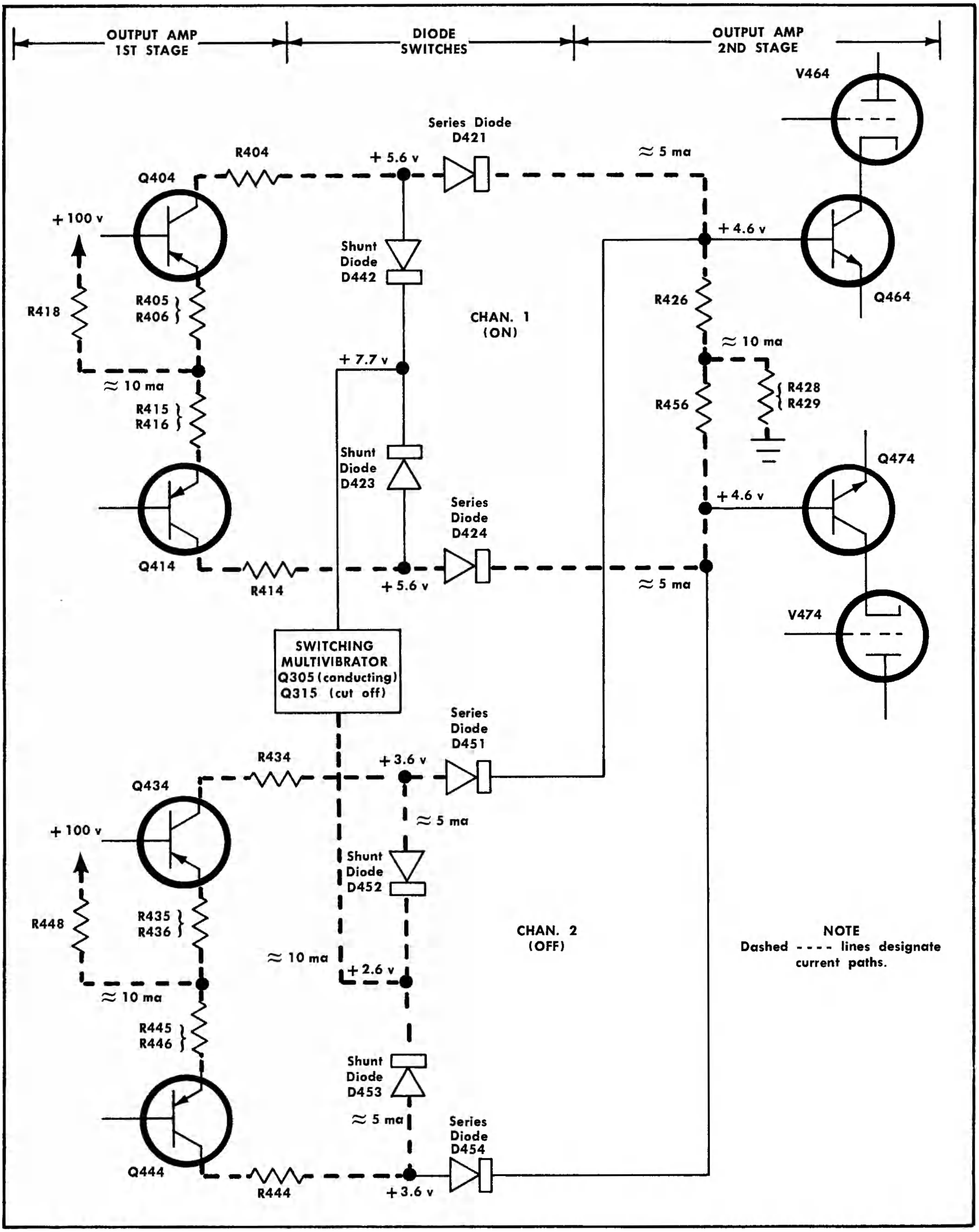


Fig. 4-2. Simplified circuit diagram showing the main dc current paths when Channel 1 is "ON and Channel 2 is "OFF".

tween the oscilloscope and the Type 1A1. From pin 7 of the interconnecting plug the pulse is applied through pin X of the Output Amp. 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 Alt. Trig. B.O. The trigger from the Alt. Trig. B.O. drives Q315 toward cut off, 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-mc 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 μsec 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 emitters 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 Alt. Trig. B.O. stage 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 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 Amp. card connector and pin 8 of the interconnecting plug.

In its quiescent state Q330 is held at cut off by the reverse bias between the base and emitter. 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 reverse biases, and the collapsing field produces a slight backswing voltage. During the time that the Alt. Trig. B.O. 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.

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 cathode follower to drive the Alt. Trig. B.O. stage. Since the Alt. Trig. B.O. stage is not being driven, the stage is inoperative during these modes of operation.

Blanking Multivibrator Q343/Q353

The Blanking Multivibrator Q343/Q353 stage is a monostable, common-emitter, collector-to-base clamp multivibrator. When triggered during chopped mode of operation, this stage produces a blanking pulse of sufficent 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 wave-shape 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 cut off. 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 μsec after the Switching Multivibrator has triggered the Blanking Multivibrator. The 0.25-μsec 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 Amp. card to pin 16 of 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 tube in the oscilloscope. From 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.

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 short 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-cycle 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 connected in series is about 36 volts. This 36-volt drop leaves about 39 volts which is applied to the Channel 1 and 2 EF 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 Amp. 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 Channel 1 and 2 Input CF stages.

SECTION 5
MAINTENANCE

PREVENTIVE MAINTENANCE

Cleaning the Interior

To clean the interior of the Type 1A1, blow off the accumulated dust using low-velocity compressed air. A very high velocity air stream should be avoided, however, to prevent damage to some of the components.

Visual Inspection

Many potential or existing troubles can be detected by a visual inspection of the unit. For this reason, a complete visual check should be performed periodically or every time the unit is inoperative, needs repair, or needs recalibration. Visual defects may include loose or broken connections, frayed coax-shield (that could cause a short), damaged connectors, improperly seated tubes or semiconductors and scorched or burned parts.

The remedy for these troubles is readily apparent except in the case of heat-damaged parts. Damage to parts due to heat is often the result of other less apparent troubles in the unit. It is essential that the cause of overheating be determined and corrected before replacing the damaged parts.

Checking Tubes and Semiconductors

Periodic tester checks on the tubes and semiconductors used in the Type 1A1 are not recommended. Tube and semiconductor testers in many cases, indicate a defect when a component is operating satisfactorily in a circuit, and fail to indicate defects which affect circuit performance.

The true test of tube or semiconductor usability is whether or not the component works properly in the circuit. If it is working correctly, it should not be replaced.

Calibration

The Type 1A1 should provide many hours of trouble-free operation. However, to insure the reliability of measurements, check the calibration of the unit after each 500-hour period of operation (or every six months if the unit is used intermittently). A complete step-by-step procedure for calibrating the unit and checking its operation is given in the Calibration section of this manual.

CORRECTIVE MAINTENANCE

Soldering Precautions

A. Replacing components on the etched wiring cards. Use ordinary electronic grade 60/40 solder and a 35- to 40-watt pencil soldering iron with a ⅛"wide chisel tip. The tip of the iron should be clean and properly tinned for best heat transfer in a short time to a soldered connection. A higher wattage soldering iron, if used and applied for too long a time, will cause deterioration of the bond between the etched wiring and base material by charring the glass epoxy laminate.

When replacing components, mount the new parts in the same physical location as the old parts. Use short leads where necessary and solder each part carefully into place. Use care in handling the leads from the components to keep them from being weakened or broken.

The step-by-step technique is as follows:

1. Remove the component by cutting 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 the board, and then pull gently on the lead.
3. When the solder first begins to melt, the lead will come out, leaving a clean hole. If a clean hole is not obtained, use a scribe or pointed tool and the soldering iron to open the terminal hole.
4. Bend the leads on the new component to the correct shape and carefully insert the leads into the holes.
5. Apply the iron for a short time at each connection on the side of the board opposite the location of the component to let the component become fully seated.
6. Finally, apply the iron and a little solder to the connections to make a finished soldering joint.
7. Clip the excess lead lengths protruding beyond the solder fillets.

B. Soldering to metal terminals.

In soldering to metal terminals (such as interconnecting plug pins, switch terminals, potentiomenters. etc.), ordinary 60/40 solder and a 40- to 75-watt soldering iron with ⅛" wide chisel tip can be used. The chisel tip must be properly tinned.

The procedure for soldering is as follows:

1. Apply only enough heat to melt the solder and remove the lead.
2. When resoldering the lead, apply enough heat to make the solder flow freely.
3. If the lead extends beyond the solder joint, clip the excess close to the solder joint.

Replacing Tubes and Transistors

Care should be taken, both in preventive and corrective maintenance, that tubes and transistors are not replaced unless they actually cause trouble. During routine maintenance, it may be necessary to remove tubes or transistors from their sockets. It is important that these components be returned to the same socket.

Unnecessary replacement or switching of tubes or transistors will often necessitate recalibration of the instrument. If these components do require replacement, it is recommended that they be replaced by previously checked, high quality components. The best way to check tubes and transistors is to place them in the circuit and then check for proper operation.

CAUTION

Turn the oscilloscope power off when replacing tubes or transistors to safeguard their life expectancy. Be sure the voltages and loads on the transistors are normal before making the substitution.

After completing the check, if you have replaced any tubes or transistors in the amplifier stages, check the gain and transient response of the Type 1A1 before using the unit for waveform measurements.

Removing and Installing the Etched-Wiring Cards

The etched-wiring cards are the plug-in type and can be removed easily by proceeding as follows:

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

2. To remove the Channel 1 or 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.

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 or 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 Replacing Switches

If the INPUT SELECTOR switch is defective, remove and replace the switch. Use normal care in disconnecting and reconnecting the leads. To remove the nut that mounts the switch and the attenuator chassis, use a 1" open end wrench which is ground down for clearance.

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 Engineering Office either unwired or wired, as desired. Refer to the Parts List to find the unwired and wired switch part numbers.

CAUTION

When disconnecting or connecting 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.

OBTAINING REPLACEMENT PARTS

Standard Parts

Replacements for all electrical and mechanical parts used in the Type 1A1 can be purchased through your local Tektronix Field Engineer or Field Office. However, since many of the electrical components are standard parts, they can generally be obtained locally in less time than is required to obtain them from the factory. Before ordering or purchasing electrical components locally, be sure to consult the Parts List to determine the values, tolerances and ratings required.

Special Parts

In addition to the standard electrical components mentioned in the previous paragraph, special parts are also used in the assembly of the Type 1A1. These parts are manufactured or selected by Tektronix to satisfy particular requirements or are manufactured specially for Tektronix by other companies in accordance with Tektronix specifications. These parts and most mechanical parts should be ordered from your Tektronix Field Engineer or Field Office as they are normally difficult or impossible to obtain from other sources.

TROUBLESHOOTING

Introduction

In the event trouble develops, use the information in this portion of the Instruction Manual to more efficiently troubleshoot the Type 1A1. The information begins with preliminary checks to make and advances to more detailed circuit troubleshooting.

Front-Panel Controls

Before troubleshooting, double-check the front-panel controls for proper settings. In addition, check the front-panel screwdriver-adjustable controls to determine if their settings are proper. This is important since symptoms caused by incorrect control settings are not described in this section of the manual. Next, determine whether the trouble is in the oscilloscope or the Type 1A1.

Type 1A1 or Oscilloscope

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 1A1 is operating normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 1A1.

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

NOTE

Be sure proper line voltage is applied to the oscilloscope used with the Type 1A1. For proper oscilloscope low-voltage power supply regulation, the ac line voltage should contain no more than 3% to 5% sine-wave distortion.

If the Type 1A1 is definitely at fault and not the associated oscilloscope, make a careful operational check of the Type 1A1. Carefully note the effect that each front-panel control has on the symptom. By analyzing such effects, you can sometimes isolate a trouble to either a defective control or circuits containing the trouble. In addition, the normal or abnormal operation of each control should indicate checks to make.

The remainder of this section deals with detailed troubleshooting. Table 5-2 gives the interconnecting plug to ground resistances. A step-by-step method of checking and adjusting the Type 1A1 is given in the Calibration section. The Calibration procedure can be used to check the operational standards of the Type 1A1. Any deficiency that shows up while performing the steps can lead you to the area at fault and the possible causes.

CIRCUIT TROUBLESHOOTING

Diagrams

Block and circuit diagrams are contained in the pull-out pages of section 7. The circuit diagrams contain component circuit numbers, voltages, and waveforms. Conditions under which the voltages and waveforms were taken are also indicated on the diagrams.

Etched Wiring Cards

The Type 1A1 contains three compact plug-in etched wiring cards. Figs. 5-1 through 5-3 show the circuit number of each component and its location. Fig. 5-4 labels the connector wiring for each card.

Coding of Switch Wafers

Switch wafers shown on the circuit diagrams are coded to indicate the physical location of the wafer on the 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 a VOLTS/CM switch is the second wafer when counting back from the detent section, and R is the rear side of the wafer.

Cable Color Coding

All wiring in the Type 1A1 is color coded to facilitate circuit tracing. The power-supply wires originating at the oscilloscope interconnecting plug are identified by the following code; the widest strip identifies the first color in the code.

Supply Voltage	Cable Color Code
+225 v	Red/red/dark-brown or white
+100 v	Dark-brown/black/dark-brown on white
+75 v	Purple/green/black on white
—150 v	Dark-brown/green/dark-brown on tan

Test Equipment

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

(1) Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer.
Purpose: To test transistors and diodes used in the Type 1A1.

(2) VOM or VTVM

Description: VOM dc sensitivity should be at least 20,000 ohms per volt; dc voltage accuracy for either the VOM or VTVM should be within 3%.

CAUTION

Be sure the test prods are well insulated (except for the very tip) to prevent accidental shorts when reaching a test point. If you use the VOM or VTVM as an ohmmeter to measure resistances when semiconductors are in the circuit, know and use ranges (usually RX1K and higher) that deliver a current of less than 2 ma at full deflection.

Purpose: 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) Milliammeter

Description: Range 0 to 2 ma.
Purpose: To determine full-scale current delivered by the VOM or VTVM on ohmmeter ranges used for semiconductor testing.

(4) Test Oscilloscope

a. Low-bandwidth Test Oscilloscope with a 10X attenuator probe.

Description: Bandwidth, dc to about 300 kc or better. Calibrated vertical deflection factors down to 5 mv/cm without a 10X probe (50 mv/cm with a 10X probe and 10 megohms with a 10X probe. An Ext. Trig. input connector on the test oscilloscope is desirable.

Purpose: To low-frequency signal trace and check dc levels in each amplifier stage. Can be used to signal trace the switching circuits if bandwidth limitation is considered.

b. Wide-bandwidth Test Oscilloscope with a 10X attenuator probe.

Description: Bandwidth, dc to 10 mc or better. Calibrated vertical deflection factors down to 0.1 volt/cm without a 10X probe (1 volt/cm with a 10X probe).

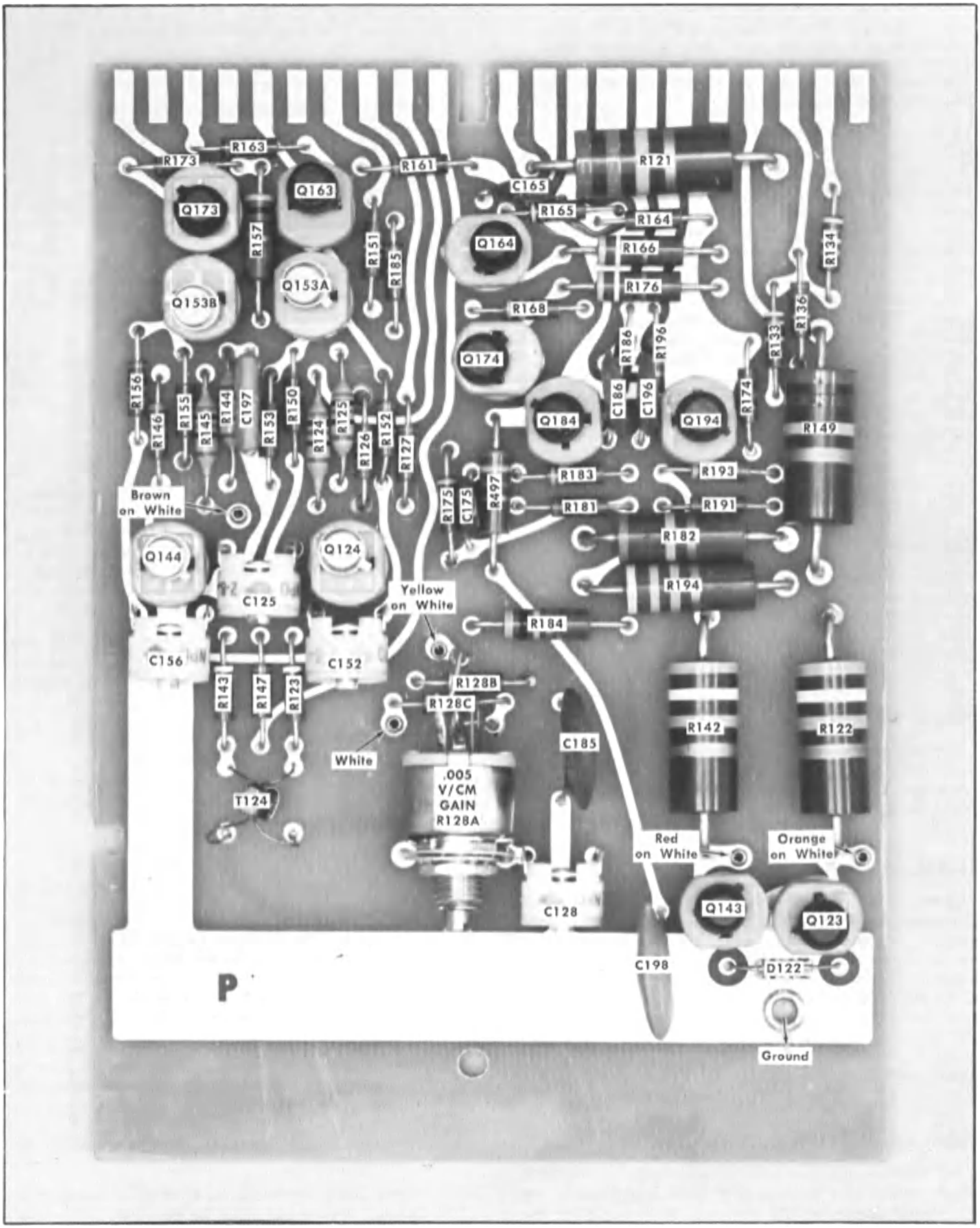


Fig. 5-1. Channel 1 Input Amplifier card.

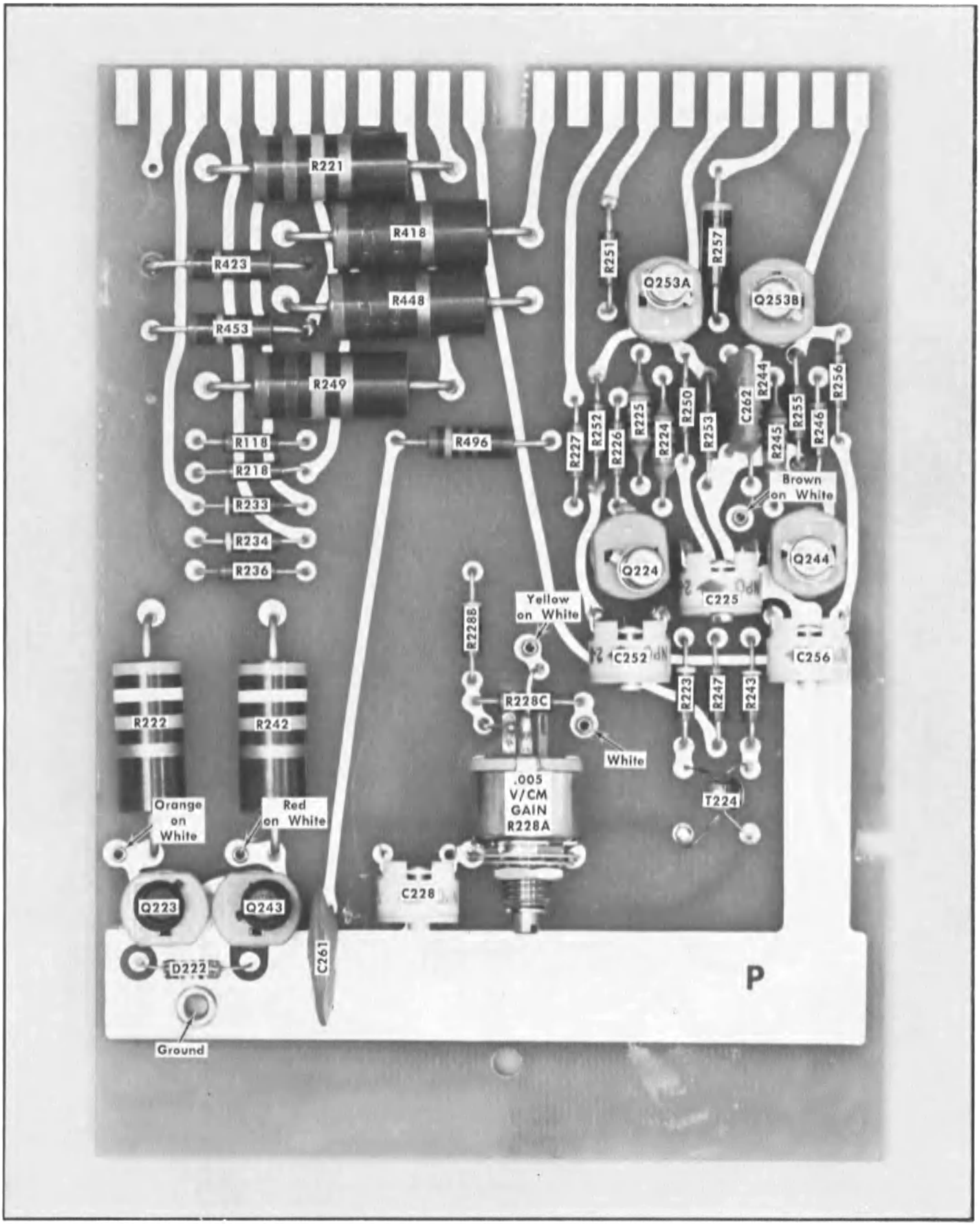


Fig. 5-2. Channel 2 Input Amplifier card.

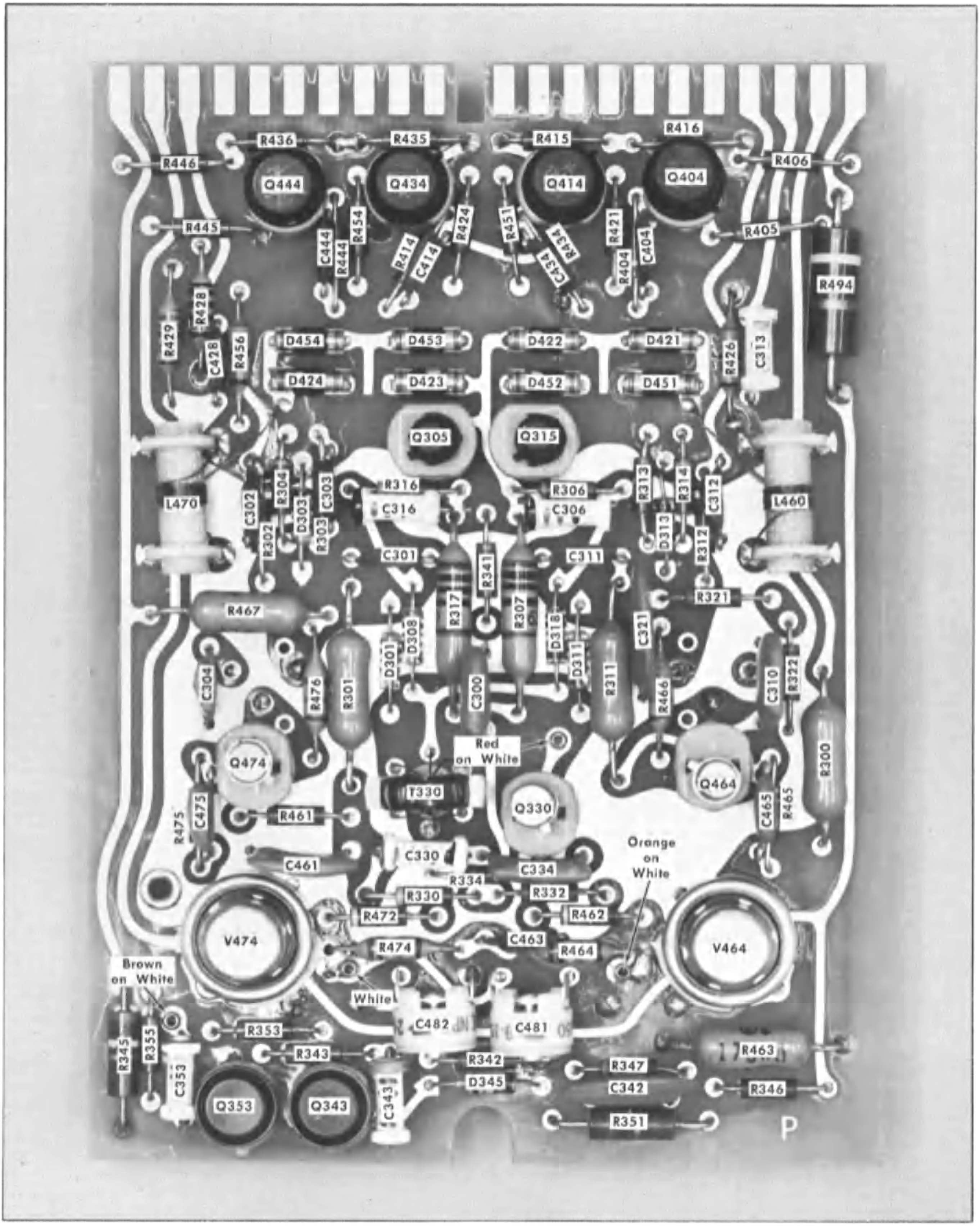


Fig. 5-3. Output Amplifier card.

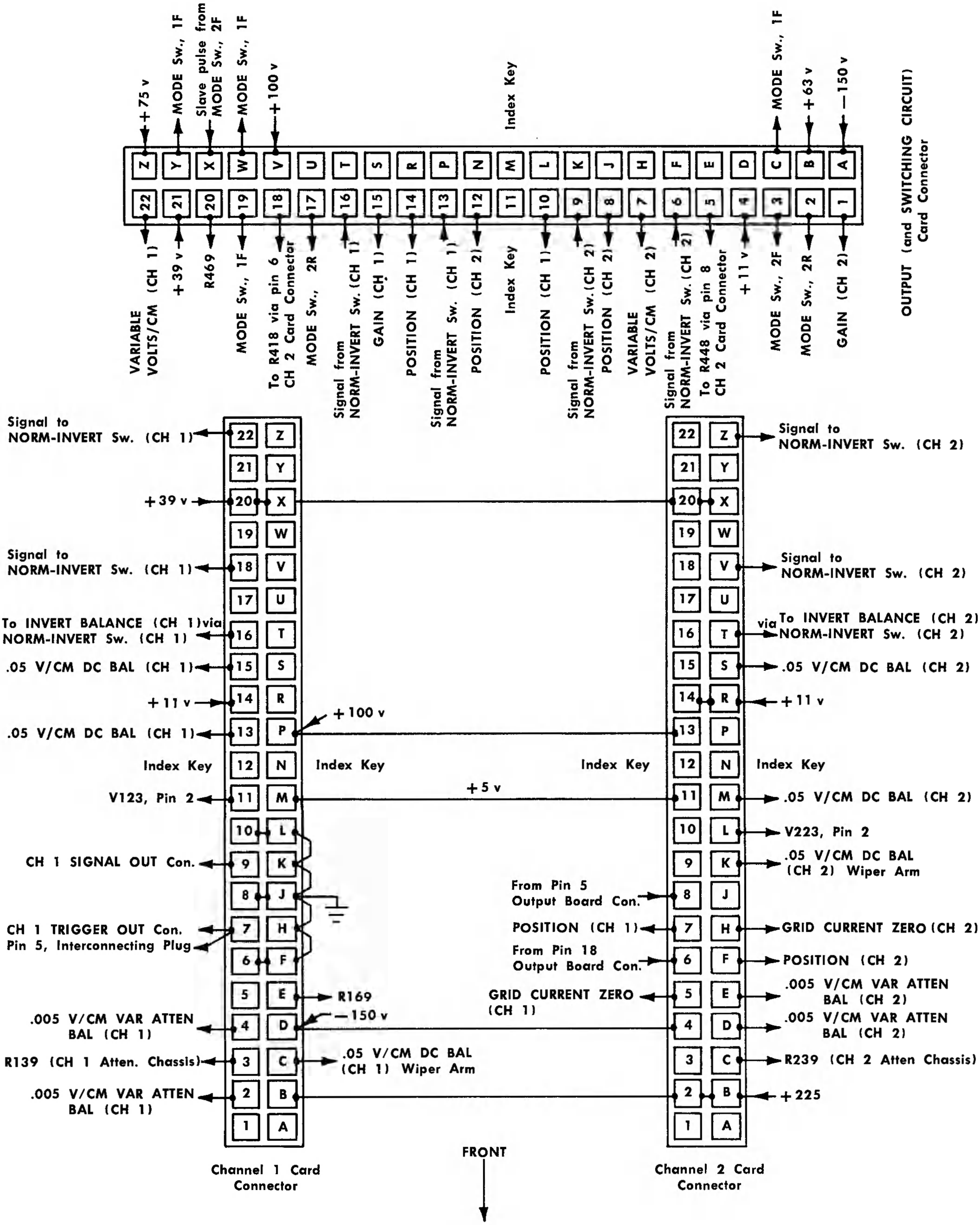


Fig. 5-4. Etched wiring card connector-top view.

Purpose: 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 4a.

(5) Autotransformer

Description: Output voltage variable between 105 and 125 volts (or 210 and 250 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).

Purpose: To apply design-center line voltage to the oscilloscope/Type 1A1 combination.

(6) Ac Voltmeter

Description: RMS-calibrated ac voltmeter capable of indicating voltages in the 105 to 125-volt range (or from 210 to 250 volts if the oscilloscope used with the Type 1A1 is wired for this operating range).

Purpose: To monitor the line voltage.

(7) Flexible Cable Plug-In Extension

Description: 30"long, Tektronix Part No. 012-038.

Purpose: Permits operating the Type 1A1 out of the plug-in compartment so that all sides of the unit are accessible for servicing.

(8) Etched Wiring Extender Card-Tektronix Part No. 012-079

Description: One extender card complete with four signal extension leads and two ground extension leads attached to the card.

Purpose: Permits operating the etch-wiring card partially out of the unit for troubleshooting.

(9) Adapter

Description: Adapter with BNC jack and UHF plug connector fittings. Fits BNC plug and UHF jack connectors. Tektronix Part No. 103-015.

Purpose: Use if test oscilloscope (item 4) Ext. Trig. connector is a UHF jack type of 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 11.)

(10) BNC T Connector

Description: Fits one BNC jack and two BNC plugs. Tektronix Part No. 103-030.

Purpose: Use in a low-frequency signal-tracing setup for connecting to the two BNC coaxial cables (item 11) and to the Cal. Out connector on the oscilloscope used with the Type 1A1.

(11) Coaxial Cables (two required)

Description: Equipped with BNC plug connectors on each end. Tektronix Part No. 012-057.

Purpose: Use in low-frequency signal-tracing setup to apply the calibrator signal to the Type 1A1 and to the test oscilloscope Ext. Trig. input connector.

(12) Miscellaneous: Replacement tubes, transistors, and diodes.

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 5-1 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 schematics, 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.

NOTE

As a general rule, do not use the RX1 and RX10 ohmmeter ranges. Use the higher ranges where the current is limited to less than 2 ma. You can quickly check the current by inserting a milliameter between the ohmmeter leads and then noting the current for each range you intend to use.

TABLE 5-1

Normal Diode Bias Conditions

	MODE Switch Setting				
Diode	CH 1	ALT[1]	CHOP	ADD	CH 2
D121	Forward	Forward	Forward	Forward	Forward
D122	Reverse	Reverse	Reverse	Reverse	Reverse
D221	Forward	Forward	Forward	Forward	Forward
D222	Reverse	Reverse	Reverse	Reverse	Reverse
D421	Reverse			Forward	Forward
D422	Forward			Reverse	Reverse
D423	Forward			Reverse	Reverse
D424	Reverse			Forward	Forward
D451	Forward			Forward	Reverse
D452	Reverse			Reverse	Forward
D453	Reverse			Reverse	Forward
D454	Forward			Forward	Reverse
D303	Reverse	Reverse	Reverse	Forward	Forward
D313	Forward	Reverse	Reverse	Forward	Reverse
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 μsec/cm free running sweep.

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

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, even when using the same ranges. Therefore, empty columns are provided in the table for logging your own measurements, and the type of meter used, for future reference.

Significant difference 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.

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]	Ohms Range Used	Resistance Readings[2]	Ohms Range Used
1	Any	6.7k, 5k	RX1K		
2	Any	0 (Gnd.)			
3	Any	6.7k, 5k	RX1K		
4	Any	0 (Gnd.)			
5	Any	7k, 6.8k	RX1K		
6	Any	Infinite (No connection)			
7	Any except ALT	0 (Gnd.)			
	ALT	Infinite	RX1K		
8	Any	0.3 Ω	RX1		
9	Any	4.6k, 6.6k	RX1K		
10	Any	4.5k, 2.9k	RX1K		
11	Any	30k, 8.6k	RX1K		
12 13 14	Any	Infinite (No connection)			
15	CH 1 or CH 2	500 Ω, 430 Ω	RX100		
	ALT	490 Ω, 430 Ω	RX100		
	CHOP	450 Ω, 400 Ω	RX100		
	ADD	510 Ω, 430 Ω	RX100		
16	CH 1, ADD, or CH 2	Infinite (No connection)			
	ALT	27k, 16k	RX10K		
	CHOP	10k	RX1K		

[1]VOM used to obtain these measurements is a 20,000 ohms per volt dc meter with a center-scale reading of 4.5 k on the RX1K range. For the RX1K range, mid-scale deflection current is 160 μa; at full scale it is 320 μa.

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

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 visiblity.

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 of the viewing area.

TABLE 5-3

Trouble Isolation Procedure

Symptoms	Checks to Make	
	Some Possible Causes	Probable Circuit Area At Fault
1. No trace or waveform 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: +225v, +100v, +75v, +39v, +11v, +5v, and —150v. If any of these voltages are incorrect, find the trouble before going to the third column.	Check for dc imbalance in the Output Amp. Second stage. Refer to Fig. 5-5.
2. Trace but no waveform display, either channel.	R467 open.	Check Output Amp. Second stage.
3. No Channel 1 trace or waveform display.	Check for open series diode D421 or D424, V123 or V143 defective. Check that the Switching Multivibrator stage is working properly. Q305 should be conducting and Q315 should be cut off. D121 open. D421 open. D452 open. D122 shorted. D424 open. D453 open.	Check for dc imbalance in Channel 1. Refer to Fig. 5-5.
4. No Channel 2 trace or waveform display.	Check for open series diode D451 or D454, V223 or V243 defective. Check that the Switching Multivibrator stage is working properly. Q315 should be conducting and Q305 should be cut off. D221 open. D422 open. D451 open. D222 shorted. D423 open. D454 open.	Check for dc imbalance in Channel 2. Refer to Fig. 5-5.
5. Channel 1 trace but no waveform display.	Check for short or open circuit between Channel 1 input connector and grid of V123.	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 grid of V223.	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, D313 shorted }—Ch. 1 only is "on". D303 shorted, D318 open }—Ch. 2 only is "on".	Check Alt. Trig. B.O. Q330 stage.
9. No chopped mode of operation. Alternate mode is normal.	Defective contact on the MODE switch in 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 Q343/Q353 stage.
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 Sig. Pickoff EF and Amplifier stages.
12. No signal or insufficient amplitude signal at CH 1 TRIGGER OUT connector.	Q184 and Q194 defective.	Check Channel 1 Trig. Output Amp. Q184/Q194 stage.

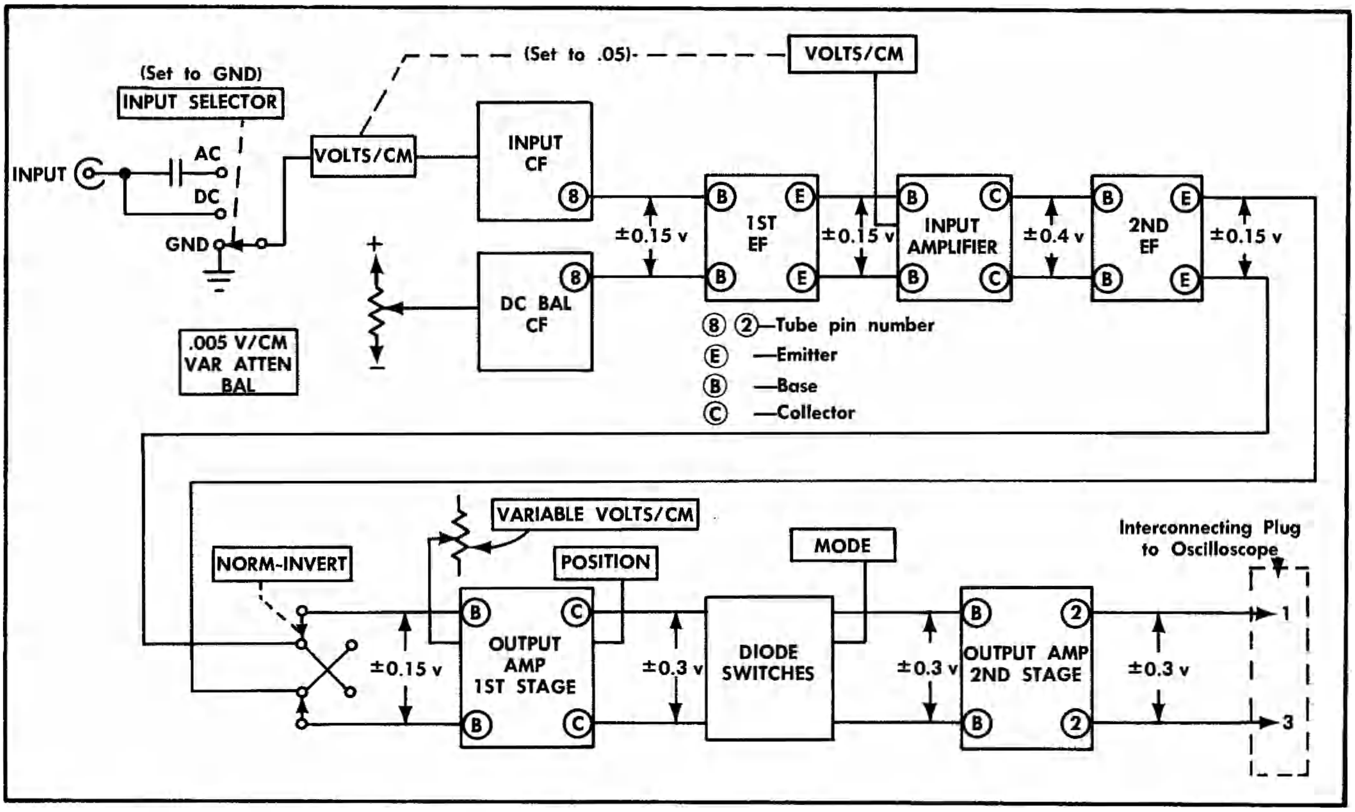


Fig. 5-5. Dc balance voltage limits at each stage, which, if not exceeded, should position the trace on the crt. The trace should appear within ±3 cm from the oscilloscope vertical-amplifier electrical center.

Fig. 5-5 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 Chan. 1 Input Amplifier stage reads +0.8 volt, the voltage between the collectors of Q404 and Q414 in the Output Amp. first stage will read +0.6 volts, and the voltage 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 Amp. 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 Amp. 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.

Troubleshooting Table

Table 5-3 is a list of typical symptoms, their possible causes and the probable circuit at fault. The list is based on deliberate troubles placed in various areas of the Type 1A1. 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 methods of troubleshooting; i.e. signal tracing, voltage and resistance checks, and parts substitution. To reduce the parts substitution method of troubleshooting to a minimum, however, use the other 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.

SECTION 6
CALIBRATION PROCEDURE

Introduction

The Type 1A1 should be calibrated after each 500 hours of operation, or at least every six months. Also, when transistors, tubes, and other components are changed, the calibration of the circuit under repair should be checked.

The instructions that follow are arranged in proper sequence to calibrate the unit and avoid unnecessary repetition of checks and adjustments. The steps may be performed out of sequence, or a single step may be performed individually. However, it may be necessary to refer to the preceding step(s) and/or preliminary procedure for additional setup information.

NOTE

This procedure is a combination performance check and adjustment procedure. Step titles which begin with the word "Check" permit you to check the operational standards of the unit with very little change, if any, in the setup. All other step titles represent the name of the adjustment. All adjustment steps are check-and-adjust-if-necessary type of procedures.

EQUIPMENT REQUIRED

The following equipment, or its equivalent, is required for a complete calibration of the Type 1A1.

(1) Calibrated Type 544, 546, or 547 oscilloscope, or their equivalents. Purpose: For use with the Type 1A1 Plug-In Unit.

(2) Amplitude Calibrator. Output frequency of about 1 kc; peak-to-peak output amplitudes: 20 mv, 50 mv, 100 mv, 200 mv, 0.5 v, 1 v, 2 v, 5 v, 10 v, 20 v, 50 v and 100 v; amplitude accuracy of 1% or better. Purpose: For use in performing steps 5, 7, 9, 10 and 21 of the calibration procedure if greater accuracy than provided by the oscilloscope (item 1) calibrator is needed.

(3) Square-wave generator, Tektronix Type 105. Required specification: 13-nsec or less risetime into a 50-ohm cable terminated at both ends; output frequency of approximately 2.5 kc; output amplitude variable from 10 to 100 volts across a 600-ohm load.

(4) TU-5 Pulser complete kit, Tektronix Part No. 015-043, contains the following items*:

Qty.	Description	Part Number
1	TU-5 Pulser (alone) with BNC plug-and-jack connector fittings.	015-038
1	50-ohm termination with BNC plug-and-jack connector fittings.	011-049
1	50-ohm 10:1 T attenuator, ½ w, with BNC plug-and-jack connector fittings.	011-059
1	Connector adapter with UHF-plug BNC-jack connector fittings	103-015
1	50-ohm (nominal impedance) coaxial cable, 42" long, with a BNC plug connector on each end.	012-057

*The following items can be ordered separately through your local Tektronix Field Engineering Office.

TU-5 Pulser (015-038) characteristics:

Input Voltage Required—+100-volt (from ground) square wave capable of supplying 10 ma. The oscilloscope calibrator on item 1 fulfills this requirement.

Output Voltage—200 mv or more into 50 ohms.

Output Pulse Risetime—1.5 nsec or less into a 50-ohm resistive load such as the 50-ohm termination (011-049).

(5) 15-pf Input RC Standardizer, 1 meg X 15-pf, 2X attenuation, with BNC plug-and-jack connector fittings, Tektronix Part No. 011-073.

(6) 50-ohm (nominal impedance) coaxial jumper cable 20" long; equipped with a BNC plug connector on each end, Tektronix Part No. 012-076.

(7) BNC T connector. Fits one BNC jack and accepts two BNC plugs. Tektronix Part No. 103-030.

(8) Miscellaneous

1—Small screwdriver with a ⅛" wide tip to fit screwdriver-adjust potentiometers.

1—Insulated low-capacitance screwdriver, Jaco No. 125, 1½" shank, ⅛" wide metal tip. Tektronix Part No. 003-000.

2—Low-capacitance alignment tools, each tool consists of a handle (Part No. 003-307) and a 5/64" hexagonal wrench insert (Part No. 003-310).

1—Gray nylon insert with a wire pin (Part No. 003-308), fits into handle (Part No. 003-307).

PRELIMINARY PROCEDURE

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

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

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

d. Connect the power cord of the oscilloscope to the design-center operating voltage for which the oscilloscope is wired.

e. Turn on the oscilloscope and allow 15 minutes for warm-up and stabilization.

f. Preset the oscilloscope* front and rear panel controls as follows:

Horizontal Display	B (546, 547) Normal (544)
Single Sweep Switch	Normal
Triggering Level	Fully clockwise
Triggering Source	Norm
Triggering Coupling	AC
Triggering Slope	+
Triggering Mode	Auto
Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated
Horizontal Position	Centered
Vernier (Horizontal Position)	Centered
Crt Cathode Selector	Crt Cathode
Amplitude Calibrator	Off

g. Preset the Type 1A1 front-panel controls (both channels) to these settings:

POSITION	Centered
NORM-INVERT	NORM
VARIABLE VOLTS/CM	CALIB
VOLTS/CM	.005
INPUT SELECTOR	GND
MODE	CH 1

CALIBRATION PROCEDURE

1. Channel 1 .005 V/CM VAR ATTEN BAL

a. A free-running trace should be present near the center of the screen and the trace should 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 to vertically position the trace onto the screen. Then adjust the Channel 1 .005 V/CM VAR ATTEN BAL control once again for no trace shift while rotating the Channel 1 VARIABLE VOLTS/CM control back and forth.

b. 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.

*For those oscilloscopes which have two time bases, Main Time Base B front-panel controls are used throughout this procedure.

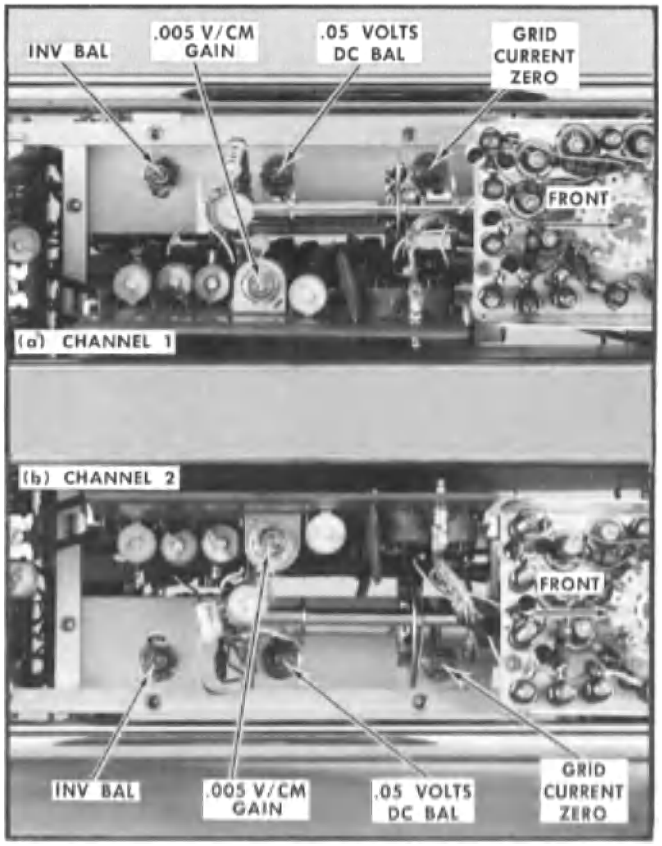


Fig. 6-1. (a) Bottom left half section of the Type 1A1 showing the location of the Channel 1 adjustments, and (b) bottom right half section showing the location of the Channel 2 adjustments.

2. Channel 1 .05 VOLTS DC BAL

Set the Channel 1 VOLTS/CM switch to .05. The trace should coincide with graticule center. If it does not, adjust the Channel 1 .05 VOLTS DC BAL control (see Fig. 6-1a) to vertically position the trace to coincide with graticule center.

NOTE

There is some interaction between the adjustments made in steps 1 and 2. As a check, set Channel 1 VOLTS/CM switch to .005. If the trace no longer coincides with graticule center, adjust the .005 V/CM VAR ATTEN BAL control to make the trace coincide properly. Then, repeat step 2.

3. Channel 2 .005 V/CM VAR ATTEN BAL

a. Set the MODE switch to CH 2.

b. Using step 1 as a guide, check and adjust, if necessary, Channel 2 .005 V/CM VAR ATTEN BAL control for no trace shift.

c. Use the Channel 2 POSITION control to make the trace coincide with graticule center. Leave the control at this setting until completing the next step.

4. Channel 2 .05 VOLTS DC BAL

Using step 2 as a guide, adjust Channel 2 .05 VOLTS DC BAL control (see Fig. 6-1b) to position the trace to coincide with graticule center.

NOTE

Due to some interaction between the adjustments made in steps 3 and 4, repeat the procedures using step 2 NOTE as a guide.

5. Channel 2 .05 V/CM GAIN

a. Check that Channel 2 VOLTS/CM switch is set to .05 and the VARIABLE VOLTS/CM control is set to CALIB.

b. Apply a 200 millivolt peak-to-peak calibrator signal through a coaxial cable (012-057) to the Channel 2 input connector.

c. Set Channel 2 INPUT SELECTOR switch to DC.

d. Using the Channel 2 POSITION control, center the free-running display in the graticule viewing area. The display should be 4 centimeters in amplitude. If it is not, adjust Channel 2 .05 VOLTS/CM GAIN control for a vertical deflection of exactly 4 centimeters.

NOTE

Use the Channel 2 POSITION control to position the display for convenient measuring.

6. Check Channel 2 VARIABLE VOLTS/CM Control

a. Rotate Channel 2 VARIABLE VOLTS/CM control to its maximum counterclockwise position.

b. Check the amplitude of the display. The display should be 1.6 centimeters peak-to-peak or less. This indicates that the ratio of the control is at least 2.5 to 1.

c. Rotate the control through the 1.6-cm to 4-cm amplitude range and check for smooth electrical operation.

NOTE

If rotation of the VARIABLE VOLTS/CM control through the 1.6-cm to 4-cm amplitude range causes erratic jumping of the trace, replace the control.

d. Set the Channel 2 VARIABLE VOLTS/CM to the CALIB position.

7. Channel 1 .05 V/CM GAIN

a. Apply the 200-millivolt calibrator signal to Channel 1 Input connector.

b. Set the INPUT SELECTOR switch to DC and the MODE switch to CH 1; check that the VOLTS/CM switch is set to .05 and the VARIABLE VOLTS/CM control is set to CALIB.

c. The amplitude of the display should be 4 centimeters. If it is not, adjust the Channel 1 .05 V/CM GAIN control for proper amplitude.

NOTE

Use the Channel 1 POSITION control to position the display to a convenient point for measuring purposes.

8. Check Channel 1 VARIABLE VOLTS/CM Control

a. Rotate Channel 1 VARIABLE VOLTS/CM control to its maximum counterclockwise position.

b. Check the amplitude of the display. The display should be 1.6 centimeters peak-to-peak or less.

c. Rotate the control through the 1.6-cm to 4-cm amplitude range and check for smooth electrical operation.

NOTE

If rotation of the VARIABLE VOLTS/CM control through the 1.6-cm to 4-cm amplitude range causes erratic jumping of the trace, replace the control.

9. Channel 1 .005 V/CM GAIN

a. Set the Amplitude Calibrator for an output of 20 millivolts.

b. Set Channel 1 VOLTS/CM switch to .005.

c. The display should be 4 centimeters in amplitude. If it is not, adjust Channel 1 .005 V/CM GAIN control (see Fig. 6-1a) to obtain a correct amplitude display.

NOTE

Interaction occurs between this adjustment and the Channel 1 .05 V/CM GAIN adjustment (step 7). Check by repeating step 7 and then repeating step 9.

10. Channel 2 .005 V/CM GAIN

a. Apply the 20-millivolt calibrator signal to channel 2 input connector.

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

c. Check for a display amplitude of exactly 4 centimeters. If it is not, adjust Channel 2 .005 V/CM GAIN control (see Fig. 6-1b) to obtain a display of correct amplitude.

NOTE

Some interaction occurs between this adjustment and Channel 2 .05 V/CM GAIN adjustment (step 5). Check by repeating step 5 and then step 10.

d. Disconnect the calibrator signal.

11. Check for Microphonics (Both Channels)

a. Check that the Channel 2 VOLTS/CM switch is set to .005; adjust the POSITION control so the trace is positioned to graticule center.

b. Tap the left side of the oscilloscope near the Type 1A1 front panel and watch for excessive microphonics. Amplitude of the microphonics should not exceed 1 centimeter peak-to-peak..

NOTE

If the microphonics are excessive, turn off the oscilloscope power and replace V223 and/or V243. Turn on the oscilloscope. Allow sufficient warm-up time (about 15 minutes) for the new tube(s). Get the trace on the crt by adjusting the Channel 2 .005 V/CM VAR ATTEN BAL control. Check for microphonics. If they are not excessive repeat steps 3, 4, 5, and 10.

c. Set the MODE switch to CH 1, and check that the Channel 1 VOLTS/CM switch is set to .005.

d. Adjust the POSITION control so the trace is positioned to graticule center.

e. Repeat step 11b. In this case if microphonics are excessive, turn off the oscilloscope power, and replace V123 and/or V143. Turn on the power and allow about 15 minutes warmup time. Get the trace on the crt by adjusting the Channel 1 .005 V/CM VAR ATTEN BAL control. Check for microphonics. If they are not excessive, repeat steps 1, 2, 7 and 9.

12. Channel 1 GRID CURRENT ZERO

a. Note the position of the trace.

b. Set the Channel 1 INPUT SELECTOR switch to GND. If the trace shifts away from the position noted in step 12a, set Channel 1 INPUT SELECTOR to DC and adjust the Channel 1 GRID CURRENT ZERO control (see Fig. 6-1a) to position the trace to the same point as was noted in step 12a.

c. To check on the accuracy of your adjustment, switch from DC to GND and back again several times. If trace shifts, readjust Channel 1 GRID CURRENT ZERO for no trace shift.

13. Channel 2 GRID CURRENT ZERO

a. Set the MODE switch to CH 2.

b. Note the position of the trace.

c. Set Channel 2 INPUT SELECTOR switch to GND. If the trace shifts away from the position noted in step 13b, set the INPUT SELECTOR switch to DC, and adjust the channel 2 GRID CURRENT ZERO control (see Fig. 6-1b) to position the trace to the same point as noted in step 13b.

d. To check on the accuracy of your adjustment, switch from DC to GND and back again several times. If trace shifts, readjust Channel 2 GRID CURRENT ZERO for no trace shift.

14. Channel 2 INV BAL

Due to slight normal drifting in the Type 1A1, the dc balance adjustments must be rechecked before adjusting the Channel 1 INV BAL control. To do this proceed as follows:

a. Set Channel 2 INPUT SELECTOR switch to GND and center the POSITION control.

b. Repeat steps 3 and 4.

c. Check that the Channel 2 VOLTS/CM switch is set to .05.

d. Note the position of the trace.

e. Set the Channel 2 NORM-INVERT switch to INVERT. There should be no trace shift when switching to the INVERT position. If there is, leave the switch in the INVERT position and adjust Channel 2 INV BAL control (see Fig. 6-1b) to vertically position the trace to the point noted in step 14d.

NOTE

To check on the accuracy of your adjustment, set Channel 2 NORM-INVERT switch to NORM. Then repeat steps 14d and 14e to readjust, if necessary, the Channel 2 INV BAL control for no trace shift.

f. Set Channel 2 NORM-INVERT switch to NORM.

15. Channel 1 INV BAL

a. Set Channel 1 INPUT SELECTOR switch to GND, the POSITION control to center, and the MODE switch to CH 1.

b. Repeat steps 1 and 2.

c. Check that the Channel 1 VOLTS/CM switch is set to .05.

d. Note the position of the trace.

e. Set channel 1 NORM-INVERT switch to INVERT. There should be no trace shift when switching to the INVERT position. If there is, adjust Channel 1 INV BAL control (see Fig. 6-1a) to vertically position the trace to the point noted in step 15d.

NOTE

To check on the accuracy of your adjustment, set Channel 1 NORM-INVERT switch to NORM. Repeat steps 15d and 15e.

f. Set Channel 1 NORM-INVERT switch to NORM.

16. Check Chopped-Mode Operation

a. Set the MODE switch CHOP. Two free running traces should be displayed.

Ⓐ1

b. Set both VOLTS/CM switches to .005.

c. 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 centimeters apart and the display is centered on crt.

d. Set the oscilloscope Time/Cm switch to 0.5 μSec and adjust the Triggering Level control to obtain a stable display.

e. Horizontally position the display so the display starts at the left side of the graticule.

f. Check the repetition rate of the displayed waveform. The repetition rate should be approximately 1 mc, within a tolerance of ±15%. This is equal to a time duration of one microsecond per cycle and a tolerance of ±0.15 μsec (see Fig. 6-2a).

g. Set the oscilloscope Crt Cathode Selector switch to the Chopped Blanking position. Note that the switching portion of the trace from one channel to the next blanks out (becomes dim). This indicates that the Type 1A1 blanking pulses are blanking the beam during the switching-time interval between channels (see Fig. 6-2b).

h. Set the oscilloscope Time/Cm switch to .1 mSEC and free run the time base.

i. At normal intensity check the width (thickness) of the traces. Normal trace width 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.

j. Set the Crt Cathode Selector Switch to the EXT Crt Cathode position.

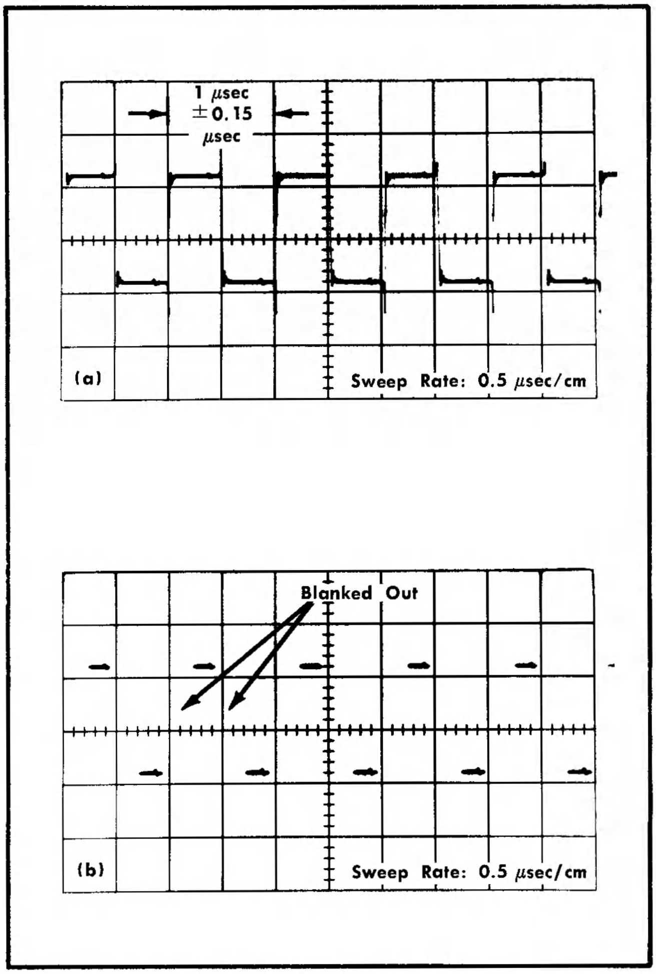


Fig. 6-2. (a) Unblanked chopped-mode waveform, and (b) blanked waveform.

17. Check Alternate-Mode Operation

a. Set the MODE switch to the ALT position.

b. Rotate the oscilloscope Triggering Level control fully clockwise so the oscilloscope time base is free running.

c. Check for a two-trace display on the crt.

d. Set the oscilloscope Time/Cm switch to various sweep rates and check that the traces run alternately across the face of the crt.

18. Check the Add Mode Operation

a. Connect a BNC T connector to the Channel 2 Input connector.

b. Connect a (012-057) coaxial cable between the Calibrator Output connector and the BNC T connector.

c. Connect a coaxial jumper cable (item 6) from Channel 2 input connector to Channel 1 input connector.

d. Set the INPUT SELECTOR switches of both channels to AC and both VOLTS/CM switches to .05.

e. Set the Amplitude Calibrator for a 0.1-volt peak-to-peak output.

f. Set the oscilloscope Time/Cm switch to .5 mSEC and adjust the Triggering Level control to obtain a stable display. There should be two calibrator waveforms, two centimeters in amplitude, displayed on the crt.

g. Set the MODE switch to ADD. With the same amount of calibrator signal applied to both channels of the Type 1A1 as in the previous step, check for a single calibrator waveform display four centimeters in amplitude.

h. Set Channel 1 MODE switch NORM-INVERT switch to INVERT.

i. Set the Amplitude Calibrator for an output of 0.5 volt. The two signals should cancel each other out within 0.5 centimeter. Adjust the VARIABLE VOLTS/CM control of one or both channels to accomplish the cancellation.

NOTE

If the cancellation just described takes place, set Channel 1 NORM-INVERT switch to NORM and Channel 2 NORM-INVERT switch to INVERT. Now check for proper cancellation. The Type 1A1 is operating satisfactorily if either condition will permit the proper cancellation of the signals.

19. Check Channel 1 Signal Output Amplitude

a. Set the Amplitude Calibrator switch for 10 millivolts output.

b. Remove the BNC T connector and the coaxial jumper cable (item 6).

c. Connect the coaxial jumper cable (item 6) to the CH 1 SIGNAL OUT connector and to the Channel 2 input connector.

d. Connect the (012-057) coaxial cable from the Calibrator Output connector to the Channel 1 input connector.

e. Set Channel 1 VOLTS/CM switch to .005.

f. Check that the Channel 2 INPUT SELECTOR switch is set to AC and the VOLTS/CM switch to .05.

g. Set the VARIABLE VOLTS/CM controls (both channels) to CALIB.

h. Set the MODE switch to CH 2 and the channel 2 NORM-INVERT switch to NORM.

i. Check that the peak-to-peak amplitude of the display is about two centimeter (100 millivolts). This is a gain of approximately 10.

20. Check Channel 1 Trigger Amplifier Gain

a. Set Channel 2 VOLTS/CM switch to .5.

b. Disconnect the coaxial jumper 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 centimeters (1 volt). This indicates that the gain is 100X. Tolerance is ±20%.

d. Disconnect the coaxial jumper cable (item 6).

21. Check VOLTS/CM Attenuation Ratios (Both Channels)

a. Set the Amplitude Calibrator for an output of 20 millivolts.

b. Set Channel 1 INPUT SELECTOR switch to DC and the MODE switch to CH 1.

c. Adjust the oscilloscope Triggering Level control to obtain a stable display.

d. Align the display with the horizontal graticule lines using the Channel 1 POSITION control.

e. Check for proper vertical deflection at each Channel 1 VOLTS/CM switch position by using Table 6-1 as a convenient guide.

If an oscilloscope calibrator is used as the signal source, the display-amplitude worst-case tolerance at each attenuated switch position can be ±6% (VOLTS/CM) attenuators and oscilloscope calibrator tolerances are each ±3%.) If the calibrator you are using has an accuracy better than ±3%, then check the attenuation ratios based on the better accuracy.

NOTE

At the factory the accuracy of the VOLTS/CM switches were checked with an Amplitude Calibrator Standardizer which employs ¼% resistors.

TABLE 6-1

Checking the VOLTS/CM Attenuator Ratios

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

f. After checking the attenuation ratios of the Channel 1 VOLTS/CM switch, set the Amplitude Calibrator switch in 20 mVolts and apply the calibrator signal to the Channel 2 input connector.

g. Set Channel 2 INPUT SELECTOR switch to DC, VOLT/CM switch to .005 and the MODE switch to CH 2.

h. Check for proper vertical deflection at each Channel 2 VOLTS/CM switch position. Use Table 6-1 as a guide.

i. After completing the pervious step, turn off the Amplitude Calibrator and disconnect the coaxial cable.

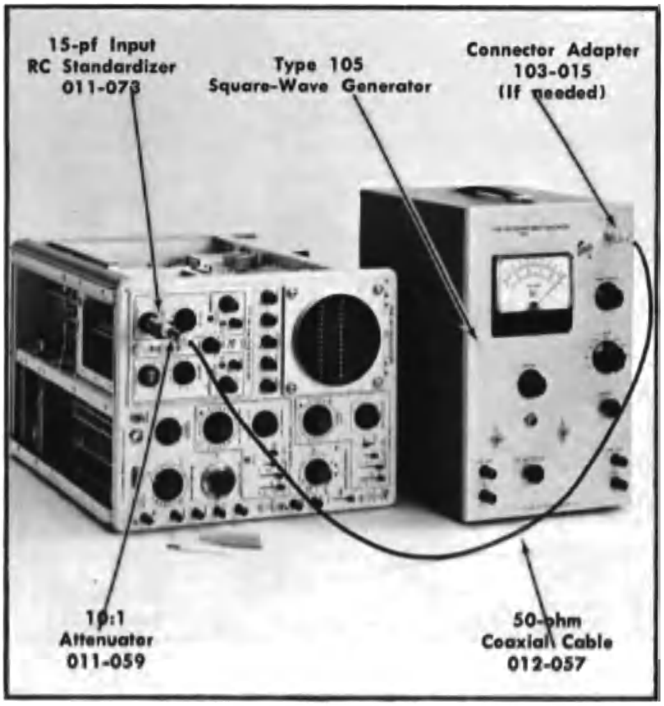


Fig. 6-3. Test setup when performing step 22.

22. Input-Capacitance Standardization and Attenuator Compensation (Both Channels)

This step describes how to properly adjust the input shunt capacitance of each channel so the input time constant is the same for each position of the VOLTS/CM switch. Thus, an attenuator probe, when compensated to match one setting of the VOLTS/CM switch, will work into the same time constant when using the other VOLTS/CM switch positions. Standardizing the input capacitance virtually eliminates the need for recompensating the probe each time a different switch position is used.

This procedure also describes a method for compensating the input attenuators so the ac attenuation is equal to the dc attenuation. Since there is some interaction between both sets of adjustments (input capacitance and attenuator compensation,) faster, more accurate results are obtained by combining both sets of adjustments in this one procedure.

To perform the adjustments, proceed as follows:

a. Turn on the Type 105 Square-Wave Generator, or equivalent, and rotate the Output Amplitude control for minimum output.

b. Connect the output of the Type 105 through an adapter (Part No. 103-015, if needed), a 42" coaxial cable (012-057), 10:1 T attenuator (011-059) and a 15-pf input rc standardizer (item 5) to the Channel 1 input connector on the Type 1A1. Connect all items in the order just given. Fig. 6-3 shows the entire setup.

c. Set the VOLTS/CM switches for both channels to .05 and the MODE switch to CH 1.

d. Set the generator for an output frequency of 2.5 kc and increase the output amplitude to produce a vertical deflect ion of about three centimeters on the crt.

e. Adjust the oscilloscope triggering controls to obtain a stable display.

f. Adjust the generator symmetry control to obtain a symmetrical waveform display.

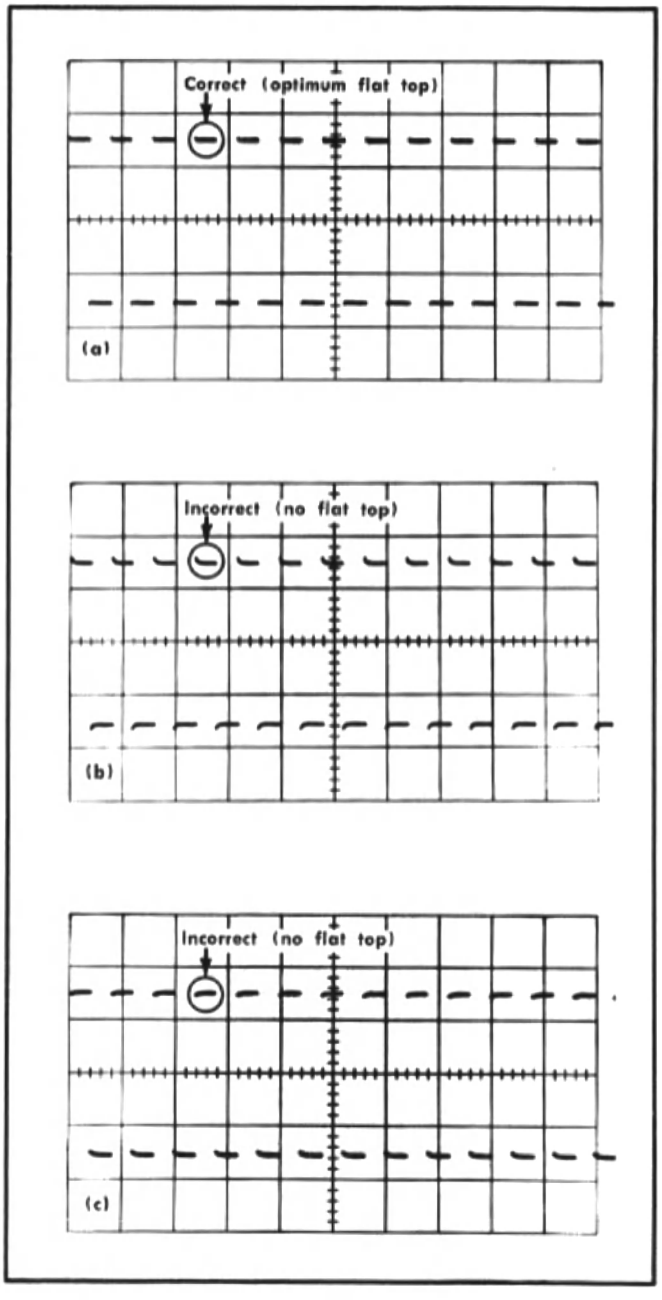


Fig. 6-4. Standardizing the input time constant of the Type 1A1. Square-wave repetition rate is 2.5 kc; sweep rate is 0.5 msec/cm.

NOTE

Use the Type 1A1 POSITION controls and oscilloscope triggering controls for the remaining portion of this calibration procedure whenever it is necessary to position the display for best viewing and to obtain a stable display.

g. The waveform display should be flat topped as shown in Fig. 6-4a. If the waveform is not optimum and looks something like Fig. 6-4b or 6-4c, adjust C104 (see Fig. 6-5) for best square-wave response (see Fig. 6-4a).

h. Use Table 6-2 and the information that follows. Column 1 in Table 6-2 lists the settings of the VOLTS/CM switch which connect each of the input attenuators into the circuit. The variable shunt capacitors for each channel and their effect on on the waveform are listed in columns 4 and 5. Figs. 6-4a and 6-6a show the waveforms obtained when the capacitors are correctly adjusted for optimum square corner and flat top. Figs. 6-4b, 6-4c, 6-6b and 6-6c show four types of distortion that can result if the capacitors are incorrectly adjusted. Fig. 6-5 shows the physical location of the adjustments.

TABLE 6-2

Input Time-Constant Standardization and Frequency Compensation

VOLTS/CM	Channel 1		Channel 2	
Switch Setting	*Input Shunt Capacitor	**Frequency Compensating Capacitor	*Input Shunt Capacitor	**Frequency Compensating 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

*Use a 0.5-millisec/cm sweep rate and adjust for optimum flat top.

**Use a 0.1-millisec/cm sweep rate and adjust for optimum leading corner (minimum fast rolloff or spike).

†Remove the 10XT attenuator to get more signal drive.

††Maximum amplitude of the display is 2.5 cm since 100 volts is the maximum output amplitude of the Type 105.

WARNING

To avoid a signal shock hazard, reduce the generator output to minimum when changing signal connections.

Maintain about three centimeters of vertical deflection by adjusting the Output Amplitude control on the square-wave generator each time the VOLTS/CM switch position is changed.

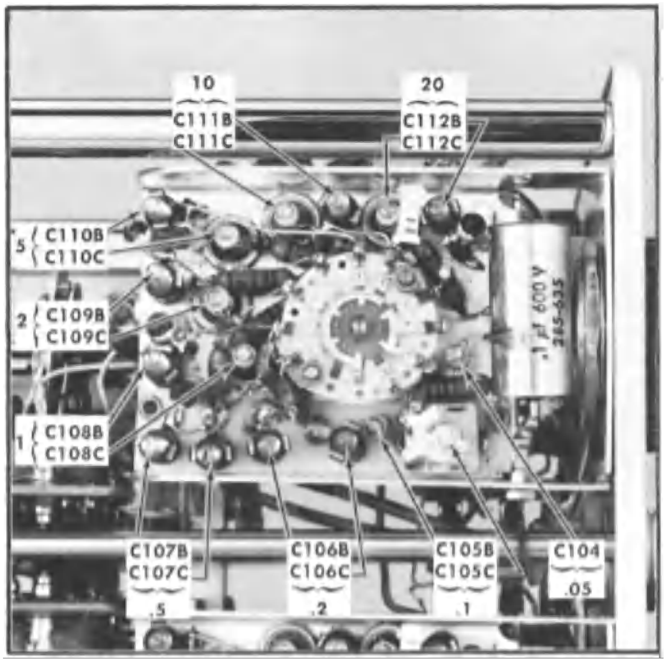


Fig. 6-5. Bottom left front portion of the Type 1A1 showing the location of the Channel 1 shunt capacitance and attenuator compensation adjustments. VOLTS/CM switch positions associated with the adjustments are also shown.

i. After checking (and adjusting, if necessary) the channel 1 input-capacitance and attenuator adjustments, set the MODE switch to CH 2 and decrease the generator output level to minimum.

j. Apply the generator signal to Channel 2 input connector using the same setup as for Channel 1 (step 22b).

k. Check the waveform. If necessary, adjust C204 (see Fig. 6-7) for optimum flat-topped (best square-wave response) waveform. The effect of the adjustment is the same as the one that was made in step 22g.

l. Continue on with the remaining Channel 2 adjustments. Use Table 6-2 as a guide. Fig. 6-7 shows the physical location of each adjustment.

m. After completing the Channel 2 adjustments, decrease the amplitude of the square-wave generator to minimum.

n. Disconnect the rc standardizer and coaxial cable.

23. High-Frequency Compensation at .05 Volts/Cm (Both Channels)

a. Connect the following items, according to the order given, starting from the calibrator output and going to the Channel 2 input connector: 50-ohm coaxial cable (012-057), TU-5 pulser (015-038), 50-ohm termination (011-059) to the Channel 2 input connector. Fig. 6-8 shows the conections for this setup.

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

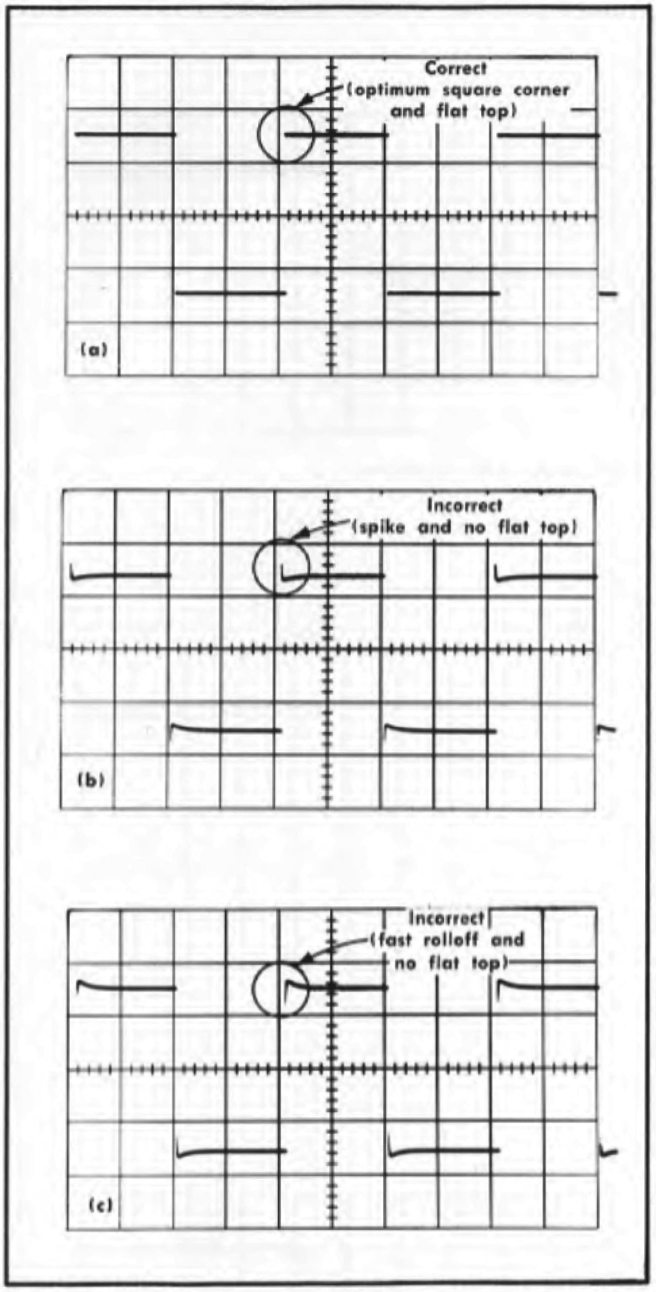


Fig. 6-6. Waveform (a) shows desired result obtained when the attenuator adjustments are set to obtain an optimum square corner and flat top. Waveforms (b) and (c) show effect obtained when both the input-capacitance and attenuator adjustments are mis-adjusted. Square-wave repetition rate is 2.5 kc and sweep rate is 0.1 msec/cm.

c. Set the Amplitude Calibrator for an output of 100 volts peak-to-peak.

d. Set the oscilloscope Time/Cm switch to 2 μSec.

e. Rotate the bias control on the pulser slowly clockwise from a fully counterclockwise position until the tunnel diode in the TU-5 triggers and produces a step waveform display on the crt.

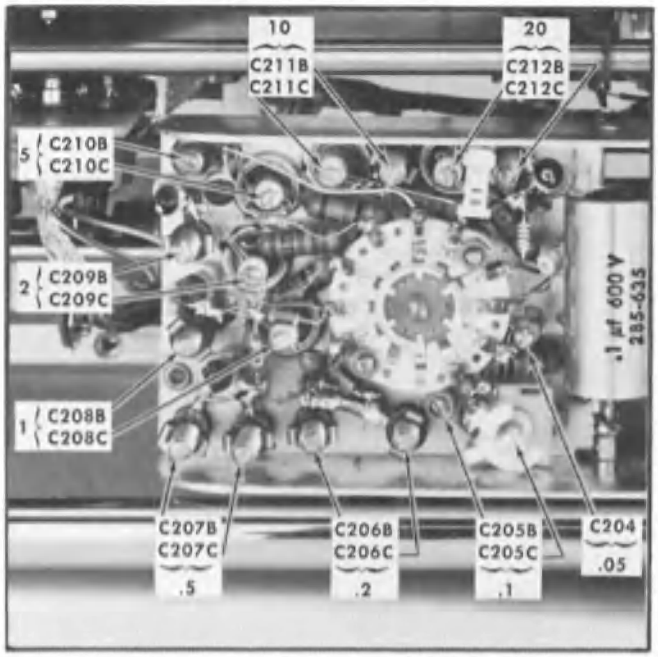


Fig. 6-7. Bottom right front portion of the Type 1A1 showing the location of the Channel 2 shunt capacitance and attenuator compensation adjustments. VOLTS/CM switch positions associated with the adjustments are also shown.

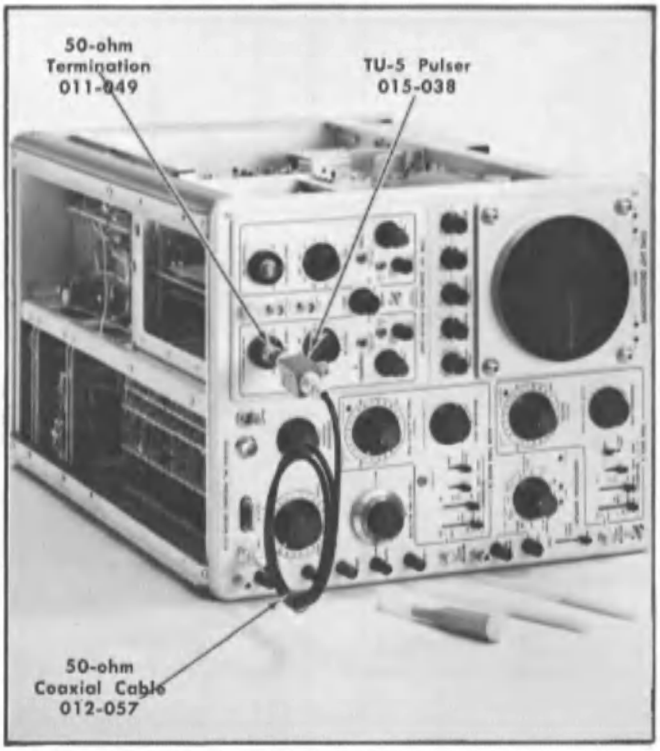
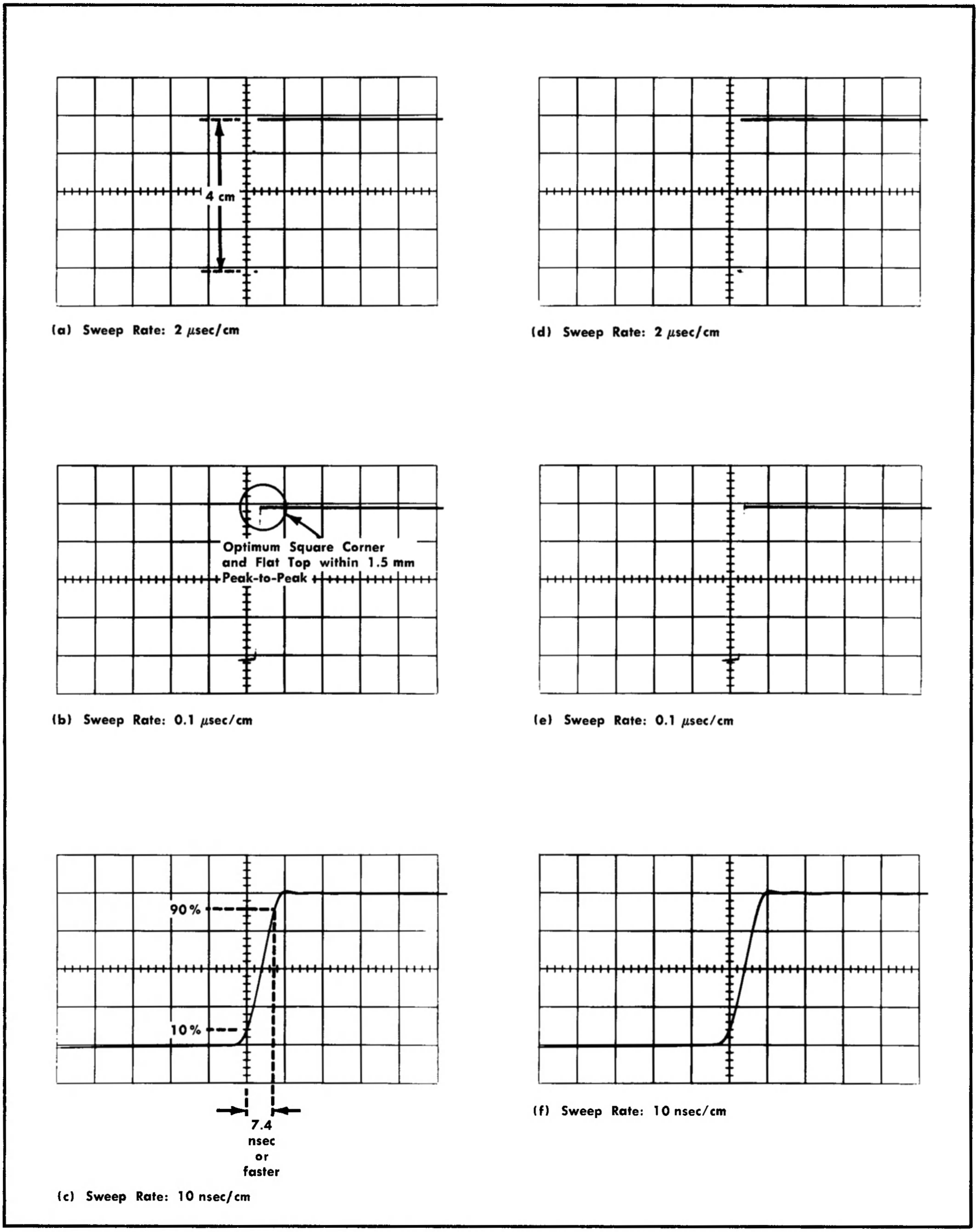


Fig. 6-8. Setup for checking the high-frequency response of the Type 1A1.

NOTE

The bias control should be set only a few degrees clockwise from the triggering point to obtain a stable pulse display with optimum leading top square corner. If the control is advanced too



(a) Sweep Rate: 2 µsec/cm

(b) Sweep Rate: 0.1 µsec/cm

(c) Sweep Rate: 10 nsec/cm

(d) Sweep Rate: 2 µsec/cm

(e) Sweep Rate: 0.1 µsec/cm

(f) Sweep Rate: 10 nsec/cm

Fig. 6-9. (a), (b) and (c) show proper Channel 2 waveform displays at 0.05 volts/cm; (d), (e) and (f) show proper Channel 1 waveforms at 0.05 volts/cm.

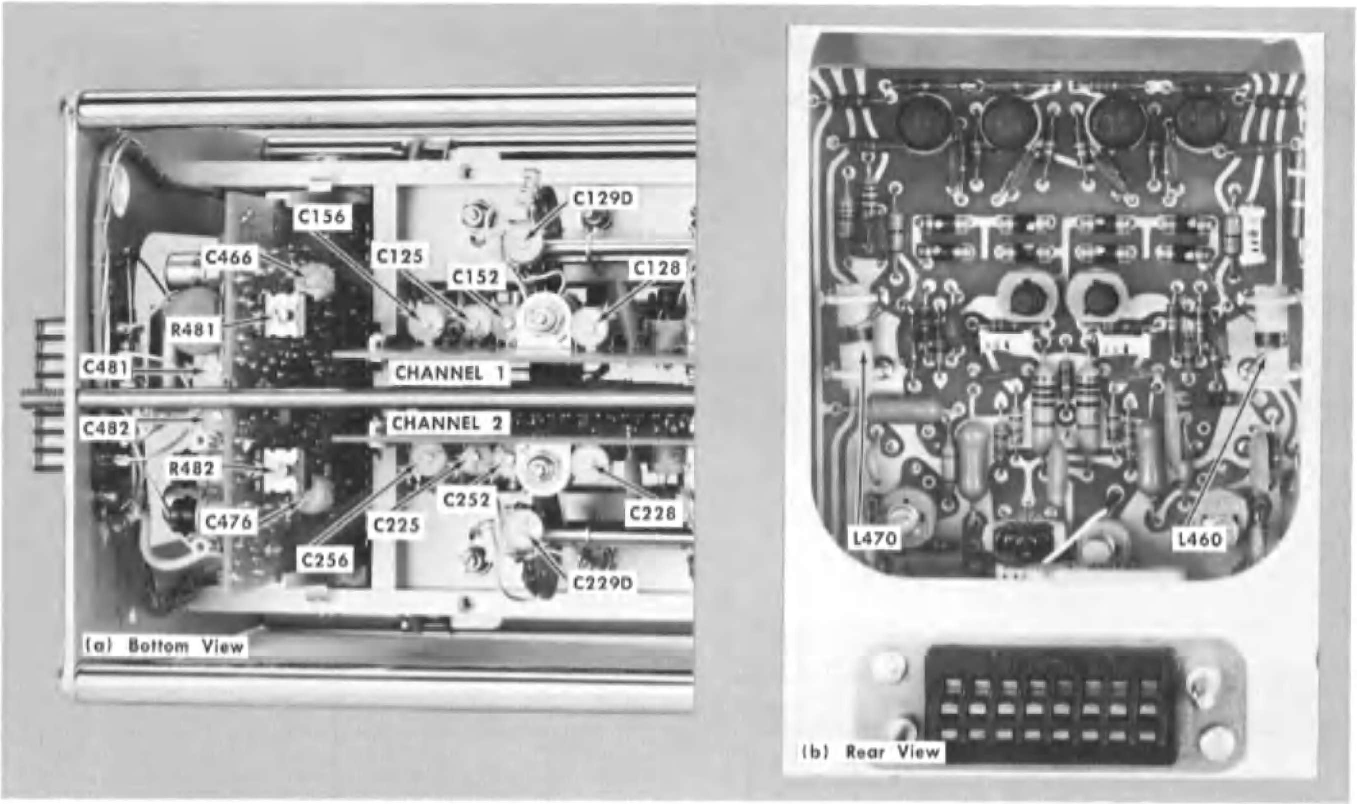


Fig. 6-10. (a) Bottom and (b) rear views of the Type 1A1 showing the locations of the high-frequency compensation adjustments.

far, the front corner of the waveform will roll off excessively producing an undesirable waveform. Use the Channel 2 POSITION control to center the display. The amplitude of the fast-rise step portion of the waveform is about 200 mv and should produce a deflection of about four cm or more on the crt.

f. Set the Channel 2 VARIABLE VOLTS/CM control so the amplitude of the fast-rise step portion is exactly 4 cm. Keep the display vertically centered so the flat-top portion of the waveform is located 1 cm from the top of the graticule.

g. Using the oscilloscope Horizontal Position control, position the rising portion of the display near graticule center.

h. Examine the waveform display produced by the system and check the risetime. Figs. 6-9a, 6-9b and 6-9c show typical appearance of the waveform at sweep rates of 2 μsec/cm, 0.1 μsec/cm and 10 nsec/cm, respectively. Fig. 6-9a and 6-9b are positioned 1.1 cm from the top of the graticule to clearly show the waveform without interference from the graticule lines. Fig. 6-9c shows that the oscilloscope/1A1/TU-5 system risetime should be 7.3 nsec as measured between the 10% and 90% points on the rising portion of the waveform.

NOTE

When checking the risetime of the waveform, take into consideration any errors introduced by the oscilloscope sweep-rate timing and crt geometry. Make sure the associated oscilloscope vertical amplifier transient response and risetime are within specifications.

If the leading top corner distortion, including the flat top portion of the waveform, exceeds 1.5 mm peak-to-peak in amplitude, set the oscilloscope Time/Cm switch to 0.1 μsec. Adjust the high-frequency compensation controls for optimum transient response and risetime as directed in the steps that follow.

i. Adjust C466 and C476 (on Output Amp. Card, see Fig. 6-10a) for near maximum spike on the leading top corner of the waveform.

j. Adjust L460 and L470 (on Output Amp. Card, see Fig. 6-10b) for minimum spike on the leading top corner of the waveform. Use the two alignment tools, each consisting of a handle (000-307) and 5/64" hexagonal wrench insert (003-310). Leave the tools inserted into L460 and L470 while performing the steps that follow.

k. Adjust C225, C228, C256 and C252 (on CH 2 Input Amp. Card, see Fig. 6-10a) for best leading top corner. Steps 23i and 23j may have to be repeated to achieve best results.

l. Disconnect the termination and TU-5 from Channel 2 an connect the combination to Channel 1.

m. Set the MODE switch to CH 1, Channel 1 VOLTS/CM switch to .05 and the INPUT SELECTOR switch

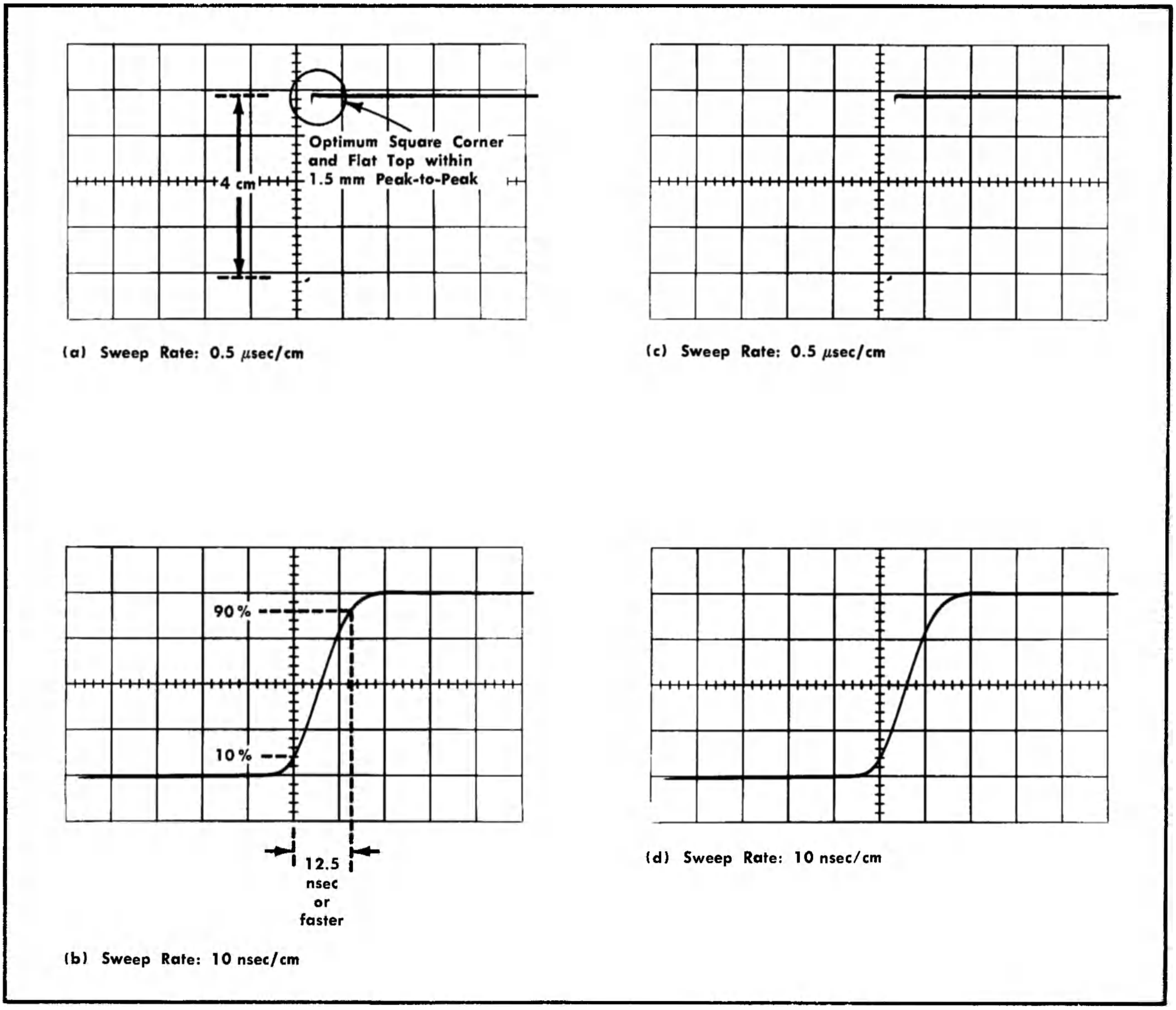


Fig. 6-11. (a) and (b) show proper Channel 2 waveform displays at 0.005 volts/cm; (c) and (d) show proper Channel 1 waveforms at 0.005 volts/cm.

to AC. Use the Channel 1 POSITION and VARIABLE VOLTS/CM controls to position the display and set the amplitude as was done when performing step 23f.

n. Adjust C125, C128, C152 and C156 (on CH 1 Input Amp. Card, see Fig. 6-10a) for best leading top corner. If necessary, readjust C466, C476, L460 and L470 to obtain optimum results. Note the appearance of the waveform (see Figs. 6-9d, 6-9e and 6-9f.). The information given in Fig.s 6-9a, b and c waveforms also applies to Figs. 6-9d, e, and f.

o. Disconnect the combination termination and TU-5 from Channel 1 and connect the combination to Channel 2.

p. Set the MODE switch to CH 2. Check that the waveform appears similar to the one that was obtained upon completion of step 23n. If it is necessary to improve the appearance of the waveform, readjust C225, C256 and C252.

q. Adjust R482 and C482 (see Fig. 6-10a) for best long term flat top.

r. Set the oscilloscope Time/Cm switch to .5 μSec. Adjust R481 and C481 (see Fig. 6-10a) for best long term flat top. Repeat step 23h. If optimum transient response and risetime is not obtained up to this point in the procedure, check that R481 and R482 are set near midrange. Then repeat steps 23h through 23r until the desired results are obtained. Repetition is necessary in making the adjustments to minimize the flat top aberrations and to obtain best leading top corner on the waveform.

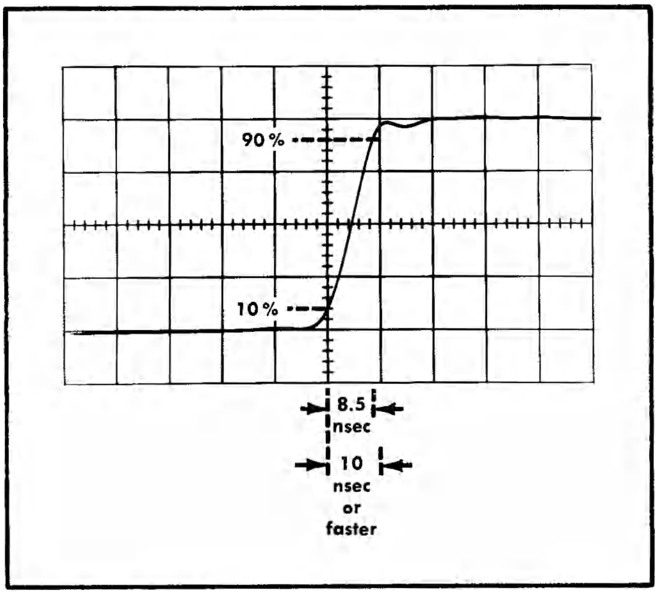


Fig. 6-12. Measuring the risetime of the CH 1 SIGNAL OUT waveform. Risetime should be 10 nsec or faster. Waveform shown has risetime of 8.5 nsec. Sweep rate is 10 nsec/cm.

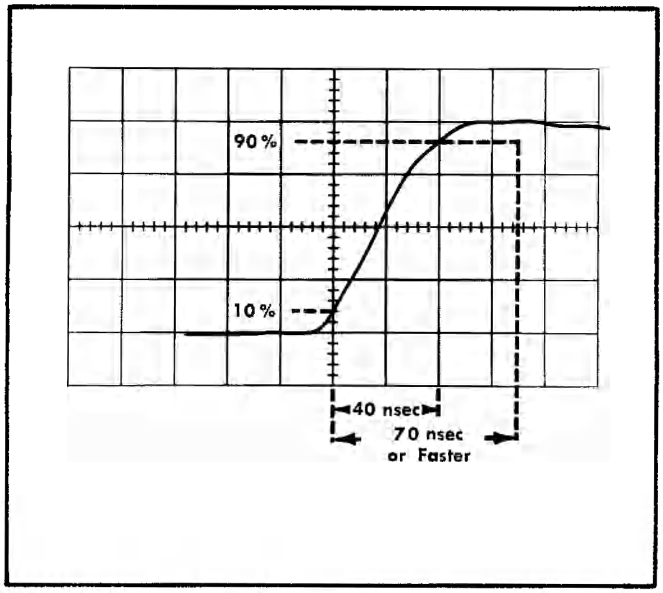


Fig. 6-13. Measuring the risetime of the CH 1 TRIGGER OUT waveform. Risetime should be 70 nsec or faster; waveform shown above has a risetime of 40 nsec. Sweep rate is 20 nsec/cm.

24. High Frequency Compensation at .005 Volts/Cm (Both Channels)

a. Insert a 50-ohm 10X attenuator (011-059) between the 50-ohm termination and the TU-5.

b. Check that the termination/X10-attenuator/TU-5 combination is connected to Channel 2.

c. Set Channel 2 VOLTS/CM switch to .005 and the oscilloscope Time/Cm switch to .5 μSec.

d. Check the waveform front leading top corner. Waveform should appear similar to the one shown in Fig. 6-11a. Aberrations should not exceed 1.5 mm peak-to-peak. If the waveshape is proper, proceed to step 24g. If the wave form does not appear similar to Fig. 6-11a but has a rolloff or overshoot on the top leading corner, adjust C229D (see Fig. 6-10a) for optimum leading corner.

e. Set the oscilloscope Time/Cm switch to .1 μSec and the Sweep Magnifier switch to X10.

f. Using the Channel 2 POSITION control and the oscilloscope Horizontal Position control, position the waveform to graticule center using Fig. 6-11b as a guide. Measure the risetime which should be 12.5 nsec or faster.

g. Disconoect the termination/10X attenuator/TU-5 combination from Channel 2 and connect the combination to Channel 1.

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

i. Set the oscilloscope Time/Cm switch to .5 μSec and the Sweep Magnifier switch to X1 OFF.

j. Using step 24d through 24f as a guide, check for proper waveshape and risetime (see Figs. 6-11c and 6-11d). The information shown on Figs. 6-11a and b waveforms also applies to Figs. 6-11c and d. If the waveform needs to be improved, adjust C129D (see Fig. 6-10a) for optimum square-cornered waveshape.

25. Check CH 1 SIGNAL OUT Risetime

a. Check that the termination/10X attenuator/TU-5 combination is connected to Channel 1.

b. Remove the 10X attenuator and connect the TU-5 directly to the 50-ohm termination.

c. Set Channel 1 and 2 VOLTS/CM switches to .05.

d. Connect the coax jumper cable from CH 1 SIGNAL OUT connector to Channel 2 input connector.

e. Using Channel 1 POSITION control and the oscilloscope Horizontal Position control, position the rising portion of the waveform to the center of the graticule so the risetime can be measured. Adjust the Channel 2 VARIABLE VOLTS/CM control so the waveform is 4 cm in amplitude.

f. Measure the risetime of the waveform from the 10% to 90% points. Risetime should be 10 nsec or faster (see Fig. 6-12).

26. Check CH 1 TRIGGER OUT Risetime

a. Set the Channel 2 VOLTS/CM switch to .5, and the oscilloscope Sweep Magnifier switch to X5.

b. Disconnect the end of the coax jumper cable from the CH 1 SIGNAL OUT connector and connect the cable to the CH 1 TRIGGER OUT connector.

c. Adjust the Channel 2 VARIABLE VOLTS/CM control so the waveform is 4 cm in amplitude.

d. Measure the risetime of the waveform from the 10% to 90% points. Risetime should be 70 nsec or faster. Risetime of the waveform shown in Fig. 6-13 is 40 nsec.

SECTION 7

PARTS LIST and DIAGRAMS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

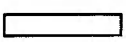
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

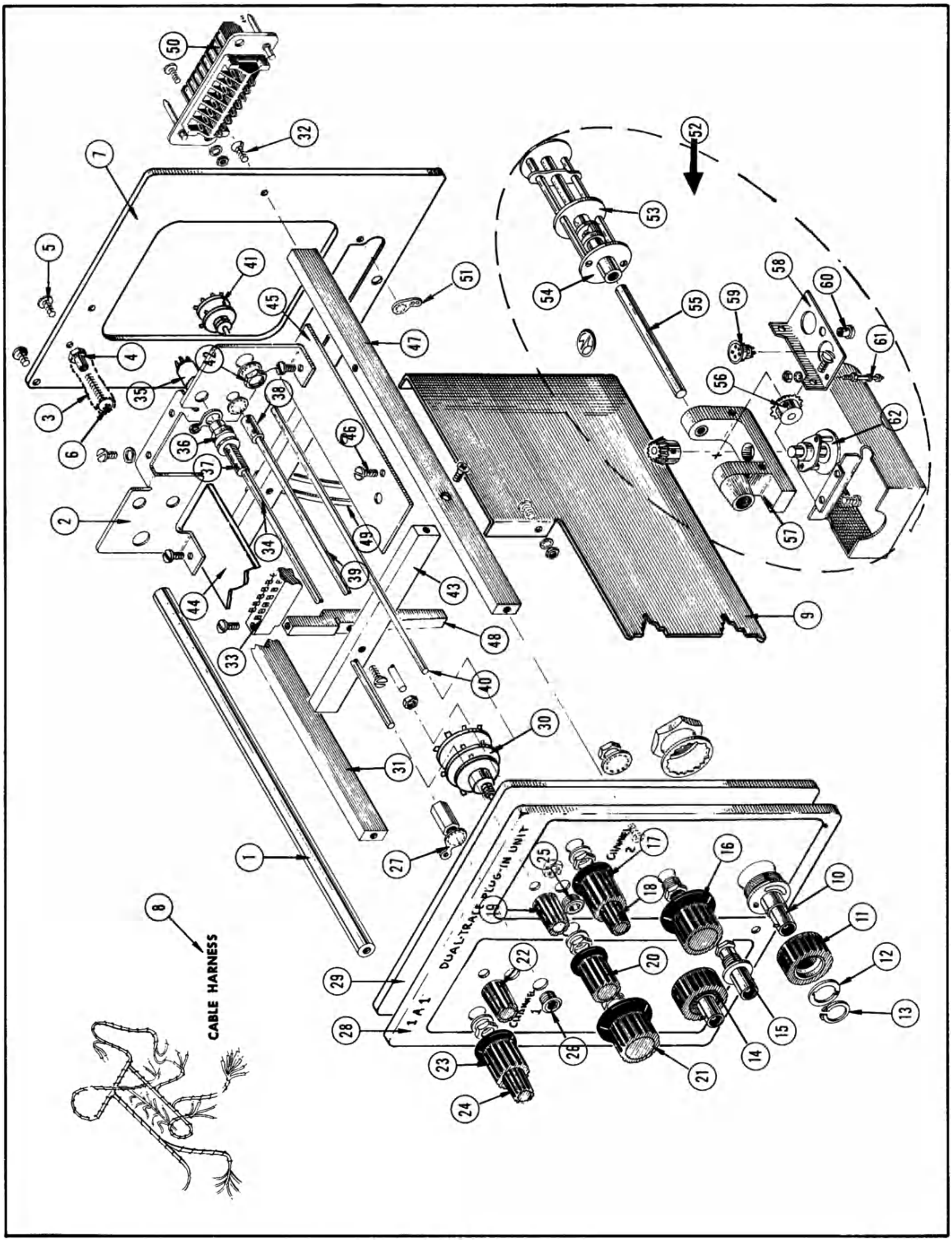
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

EXPLODED VIEW



EXPLODED VIEW

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	Q T Y.	DESCRIPTION
1	384-631			4	ROD, frame, brass 3/8 x 8 7/8 inches
	- - - -			-	Mounting Hardware For Each: (not included)
	212-044			1	SCREW, 8-32 x 1/2 inch RHS
2	406-931			1	BRACKET, mounting, aluminum
	- - - -			-	Mounting Hardware: (not included)
	211-507			2	SCREW, 6-32 x 5/16 inch BHS
3	- - - -			-	Resistor Mounting Hardware
4	210-478			2	NUT, hex, aluminum, 6-32 x 5/16 inch
5	211-507			2	SCREW, 6-32 x 5/16 inch BHS
6	211-544			2	SCREW, 6-32 x 3/4 inch THS
7	387-793			1	PLATE, frame, rear
	- - - -			-	Mounting Hardware: (not included)
	212-044			4	SCREW, 8-32 x 1/2 inch RHS
8	179-746			1	CABLE, harness
9	337-577			1	SHIELD, attenuator, aluminum
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-013			2	SCREW, 4-40 x 3/8 inch RHS
10	260-603			2	SWITCH, INPUT SELECTOR (unwired)
	- - - -			-	Mounting Hardware For Each: (not included)
	210-047			1	LOCKWASHER, internal tooth
	210-568			1	NUT, hex, 7/8-32 x 1 1/8 inches
11	366-274			1	KNOB, INPUT SELECTOR, black (Channel 1)
	- - - -			-	Mounting Hardware: (not included)
12	210-951			1	WASHER, locating
13	354-179			1	RING, retaining
14	366-274			1	KNOB, INPUT SELECTOR, black (Channel 2)
	- - - -			-	Mounting Hardware: (not included)
	210-951			1	WASHER, locating
	354-179			1	RING, retaining
15	131-276			2	CONNECTOR, chassis mount 1/2 inch
16	366-145			1	KNOB, VOLTS/CM, black (Channel 2)
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
17	366-250			1	KNOB, POSITION, black (Channel 2)
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
18	366-189			1	KNOB, NORM INVERT, red (Channel 2)
	- - - -			-	Includes:
	213-005			1	SCREW, 6-32 x 1/8 inch HSS
19	366-153			1	KNOB, VARIABLE VOLTS/CM, black (Channel 2)
	- - - -			-	Includes:
	213-005			1	SCREW, set, 6-32 x 1/8 inch HSS
20	366-173			1	KNOB, MODE, black
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
21	366-145			1	KNOB, VOLTS/CM, black (Channel 1)
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
22	366-153			1	KNOB, VARIABLE VOLTS/CM, (Channel 1)
	- - - -			-	Includes:
	213-005			1	SCREW, set, 6-32 x 1/8 inch HSS
23	366-250			1	KNOB, POSITION, black (Channel 1)
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
24	366-189			1	KNOB, NORM INVERT, red (Channel 1)
	- - - -			-	Includes:
	213-005			1	SCREW, set, 6-32 x 1/8 inch HSS

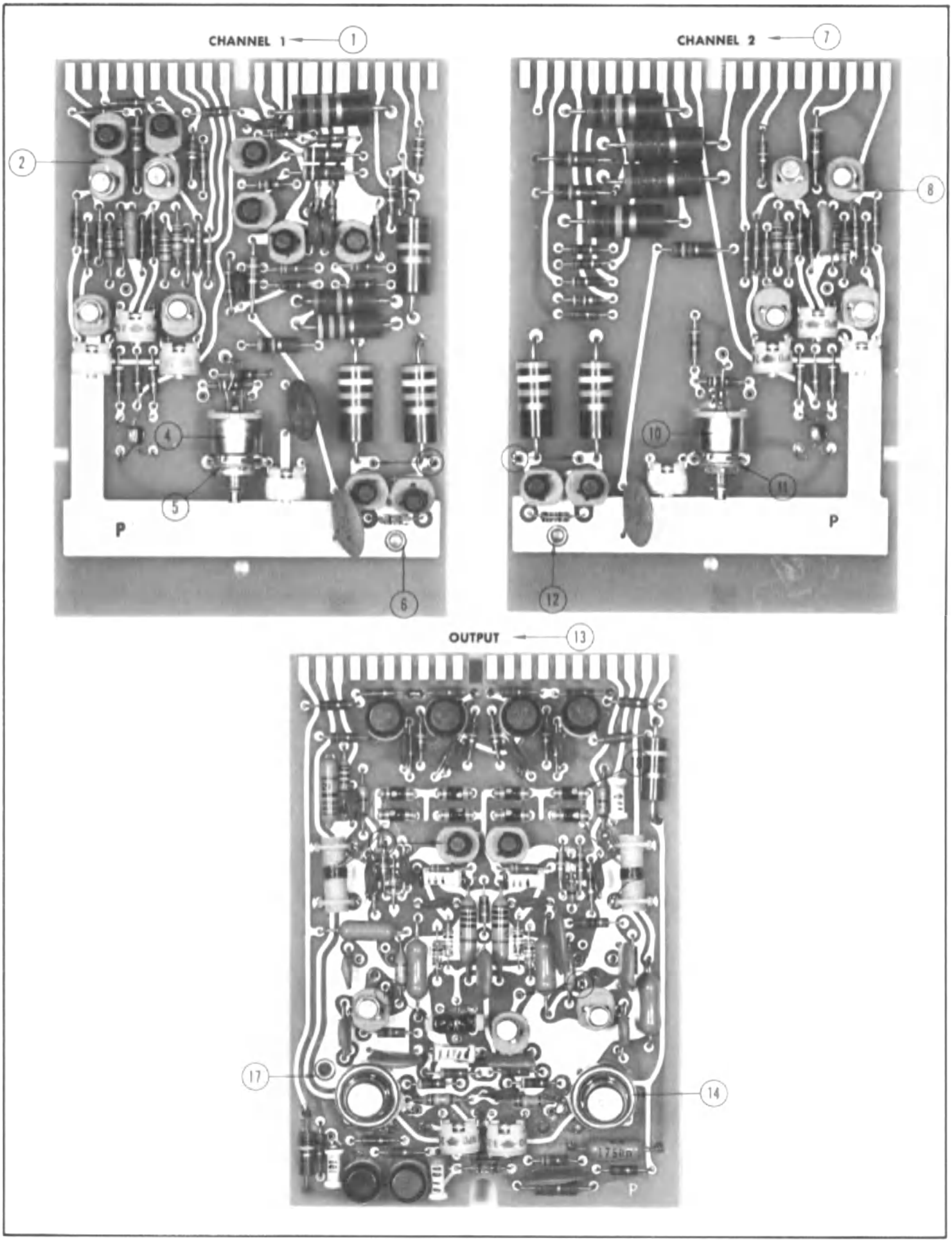
EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
25	358-054			2	BUSHING, banana jack, 1/4-32 x 13/32 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-471			1	NUT, hex, 1/4-32 x 3/8 inch
26	358-054			2	BUSHING, banana jack, 1/4-32 x 13/32 inch
	- - - -			-	Mounting Hardware For Each: (not included)
	210-046			1	LOCKWASHER, internal, .261 ID x .400 inch OD
27	210-223			1	LUG, solder, 1/4 inch
	210-465			1	NUT, hex, 1/4-32 x 5/16 inch
28	333-749			1	PANEL, front
29	387-792			1	PLATE, subpanel, front, aluminum
30	262-579			1	SWITCH, MODE, wired
	- - - -			-	Includes:
	260-561			1	SWITCH, MODE, unwired
	- - - -			-	Mounting Hardware: (not included)
	210-012			1	LOCKWASHER, pot, internal, 3/8 x 1/2 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
31	384-622			1	ROD, support, left, aluminum
	- - - -			-	Mounting Hardware: (not included)
32	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK
33	136-156			3	SOCKET, 44 pin etched circuit board
	344-099			3	SPRING, Connector
	- - - -			-	Mounting Hardware For Each: (not included)
	211-014			2	SCREW, 4-40 x 1/2 inch BHS
34	384-282			2	ROD, detent shaft
35	- - - -			-	Mini Pot Mounting Hardware: (not included)
	210-001			1	LOCKWASHER, internal, #2
	210-046			1	LOCKWASHER, internal, .261 ID x .400 inch OD
	210-223			1	LUG, solder, 1/4 inch
36	210-596			1	NUT, detent
	211-069			1	SCREW, 2-56 x 1/8 inch PHS
	214-351			1	SPRING, detent
37	376-028			1	COUPLING, pot shaft
	- - - -			-	Includes:
	213-048			2	SCREW, set, 4-40 x 1/8 inch HSS allen head
38	376-029			2	COUPLING, pot shaft
	- - - -			-	Includes:
	213-048			2	SCREW, set, 4-40 x 1/8 inch HSS allen head
39	384-284			2	ROD, detent shaft
40	384-283			2	ROD, detent shaft
41	260-537			2	SWITCH, NORM INVERT, (unwired)
	- - - -			-	Mounting Hardware For Each: (not included)
	210-012			1	LOCKWASHER, internal pot, 3/8 x 1/2 inch
42	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, pot flat
43	385-171			2	ROD, circuit board guide support
	- - - -			-	Mounting Hardware For Each: (not included)
	211-559			2	SCREW, 6-32 x 3/8 inch FHS 100° CSK
44	441-525			1	CHASSIS, component right side, aluminum
	- - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
45	441-526			1	CHASSIS, component left side, aluminum
	- - - -			-	Mounting Hardware: (not included)
46	211-507			3	SCREW, 6-32 x 5/16 inch BHS
47	384-621			1	ROD, support right, aluminum
	- - - -			-	Mounting Hardware: (not included)
	211-538			2	SCREW, 6-32 x 5/16 inch FHS 100° CSK
48	351-059			6	GUIDE, circuit board
	- - - -			-	Mounting Hardware For Each: (not included)
	211-510			1	SCREW, 6-32 x 3/8 inch BHS

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
49	344-101			2	CLIP, circuit board retainer
	- - - -			-	Mounting Hardware For Each: (not included)
	211-510			1	SCREW, 6-32 x 3/8 inch BHS
50	131-017			1	CONNECTOR, chassis mount
	- - - -			-	Mounting Hardware: (not included)
51	210-201			2	LUG, solder, SE4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
52	640-003			1	ASSEMBLY, attenuator switch #1
	- - - -			-	Includes:
	262-580			1	SWITCH, attenuator, wired
	640-004			1	ASSEMBLY, attenuator switch #2
	- - - -			-	Includes:
	262-659			1	SWITCH, attenuattor, wired
	- - - -			-	Each Assembly Includes:
53	262-580			1	SWITCH, ATTENUATOR, wired
	- - - -			-	Includes:
	210-963			1	WASHER, 1/2 inch dia., delrin rod
	214-379			2	HUB, driver, steel
	260-560			1	SWITCH, ATTENUATOR, unwired
54	387-827			1	PLATE, flange, 1 1/4 inch brass rod
55	384-295			1	ROD, shaft assembly
	- - - -			-	Includes:
	166-351			1	SLEEVE, 1/4 inch diameter, brass tube
	214-378			1	DRIVER, casting
	384-294			1	ROD, shaft, 1/4 inch diameter
56	214-272			1	GEAR, miter, 24 teeth
	- - - -			-	Inculdes:
	213-020			2	SCREW, set, 6-32 x 1/8 inch HSS allen head
57	426-201			1	FRAME, attenuator chassis
58	406-950			1	BRACKET, socket mounting
	- - - -			-	Mounting Hardware For Each: (not included)
	211-065			2	SCREW, 4-40 x 3/16 inch PHS
59	136-131			2	SOCKET, 5 pin solder mount
60	131-157			2	CONNECTOR, terminal, teflon
61	129-070			2	POST, ceramic
	- - - -			-	Mounting Hardware For Each: (not included)
	210-001			1	LOCKWASHER, internal, #2
	210-405			1	NUT, hex, 2/56 x 3/16 inch
62	262-589			1	SWITCH, rotary, wired
	- - - -			-	Includes:
	260-559			1	SWITCH, rotary, unwired
63	366-125			1	KNOB, plug-in securing, knurled (not shown)
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
	210-894			1	WASHER, polyethylene
	354-025			1	RING, retaining
	384-510			1	ROD, 3/16 OD x 10 1/2 inch ID, 10-24 thread

CIRCUIT BOARDS



CIRCUIT BOARDS

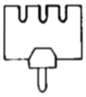
REF. NO.	PART NO.	SERIAL NO. EFF.	SERIAL NO. DISC.	QTY.	DESCRIPTION
1	670-034			1	BOARD, etched circuit, Channel 1 assembly
	- - - -			-	Includes:
2	136-150			12	SOCKET, 3 pin transistor
3	131-310			5	CONNECTOR, wire jack
4	- - - -			-	Pot Mounting Hardware:
	210-046			1	LOCKWASHER, steel, internal
	210-583			1	NUT, hex, $\frac{1}{4}$-32 x $\frac{5}{16}$ inch, double chamfer
5	387-794			1	PLATE, pot mounting
6	210-696			1	EYELET, SE46
7	670-035			1	BOARD, etched circuit, Channel 2 assembly
	- - - -			-	Includes:
8	136-150			6	SOCKET, 3 pin transistor
9	131-310			5	CONNECTOR, wire jack
10	- - - -			-	Pot Mounting Hardware:
	210-046			1	LOCKWASHER, steel, internal
	210-583			1	NUT, hex, $\frac{1}{4}$-32 x $\frac{5}{16}$ inch, double chamfer
11	387-794			1	PLATE, pot mounting
12	210-696			1	EYELET, SE46
13	670-036			1	BOARD, etched circuit, output assembly
	- - - -			-	Includes:
14	136-125			2	SOCKET, 5 pin transistor
	387-603			2	INSULATOR, for 5 pin socket
15	136-150			11	SOCKET, 3 pin transistor
16	131-310			4	CONNECTOR, wire jack
17	210-696			1	EYELET, SE46
18	344-108			16	CLIP, diode
19	426-121			1	MOUNT, toroid, nylon, $\frac{15}{32}$ x $\frac{1}{8}$ x $\frac{9}{64}$ inch
	- - - -			-	Mounting Hardware For Toroid Mount:
	361-007			1	SPACER, nylon
					ACCESSORIES (not shown)
	012-072			1	CABLE, INPUT, 4 conductor, 5 ft long
	103-015			1	ADAPTER, PROBE, BNC to UHF

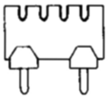
CERAMIC STRIPS

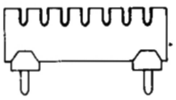
3/4 inch

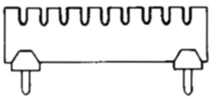

1 notch 124-100

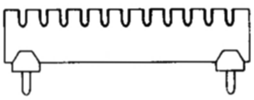

2 notch 124-086


3 notch 124-087


4 notch 124-088


7 notch 124-089


9 notch 124-090

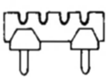

11 notch 124-091

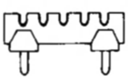
7/16 inch

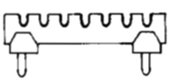

1 notch 124-118

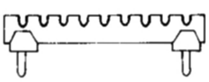

2 notch 124-119

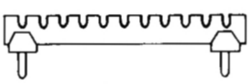

3 notch 124-092


4 notch 124-120

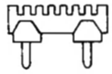

5 notch 124-093

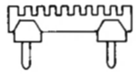

7 notch 124-094

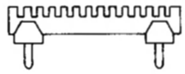

9 notch 124-095

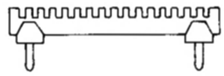

11 notch 124-106

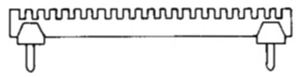
7/16 inch SMALL NOTCH —Short Stud


7 notch 124-149

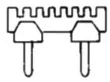

9 notch 124-148

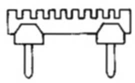

13 notch 124-147

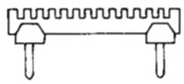

16 notch 124-146

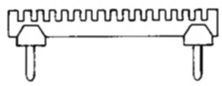

20 notch 124-145

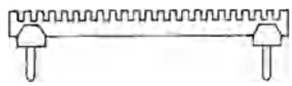
7/16 inch SMALL NOTCH —Tall Stud


7 notch 124-158


9 notch 124-157


13 notch 124-156


16 notch 124-155


20 notch 124-154

MOUNTINGS


Stud, nylon, short..355-046


Stud, nylon, tall .. 355-082


Spacer, 13/32 inch..361-039


Spacer, 9/32 inch...361-009


Spacer, 5/32 inch...361-008


Spacer, 1/16 inch...361-007

Ceramic strips include studs, but spacers must be ordered separately by part no.

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description					S/N Range

Bulbs

Ckt. No.	Tektronix Part No.	Description
B119	150-035	Neon, A1D
B219	150-035	Neon, A1D

Capacitors

Tolerance ±20% unless otherwise indicated.
Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = —10%, +250%
51 V — 350 V = —10%, +100%
351 V — 450 V = —10%, + 50%

Ckt. No.	Tektronix Part No.	Description					S/N Range
C101	Use 281-613	10 pf	Cer		200 v	10%	
C102	*285-635	0.1 μf	MT		600 v	10%	
C103	281-613	10 pf	Cer		200 v	10%	
C104	281-064	0.2-1.5 pf	Tub.	Var			
C105A	281-537	0.68 pf	Cer		500 v		
C105B }	281-081	0.2-1.5 pf	Tub.	Var			
C105C }		1.8-13 pf	Air	Var			
C106B	281-027	0.7-3 pf	Tub.	Var			
C106C	281-027	0.7-3 pf	Tub.	Var			
C107A	281-529	1.5 pf	Cer		500 v	±0.25 pf	
C107B	281-027	0.7-3 pf	Tub.	Var			
C107C	281-027	0.7-3 pf	Tub.	Var			
C108A	281-547	2.7 pf	Cer		500 v	10%	
C108B	281-027	0.7-3 pf	Tub.	Var			
C108C }	281-082	0.2-1.5 pf	Tub.	Var			
C108E }		15 pf	Mica			10%	
C109A	Use 281-604	2.2 pf	Cer		500 v	±0.25 pf	
C109B	281-027	0.7-3 pf	Tub.	Var			
C109C }	281-083	0.2-1.5 pf	Tub.	Var			
C109E }		50 pf	Mica			10%	
C110A	281-529	1.5 pf	Cer		500 v	±0.25 pf	
C110B	281-027	0.7-3 pf	Tub.	Var			
C110C }	281-084	0.2-1.5 pf	Tub.	Var			
C110E }		100 pf	Mica			10%	
C111A	Use 281-604	2.2 pf	Cer		500 v	±0.25 pf	
C111B	281-027	0.7-3 pf	Tub.	Var			
C111C }	281-085	0.2-1.5 pf	Tub.	Var			
C111E }		200 pf	Mica			10%	
C112A	281-547	2.7 pf	Cer		500 v	10%	
C112B	281-027	0.7-3 pf	Tub.	Var			

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C112C	281-086	0.2-1.5 pf	Tub.	Var			
C112E		500 pf	Mica			10%	
C115	283-003	0.01 μf	Cer		150 v		
C119	281-591	0.0056 μf	Cer		200 v		
C121	283-000	0.001 μf	Cer		500 v		
C129D	281-063	9-35 pf	Cer	Var			
C129E	281-552	25 pf	Cer		500 v		
C129F	Use 281-600	35 pf		Selected		10%	
C138	285-598	0.01 μf	PTM		100 v	5%	
C201	Use 281-613	10 pf	Cer		200 v	10%	
C202	*285-635	0.1 μf	MT		600 v	10%	
C203	281-613	10 pf	Cer		200 v	10%	
C204	281-064	0.2-1.5 pf	Tub.	Var			
C205A	281-537	0.68 pf	Cer		500 v		
C205B	281-081	0.2-1.5 pf	Tub.	Var			
C205C		1.8-13 pf	Air	Var			
C206B	281-027	0.7-3 pf	Tub.	Var			
C206C	281-027	0.7-3 pf	Tub.	Var			
C207A	281-529	1.5 pf	Cer		500 v	±0.25 pf	
C207B	281-027	0.7-3 pf	Tub.	Var			
C207C	281-027	0.7-3 pf	Tub.	Var			
C208A	281-547	2.7 pf	Cer		500 v	10%	
C208B	281-027	0.7-3 pf	Tub.	Var			
C208C	281-082	0.2-1.5 pf	Tub.	Var			
C208E		15 pf	Mica			10%	
C209A	Use 281-604	2.2 pf	Cer		500 v	±0.25 pf	
C209B	281-027	0.7-3 pf	Tub.	Var			
C209C	281-083	0.2-1.5 pf	Tub.	Var			
C209E		50 pf	Mica			10%	
C210A	281-529	1.5 pf	Cer		500 v	±0.25 pf	
C210B	281-027	0.7-3 pf	Tub.	Var			
C210C	281-084	0.2-1.5 pf	Tub.	Var			
C210E		100 pf	Mica			10%	
C211A	Use 281-604	2.2 pf	Cer		500 v	±0.25 pf	
C211B	281-027	0.7-3 pf	Tub.	Var			
C211C	281-085	0.2-1.5 pf	Tub.	Var			
C211E		200 pf	Mica			10%	
C212A	281-547	2.7 pf	Cer		500 v	10%	
C212B	281-027	0.7-3 pf	Tub.	Var			
C212C	281-086	0.2-1.5 pf	Tub.	Var			
C212E		500 pf	Mica			10%	
C215	283-003	0.01 μf	Cer		150 v		
C219	281-591	0.0056 μf	Cer		200 v		
C221	283-000	0.001 μf	Cer		500 v		
C229D	281-063	9-35 pf	Cer	Var			
C229E	281-552	25 pf	Cer		500 v		
C299F	Use 281-600	35 pf		Selected		10%	
C238	285-598	0.01 μf	PTM		100 v	5%	

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			S/N Range
C260	283-000	0.001 μf	Cer	500 v	100-539X
C263	283-002	0.01 μf	Cer	500 v	
C491	283-000	0.001 μf	Cer	500 v	100-539
C491	283-057	0.1 μf	Cer	200 v	540-up
C492	290-149	5 μf	EMT	150 v	
C493	283-000	0.001 μf	Cer	500 v	
C494	283-057	0.1 μf	Cer	200 v	X540-up

Diodes

D121	*152-061	Silicon	Tek Spec
D221	*152-061	Silicon	Tek Spec

Inductors

LR105A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR106A	*108-271	0.25 μh (on a 51 Ω 1/10 resistor)
LR106B	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR107A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR107B	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR108A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR109A	*108-268	0.1 μh (on a 36 Ω 1/10 resistor)
LR205A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR206A	*108-271	0.25 μh (on a 51 Ω 1/10 resistor)
LR206B	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR207A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR207B	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR208A	*108-270	0.25 μh (on a 62 Ω 1/10 resistor)
LR209A	*108-268	0.1 μh (on a 36 Ω 1/10 resistor)

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R101	Use 317-200	20 Ω	1/10 w		5%
R103	317-560	56 Ω	1/10 w		5%
R104	317-560	56 Ω	1/10 w		5%
R105C	322-610	500 k	¼ w	Prec	1%
R105E	322-481	1 meg	¼ w	Prec	1%
R106C	322-469	750 k	¼ w	Prec	1%
R106E	321-628	333 k	⅛ w	Prec	1%
R107C	322-621	900 k	¼ w	Prec	1%
R107E	321-617	111 k	⅛ w	Prec	1%
R108C	322-622	950 k	¼ w	Prec	1%
R108E	321-616	52.6 k	⅛ w	Prec	1%
R108G	317-430	43 Ω	1/10 w		5%
R109C	322-623	975 k	¼ w	Prec	1%

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R109E	321-627	25.6 k	⅛ w		Prec	1%	
R109G	317-620	62 Ω	1/10 w			5%	
R110C	322-624	990 k	¼ w		Prec	1%	
R110E	321-614	10.1 k	⅛ w		Prec	1%	
R110G	317-820	82Ω	1/10 w			5%	
R111C	322-625	995 k	¼ w		Prec	1%	
R111E	321-613	5.03 k	⅛ k		Prec	1%	
R111G	317-151	150 Ω	1/10 w			5%	
R112A	317-101	100 Ω	1/10 w			5%	
R112C	322-626	997.5 k	¼ w		Prec	1%	
R112E	321-626	2.51 k	⅛ w		Prec	1%	
R114	317-270	27 Ω	1/10 w			5%	
R115	315-101	100 Ω	¼ w			5%	
R116	322-481	1 meg	¼ w		Prec	1%	
R117	311-258	100 Ω		Var	GRID CURRENT ZERO		
R119	317-474	470 k	1/10 w			5%	
R120	315-432	4.3 k	¼ w			5%	
R129A	321-607	80 Ω	⅛ w		Prec	1%	
R129B	321-134	243 Ω	⅛ w		Prec	1%	
R129C	321-187	750 Ω	⅛ w		Prec	1%	
R129E	315-152	1.5 k	¼ w			5%	
R130	Use 311-459	2 x 500 k		Var	.005 V/CM VAR ATTEN BAL		
R138	316-222	2.2 k	¼ w				
R139	316-470	47 Ω	¼ w				
R148	311-310	5 k		Var	.05 V/CM DC BAL		
R152	311-350	500 k		Var	INVERT BALANCE		
R169	308-008	10 k	5 w		WW	5%	
R201	Use 317-200	20 Ω	1/10 w			5%	
R203	317-560	56 Ω	1/10 w			5%	
R204	317-560	56 Ω	1/10 w			5%	
R205C	322-610	500 k	¼ w		Prec	1%	
R205E	322-481	1 meg	¼ w		Prec	1%	
R206C	322-469	750 k	¼ w		Prec	1%	
R206E	321-628	333 k	⅛ w		Prec	1%	
R207C	322-621	900 k	¼ w		Prec	1%	
R207E	321-617	111 k	⅛ w		Prec	1%	
R208C	322-622	950 k	¼ w		Prec	1%	
R208E	321-616	52.6 k	⅛ w		Prec	1%	
R208G	317-430	43 Ω	1/10 w			5%	
R209C	322-623	975 k	¼ w		Prec	1%	
R209E	321-627	25.6 k	⅛ w		Prec	1%	
R209G	317-620	62 Ω	1/10 w			5%	
R210C	322-624	990 k	¼ w		Prec	1%	
R210E	321-614	10.1 k	⅛ w		Prec	1%	
R210G	317-820	82 Ω	1/10 w			5%	
R211C	322-625	995 k	¼ w		Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R211E	321-613	5.03 k	1/8 w		Prec	1%	
R211G	317-151	150 Ω	1/10 w			5%	
R212A	317-101	100 Ω	1/10 w			5%	
R212C	322-626	997.5 k	1/4 w		Prec	1%	
R212E	321-626	2.51 k	1/8 w		Prec	1%	
R214	317-270	27 Ω	1/10 w			5%	
R215	315-101	100 Ω	1/4 w			5%	
R216	322-481	1 meg	1/4 w		Prec	1%	
R217	311-258	100 Ω		Var		GRID CURRENT ZERO	
R219	317-474	470 k	1/10 w			5%	
R220	315-432	4.3 k	1/4 w			5%	
R229A	321-607	80 Ω	1/8 w		Prec	1%	
R229B	321-134	243 Ω	1/8 w		Prec	1%	
R229C	321-181	750 Ω	1/8 w		Prec	1%	
R229E	315-152	1.5 k	1/4 w			5%	
R230	Use 311-459	2 x 500 k		Var		.005 V/CM VAR ATTEN BAL	
R238	316-222	2.2 k	1/4 w				
R239	316-470	47 Ω	1/4 w				
R248	311-310	5 k		Var		.05 V/CM DC BAL	
R252	311-350	500 k		Var		INVERT BALANCE	
R360	302-275	2.7 meg	1/2 w				X540-up
R408†	311-422	500 Ω		Var		CH 1 VARIABLE VOLTS/CM	
R409	311-169	100 Ω		Var		CH 1 GAIN	
R422	311-381	2 x 100 k		Var		CH 1 POSITION	
R438††	311-422	500 Ω		Var		CH 2 VARIABLE VOLTS/CM	
R439	311-169	100 Ω		Var		CH 2 GAIN	
R452	311-381	2 x 100 k		Var		CH 2 POSITION	
R469	315-101	100 Ω	1/4 w			5%	
R490	303-622	6.2 k	1 w			5%	
R493	315-183	18 k	1/4 w			5%	
R495	308-274	470 Ω	5 w		WW	5%	
R499	315-363	36 k	1/4 w			5%	

Switches

	Unwired	Wired		
SW101	260-603		Rotary	CH 1 INPUT SELECTOR
SW105	Use 260-620	*262-589	Rotary	CH 1 VOLTS/CM
SW129	260-560	*262-580	Rotary	CH 1 VOLTS/CM
SW201	260-603		Rotary	CH 2 INPUT SELECTOR
SW205	Use 260-620	*262-589	Rotary	CH 2 VOLTS/CM
SW229	260-560	*262-659	Rotary	CH 2 VOLTS/CM

†Furnished as a unit with SW409.

††Furnished as a unit with SW439.

Switches *(Cont'd)*

Ckt. No.	Tektronix Part No. Unwired	Wired	Description		S/N Range
SW320	260-561	*262-579	Rotary	MODE	
SW405	260-537		Rotary	NORM/INVERT	
SW409†	311-422				
SW435	260-537		Rotary	NORM/INVERT	
SW439††	311-422				

Electron Tubes

V123	154-306	7586
V143	154-306	7586
V223	154-306	7586
V243	154-306	7586

CHANNEL 1 INPUT AMPLIFIER CARD

Ckt. No.	Tektronix Part No.	Description				Model No.
		Card				
	*670-034	Complete Card				
		Capacitors				
C125	281-089	2-8 pf	Cer	Var		
C128	281-096	5.5-18 pf	Air	Var		
C152	281-089	2-8 pf	Cer	Var		
C156	281-096	5.5-18 pf	Air	Var		
C165	283-000	0.001 μf	Cer		500 v	
C175	283-000	0.001 μf	Cer		500 v	
C185	283-002	0.01 μf	Cer		500 v	
C186	283-003	0.01 μf	Cer		150 v	
C196	283-003	0.01 μf	Cer		150 v	
C197	283-059	1 μf	Cer		25 v	
C198	283-081	0.1 μf	Cer		25 v	
		Diode				
D122	*152-075	Germanium	Tek Spec			
		Transistors				
Q123	Use 151-131	2N964				
Q124	*151-120	Selected from 2N2475				
Q143	Use 151-131	2N964				
Q144	*151-120	Selected from 2N2475				
Q153A	*151-120	Selected from 2N2475				

†Furnished as a unit with R408.

††Furnished as a unit with R438.

Transistor *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
Q153B	*151-120	Selected from 2N2475	
Q163	Use 151-131	2N964	
Q164	Use 151-131	2N964	
Q173	Use 151-131	2N964	
Q174	Use 151-131	2N964	
Q184	151-094	2N835	
Q194	Use 151-131	2N964	

Resistors

R121	305-183	18 k	2 w			5%
R122	305-393	39 k	2 w			5%
R123	315-912	9.1 k	1/4 w			5%
R124	321-127	205 Ω	1/8 w		Prec	1%
R125	321-127	205 Ω	1/8 w		Prec	1%
R126	315-561	560 Ω	1/4 w			5%
R127	315-682	6.8 k	1/4 w			5%
R128A	311-258	100 Ω		Var		.005 V/CM GAIN
R128B	315-470	47 Ω	1/4 w			5%
R128C	315-390	39 Ω	1/4 w			5%
R133	316-475	4.7 meg	1/4 w			
R134	316-474	470 k	1/4 w			
R136	316-185	1.8 meg	1/4 w			
R142	305-393	39 k	2 w			5%
R143	315-912	9.1 k	1/4 w			5%
R144	321-127	205 Ω	1/8 w		Prec	1%
R145	321-127	205 Ω	1/8 w		Prec	1%
R146	315-621	620 Ω	1/4 w			5%
R147	315-682	6.8 k	1/4 w			5%
R149	305-123	12 k	2 w			5%
R150	315-510	51 Ω	1/4 w			5%
R151	316-564	560 k	1/4 w			
R153	315-202	2 k	1/4 w			5%
R154	315-152	1.5 k	1/4 w			5%
R155	315-202	2 k	1/4 w			5%
R156	315-101	100 Ω	1/4 w			5%
R157	301-302	3 k	1/2 w			5%
R161	315-681	680 Ω	1/4 w			5%
R163	315-682	6.8 k	1/4 w			5%
R164	315-510	51 Ω	1/4 w			5%
R165	315-471	470 Ω	1/4 w			5%
R166	301-392	3.9 k	1/2 w			5%
R168	315-330	33 Ω	1/4 w			5%
R173	315-682	6.8 k	1/4 w			5%
R174	315-221	220 Ω	1/4 w			5%

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description			Model No.
R175	315-361	360 Ω	1/4 w	5%	
R176	301-392	3.9 k	1/2 w	5%	
R181	315-102	1 k	1/4 w	5%	
R182	303-623	62 k	1 w	5%	
R183	315-332	3.3 k	1/4 w	5%	
R184	301-303	30 k	1/2 w	5%	
R185	315-101	100 Ω	1/4 w	5%	
R186	315-103	10 k	1/4 w	5%	
R191	315-102	1 k	1/4 w	5%	
R193	315-332	3.3 k	1/4 w	5%	
R194	303-433	43 k	1 w	5%	
R196	315-103	10 k	1/4 w	5%	
R497	301-131	130 Ω	1/2 w	5%	

Transformer

Ckt. No.	Tektronix Part No.	Description		Model No.
T124	*120-286	Toroid,	2T Bifilar	

CHANNEL 2 INPUT AMPLIFIER CARD

Card

Ckt. No.	Tektronix Part No.	Description	Model No.
	*670-035	Complete Card	

Capacitors

Ckt. No.	Tektronix Part No.	Description				Model No.
C225	281-089	2-8 pf	Cer	Var		
C228	281-096	5.5-18 pf	Air	Var		
C252	281-089	2-8 pf	Cer	Var		
C256	281-096	5.5-18 pf	Air	Var		
C261	283-081	0.1 μf	Cer		25 v	
C262	283-059	1 μf	Cer		25 v	

Diode

Ckt. No.	Tektronix Part No.	Description	Model No.
D222	*152-075	Tek Spec	

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q223	Use 151-131	2N964	
Q224	*151-120	Selected from 2N2475	
Q243	Use 151-131	2N964	
Q244	*151-120	Selected from 2N2475	
Q253A	*151-120	Selected from 2N2475	
Q253B	*151-120	Selected from 2N2475	

Resistors

Ckt. No.	Tektronix Part No.	Description					Model No.
R118	316-105	1 meg	¼ w				
R218	316-105	1 meg	¼ w				
R221	305-183	18 k	2 w			5%	
R222	305-393	39 k	2 w			5%	
R223	315-912	9.1 k	¼ w			5%	
R224	321-127	205 Ω	⅛ w		Prec	1%	
R225	321-127	205 Ω	⅛ w		Prec	1%	
R226	315-561	560 Ω	¼ w			5%	
R227	315-682	6.8 k	¼ w			5%	
R228A	311-258	100 Ω		Var		.005 V/CM GAIN	
R228B	315-470	47 Ω	¼ w			5%	
R228C	315-390	39 k	¼ w			5%	
R233	316-475	4.7 meg	¼ w				
R234	316-474	470 k	¼ w				
R236	316-185	1.8 meg	¼ w				
R242	305-393	39 k	2 w			5%	
R243	315-912	9.1 k	¼ w			5%	
R244	321-127	205 Ω	⅛ w		Prec	1%	
R245	321-127	205 Ω	⅛ w		Prec	1%	
R246	315-621	620 Ω	¼ w			5%	
R247	315-682	6.8 k	¼ w			5%	
R249	305-123	12 k	2 w			5%	
R250	315-510	51 Ω	¼ w			5%	
R251	316-564	560 k	¼ w			5%	
R253	315-202	2 k	¼ w			5%	
R254	315-152	1.5 k	¼ w			5%	
R255	315-202	2 k	¼ w			5%	
R256	315-101	100 Ω	¼ w			5%	
R257	301-302	3 k	½ w			5%	
R418	305-622	6.2 k	2 w			5%	
R423	301-123	12 k	½ w			5%	
R448	305-622	6.2 k	2 w			5%	
R453	301-123	12 k	½ w			5%	
R496	301-131	130 Ω	½ w				

Transformer

T224	*120-286	Toroid, 2T Bifilar

OUTPUT AMPLIFIER CARD

Card

	*670-036	Complete Card

Capacitors

Ckt. No.	Tektronix Part No.	Description					Model No.
C300	283-010	0.05 μf	Cer		25 v		
C301	283-051	0.0033 μf	Cer		100 v		
C302	283-000	0.001 μf	Cer		500 v		
C303	283-000	0.001 μf	Cer		500 v		1, 2
C303	283-010	0.001 μf	Cer		500 v		3-up
C304	283-000	0.001 μf	Cer		500 v		1, 2
C304	283-010	0.001 μf	Cer		500 v		3-up
C306	281-511	22 pf	Cer		500 v	10%	1, 2
C306	281-518	47 pf	Cer		500 v		3-up
C310	283-010	0.05 μf	Cer		50 v		
C311	283-051	0.0033 μf	Cer		100 v	5%	
C312	283-000	0.001 μf	Cer		500 v		
C313	281-525	470 pf	Cer		500 v		
C316	Use 281-511	22 pf	Cer		500 v	10%	
C316	281-518	47 pf	Cer		500 v		3-up
C321	283-081	0.1 μf	Cer		25 v		
C330	281-524	150 pf	Cer		500 v		
C334	283-026	0.2 μf	Cer		25 v		
C342	283-081	0.1 μf	Cer		25 v		
C343	281-540	51 pf	Cer		500 v	5%	
C344	281-524	150 pf	Cer		500 v		X3-up
C353	281-536	0.001 μf	Cer		500 v	10%	
C404	283-051	0.0033 μf	Cer		100 v	5%	
C414	283-051	0.0033 μf	Cer		100 v	5%	
C428	283-000	0.001 μf	Cer		500 v		
C434	283-051	0.0033 μf	Cer		100 v	5%	
C444	283-051	0.0033 μf	Cer		100 v	5%	
C461	283-001	0.005 μf	Cer		500 v		
C463	283-000	0.001 μf	Cer		500 v		
C465	283-028	0.0022 μf	Cer		50 v		
C466	281-096	5.5-18 pf	Air	Var			
C475	283-028	0.0022 μf	Cer		500 v		
C476	281-096	5.5-18 pf	Air	Var			
C481	281-097	9-35 pf	Cer	Var			
C482	281-089	2-8 pf	Cer	Var			

Diodes

Ckt. No.	Tektronix Part No.	Description		Model No.
D301	*152-075	Germanium	Tek Spec	
D303	*152-075	Germanium	Tek Spec	1, 2
D303	152-141	Silicon	1N3605	3-up
D308	*152-075	Germanium	Tek Spec	
D311	*152-075	Germanium	Tek Spec	
D313	*152-075	Germanium	Tek Spec	
D318	*152-075	Germanium	Tek Spec	
D330	152-075	Germanium	Tek Spec	X4-up
D345	*152-075	Germanium	Tek Spec	
D421	*152-117	Tek GaAs		1, 2, 3, 4
D421	*152-153	Silicon	Replaceable by 1N4244	5-up
D422	*152-117	Tek GaAs		1, 2, 3, 4
D422	*152-153	Silicon	Replaceable by 1N4244	5-up
D423	*152-117	Tek GaAs		1, 2, 3, 4
D423	*152-153	Silicon	Replaceable by 1N4244	5-up

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	Model No.
D424	*152-117	Tek GaAs	1, 2, 3, 4
D424	*152-153	Silicon Replaceable by 1N4244	5-up
D451	*152-117	Tek GaAs	1, 2, 3, 4
D451	*152-153	Silicon Replaceable by 1N4244	5-up
D452	*152-117	Tek GaAs	1, 2, 3, 4
D452	*152-153	Silicon Replaceable by 1N4244	5-up
D453	*152-117	Tek GaAs	1, 2, 3, 4
D453	*152-153	Silicon Replaceable by 1N4244	5-up
D454	*152-117	Tek GaAs	1, 2, 3, 4
D454	*152-153	Silicon Replaceable by 1N4244	5-up

Inductors

Ckt. No.	Tektronix Part No.	Description			Model No.
L460	*114-159	1-1.5 μh	Var	276-506	
L470	*114-159	1-1.5 μh	Var	276-506	

Transistors

Ckt. No.	Tektronix Part No.	Description	Model No.
Q305	Use 151-131	2N964	1, 2
Q305	*153-530	2N964 (Selected)	3-up
Q315	Use 151-131	2N964	1, 2
Q315	*153-530	2N964 (Selected)	3-up
Q330	151-080	2N706	
Q343	151-076	2N2048	
Q353	151-076	2N2048	
Q404	Use *151-130	2N1195	
Q414	Use *151-130	2N1195	
Q434	Use *151-130	2N1195	
Q444	Use *151-130	2N1195	
Q464	*151-120	Selected from 2N2475	
Q474	*151-120	Selected from 2N2475	

Resistors

Ckt. No.	Tektronix Part No.	Description				Model No.
R300	308-303	750 Ω	3 w	WW	1%	
R301	308-304	1.5 k	3 w	WW	1%	
R302	315-101	100 Ω	1/4 w		5%	
R303	315-123	12 k	1/4 w		5%	
R304	315-303	30 k	1/4 w		5%	
R306	315-332	3.3 k	1/4 w		5%	
R307	323-126	200 Ω	1/2 w	Prec	1%	
R311	308-304	1.5 k	3 w	WW	1%	
R312	315-101	100 Ω	1/4 w		5%	
R313	315-123	12 k	1/4 w		5%	
R314	315-303	30 k	1/4 w		5%	
R316	315-332	3.3 k	1/4 w		5%	
R317	323-126	200 Ω	1/2 w	Prec	1%	
R321	315-100	10 Ω	1/4 w		5%	
R322	315-101	100 Ω	1/4 w		5%	
R330	315-472	4.7 k	1/4 w		5%	
R332	315-102	1 k	1/4 w		5%	
R334	315-272	2.7 k	1/4 w		5%	
R341	315-102	1 k	1/4 w		5%	
R342	315-102	1 k	1/4 w		5%	
R343	315-122	1.2 k	1/4 w		5%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					Model No.
R345	301-154	150 k	½ w			5%	
R346	315-512	5.1 k	¼ w			5%	
R347	315-332	3.3 k	¼ w			5%	
R351	301-272	2.7 k	½ w			5%	
R353	315-122	1.2 k	¼ w			5%	
R355	315-103	10 k	¼ w			5%	
R404	315-221	220 Ω	¼ w			5%	
R405	315-111	110 Ω	¼ w			5%	
R406	315-512	5.1 k	¼ w			5%	
R414	315-221	220 Ω	¼ w			5%	
R415	315-111	110 Ω	¼ w			5%	
R416	315-512	5.1 k	¼ w			5%	
R421	315-823	82 k	¼ w			5%	
R424	315-823	82 k	¼ w			5%	
R426	321-141	289 Ω	⅛ w		Prec	1%	
R428	321-097	100 Ω	⅛ w		Prec	1%	
R429	321-136	255 Ω	⅛ w		Prec	1%	
R434	315-221	220 Ω	¼ w			5%	
R435	315-111	110 Ω	¼ w			5%	
R436	315-512	5.1 k	¼ w			5%	
R444	315-221	220 Ω	¼ w			5%	
R445	315-111	110 Ω	¼ w			5%	
R446	315-512	5.1 k	¼ w			5%	
R451	315-823	82 k	¼ w			5%	
R454	315-823	82 k	¼ w			5%	
R456	321-141	287 Ω	⅛ w		Prec	1%	
R461	315-103	10 k	¼ w			5%	
R462	315-470	47 Ω	¼ w			5%	
R463	308-300	1.75 k	3 w		WW	1%	
R464	321-077	61.9 Ω	⅛ w		Prec	1%	
R465	315-331	330 Ω	¼ w			5%	
R466	321-005	46.4 Ω	⅛ w		Prec	1%	
R467	308-301	10 k	3 w		WW	1%	
R472	315-470	47 Ω	¼ w			5%	
R474	321-077	61.9 Ω	⅛ w		Prec	1%	
R475	315-331	330 Ω	¼ w			5%	
R476	321-005	46.4 Ω	⅛ w		Prec	1%	
R481	311-454	100 k		Var			
R482	311-453	10 k		Var			
R494	303-242	2.4 k	1 w			5%	

Transformer

T330	*120-161	Toroid, 12T Quintifilar

Electron Tubes

V464	154-306	7586
V474	154-306	7586

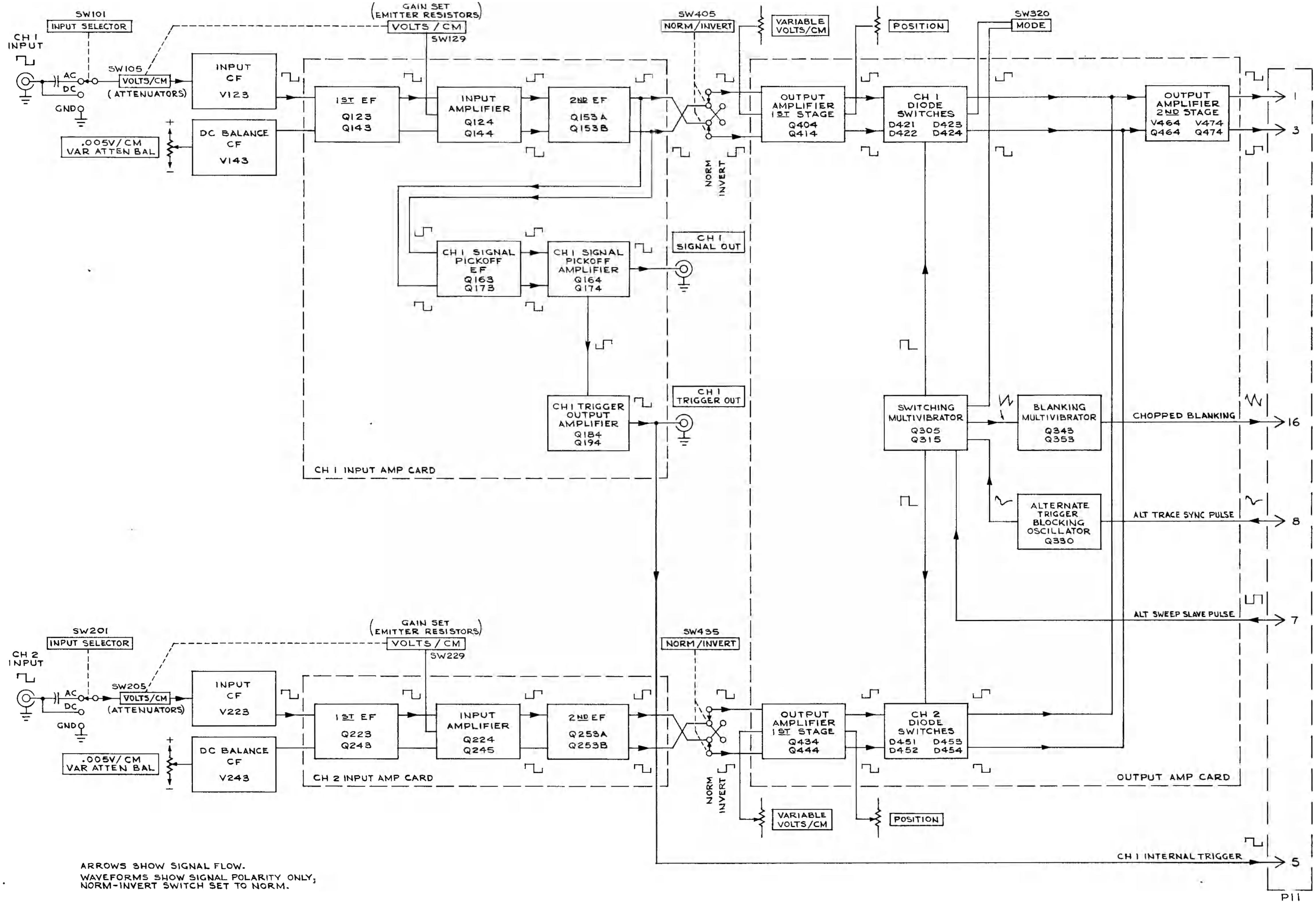
IMPORTANT:

Circuit voltages obtained with 20,000 Ω/VOLT VOM. Readings in VOLTS.

Voltage and waveform amplitude measurements are not absolute and may vary from instrument to instrument. For these measurements, a 30" flexible cable plug-in extension (012-038) was used to operate the 1A1 out of the oscilloscope plug-in opening.

Actual waveform photographs are shown with test oscilloscope set for + INT. Triggering. Bandwidth of test oscilloscope and 10X probe is dc to 10 mc. A dc to 1 mc test oscilloscope may be used, allowing for bandwidth limitations.

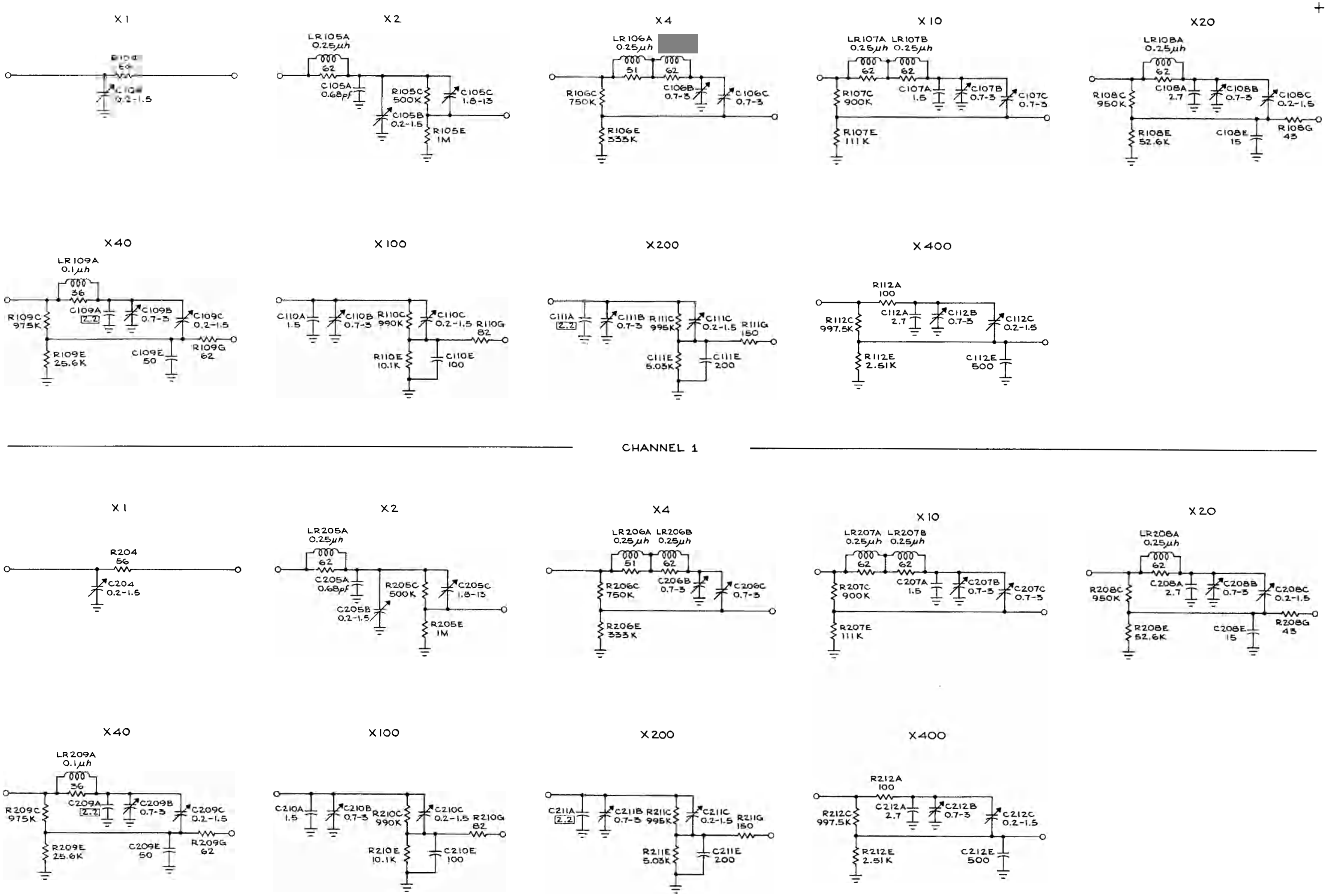
The Time Base of the oscilloscope used with the Type 1A1 was free running at a 1-μsec/cm rate.



ARROWS SHOW SIGNAL FLOW.
WAVEFORMS SHOW SIGNAL POLARITY ONLY;
NORM-INVERT SWITCH SET TO NORM.

MRH
264

BLOCK DIAGRAM



CHANNEL 2

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

TYPE 1A1 PLUG-IN

B

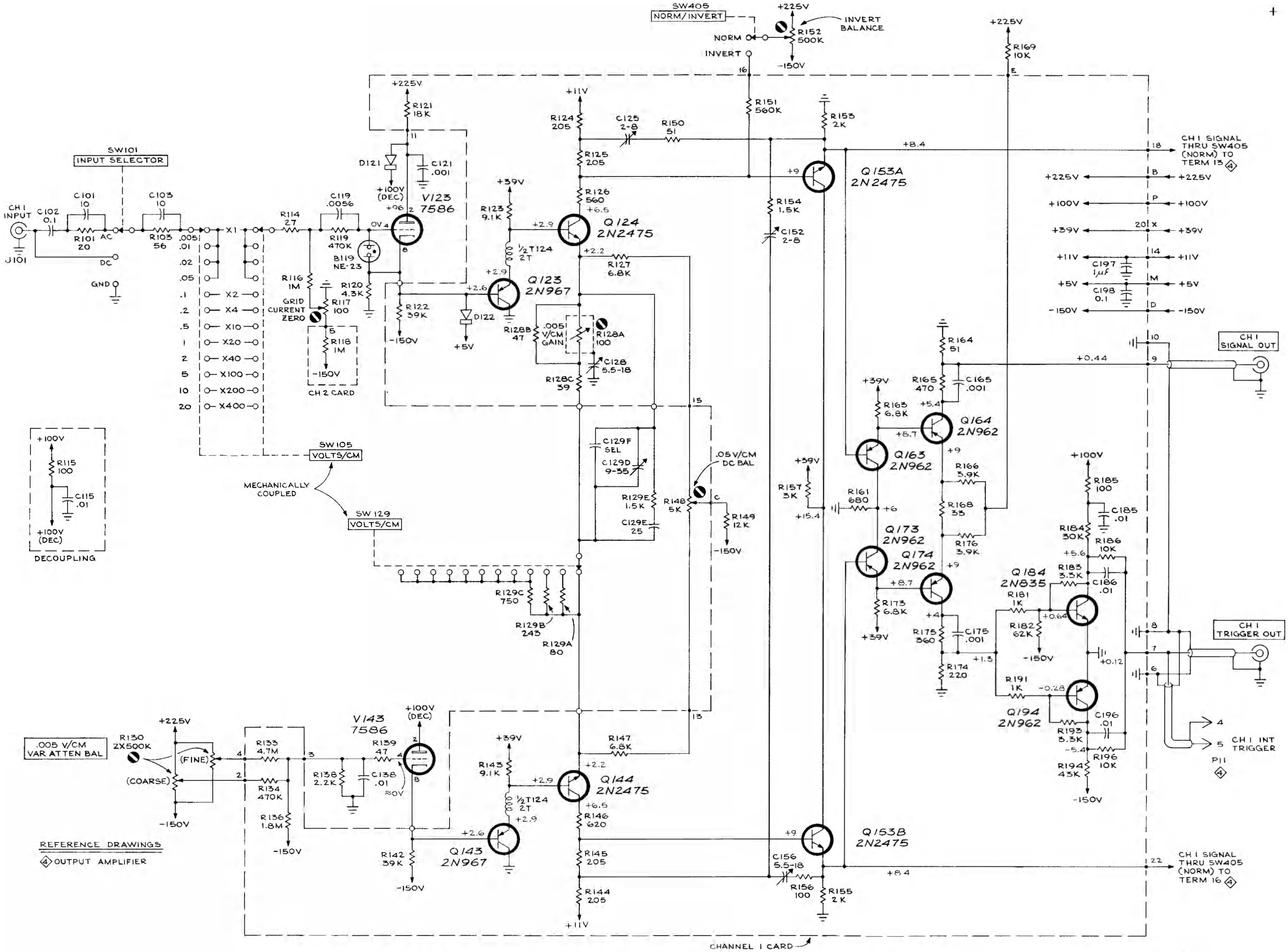
ATTENUATORS ⟨1⟩

DON
764

VOLTAGE READINGS were obtained under the following conditions:

Input Signal	None
AC-DC-GND	GND
VOLTS/CM	.05
POSITION	Centered
NORM-INVERT	NORM
VARIABLE VOLTS/CM	CALIB
MODE	CH 1

Also see IMPORTANT note on Block Diagram.



DON 764

TYPE 1A1 PLUG-IN

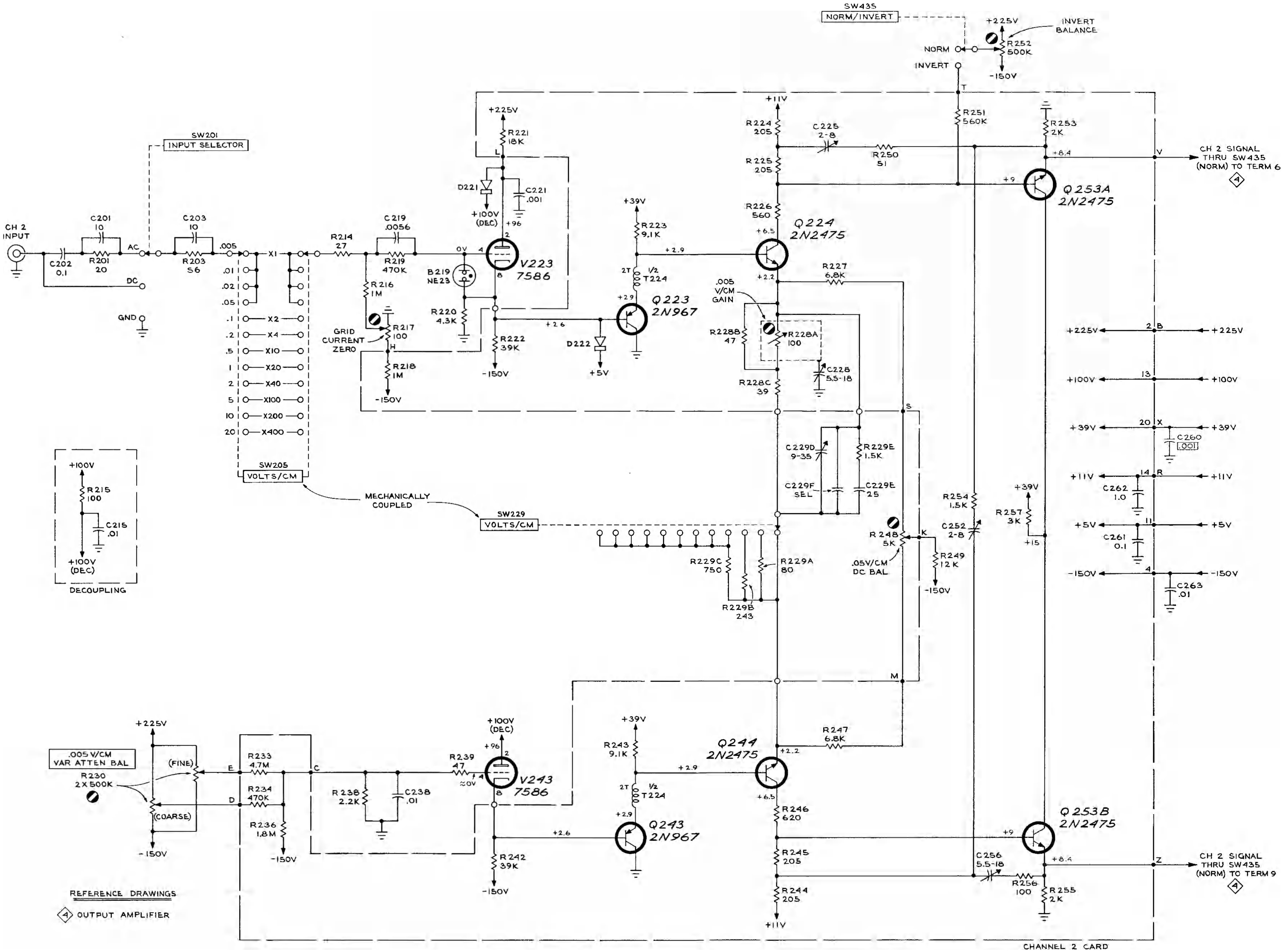
A1

CHANNEL 1 INPUT AMPLIFIER ②

VOLTAGE READINGS were obtained under the following conditions:

Input Signal	None
AC-DC-GND	GND
VOLTS/CM	.05
POSITION	Centered
NORM-INVERT	NORM
VARIABLE VOLTS/CM	CALIB
MODE	CH 2

Also see IMPORTANT note on Block Diagram.



CMD 764

TYPE 1A1 PLUG-IN

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

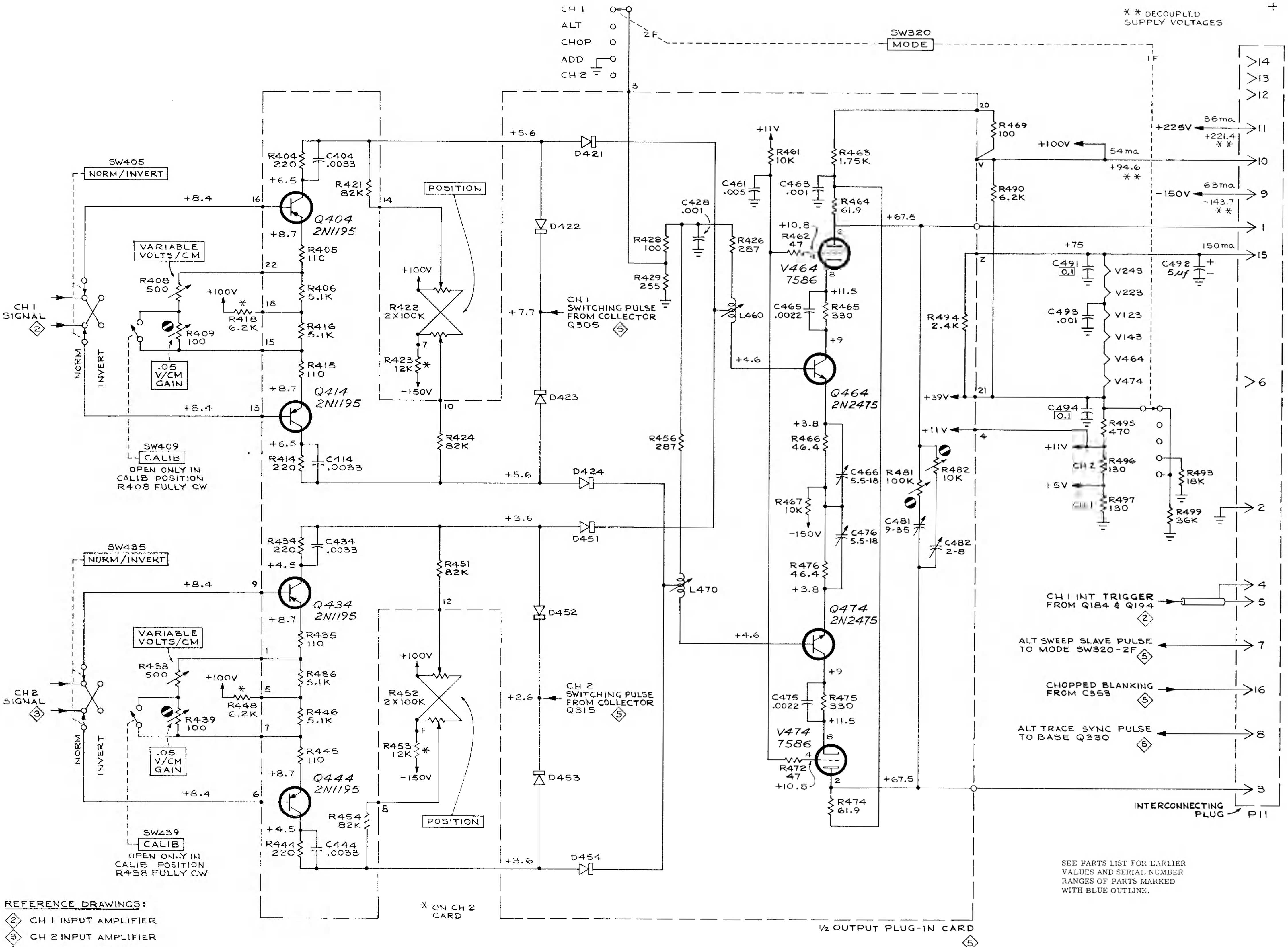
B

CHANNEL 2 INPUT AMPLIFIER 3

VOLTAGE READINGS were obtained under the following conditions:

Input Signal	None
AC-DC-GND (Both Chan.)	GND
VOLTS/CM (Both Chan.)	.05
POSITION (Both Chan.)	Centered
NORM-INVERT (Both Chan.)	NORM
VARIABLE VOLTS/CM (Both Chan.)	CALIB
MODE	CH 1

Also see IMPORTANT note on Block Diagram.



REFERENCE DRAWINGS:

- 2 CH 1 INPUT AMPLIFIER
- 3 CH 2 INPUT AMPLIFIER
- 5 SWITCHING CIRCUIT

MRH
764

TYPE 1A1 PLUG-IN

B

OUTPUT AMPLIFIER 4

VOLTAGE READINGS were obtained under the following conditions:

Input Signal	None
AC-DC-GND (Both Chan.)	GND
VOLTS/CM (Both Chan.)	.05
POSITION (Both Chan.)	Centered
NORM-INVERT (Both Chan.)	NORM
VARIABLE VOLTS/CM (Both Chan.)	CALIB

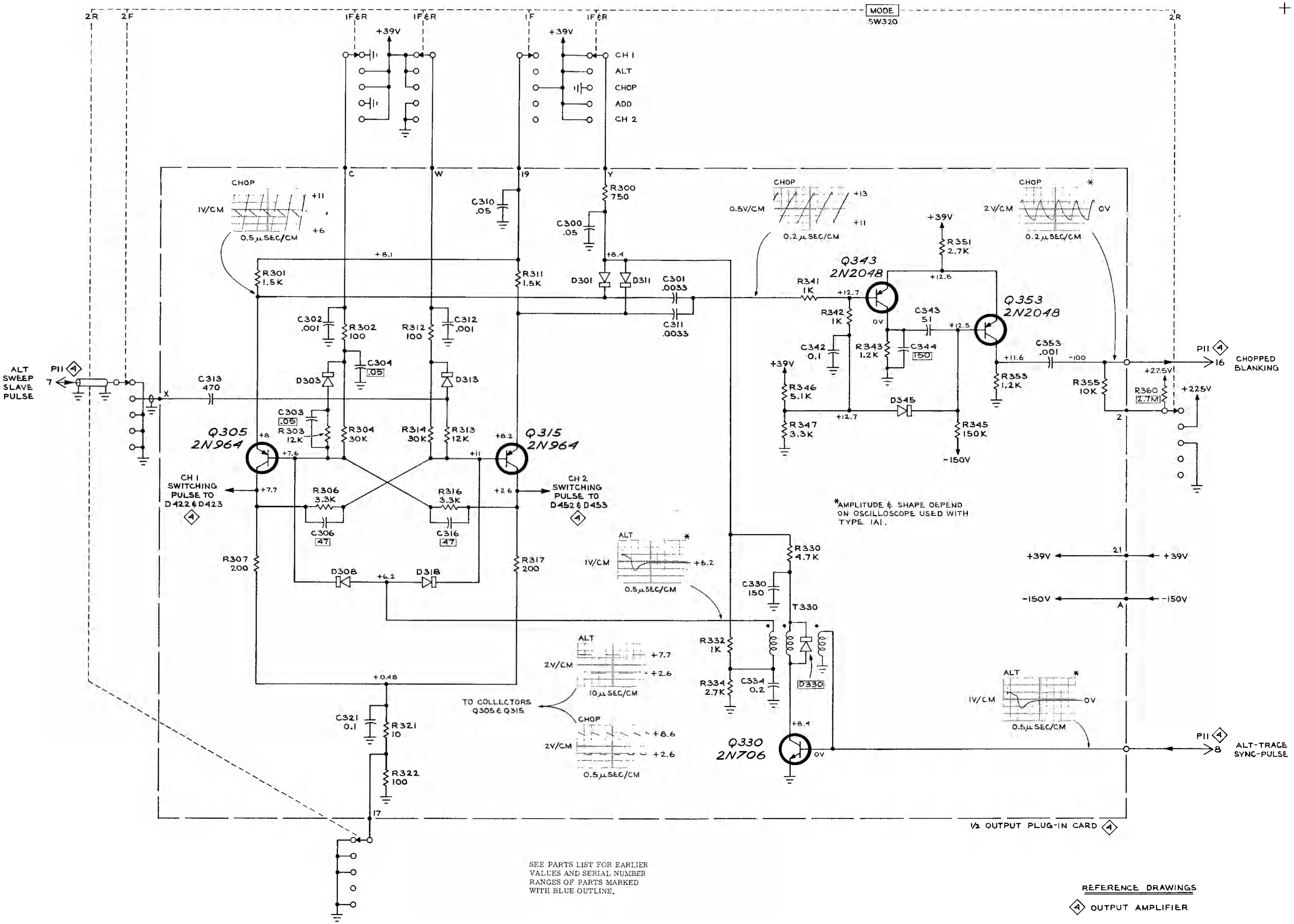
VOLTAGE READINGS:

MODE	CH 1

WAVEFORMS:

MODE	See waveforms

Also see IMPORTANT note on Block Diagram.



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

REFERENCE DRAWINGS

4 OUTPUT AMPLIFIER

CMD
764

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. If it does not, your manual is correct as printed.

TYPE 1A1 -- TENT. S/N 2110

PARTS LIST CORRECTIONS

OUTPUT AMPLIFIER CARD (Model 6)

ADD:

C314 *	283-010	0.05 µf	Cer	50 v
R310 **	315-123	12 k	1/4 w	5%
R331 ***	315-470	47 Ω	1/4 w	5%

* Added in parallel with R373.

** Added from pin U to pin X.

*** Added in series with base (green) lead of T330.

M8837/1164