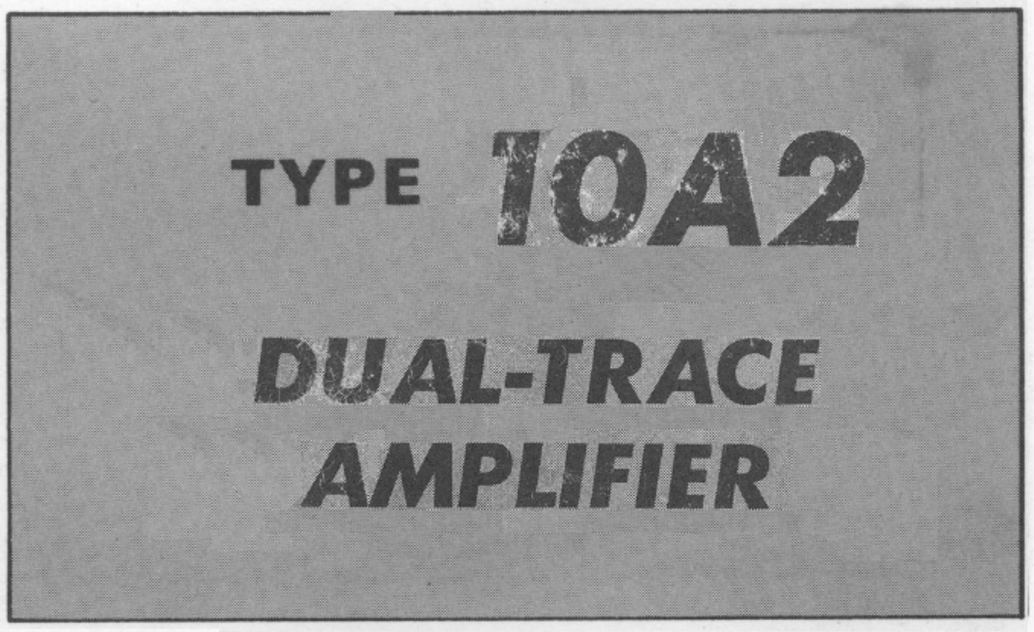
INSTRUCTION MANUAL

Serial Number _____



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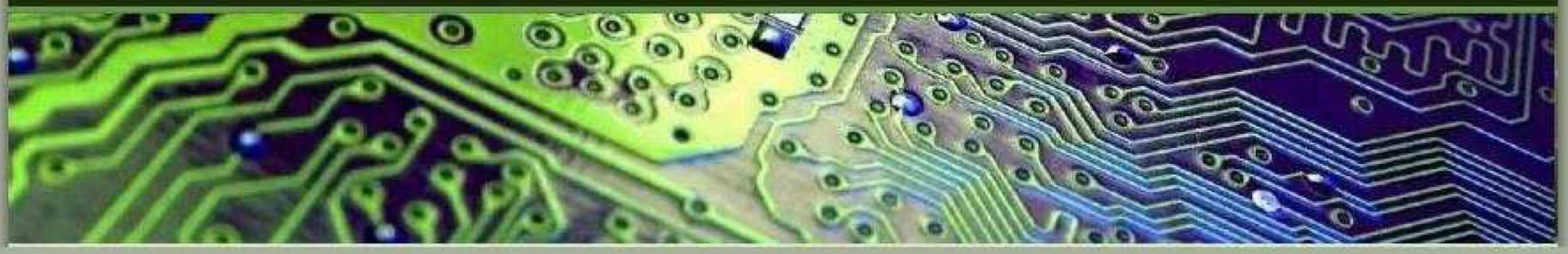

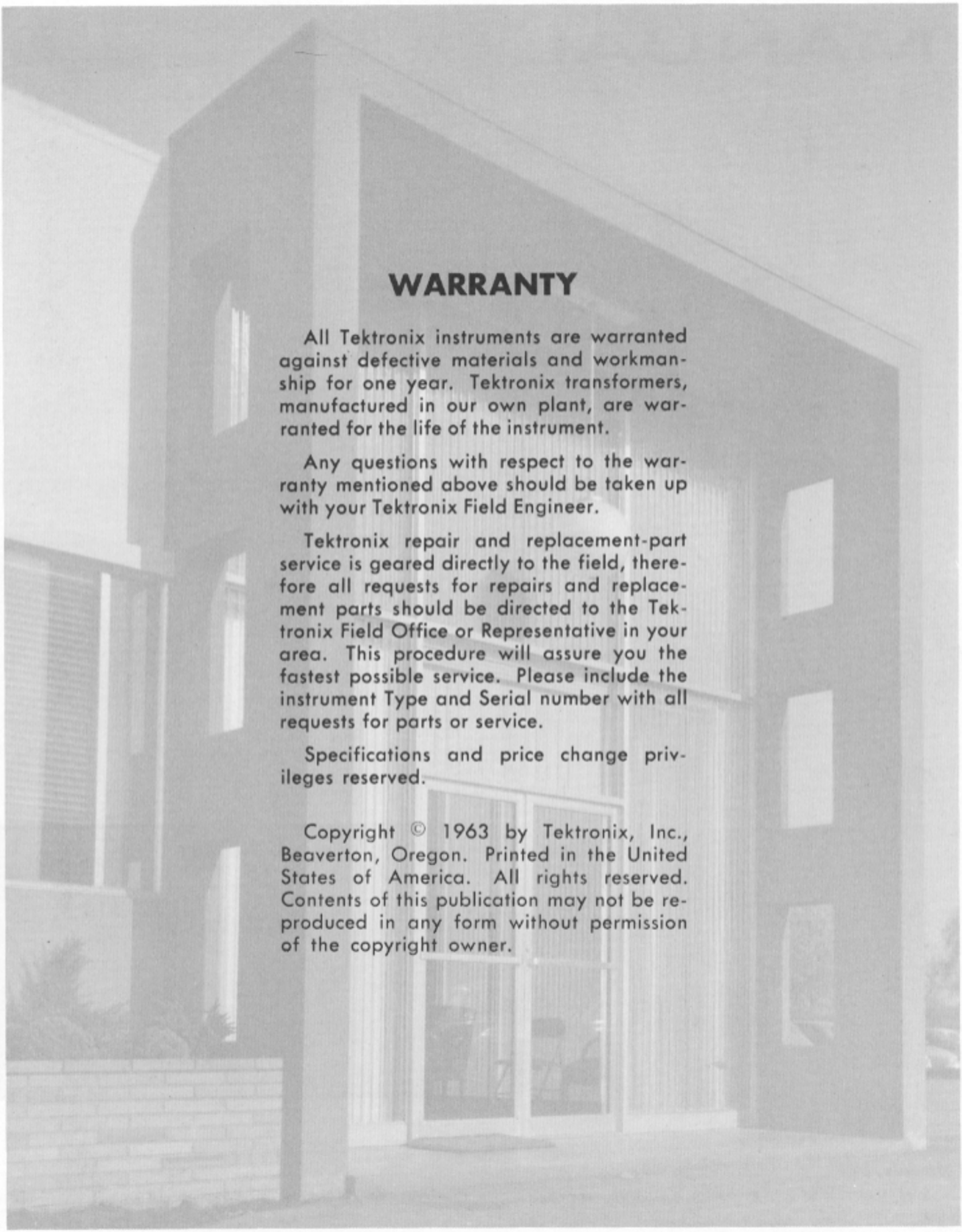

WARRANTY

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.

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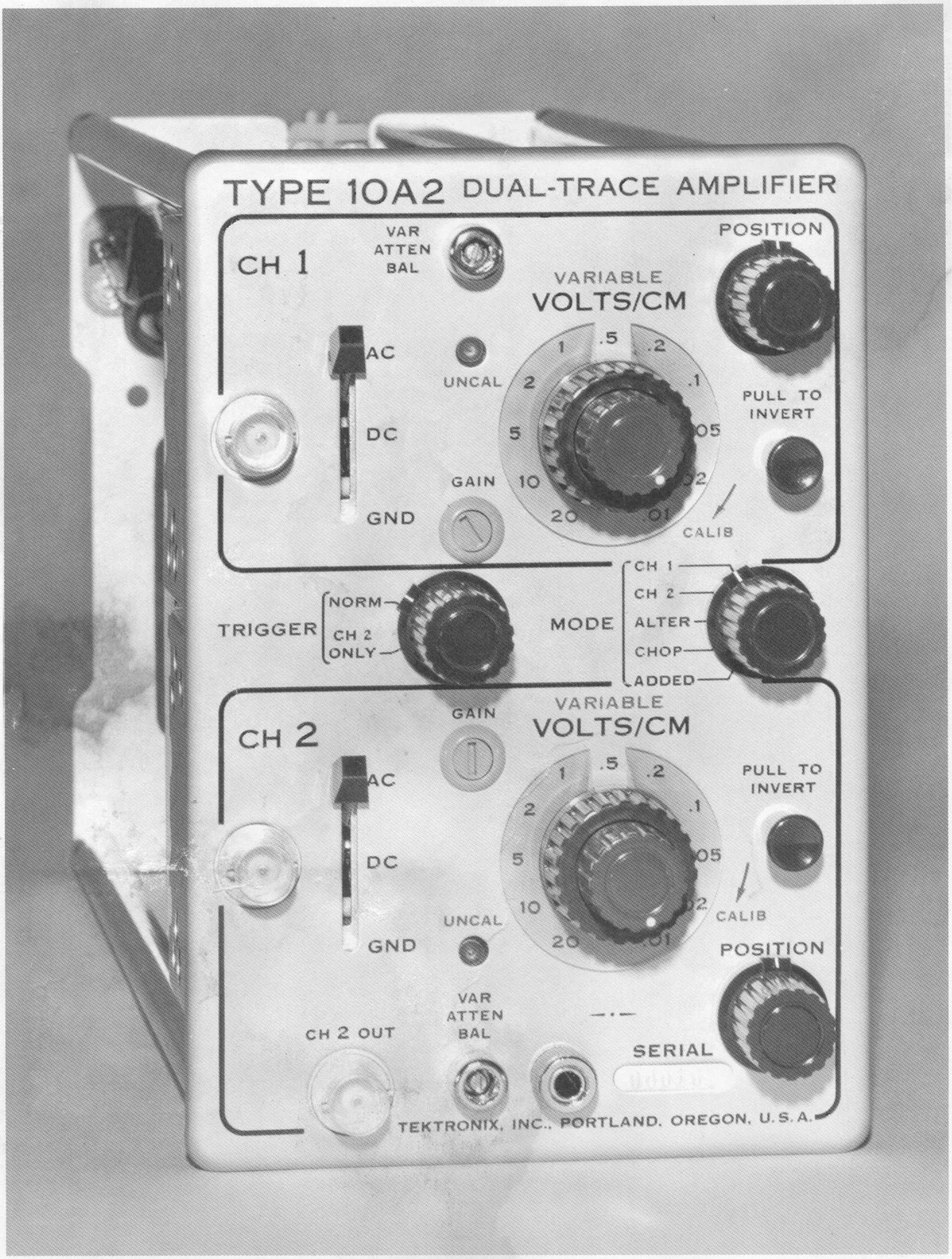
CONTENTS

A list of abbreviations and symbols used in this manual will be found on page 5-1. Change information, if any, is located at the rear of this manual.



The Type 10A2 Dual-Trace Amplifier

SECTION 1
CHARACTERISTICS

General Information

The Type 10A2 Dual-Trace Amplifier plug-in unit is part of a wide-band oscilloscope system designed for severe environmental operation and storage. It contains two identical vertical preamplifiers that can be used singly or combined for a variety of measurements. The Type 10A2 operates in the Type 647 Oscilloscope.

ELECTRICAL

The following electrical characteristics are divided into general operating characteristics and environmental specifications. All data applies to the Type 10A2 as operated in a Type 647 Oscilloscope.

Deflection Factors

Each channel has eleven calibrated steps from 10 mv/cm to 20 volts/cm in a 1, 2, 5 sequence. A variable control with at least a 2.5:1 uncalibrated range extends the maximum deflection factor to 50 volts/cm.

Calibration Accuracy

Adjustable to 0% at 10 mv/cm at the front panel.

Attenuation Accuracy

±2% from −30°C through +65°C.

Risetime (0°C to +40°C)

Typically 6.4 nsec, never longer than 7 nsec, 10% to 90%, for all positions of VOLTS/CM switch. (50 Ω signal source impedance with 50 Ω termination at the Type 10A2 input.)

Frequency Response (0°C to 40°C)

Dc to 50 mc minimum. Ac Coupled: 2 cps to 50 mc minimum.

Input Impedance

1 megohm paralleled by 20 pf.

Maximum Input Voltage

600 volts combined dc and ac peak.

Operating Modes

Channel 1 only, normal or inverted.

Channel 2 only, normal or inverted.

Alternate between channels.

Chopped between channels at 1-mc rate.

Added algebraically.

Channel Isolation

At least 80 db up to 20 mc (input circuits).

Algebraic Addition Common-Mode Signal

Maximum of 50 X the VOLTS/CM switch setting (limited to 600 volts at 20 volts/cm) for linear display operation.

Algebraic Subtraction Common-Mode Rejection Ratio

At least 20:1 for common-mode signals up to 10 cm from dc to 25 mc.

Trace Drift

At 25°C ambient temperature: Typically 2 mm/hr after 15-minute warmup.

Internal Triggering Information

Internal triggering information to the time-base plug-in unit can be selected from the common output amplifier or from the Channel 2 input signal only. Signal to the time base allows reliable internal triggering to a frequency beyond 50 mc.

Channel 2 Output Signal

Front-panel BNC connector labeled CH 2 OUT provides a dc-coupled signal from Channel 2. Output level centered at ground. Output signal: 100 mv/cm related to crt display. Output impedance: 100 Ω.

ENVIRONMENTAL

TABLE 1-1

Characteristic	0°C to +40°C	−30°C to +65°C
Ac Gain Stability		
Display Signal	±1.5%	±3%
CH 2 OUT Signal	±1%	±2%
3-db Bandwidth		
Display Signal	50 mc, minimum	40 mc, minimum
CH 2 OUT into 50 Ω	20 mc, minimum	20 mc, minimum
Chopped Mode Frequency, 1 Mc	±10%	±15%
Dc Trace Displacement	1 cm/20°C	<1 cm/20°C

Storage

The Type 10A2 Dual-Trace Amplifier can be stored alone, or in the Type 647 Oscilloscope at any temperature between —65°C and +75°C. After storage at either extreme, the instrument must be allowed sufficient time for all components to return to the operating ambient temperature range of —30°C to +65°C.

MECHANICAL

Construction

Aluminum-alloy chassis with chrome-plated brass side rails.

Finish

Anodized aluminum panel.

Dimensions

6¼ inches high, 4¼ inches wide, 14¼ inches deep.

Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list

SECTION 2

OPERATING INSTRUCTIONS

FUNCTION OF FRONT PANEL CONTROLS

AC-DC-GND — In the DC position, both the ac and dc components of input signals are displayed. In the AC position, a capacitor blocks dc components of the signal. The low-frequency limit (3-db point) of the AC position is about 2 cps (0.2 cps when a 10 meg Ω 10X probe is used). In the GND position, the Type 10A2 input circuit is grounded (it does not ground the signal).

VOLTS/CM — An 11-position switch that sets the vertical deflection factor of the Type 10A2. All positions are calibrated when the red VARIABLE knob is in the switch detent at the CALIB position. Range is from 0.01 to 20 volts/cm.

VARIABLE VOLTS/CM — Red knob concentric with the VOLTS/CM switch provides continuously variable reduction in amplifier gain (uncalibrated) to at least 2.5 to 1. For example, if the VOLTS/CM switch is in the 1 position, the VARIABLE control will vary the sensitivity between the deflection factors of 1 volt/cm and about 2.5 volts/cm. When used in conjunction with the oscilloscope calibrator voltage, this control permits setting any specific deflection factor within the range of the instrument.

UNCAL — A neon lamp that lights when the VARIABLE control is turned away from its CALIB position.

POSITION — Varies the vertical position of the trace.

PULL TO INVERT — A two-position switch that presents the signal in normal or inverted polarity.

MODE — A five-position switch that sets the mode of operation. The positions are as follows:

CH 1: Connects the internal circuits to operate Channel 1 only. The signal in Channel 2 is still applied to the CH 2 OUT connector.

CH 2: Connects the internal circuits to operate Channel 2 only.

ALTER: Sets the amplifier channels to display on alternate sweeps. For example, the first sweep would be the Channel 1 signal; the second sweep the Channel 2 signal. The flicker between channels will depend on the sweep rate.

CHOP: Electronic switching changes the display between channels at a 1-mc rate. Each display segment lasts for about 0.5 μsec.

ADDED: The algebraic sum of the Channel 1 and Channel 2 signals will be displayed with the MODE switch in this position. To measure the algebraic difference between signals, use one PULL TO INVERT knob.

TRIGGER — A two-position switch that selects the trigger signal to the time-base plug-in unit trigger circuits. Either Channel 2 or the signal driving the crt vertical deflection plates can be selected.

GAIN — A screwdriver adjustment that permits the gain of the channel to be correctly set.

VAR ATTEN BAL — A screwdriver adjustment that balances the amplifier so that with no signal applied there is no vertical shift of the trace as the VARIABLE VOLTS/CM control is turned.

FIRST-TIME OPERATION

The Type 10A2 should be inserted into the [illegible]nd (Y-axis) opening of the Type 647 Oscilloscope. A time-base plug-in unit such as the Type 11B2 should be inserted in the right-hand (X-axis) opening.

The following procedure will help you become familiar with the Type 10A2 operation:

1. Set the front-panel controls as follows:

AC-DC-GND	DC (both channels)
VOLTS/CM	.01 (both channels)
VARIABLE	CALIB (both channels)
POSITION	Midrange (both channels)
MODE	CH 1
PULL TO INVERT	Pushed in (both channels)
TRIGGER	NORM

2. Apply a 20-mv signal from the oscilloscope calibrator to both Type 10A2 input connectors. Adjust the time-base controls for a stable display. Use ac low-frequency reject internal-trigger coupling. The display will be a rectangular waveform 2 divisions in amplitude. With the Channel 1 POSITION control, move the display above the graticule centerline.

3. Turn the MODE switch to CH 2. A similar two-division waveform will be displayed. With the Channel 2 POSITION control, move the display below the graticule centerline.

4. Set the MODE switch to ALTER. If necessary, adjust the time-base triggering for a stable display. Both signals should be displayed. The switching rate will depend on the sweep rate.

5. Set the MODE switch to CHOP, and the TRIGGER switch to CH 2 ONLY. If necessary, adjust the time-base triggering for a stable display. Two separate traces should appear.

6. Set the MODE switch to ADDED. There should be one display 4 divisions in amplitude. This is the addition of the Channel 1 and 2 waveforms (2 divisions each). Notice that either POSITION control can move the trace vertically.

7. Pull the Channel 1 PULL TO INVERT switch. Free run the time base. The display should be a straight line, indicating the algebraic difference between the two signals. Since the signal amplitudes are equal, the difference is zero.

Variable Attenuator Balance and Gain Adjustment

Before the Type 10A2 is used for accurate measurements, the VAR ATTEN BAL and GAIN controls (front-panel screwdriver adjustments) for each channel should be checked and adjusted as necessary. The GAIN should also be checked each time the Type 10A2 is moved from one Type 647 Oscilloscope to another.

If the variable dc balance of a channel is not properly set, the position of a no-signal trace will shift vertically as the VARIABLE VOLTS/CM control of that channel is turned.

Adjust the VAR ATTEN BAL control as follows:

1. Set both AC-DC-GND switches to GND.

2. Set the MODE switch to CH 1 and position a free-running sweep to the center of the crt.

3. Adjust the Channel 1 VAR ATTEN BAL control to a point where there is no trace shift as the VARIABLE VOLTS/CM control is turned throughout its range.

4. Repeat the preceding steps for Channel 2.

Set the GAIN control as follows:

1. Set the TRIGGER switch to NORM.

2. Set the Channel 1 AC-DC-GND switch to DC and the MODE switch to CH 1.

3. Set the Channel 1 VOLTS/CM switch to .01 (or other required position) and the VARIABLE control to CALIB.

4. Set the time-base plug-in unit for a free-running 0.1 msec/cm sweep.

5. Apply 50 mv (or other required value) from the oscilloscope calibrator to the Channel 1 input connector.

6. There should be 5 cm of display; if not, adjust the GAIN control.

7. Repeat the preceding steps for Channel 2 GAIN adjustment.

General Operation

Either of the two preamplifier 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 10A2 input. Fig. 2-1 shows a block diagram of the input when using Method 7 of Table 2-1.

TABLE 2-1

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-2 & 2-3, Input R_p & C_p Curves.	Precautions
1. Open test leads.	Simplicity.	Limited frequency response. Subject to stray pickup.	BNC to Banana Jack adapter (103-033). Two test leads.	1 meg Ω & 20 pf at input, plus test leads.	Stray pickup.
2. Unterminated coax cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coax cable with BNC connector-(s).	1 meg Ω & 20 pf plus cable capacitance.	High capacitive loading.

TABLE 2-1 *(cont'd)*

Method	Advantages	Limitations	Accessories Required	Source Loading. See Fig. 2-2 & 2-3, Input R_p & C_p Curves.	Precautions
3. Terminated coax cable. Termination at 10A2 input.	Full sensitivity. Total 10A2/647 bandwidth. Relatively flat-response 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 10A2 input. (BNC 50 Ω Termination 011-049).	R_o plus 20 pf at 10A2 end of coax can cause reflections.	Reflection from 20 pf at input. Dc and ac loading on test point. Power limit of termination.
4. Same as 3, with coax attenuator at termination.	Less reflection from 20 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 10-A2 input.)	Permits signal to go to normal load. Dc or ac coupling without coaxial attenuators.	20-pf load at tap point.	BNC Tee and BNC connectors on signal cables.	1 meg Ω & 20 pf at tap point.	Reflections from 20 pf input.
6. 10X, 10 meg Ω probe. 100X, 9.1 meg Ω probe. 1000X, 100 meg Ω probe.	Reduced resistive and capacitive loading; nearly full bandwidth of 10A2/647.	X0.1 sensitivity. X0.01 sensitivity. X0.001 sensitivity.	P6006, P6008, P6003: 10X (P-6005 is 100X, P6015 is 1000X).	P6006: ≈7 pf, 9 meg Ω. P6008: ≈7 pf, 10 meg Ω. P6003: 12 pf, 10 meg Ω. P6005: 26 pf, 9.1 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 10A2 input.)	Reduced capacitive loading to about 0.7 pf. Bandwidth that of 10A2/647.	Resistive loading. X0.1 or X0.01 sensitivity. May need blocking capacitor to prevent dc loading or damage to termination. Limited low-frequency response when ac coupled. See Fig. 2-1.	P6043: 10X. P6035: 100X. Items in Fig. 2-1.	P6034: 500 Ω, 0.7 pf. P6035: 5 k Ω, 0.6 pf. See R_p & C_p curves in Fig. 2-2.	Dc and ac loading. Voltage rating of probe.
8. Current transformer. Terminated in 50 Ω at 10-A2. Bandwidth that of 10A2/647.	Current transformer 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 limits about 1.2 kc, and is 1/5th as sensitive as the CT-1.

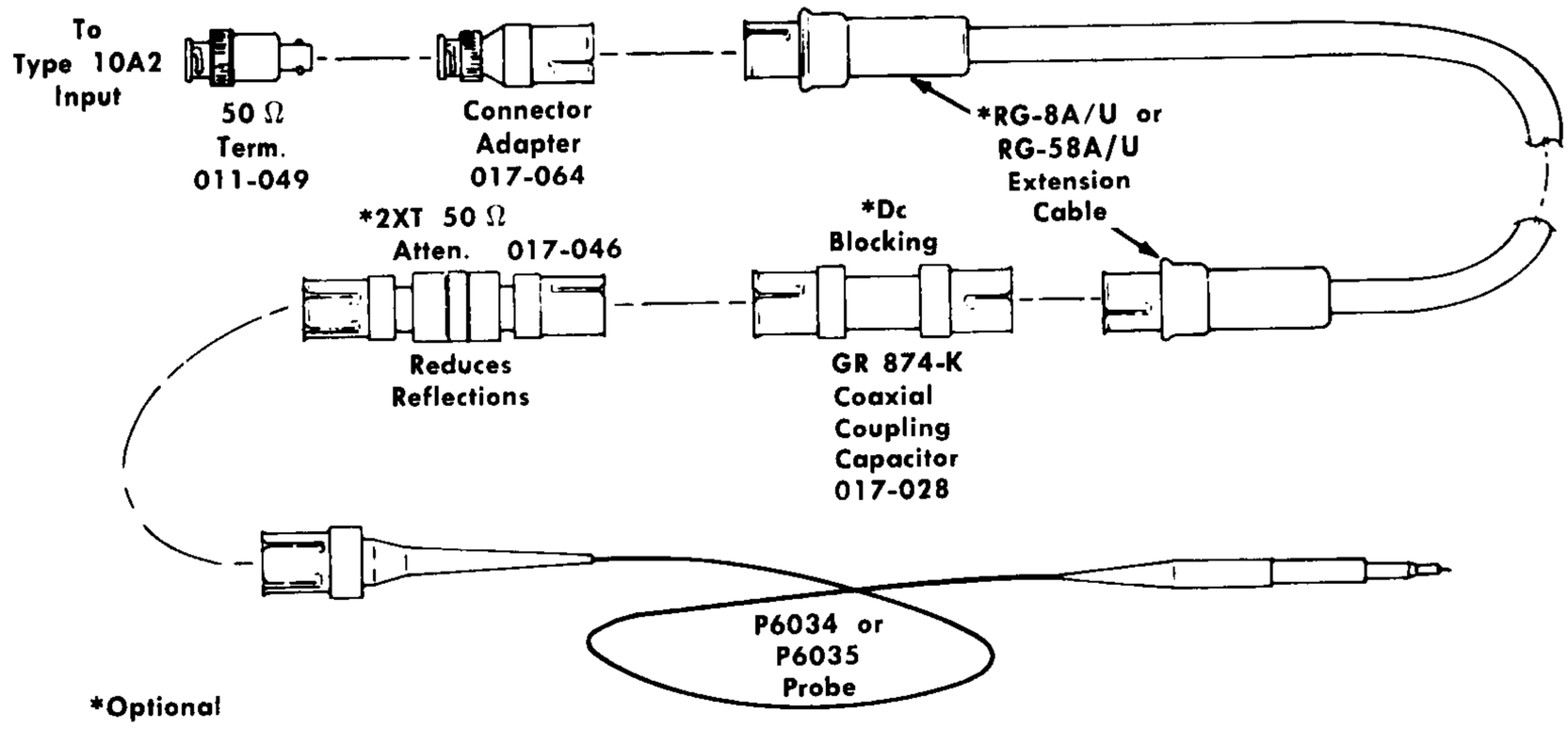


Fig. 2-1. Recommended component sequence when using the P6034 or P6035 Probe.

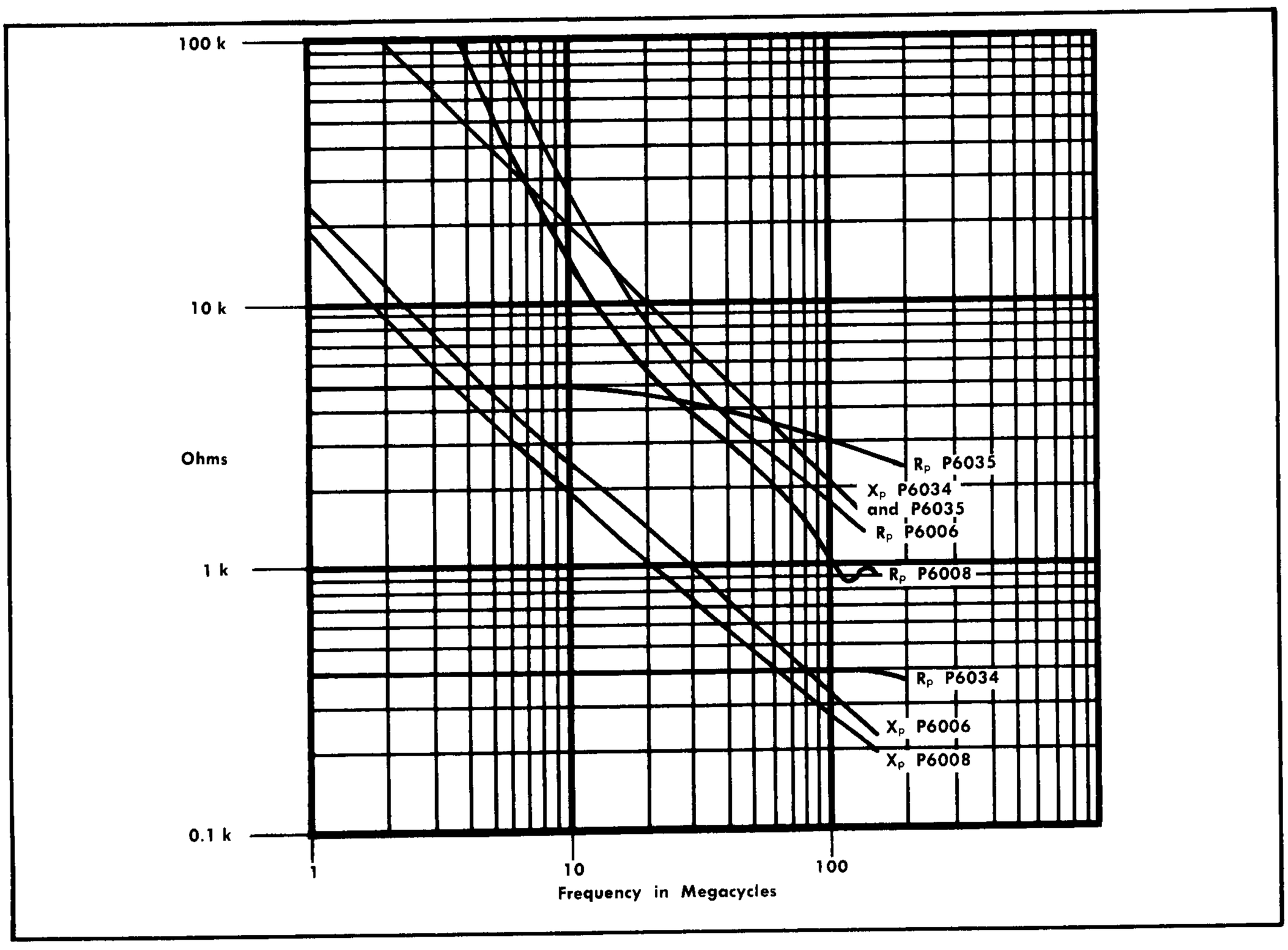


Fig. 2-2. Nominal input resistance (R_p), and capacitive reactance (X_p), of several attenuator probes when properly compensated and used with a Type 10A2.

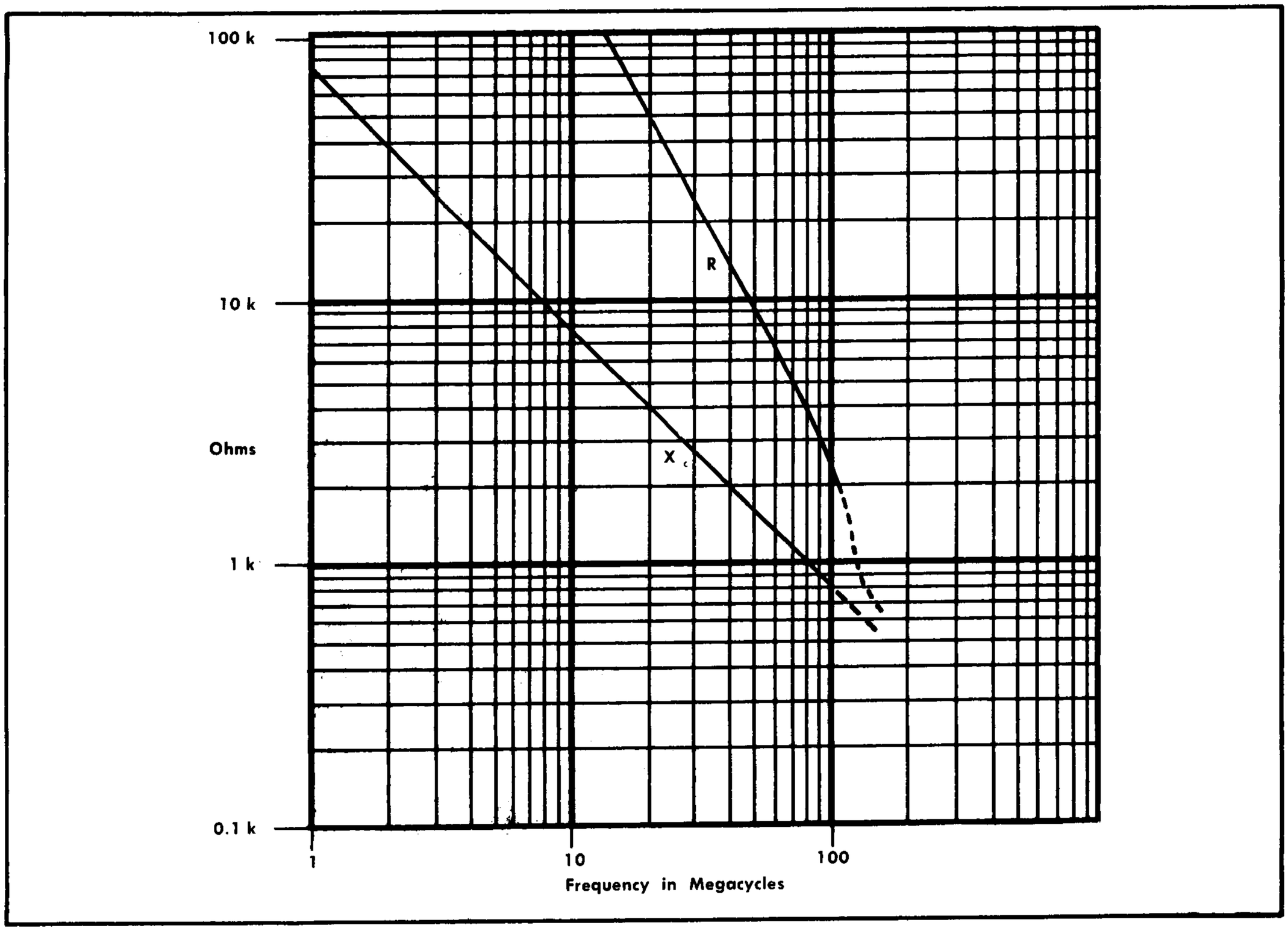


Fig. 2-3. Type 10A2 nominal input resistance and capacitive reactance vs frequency at any position of the VOLTS/CM switch.

Input Coupling

To display both the ac and dc components of an applied signal, set the appropriate AC-DC-GND switch to DC; to display only the ac component of a signal, set the 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 low-frequency ac —3-db point is about 2 cps when the source impedance is low. Therefore, some low-frequency distortion of signals with components near this frequency can be expected when using the AC position. When using a 10X 10 megΩ probe, the low-frequency response is about 0.2 cps in the AC position.

Deflection Factor

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor (if any) of a probe, the setting of the VOLTS/CM switch, and the setting of the VARIABLE VOLTS/CM control. Calibrated deflection factors indicated by the VOLTS/CM switch apply only when the VARIABLE control is set fully clockwise to the CALIB position.

The range of the VARIABLE VOLTS/CM control is at least 2.5:1 to provide variable (uncalibrated) vertical deflection factors between calibrated settings of the VOLTS/CM switch.

The VARIABLE VOLTS/CM control extends the vertical deflection factor of the Type 10A2 to above 50 volts/cm.

Dual Trace Operation

The choice of alternate or chopped mode of operation can be made from the following discussions and Table 2-2.

Displaying Two Non-Repetitive Signals. The chop mode of operation allows good resolutions of non-repetitive signals to be obtained using sweep rates as fast as 10 μsec/cm. The 10 μsec/cm sweep rate is probably the fastest sweep rate you will want to use and still get good resolution. Thus, non-repetitive signals up to 0.1 msec duration will produce a useful display with about 100 segments making up each trace.

To obtain useful displays when observing fast non-repetitive signals with the faster sweep rates, use one-channel operation.

Displaying Two Repetitive Signals. When displaying two repetitive signals using the alternate mode of operation, use sweep rates of 0.5 msec/cm or faster. When viewing a repetitive display from signals 250 cps or higher, alternate mode of operation produces an uninterrupted display (the

TABLE 2-2

Dual-Trace Internal Triggering

Signals	MODE Switch	TRIGGER Switch	Time-Base Triggering
1. Two of same or harmonically related frequency, 250 cps and above. (Lower frequency into Channel 2.)	ALTER	CH 2 ONLY	AC
2. Two of same or harmonically related frequency, anywhere within full bandwidth.*	CHOP	CH 2 ONLY	AC, DC, or AC LF REJ
3. Two of dissimilar (not harmonically related) frequency, 1 kc and above.	ALTER	NORM	AC LF REJ only
4. Two one-shot signals. First signal to Channel 2. Sweep rate limited to 10 μsec/cm, max.	CHOP	CH 2 ONLY	AC, DC, or AC LF REJ

*** Occasionally the signals will be harmonically related to the chopping rate, then at sweep rates above 10 μsec/cm the chop segments may be too obvious.**

alternate-mode switching cycle is sufficiently fast to produce an apparently steady display). If slower sweep rates are used for viewing signals 250 cps or lower, the alternate-mode switching cycle becomes more apparent and you may prefer to use chopped mode of operation.

Voltage Measurements

To measure the voltage between two points on a signal (such as peak-to-peak ac volts), measure the vertical distance in graticule divisions between the two points and multiply by the setting of the VOLTS/CM switch and the attenuation factor, if any, of a probe. Be certain that the VARIABLE VOLTS/CM control is in the CALIB position.

For example, assume you use a 10X probe with the VOLTS/CM switch set to .02, and your display has a vertical deflection of 4 cm. In this case, 4 divisions X 0.02 volt/div = 0.08 volt. This voltage times the probe attenuation factor of 10 shows a true peak-to-peak voltage of 0.8 volt.

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

1. Set the VOLTS/CM switch so that the expected voltage (at the input connector) is not more than six times the setting. Be sure the VARIABLE VOLTS/CM control is in the CALIB position.
2. Set the time-base controls so that the sweep free runs.
3. Set the AC-DC-GND switch to GND, and use the POSITION control to align the trace with one of the graticule lines. This line is a ground (or zero) reference. The position selected for this reference line depends on the polarity and amplitude of the signal to be measured. Do not move the POSITION control once the reference line has been established.
4. Set the AC-DC-GND switch to DC.
5. Apply the signal to the input connector and set the time-base triggering controls for a stable display.
6. Measure the vertical distance, in major graticule divisions, from the ground (zero) reference line to the point on the waveform that you wish to measure.
7. Multiply this distance by the setting of the VOLTS/CM switch and any probe attenuation factor. This is the instantaneous dc level of the point measured.

Check the zero reference line at any time by setting the AC-DC-GND switch to GND. It is not necessary to disconnect the signal probe from the Type 10A2. To use a reference other than zero, set the AC-DC-GND switch to DC and touch the signal probe to the reference voltage; then use the POSITION control to align the trace with a reference graticule line.

Voltage Comparison Measurements

In some applications, a set of vertical deflection factors other than those set by the VOLTS/CM switch need to be used. This is convenient for measuring signals that are multiples of fractional voltages between VOLTS/CM switch positions. To establish a set of deflection factors based on some specific voltage, use the following procedure:

1. Apply the new voltage reference signal to either Type 10A2 input connector. Set the VOLTS/CM switch and the VARIABLE control so that the display covers an exact number of graticule divisions. Do not move the VARIABLE control.
2. Divide the amplitude of the reference signal (in volts) by the product of the deflection established in step 1 (in centimeters) and the setting of the VOLTS/CM switch. The result is the deflection Conversion Factor.

   Conversion Factor =

$$\frac{\text{Amplitude of reference signal (in volts)}}{\text{Amount of deflection X VOLTS/CM switch setting}}$$

3. To calculate the true deflection factor at any position of the VOLTS/CM switch, multiply the switch setting by the deflection Conversion Factor:

   True Deflection Factor =
   VOLTS/CM switch setting X Conversion Factor

This new set of deflection factor values applies to this channel only, and only if the VARIABLE control is not moved.

Accurate Dc Millivolt Measurements

Operation of the Type 10A2 at 0.01 mv/cm may be quite common when working with 50-ohm coaxial systems near the upper frequency limit of the Type 647 system. Measurement accuracy requires careful attention to both the VAR ATTEN BAL adjustment and the input-stage grid current. The VAR ATTEN BAL adjustment must be made first as described under "First-Time Operation" in this section.

To check the input-stage grid current, warm up the Type 10A2 at least 10 minutes. Check grid current as follows:

1. Set the MODE switch to the channel in use.
2. Adjust the VAR ATTEN BAL control.
3. Set the VOLTS/CM switch to .01, VARIABLE to CALIB, and input selector to GND.
4. Center a free-running sweep. Switch input selector to DC and watch for a trace shift. If the trace shifts, you may wish to touch-up the internal GRID CURRENT ZERO adjustment in the affected channel. See Section 4, "Dc Adjustments", step 10.

SECTION 3
CIRCUIT DESCRIPTION

General Information

The Type 10A2 Dual-Trace Amplifier is a wide-band vertical plug-in unit for the Type 647 Oscilloscope.

The VOLTS/CM attenuators permit large signal amplitudes to be reduced before being amplified. Drift and noise characteristics are the same for all positions of the VOLTS/CM switch since the amplifier gain is not changed when switching between various deflection factors.

The Input Amplifiers raise the signal level before positioning is added. The Input Amplifier essentially changes the input voltage signal to an internal current signal. Thus, the positioning is by current offset of the Input Amplifier output. The PULL TO INVERT switch is between the Input Amplifier and the POSITION control to permit inverting the display without inverting the POSITION control action.

The Channel 2 Input Amplifier sends an isolated signal to the Channel 2 Trigger Amplifier. The Channel 2 Trigger Amplifier sends the Channel 2 signal to both the Trigger Amplifier (for internal triggering) and to the front-panel CH 2 OUT connector.

The Switching Circuit accepts one channel at a time or both channels together for use by the Output Amplifier. The MODE switch sets the Switching Circuit operating conditions.

The Output Amplifier sends an isolated output signal to the Trigger Amplifier for internal triggering.

The Trigger Amplifier receives information from either the Channel 2 Trigger Amplifier or the Output Amplifier through the TRIGGER switch. Thus, the time-base plug-in unit can be triggered either from the (composite) vertical information, or from Channel 2 information only.

Input Circuit

The Type 10A2 input connectors are the BNC type. The input signals pass through frequency-compensated voltage dividers, except at 0.01 volt/cm. All deflection factors present 1 megΩ paralleled by 20 pf to the input circuit (see Fig. 2-2 and Fig. 2-3). Each position of the VOLTS/CM switch (see Attenuators schematic) is individually adjustable for input capacitance and frequency compensation. This system permits the full bandpass of the instrument to be used at all deflection factors.

Each attenuator is made up of two or three resistors in series and two capacitors in series, forming a frequency-compensated attenuator. An additional small shunt input capacitor permits adjusting each attenuator to exhibit a 20 pf input.

Channel 1 Input Amplifier

Input tube V133 is a cathode follower that drives the Input Amplifier. The plate voltage for V133 comes from cascaded emitter followers Q123 and Q133. By adjusting the plate voltage of V133, its cathode voltage is set to the correct value of about +1.2 volts. Any grid current of V133 is offset by a small negative voltage set by R117, the CH 1 GRID CURRENT ZERO internal control.

The cathode voltage of V133 is adjusted to be equal to the voltage at the junction of R135-R136. The GAIN (R138) and VARIABLE (R144) resistors have no dc current through them. Thus, either control can be turned without shifting the crt display vertically. The base current of Q154 (that would otherwise apply current to the VARIABLE control) is canceled by R140, the Q154 BASE CURRENT internal control.

By proper adjustment of the plate voltage and grid current of V133 and the base current of Q154, the GAIN and VARIABLE controls pass no dc current when the input signal is zero.

Q154 is one-half of a paraphase amplifier stage (with fixed emitter degeneration) that drives a second push-pull amplifier stage (Q174-Q184). The CH 1 GAIN RANGE control in the emitter circuit of Q174-Q184 permits adjusting the total Input Amplifier gain so the front-panel GAIN control has its proper range of adjustment.

The dc balance of the two amplifier stages is set at the base of Q164 by CH 1 INV BAL control R160. R160 is adjusted during calibration, using the PULL TO INVERT switch to check the amplifier balance.

The dc level of the push-pull output leads of the Input Amplifier is set by varying the supply voltage to Q154-Q164 with the CH 1 COM MODE CURRENT control R150.

First-order temperature compensation of Q174-Q184 is by D157 in the base ground-return lead. The change in voltage across D157 with temperature is almost equal to and is opposite the change across the base-emitter diodes of Q174-Q184.

Protection for Common Base stage Q304-Q314 from overdrive is by D192-D193. Should the signal to one of the common-base amplifiers be great enough to reverse bias its emitter-base junction, one of the diodes will conduct. Conduction of D192 or D193 prevents the reverse biasing, and assures a rapid amplifier recovery after overload.

Signal Tracing vs Current Gain

Correct analysis of the Input Amplifier requires consideration of both current gain and voltage gain. To show the true conditions, Table 3-1 lists voltage and current signals in one-half the Input Amplifier.

TABLE 3-1

Approximate Voltage and Current Gains of One-Half the Input Amplifier

Test Point	Approximate Impedance	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q154 Base	2600 Ω	5.7	0.0022	(Q154 and Q174 $\beta \approx$ 40 each)
Q154 Collector	114 Ω	10	0.088	
Q174 Base	2400 Ω	10	0.0042	Q154B to Q174B: A = 1.75, G = 1.95
Q174 Collector	95 Ω	16	0.168	Q154B to Q174C: A = 2.8, G = 76.4

Q174 collector drives common-base amplifier Q304 through R190 and R192 (PULL TO INVERT switch pushed in). About a 1 mv/cm signal can be measured at the emitter of Q304 even though it is being driven at 0.168 ma/cm.

Fig. 3-1 shows the dc current and voltage conditions of the switching diodes, except for the ADDED mode of operation. Fig. 3-1 and the Channel 1 Input Amplifier schematic shows that measuring the dc level or signal voltage at the collector of Q174 does not indicate that Channel 1 is being displayed.

Common-Base Stage of Switching Circuit

The "pentode-like" characteristics of the collectors of Q304-Q314, and their common-base circuit, permit their collector voltages to be changed without affecting the Input Amplifier. Switching multivibrator Q345-Q355 diverts the collector current of the common-base stage of the channel not being displayed. Fig. 3-1 shows that the common base stage current is independent of operating mode.

Added mode of operation combines the output of both input amplifiers. (See Fig 3-2.) This requires 12 ma in each base lead from the Q413-Q423 input circuit. R318 and R338 are placed in parallel with the current supply to common-base stages R411-R317 on one side and R421-R337 on the other. The dc current through resistors normally used for single-channel operation remains the same. The switching multivibrator is set so it does not supply current to either channel common-base stage.

Output Amplifier

The voltage level at the base of Q413-Q423 (+6.6 volts) is set by the emitter return voltage of Q434-Q444. The base-emitter diode drop of each transistor is about 0.7 volt which elevates the 5.1 volts at the emitters of Q434-Q444 to 6.6 volts at the bases of Q413-Q423.

Q413 and Q423 are emitter followers with shunt feedback for stabilized current gain. Their emitters are isolated so they are not in push-pull. Q434-Q444 emitters are also isolated, but feedback to their bases makes them part of push-pull output pair Q454-Q464. The static current of the Output Amplifier three transistor pairs, and thus the common-mode dc output voltage, is set at the bases of Q413-Q423 by MAIN AMP CURRENT control R336.

Feedback resistors R450 and R460 set the current gain of output transistors Q434-Q444 and Q454-Q464 to a low value so the multi-stage current gain will be virtually independent of transistor beta throughout the required temperature and frequency ranges.

Table 3-2 shows the voltage gain and current gain data for the Output Amplifier.

TABLE 3-2

Approximate Voltage and Current Gains of One-Half the Output Amplifier

Test Point	Approximate Impedance	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q413 Stage Input		$\approx$3	0.132	
Q434 Stage Input	5 Ω	$\approx$1.6	0.317	Q413 stage input to Q434 stage input: A$\approx$ 0.53, G=2.4
Q434 Collector	154 Ω	$\approx$48	0.312	
Q454 Base	1.7 k Ω	$\approx$48	0.028	(Z and Ma/Cm only theoretical.)
Q454 Collector	46 Ω	75	1.62	Q434 stage input to Q454C: A=48, G=5.3.
Type 647 Input	93 Ω	75	0.81	

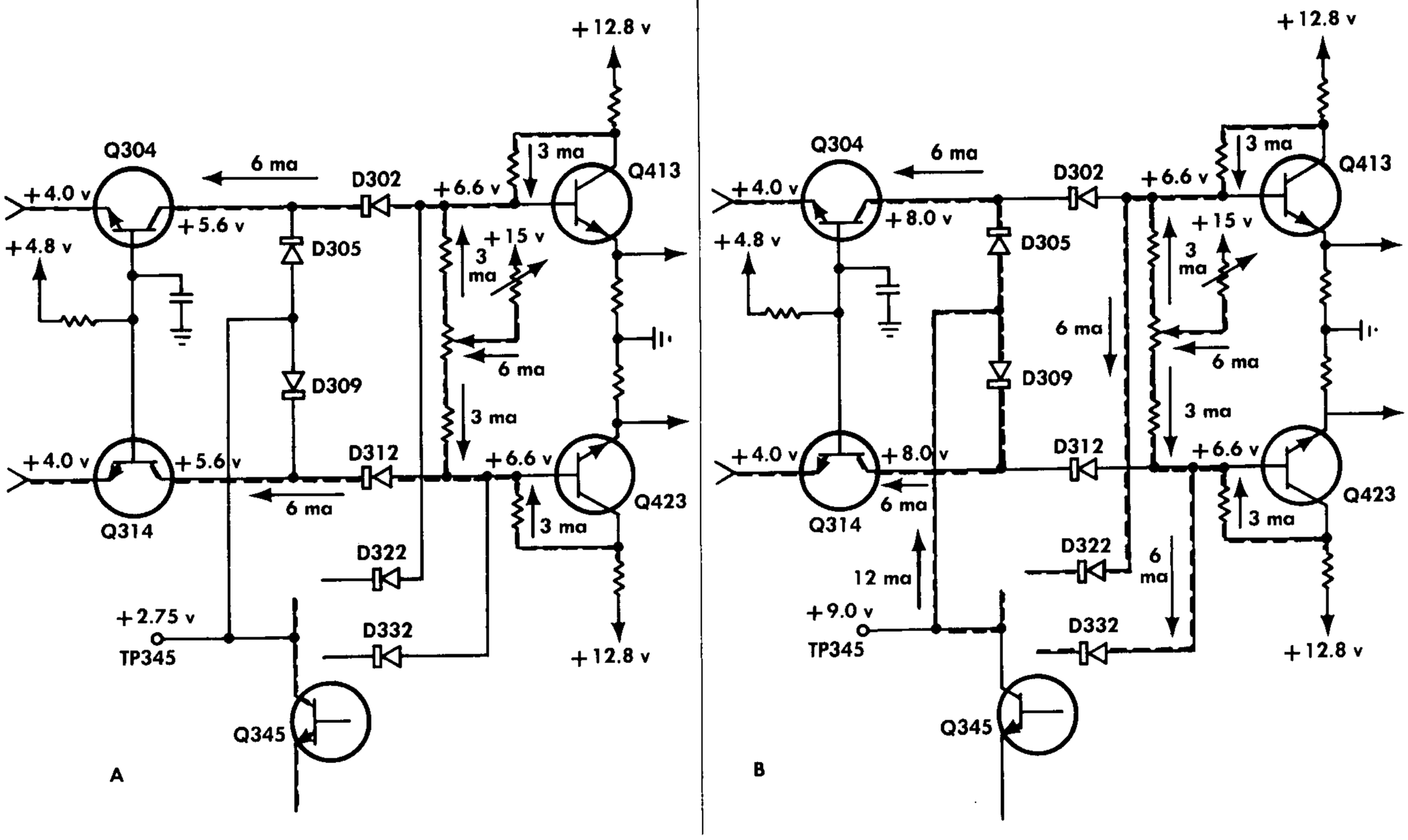


Fig. 3-1. Dc current flow and voltage levels at switching diodes for a centered trace. A: Channel 1 displayed. B: Channel 2 displayed.

Channel 2 Input Amplifier

The Channel 2 Input Amplifier is identical with that of Channel 1, except for the trigger takeoff point in the emitter circuit of Q274-Q284. The emitter-circuit resistors are different than in Channel 1 to keep the emitter degeneration the same while providing the trigger takeoff as if from an emitter follower. The Channel 2 trigger signal goes first to the base terminals of Q504-Q514, then to the TRIGGER switch.

Trigger Amplifiers

The Channel 2 Trigger Amplifier and the Trigger Amplifier are similar with low input impedance and high current output. Each has a stabilizing feedback loop that keeps the stage current gain virtually independent of transistor parameter changes throughout the required temperature and frequency ranges.

Signal voltage and current data for both amplifiers is in Table 3-3. The information is based upon the TRIGGER switch being at CH 2 ONLY.

Dual-Trace Switching Multivibrator

The dual-trace multivibrator transistors Q345-Q355 conduct current only when the MODE switch is at either CHOP or ALTER. In the Chopped mode, the emitter leads are connected to the —15-volt supply through R345-R355 and the primary of T371. The multivibrator free runs and the blanking amplifier delivers an output signal. In the Alternate mode, the multivibrator emitter leads are connected to the —15-volt supply through D348-D358 and R364-Q364. The multivibrator is then bistable and the blanking amplifier is inoperative.

TABLE 3-3

Approximate Voltage and Current Gain of One-Half the Trigger Amplifiers

Test Point	Mv/Cm	Ma/Cm	Gain: A = Voltage, G = Current
Q504 Stage Input	0.8	0.042	
Q523 Base	19		
Q523 Emitter	17	1.0	Q504 stage input to Q523E: A ≈ 22, G = 24
Q554 Stage Input	≈1.5	0.10	
Q574 Base	50		
Q574 Collector	100	1.13	Q554 stage input to Q574C: A ≈ 70, G = 11

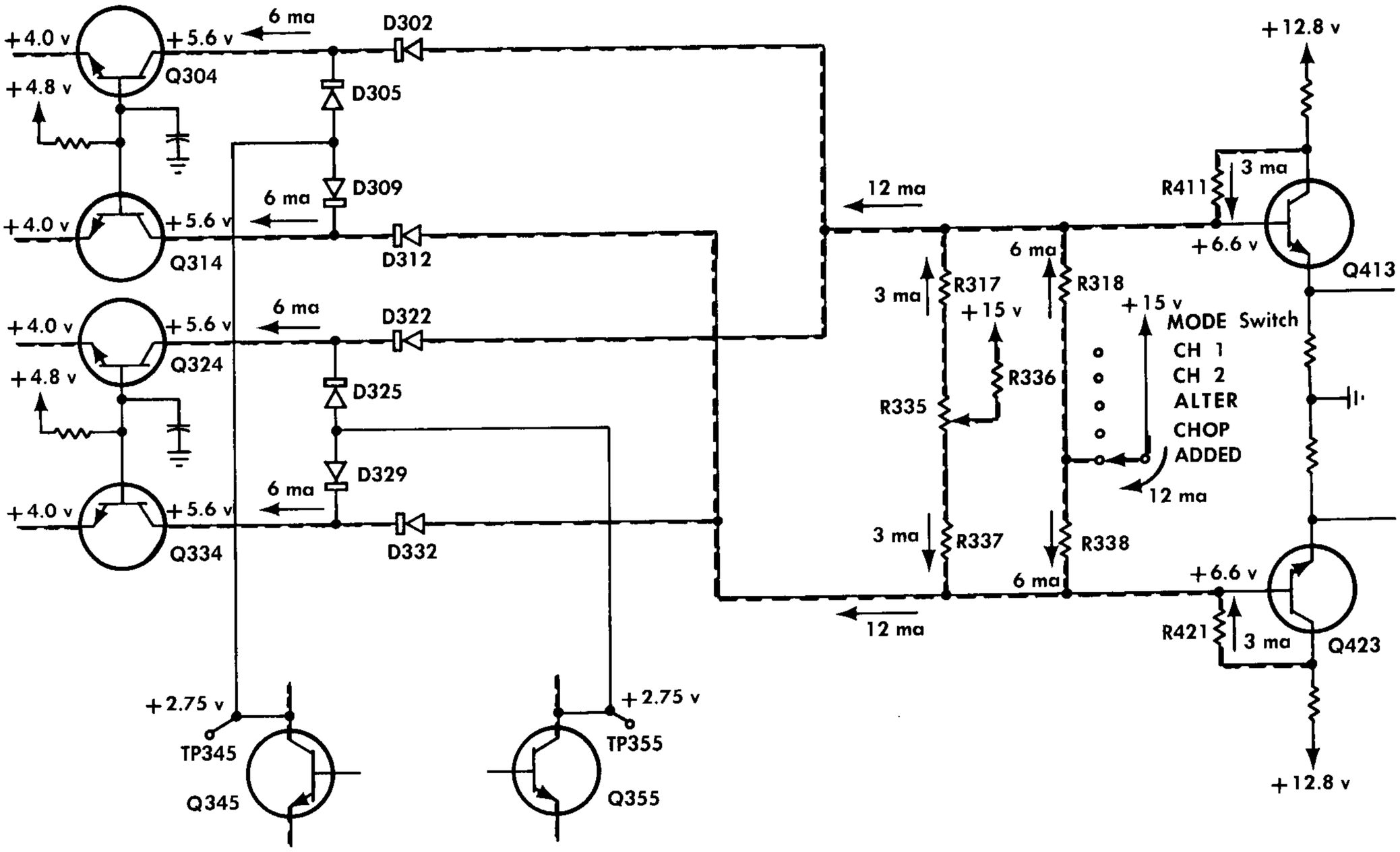


Fig. 3-2. Dc current flow and voltage levels for Added mode operation.

The voltages at the multivibrator test points are listed for all modes of operation in Table 3-4. The emitter voltages listed in Table 3-4 do not indicate transistor conduction for the Ch 1, Ch 2 or Added modes, but rather are a measure of the base voltage set by the base divider resistors.

TABLE 3-4

Switching Multivibrator Conditions

Test Point	MODE				
	CH 1	CH 2	ALTER	CHOP	ADDED
TP345	+2.8*	+8.8	+6.5	+6.5	+2.8
TP355	+8.8	+2.8	+6.5	+6.5	+2.8
Q345 Emitter	+2.0	+2.0	+0.9	+1.8	+2.0
Q355 Emitter	+2.0	+2.0	+0.9	+1.8	+2.0

* Meter: 20,000 Ω/volt.

Chopped-Mode Operation

The multivibrator is a non-saturating form with the switching time-constant network connected between emitters. The capacitors in the base circuits are for coupling only.

Chopped-mode multivibrator waveforms are shown in Fig. 3-3. They show that the emitter of conducting Q345 (Q345E) rests at 2.5 volts until the emitter voltage of Q355 (Q355E) falls to —1.6 volts at the flip point. As the flip action begins, Q345 cuts off; its collector goes positive (TP345) taking the base and emitter of Q355 positive. As the emitter of Q355 rises, it takes the emitter of Q345 to +4.3 volts via C348, assuring that Q345 goes deep into cutoff. Then the RC fall of C348-R345 takes the Q345 emitter negative (the slope from +4.3 to —1.6 volts). As soon as the Q345 emitter drops below its base voltage, the multivibrator flips back to the first condition.

NOTE

Fig. 3-3 through Fig. 3-8 were taken with a Tektronix C-12 Camera, a Type 535A Oscilloscope with Type CA Dual-Trace Plug-In Unit, and two 10X, 10 megΩ probes. The oscilloscope was externally triggered from TP345 and the plug-in unit operated in the Alternate mode.

Crt Blanking

The Type 647 crt is blanked during the brief Chopped-mode switching time of the Type 10A2. The blanking pulse is generated by Q374, Q383, and Q390.

Q374 is energized by the MODE switch and turns on briefly each time the Q345-Q355 multivibrator switches. As the multivibrator flips, the positive pulse from the multivibrator emitters is coupled through T371, in phase, to the base of Q374. Q374 turns on to saturation and its collector falls to about —12 volts (see Fig. 3-4). The signal to the base of Q383 is greatly attenuated by R374 and R375 in series to ground. As the voltage across T371 collapses, Q374 is turned off and held off by the stored charge on C371 until the next multivibrator pulse turns it on.

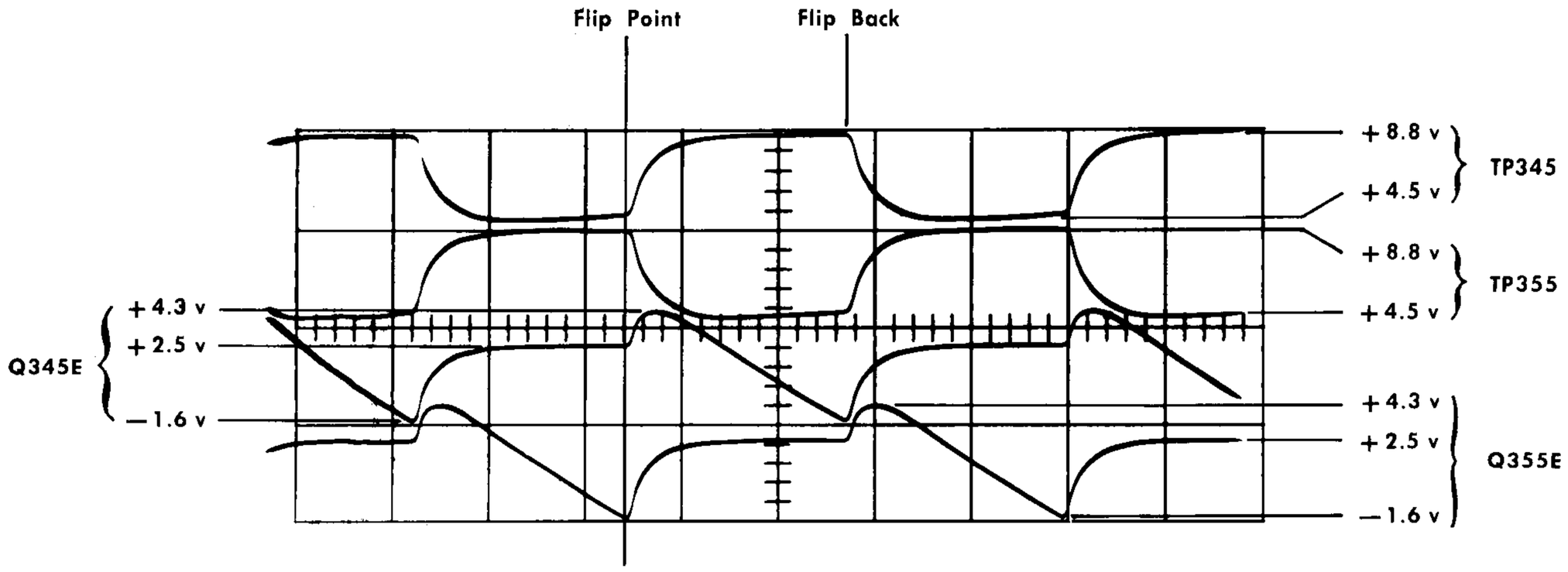


Fig. 3-3. Chopped mode signals of Q345 and Q355. Type 543A Oscilloscope with Type CA Dual-Trace Plug-in Unit.

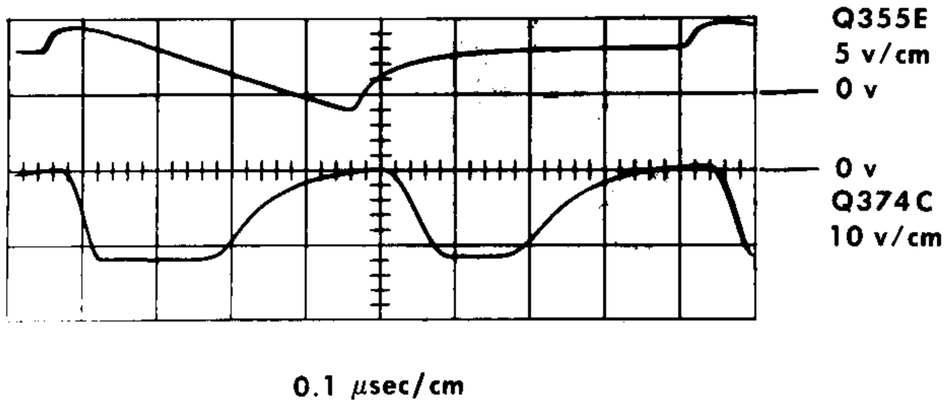


Fig. 3-4. Chopped-mode blanking circuit input voltages.

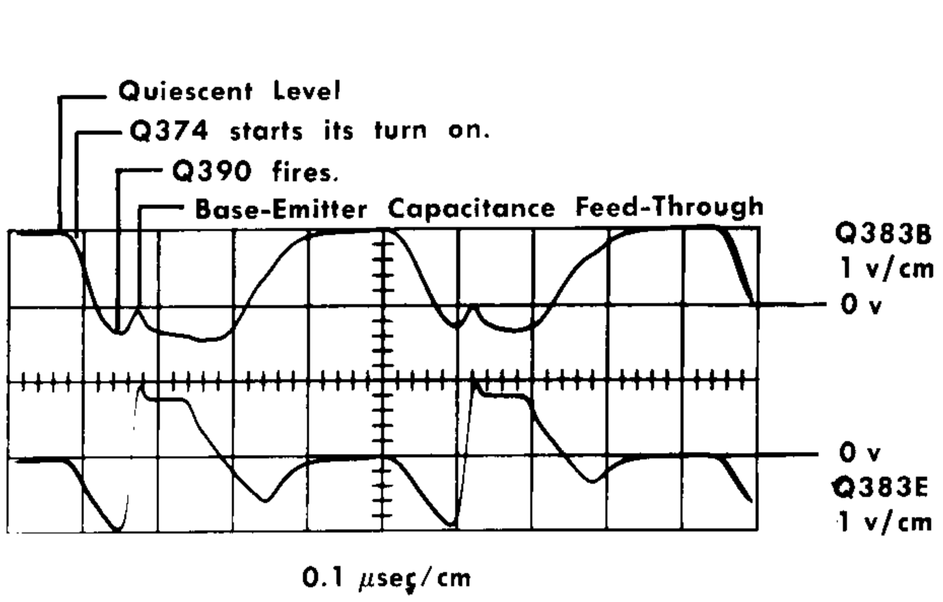


Fig. 3-5. Chopped-mode Q383 voltages. Q383E waveform explained in Fig. 3-6.

The base voltage of Q383 rests at about 0.7 volt when Q374 is off. The emitter of Q383 is at about zero volts (see Fig. 3-5). C387 is at zero volts keeping Q390 at cutoff.

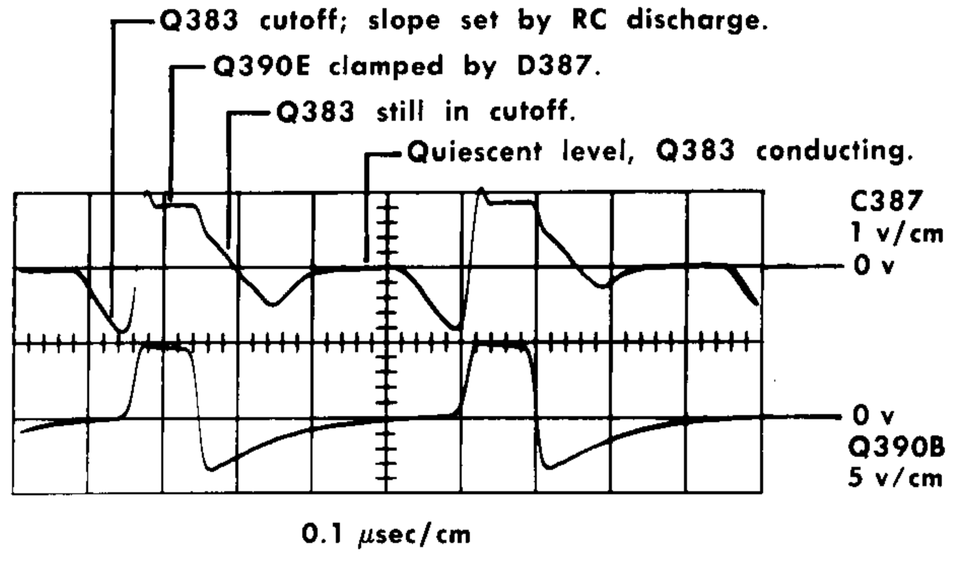


Fig. 3-6. Chopped-mode blanking circuit voltages of Q383 and Q390.

As Q374 saturates, Q383 is cut off and its emitter starts to fall at a rate set by C387 and the current through R387 and R384. As soon as C387 reaches about −0.7 volt, Q390 conducts and regenerates in blocking oscillator action. The base winding of T390 takes the base of Q390 from ground to about +4 volts (see Fig. 3-6) and sends about 100 mv of signal through D392 to the Type 647. The pulse lasts about 0.08 μsec.

Alternate-Mode Operation

When the MODE switch is at ALTER, Q364 is energized and Q345-Q355 emitters are connected to the −15-volt supply through D348-D358, and R364. The multivibrator emitter impedance is such that a trigger is required before it will switch. The trigger arrives from terminal 17 of P11 and the Type 647. The signal at terminal 17 rests at about +5 volts, and goes rapidly to ground at the end of each sweep (see Fig. 3-7).

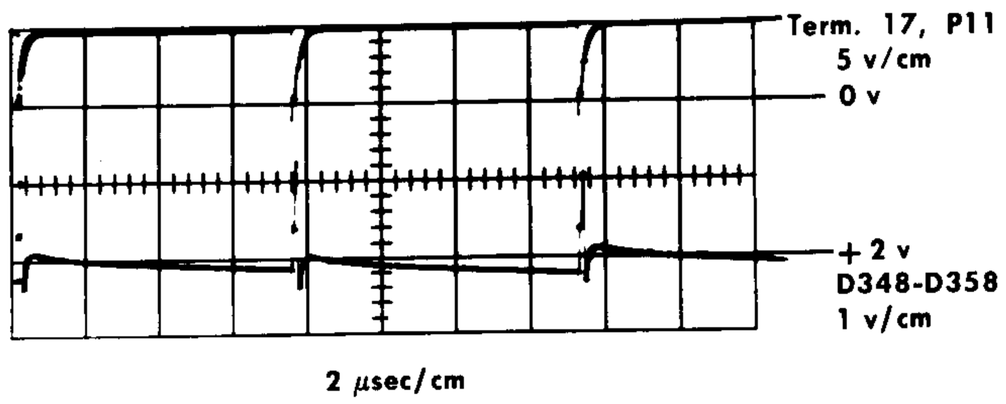


Fig. 3-7. Alternate mode. Type 11B2 Time Base free running at 0.2 μsec/cm.

The alternate trigger-amplifier base voltage is about —10.9 volts, (the decoupled —15-volt supply is about —11.6 volts) and the collector voltage is about —11.5 volts; Q364 is saturated. The junction of D348-D358 and R364 rests at +1 volt.

The negative trigger arriving at the base of Q364 momentarily turns Q364 off (see Fig. 3-7). The conducting multivibrator transistor turns off and as Q364 turns back on, the stored charge on C348 causes the opposite multivibrator transistor to turn on. Thus, the Time Base negative trigger at the end of successive sweeps switches the display first from Channel 1 to Channel 2 and back.

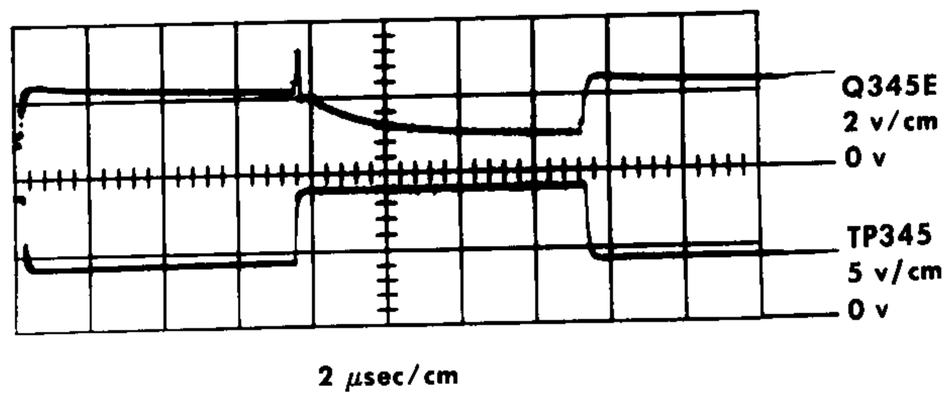


Fig. 3-8. Alternate mode. Type 11B2 Time Base free running at 0.2 μsec/cm.

The relationship between the Alternate-mode triggers to the bistable multivibrator and the voltages that control the channel diode switches is shown in Fig. 3-8.

Voltage-Source Transistors

Two voltage-setting emitter followers provide special supply voltages within the Type 10A2. They are: Q483, diagrammed with the Switching Circuit and Output Amplifier schematics, and Q593, diagrammed with the Trigger Amplifier schematic. Each transistor provides two low-current voltage sources for special use. The voltage value is set by two precision resistors in the base lead. Q483 supplies +5.1 and +4.8 volts, and Q593 supplies —3.45 and —4.2 volts.

SECTION 4

MAINTENANCE AND CALIBRATION

Introduction

Maintenance of the Type 10A2 is similar to that of the oscilloscope and is therefore described in the oscilloscope instruction manual.

The Type 10A2 is a stable instrument which will provide many hours of trouble-free operation. However, to insure measurement accuracy, it is suggested that you recalibrate the instrument after each 500 hours of operation, or every six months if used intermittently. It will also be necessary to recalibrate certain sections of the instrument when tubes, transistors, or other components are replaced.

This section of the manual contains a complete recalibration procedure for the Type 10A2. The steps should be performed in the order they appear.

NOTE

The performance standards described in this section of your manual are provided strictly as guides to calibration of your instrument and should not be construed as advertised performance specifications. However, if your instrument performs within the guide tolerances given in the calibration procedure, it will also perform as listed in Section 1 of this manual.

Recommended Test Equipment

1. Oscilloscope such as the Tektronix Type 647. This procedure assumes that the oscilloscope has been calibrated independently. If this is not the case, refer to the oscilloscope instruction manual for information about calibrating the Type 10A2 and the oscilloscope as a system.

2. Tektronix 11-Series time-base plug-in unit such as the Type 11B2. This plug-in unit must be calibrated.

3. Plug-in unit extension (optional). Tektronix part number 012-080 (30-inch flexible) or Tektronix part number 013-077 (12-inch rigid).

4. Dc voltmeter.

5. (2 ea) 50 Ω coaxial cables about 20-inches long and fitted with BNC connectors.

6. Tektronix BNC 50 Ω termination unit. Tektronix part number 011-049.

7. Square-wave generator such as the Tektronix Type 105. Required characteristics: Output frequency of 2.5 kc. Output impedance of 600 Ω or less. Output amplitude of about 100 volts peak-to-peak when unterminated. Risetime of 1 microsecond or less when unterminated.

8. UHF male to BNC female coaxial adapter. UG-273/U.

9. Tektronix BNC 50 Ω X10 coaxial attenuator: Tektronix part number 010-314.

10. Tektronix BNC 20 pf input time-constant standardizer. Tektronix part number 011-066.

11. Pulse generator such as the Tektronix Type 109. Required characteristics: Risetime no longer than 2 nanoseconds. Amplitude about 50 millivolts across a 50 Ω termination. Repetition rate of at least 275 pulses per second.

12. Charge-line for the pulse generator, Tektronix Type 113 delay cable preferred. Electrical length should be at least 30 nanoseconds.

13. RG-58A/U coaxial cable equipped with GR Type 874 connectors and having an electrical length of 2 nanoseconds (about 1-foot long) or less. Tektronix part number 017-505. For use with Tektronix Type 113 delay cable.

14. (2 ea.) Tektronix GR Type 874, 50 Ω X10, coaxial attenuator. Tektronix part number 017-044.

15. RG-8A/U coaxial cable equipped with GR Type 874 connectors and having an electrical length of 10 nanoseconds or less.

16. GR Type 874 to BNC jack coaxial adapter: GR part number 874-QBPA.

PRELIMINARY PROCEDURE

1. Remove the left side cover from the Type 647.

2. Install the Type 10A2 in the left-hand compartment of the Type 647 and an 11-Series plug-in unit such as the Type 11B2 in the right-hand compartment. A plug-in unit extension will be helpful for troubleshooting, but should not be used when making final adjustments.

3. Set the Type 10A2 front-panel controls as follows:

CH 1 and CH 2.

VAR ATTEN BAL	180° from fully clockwise
GAIN	180° from fully clockwise
POSITION	Centered
PULL TO INVERT	Pushed in
VOLTS/CM	.01
VARIABLE	Fully counterclockwise
AC-DC-GND	GND
MODE	CH 1
TRIGGER	CH 2 ONLY

4. Set the Type 647 INTENSITY control fully counterclockwise. Turn on the instrument power and allow several minutes for warmup.

5. Set the 11-Series plug-in unit controls for a free-running, non-magnified sweep at about 0.5 msec/cm.

6. Set the Type 647 INTENSITY control to obtain a trace. If no trace is obtained, use the CH 1 INV BAL R160 adjustment as a position control to obtain the trace.

NOTE

Photographs on a foldout page following the schematics in the back of this manual show the location of each calibration adjustment and test point.

CHECK AND ADJUSTMENT PROCEDURE

Dc Adjustments

NOTE

Steps 1 through 10 apply to both Channel 1 and Channel 2. Complete these steps for Channel 1 first, disregarding the information in parenthesis. Then repeat the steps for Channel 2, substituting the information in parenthesis for the Channel 1 information. Both POSITION controls must be set to midrange and their setting must not be changed until instructed in the procedure.

1. ATTEN BAL RANGE Preliminary Adjustment (SN 100-359)

a. Set the dc voltmeter for at least +1.5 volts full scale and connect it to the V133 (V233) cathode bus shown in Fig. 4-1.

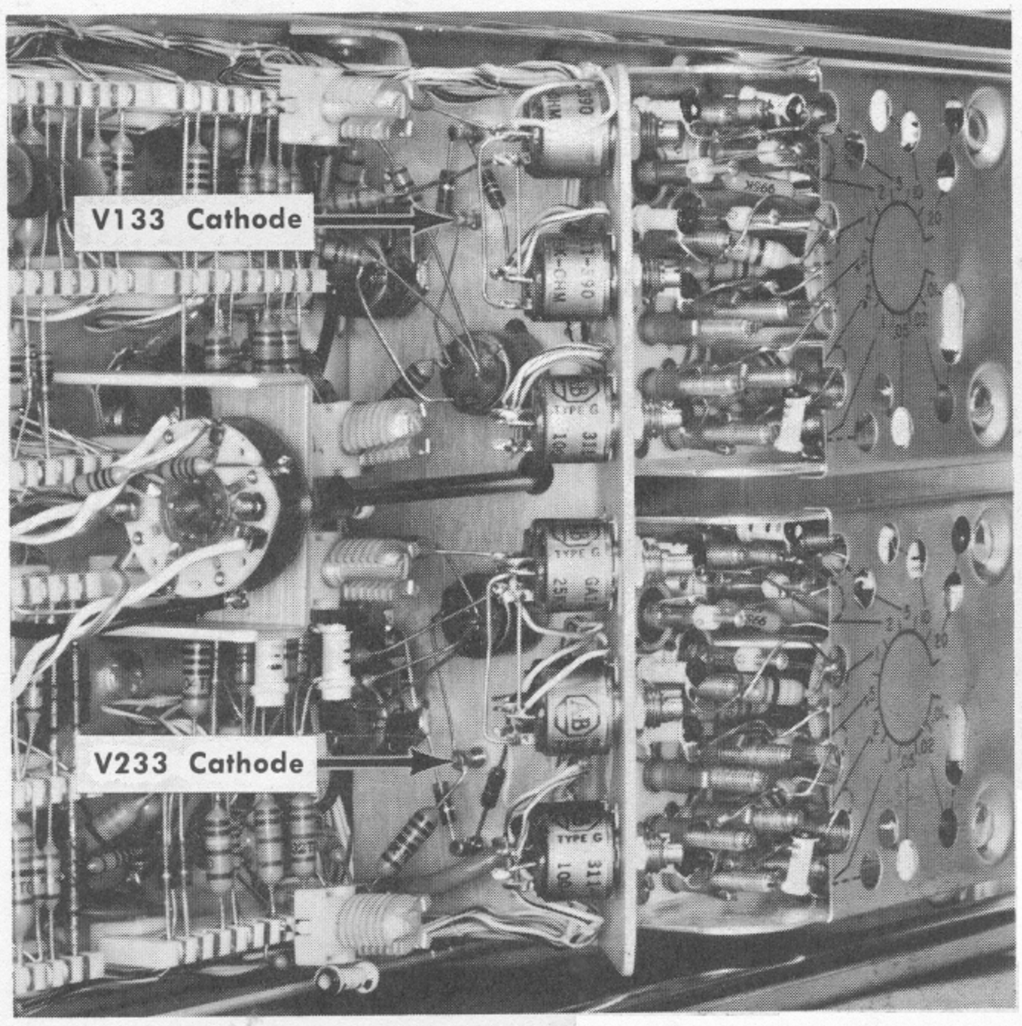


Fig. 4-1. Voltmeter connection points.

b. Adjust ATTEN BAL RANGE R122 (R222) for a meter indication of about +1.2 volts.

c. Disconnect the meter.

2. INV BAL Preliminary Adjustment

a. Adjust INV BAL R160 (R260) to position the trace to the center of the graticule.

3. COM MODE CURRENT Preliminary Adjustment

a. Set the dc voltmeter for at least +10 volts full scale and connect it to TP345 (TP355).

b. Set the MODE switch to CH2 (CH1).

c. Adjust COM MODE CURRENT R150 (R250) for a meter indication of +9 volts.

d. Disconnect the meter and set the MODE switch to CH 1 (CH 2).

4. ATTEN BAL RANGE Final Adjustment (SN 100-359)

a. Note the present position of the trace on the graticule.

b. Turn the CH 1 (CH 2) VARIABLE VOLTS/CM control fully clockwise and note the distance the trace has moved from its previous position.

c. Adjust ATTEN BAL RANGE R122 (R222) to position the trace beyond its previous position by one-half the distance noted in step (b). If necessary, adjust INV BAL R160 (R260) to keep the trace within the graticule area.

d. Turn the CH 1 (CH 2) VARIABLE VOLTS/CM control fully counterclockwise and repeat steps (a) through (c) until no further improvement can be made. Disregard any trace movement which may occur between the clockwise and counterclockwise limits of the VARIABLE VOLTS/CM control.

5. BASE CURRENT Preliminary Adjustment

a. If the trace position with the VARIABLE VOLTS/CM control near midrange differs more than 1 mm from that with the control set at either limit, set the control for the greatest deviation and note the deviation distance. Otherwise go on to step 6.

b. Adjust BASE CURRENT R140 (R240) so that the trace is beyond the position obtained with the VARIABLE VOLTS/CM control set to either limit by about four times the deviation noted in step (a). If necessary, adjust INV BAL R160 (R260) to keep the trace within the graticule area.

6. INV BAL Second Adjustment

a. Notice the present trace position.

b. Pull out the PULL TO INVERT knob.

c. Adjust INV BAL R160 (R260) to return the trace one-half the distance to its previous position.

d. Push in the PULL TO INVERT knob.

e. Repeat steps (a) through (d), if necessary, so that the trace positions differ by less than 2 mm with the PULL TO INVERT knob in or out.

7. VAR ATTEN BAL Adjustment

a. Adjust the front-panel CH 1 (CH 2) VAR ATTEN BAL control so that the trace position is the same with the VARIABLE VOLTS/CM control set fully clockwise as with it set fully counterclockwise.

8. BASE CURRENT Final Adjustment

a. Adjust BASE CURRENT R140 (R240) so that the trace does not move as the VARIABLE VOLTS/CM control is turned throughout its range.

9. INV BAL Final Adjustment

a. Adjust INV BAL R160 (R260) so that the trace position is the same within 2 mm with the PULL TO INVERT knob either pulled out or pushed in.

10. GRID CURRENT ZERO Adjustment

a. Use the CH 1 (CH 2) POSITION control to move the trace to the center of the graticule.

b. Adjust GRID CURRENT ZERO R117 (R217) so that the trace position is the same with the CH 1 (CH 2) AC-DC-GND switch set to DC as with it set to GND.

11. Channel 2 Adjustments

a. Set the MODE switch to CH 2 and repeat steps 1 through 10 for Channel 2.

12. COM MODE CURRENT and MAIN AMP CURRENT Final Adjustments

a. Connect the dc voltmeter to TP453.

b. With the MODE switch set to CH 2, adjust CH 2 COM MODE CURRENT R250 for a 0-volt indication on the meter.

c. Set the MODE switch to ADDED.

d. Adjust CH 1 COM MODE CURRENT R150 for a 0-volt indication on the meter.

e. Set the MODE switch to CH 1.

f. Adjust MAIN AMP CURRENT R336 for a 0-volt indication on the meter.

g. Set the MODE switch to CH 2.

h. Adjust CH 2 COM MODE CURRENT R250 for a 0-volt indication on the meter.

i. Check that the meter indicates 0, ±50 millivolts, with the MODE switch set to CH 1, CH 2, or ADDED. If not, repeat steps (a) through (h).

j. Disconnect the voltmeter.

13. MAIN AMP DIFF BAL Adjustment

a. Set the MODE switch to CH 2.

b. Set the CH 2 POSITION control to align the trace with the graticule centerline.

c. Set the MODE switch to ADDED.

d. Set the CH 1 POSITION control to align the trace with the graticule centerline.

e. Set the MODE switch to CH 1.

f. Adjust MAIN AMP DIFF BAL R335 to align the trace with the graticule centerline.

g. Set the MODE switch to CH 2.

h. Set the CH 2 POSITION control to align the trace with the graticule centerline.

i. Check that the trace remains within 1 minor graticule division (2 mm) of the graticule centerline when the MODE switch is set to either CH 1 or ADDED. If not, repeat steps (a) through (i).

14. NORM TRIG DC BAL Adjustment

a. Set the Type 647 1KC CALIBRATOR switch to .2 VOLTS.

b. Attach a coaxial cable between the Type 647 CAL OUT and the Type 10A2 CH 1 input connectors.

c. Set the MODE switch to CH 1, the TRIGGER switch to NORM, the CH 1 VOLTS/CM switch to .1, the VARIABLE VOLTS/CM controls (both) fully clockwise, the CH 1 AC-DC-GND switch to AC, and the CH 1 POSITION control to center the free-running square-wave display.

d. Set the 11-Series plug-in unit controls for internal, dc-coupled automatic triggering (Type 11B1 Trigger Mode switch should be set to Auto Base Line Manual Level) with the triggering level control set to zero. A triggered display may or may not be obtained.

e. Adjust NORM TRIG DC BAL R546 to obtain a triggered display. Then refine the adjustment so that R546 is centered in the range where the triggered display is obtained with the 1KC CALIBRATOR switch setting reduced to 20 mVOLTS.

f. Disconnect the input signal and restore the free-running sweeps.

15. CH 2 OUT DC LEVEL Adjustment

a. Set both AC-DC-GND switches to GND.

b. Connect a coaxial cable between the CH 2 OUT connector and the CH 1 input connector.

c. Set the CH 1 POSITION control to align the trace with the graticule centerline.

d. Set the CH 1 AC-DC-GND switch to DC.

e. Adjust CH 2 OUT DC LEVEL R530 to align the trace with the graticule centerline.

f. Remove the coaxial cable.

Gain Adjustments

1. GAIN RANGE Adjustment

a. Set the CH 1 and CH 2 VOLTS/CM switches to .01, VARIABLE controls to CALIB, AC-DC-GND switches to AC, and PULL TO INVERT knobs pushed in. Set the MODE switch to CH 1.

b. Set the Type 647 1KC CALIBRATOR switch to 50 mVOLTS.

c. Connect a coaxial cable between the CAL OUT connector and the CH 1 input. You should obtain two free-running sweeps separated by about 5 cm.

d. Adjust GAIN RANGE R176 (R276) so that the separation between the traces is exactly 5 cm.

e. Set MODE switch to CH 2 and repeat steps 1c and 1d for Channel 2.

Attenuator Checks

NOTE

The 1-Kc Calibrator in the Type 647 is used to check the division accuracy of the attenuators in the Type 10A2. Both the calibrator voltage accuracy and the attenuator accuracy are rated at ±2% between 0°C and +40°C. Although unlikely, this could permit an error of ±4% in an attenuator to appear as an acceptable ±2% error. For example, if the calibrator voltage is 2% high and the attenuator output is 4% low, the display amplitude would be only 2% low. To avoid such errors, it is suggested that you determine the actual output voltages of the calibrator within about 0.1%. The Type 647 calibration procedure describes how to check the calibrator voltage accuracy on a dc basis by using a precision dc voltmeter. Record and use the calibration voltage values.

1. Fixed Attenuators Check (CH 2)

a. Set the CH 1 and CH 2 VOLTS/CM switches at .02.

b. Connect the coaxial cable to the CH 2 input.

c. Check that the correct display amplitude is obtained (±2%) at each setting of the VOLTS/CM switch (.02 through 20).

2. Variable Attenuator Check (CH 2)

a. With the VOLTS/CM switch set to 20 and the 1KC CALIBRATOR switch set to 100 VOLTS (square wave), turn the VARIABLE VOLTS/CM control fully counterclockwise and check that the display amplitude is 2 cm or less.

b. Check that the UNCAL lamp is lit.

c. Reset the VARIABLE control to CALIB and check that the UNCAL lamp is not lit.

3. Channel 1 Attenuators

a. Set the MODE switch to CH 1.

b. Set the 1KC CALIBRATOR switch to .1 VOLTS and move the coaxial cable to the CH 1 input.

c. Repeat steps 1c and 2 for Channel 1.

d. Remove the coaxial cable.

Attenuator Compensation and Input Time-Constant Adjustments

NOTE

The numbers on the attenuator cover plates correspond to the VOLTS/CM switch positions. The solid line leading from a number points to the attenuator compensation capacitor for that switch setting. The dashed line is an extension of the solid line and points to the input time-constant standardization capacitor. The single capacitor associated with the .01 VOLTS/CM switch setting is for input time-constant adjustment since no attenuator is used.

1. Attenuator Compensation

a. Set the CH 1 and CH 2 VOLTS/CM switches to .02 and the AC-DC-GND switches to DC.

b. Connect the square-wave generator to the CH 1 input as shown in Fig. 4-2.

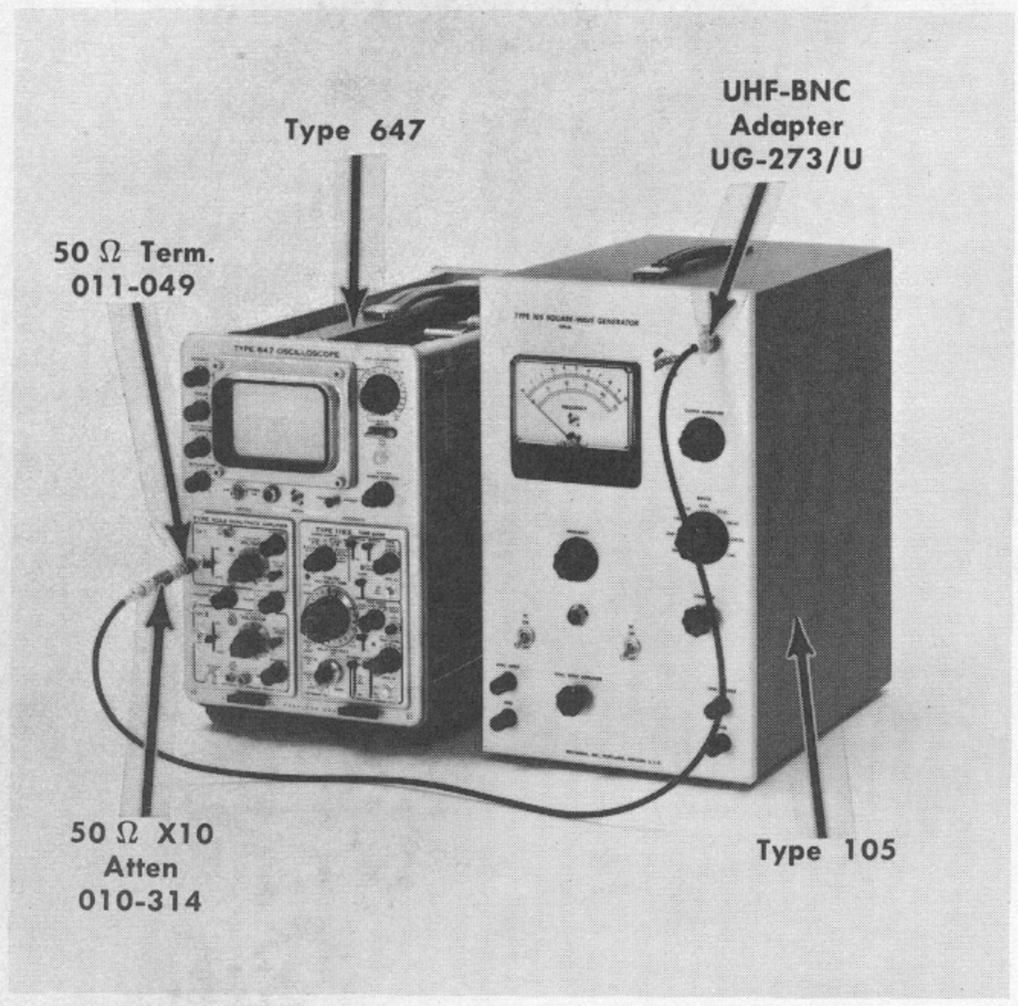


Fig. 4-2. Attenuator compensation setup.

c. With a sweep rate of 0.2 msec/cm, obtain a triggered display of 2.5-kc square waves.

d. Set the generator amplitude control for a display amplitude of about 5 cm.

e. Adjust the .02 VOLTS/CM compensation capacitor (solid line on cover plate) to make the top left corner of the display nearly square.

f. Repeat steps (d) and (e) for each position of the VOLTS/CM switch (.05 through 20).

NOTE

If a Tektronix Type 105 Square-Wave Generator is used, proper amplitude range will be obtained by first removing the X10 attenuator after making the .05 VOLTS/CM adjustment; then remove the 50Ω termination after making the 1 VOLTS/CM adjustment.

g. Set the MODE switch to CH 2 and repeat step 1 (above) for Channel 2.

h. Disconnect the square-wave generator.

2. Input Time-Constant Standardization

a. Set the Type 647 1KC CALIBRATOR switch to .1 VOLTS and both Type 10A2 VOLTS/CM switches to .01.

b. Connect the input time-constant standardizer as shown in Fig. 4-3.

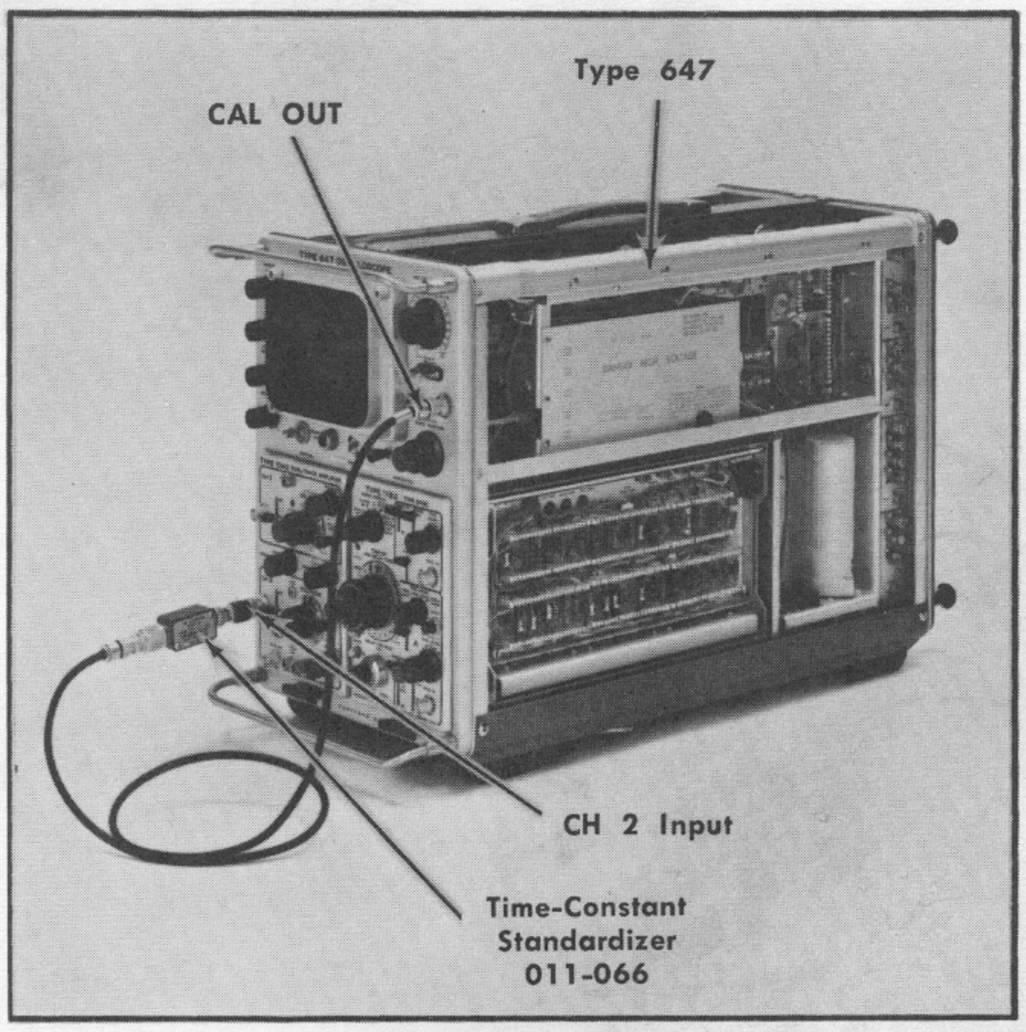


Fig. 4-3. Input time-constant standardization setup.

c. Using a 0.5 msec/cm sweep rate, obtain a triggered display of the square-wave signal. The display amplitude should be about 5 cm.

d. Adjust the .01 VOLTS/CM input time-constant standardizing capacitor to make the top of the displayed square wave as flat and level as possible. Judge the correctness of the adjustment with the alignment tool removed.

e. Set the VOLTS/CM switch to .02.

f. Set the 1KC CALIBRATOR switch to .2 VOLTS.

g. Adjust each input time-constant standardizing capacitor for the remaining settings of the VOLTS/CM switch (.02 through 20). Change the setting of the 1KC CALIBRATOR switch as required to provide either a 4- or 5-cm display amplitude at each setting of the VOLTS/CM switch.

h. Set the MODE switch to CH 1 and repeat step 2 (above) for Channel 1.

i. Remove the cable and standardizer.

High-Frequency Response Adjustments

1. Set the Type 10A2 controls as follows:

CH 1 and CH 2	
VOLTS/CM	.01
VARIABLE	CALIB
POSITION	Midrange
AC-DC-GND	DC
TRIGGER	NORM
MODE	CH 1

2. Connect the pulse generator to the Type 10A2 CH 1 input as shown in Fig. 4-4.

3. Set the pulse generator controls for positive-going pulses of about 50-mv amplitude.

4. Set the time-base plug-in unit controls for a 20 nsec/cm sweep rate (0.2 μsec/cm, 10X magnifier) and internally triggered sweeps with + slope and ac coupling.

NOTE

It may be necessary to darken the room and set the INTENSITY control more clockwise to view the display. A viewing hood may also be helpful. The display should be a positive pulse of about 5-cm amplitude.

5. Adjust C169, C176 and R159* (C269, C276 and R259*) in the CH 1 (CH 2) Input Amplifier for the squarest pulse corner with minimum ringing.

6. Adjust L465 for the squarest pulse corner.

7. Set the MODE switch to CH 2 and move the signal connection to the CH 2 input.

8. Repeat step 5 for Channel 2.

Vertical-System Risetime

1. Use the same setup and display as described under "High-Frequency Response Adjustments."

2. Set the pulse generator so that the displayed pulse amplitude is 5 cm.

3. Set the time-base plug-in unit sweep rate to 10 nsec/cm (0.01 μsec/cm, 10X magnifier).

4. Check that the 10% to 90% risetime is 7 nsec or less.

5. Check the other channel risetime in the same manner.

6. Disconnect the pulse generator.

Functional Checks

1. Chop Mode

a. Set the time-base plug-in unit controls for a free-running sweep at 0.5 μsec/cm (non-magnified).

b. Set the Type 10A2 MODE switch to CHOP. With the CH 1 and CH 2 POSITION controls properly adjusted, you should obtain two traces.

***Added at SN 1150.**

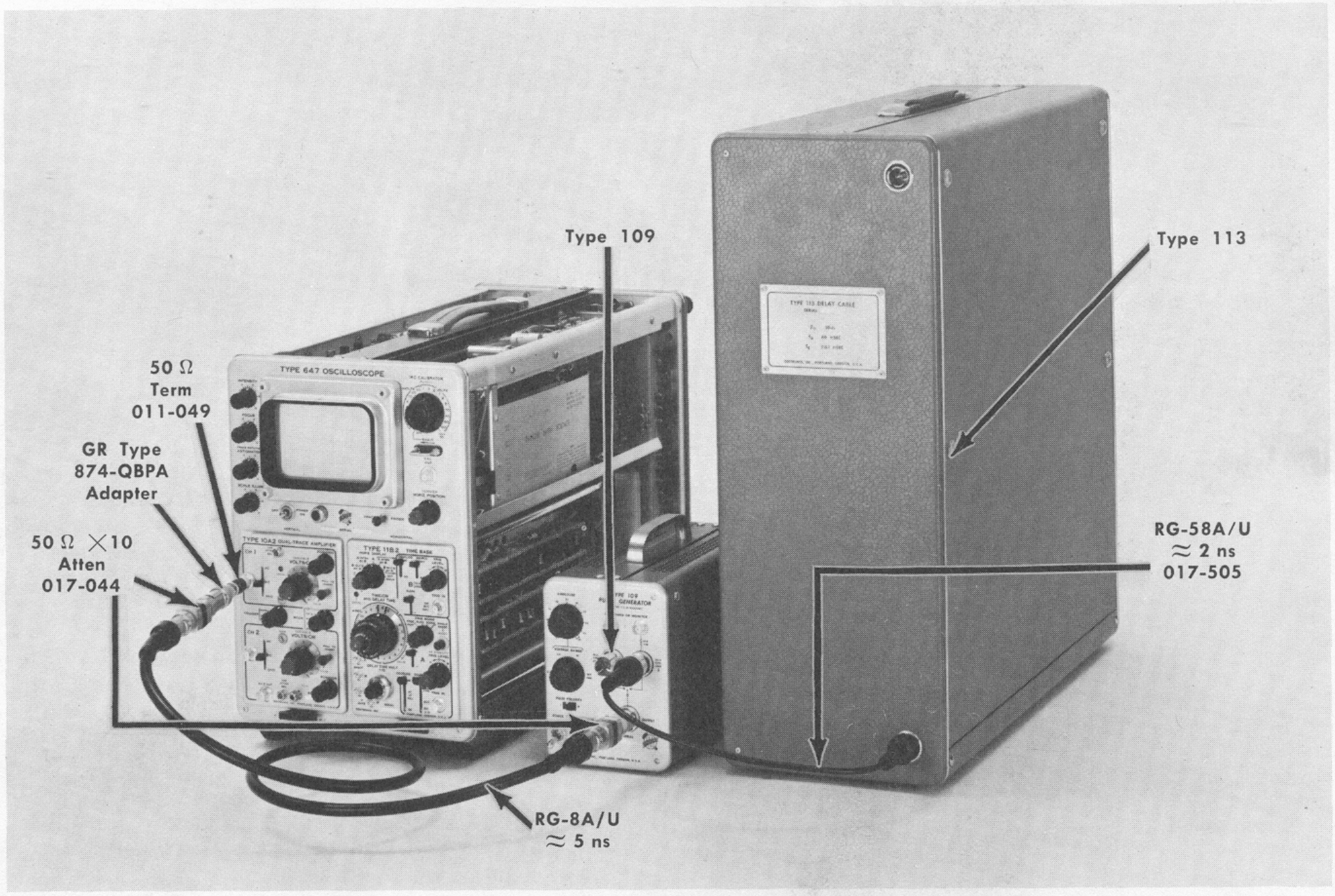


Fig. 4-4. High-frequency compensation adjustments setup.

2. Chop Blanking

a. Position one trace near the top of the graticule and one near the bottom

b. Set the time-base plug-in unit controls for triggered sweeps. You should obtain what appears to be a square-wave display. However, the rising and falling portions of the display should not be visible except when the intensity of the top and bottom portions is unnecessarily high.

3. Alternate Mode

a. Set the time-base plug-in unit controls for free-running sweeps at 20 msec/cm.

b. Set the Type 10A2 MODE switch to ALTER. The traces should now be displayed alternately.

4. Channel 2 Output Signal Amplitude

a. Set the CH 1 VOLTS/CM switch to .1, CH 2 VOLTS/CM switch to .01, and the MODE switch to CH 1.

b. Set the Type 647 1KC CALIBRATOR switch to 20 mVOLTS.

c. Connect a coaxial lead between the CAL OUT and the CH 2 input connectors.

d. Connect a coaxial lead between the CH 2 OUT and the CH 1 input connectors.

e. Set the time-base plug-in unit controls for internally triggered sweeps at 0.5 msec/cm. You should obtain a square-wave display between 2 and 3 cm in amplitude.

SECTION 5
PARTS LIST AND SCHEMATICS

PARTS ORDERING INFORMATION

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

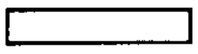
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information 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.

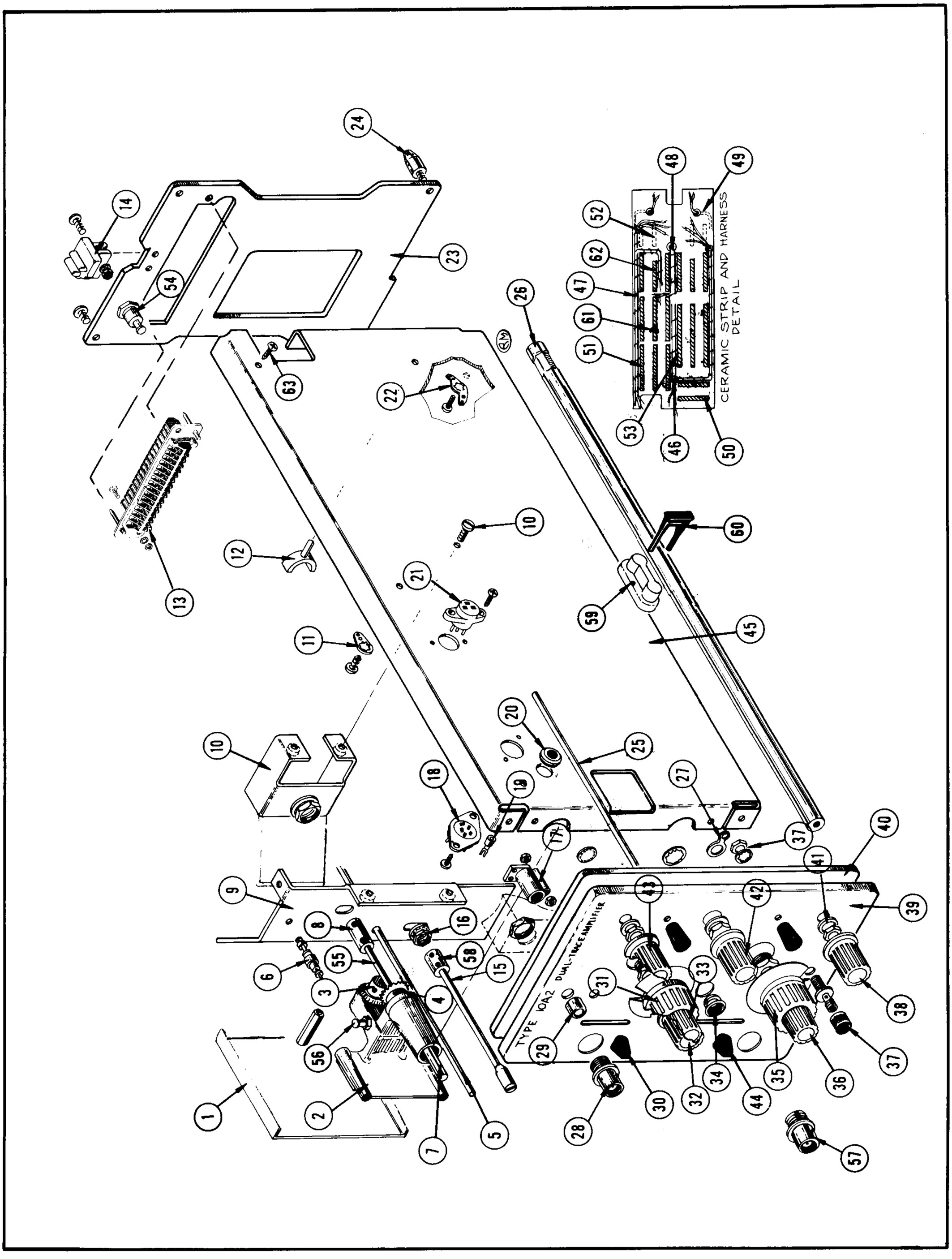
ABBREVIATIONS AND SYMBOLS

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

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/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-0582-00			2	SHIELD, attenuator
	. . . . .			.	Mounting Hardware For Each: (not included)
	361-0056-00			4	SPACER, hex
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
2	214-0348-00			2	CASTING, attenuator
	. . . . .			.	Mounting Hardware For Each: (not included)
	211-0538-00			2	SCREW, 6-32 x 5/16 inch FHS phillips
	358-0029-00			1	BUSHING, panel
3	214-0350-00			2	GEAR, miter
	. . . . .			.	Each Includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch HSS allen head
4	214-0272-00			2	GEAR, miter
	. . . . .			.	Each Includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch HSS allen head
	210-0839-00			2	WASHER, 1/4 ID x 7/16 inch OD; rippled
5	384-0273-00			1	ROD, extension
6	131-0183-00			4	CONNECTOR, feed thru
	358-0136-00			4	BUSHING, teflon
7	384-0281-00			2	ROD, extension
8	376-0030-00	100	1109	2	COUPLING, rod
	376-0050-00	1110		2	COUPLING, flexible
	- - - - - -			-	each coupling includes:
	354-0251-00	X1110		2	RING, coupling
	376-0046-00	X1110		1	COUPLING, delrin
	213-0048-00	100	1109	2	SCREW, set, 4-40 x 1/8 inch HSS
	213-0022-00	1110		4	SCREW, set, 4-40 x 3/16 inch HSS
9	406-0916-00			1	BRACKET, pot
	. . . . .			.	Mounting Hardware: (not included)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch BHS
	210-0803-00			2	WASHER, 6L x 3/8 inch
10	406-0919-00	100	649	1	BRACKET, switch
	407-0114-00	650		1	BRACKET, switch
	. . . . .			.	Mounting Hardware: (not included)
	211-0504-00			2	SCREW, 6-32 x 1/4 inch BHS
11	210-0201-00			1	LUG, solder, SE 4
	. . . . .			.	Mounting Hardware For Each: (not included)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS phillips
12	426-0121-00			2	MOUNT, toroid
	361-0007-00			2	SPACER, nylon
13	131-0096-00			1	CONNECTOR, chassis mount, 32 pin
	. . . . .			.	Mounting Hardware: (not included)
	210-0201-00			2	LUG, solder, SE 4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0008-00			2	SCREW, 4-40 x 1/4 inch BHS
	210-0004-00	X360		2	LOCKWASHER, int. #4
14	351-0063-00			2	GUIDE, shoe
	. . . . .			.	Mounting Hardware For Each: (not included)
	210-0004-00			2	LOCKWASHER, int. #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0013-00			2	SCREW, 4-40 x 3/8 inch BHS

EXPLODED VIEW *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
15	384-0272-00			2	ROD, extension
16	. . . . .			.	Pot Mounting Hardware
	210-0583-00			1	NUT, hex, 1/4-32 x 1/16 inch
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD
	210-0046-00			1	LOCKWASHER, internal, 0.261 ID x 0.400 inch OD
17	352-0067-00			2	HOLDER, neon
	. . . . .			.	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0031-00	100	1809	1	SCREW, 4-40 x 1 inch FHS
	211-0109-00	1810		1	SCREW, 4-40 x 7/8 inch FHS
	378-0541-00			2	FILTER, lens
18	136-0101-00			2	SOCKET, 5 pin tube
	. . . . .			.	Mounting Hardware For Each: (not included)
	213-0055-00			2	SCREW, thread forming, 2-56 x 3/16 inch PHS phillips
19	131-0235-00			2	CONNECTOR, terminal
	358-0136-00			2	BUSHING, teflon
20	348-0003-00			14	GROMMET, rubber 5/16 inch
21	136-0161-00	100	989	38	SOCKET, 3 pin transistor
	136-0181-00	990		38	SOCKET, 3 pin transistor
	. . . . .			.	Mounting Hardware For Each: (not included)
	213-0113-00	100	989	2	SCREW, thread forming, 2-32 x 5/16 inch PHS phillips
	354-0234-00	990		1	RING, locking, transistor socket
22	210-0204-00			3	LUG, solder, DE 6
	. . . . .			.	Mounting Hardware For Each: (not included)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch
23	387-0777-00			1	PLATE, rear
24	214-0370-00			2	PIN, locating
25	384-0275-00			2	ROD, slide switch with molded knob
26	384-0615-00			4	ROD, spacer
	. . . . .			.	Mounting Hardware For Each: (not included)
	212-0044-00			1	SCREW, 8-32 x 1/2 inch RHS phillips
27	210-0223-00			3	LUG, solder, 1/4 inch
28	131-0342-00			3	CONNECTOR, chassis mount
	. . . . .			.	Mounting Hardware For Each:
	210-0012-00			1	LOCKWASHER, int, 3/8 x 1/2 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
29	358-0075-00			2	BUSHING, pot
30	366-0215-00	100	829	1	KNOB, lever, AC-DC-GND, charcoal
	366-0215-01	830		1	KNOB, lever, AC-DC-GND, charcoal
31	366-0230-00			1	KNOB, VOLTS/CM, large charcoal
	. . . . .			.	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
32	366-0225-00			1	KNOB, TRIGGER, charcoal
	. . . . .			.	Includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
33	366-0081-00			1	KNOB, VARIABLE, small red
	. . . . .			.	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
34	358-0216-00			2	BUSHING, front panel
35	366-0230-00			1	KNOB, VOLTS/CM, large charcoal
	. . . . .			.	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS allen head
36	366-0081-00			1	KNOB, VARIABLE, small red
	. . . . .			.	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS allen head

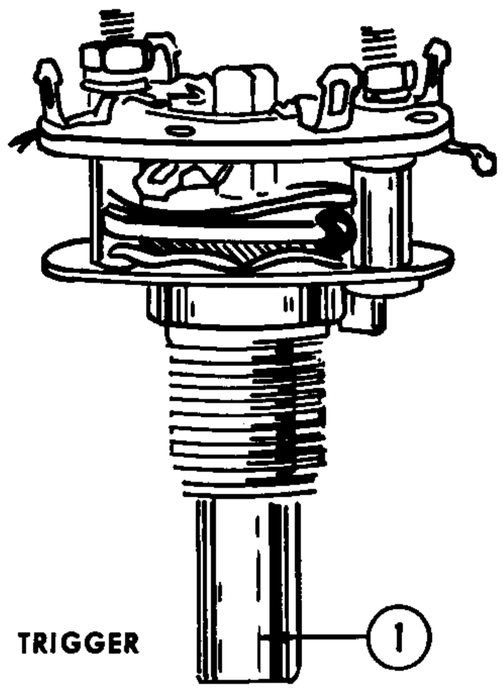
EXPLODED VIEW *(Cont'd)*

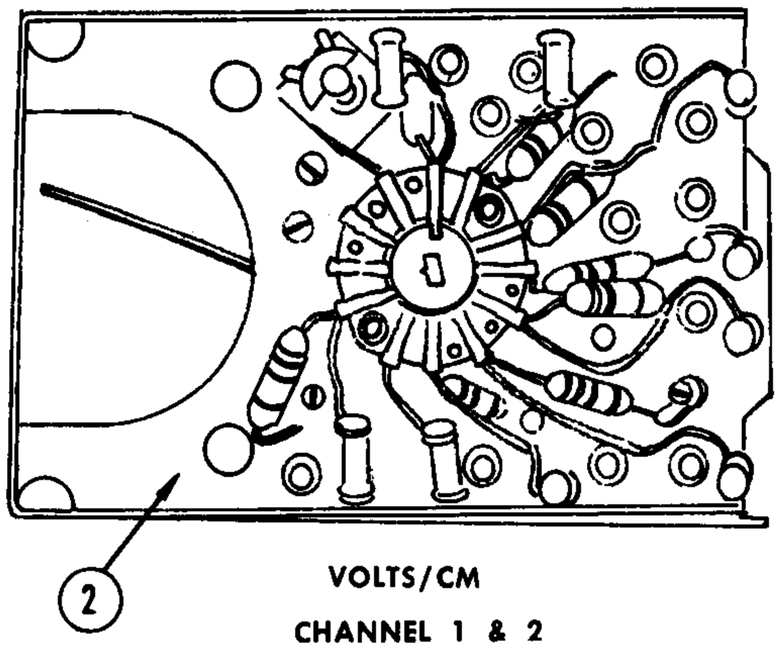
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
37	129-0035-00			1	POST, ground assembly
	. . . . .			.	Includes:
	200-0103-00			1	CAP
	210-0046-00			1	LOCKWASHER, Int., .400 OD x .261 inch ID
	210-0455-00			1	NUT, hex, 1/4-28 x 3/8 inch
	355-0507-00			1	STEM, adapter
38	366-0225-00			1	KNOB, POSITION, charcoal
	. . . . .			.	Includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
39	333-0751-00	100	809	1	PANEL, front
	333-0905-00	810		1	PANEL, front
40	387-0784-00			1	PLATE, front subpanel
41	. . . . .			.	Pot Mounting Hardware
	210-0583-00			1	NUT, hex, 1/4-32 x 5/16 inch
	210-0940-00			1	WASHER, 1/4 ID x 3/8 inch OD
42	366-0220-00			1	KNOB, MODE, charcoal
	. . . . .			.	Includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
43	366-0225-00			1	KNOB, POSITION, charcoal
	. . . . .			.	Includes:
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch HSS allen head
44	366-0215-00	100	829	1	KNOB, lever, AC-DC-GND, charcoal
	366-0215-01	830		1	KNOB, lever, AC-DC-GND, charcoal
45	441-0491-00			1	CHASSIS
	. . . . .			.	Mounting Hardware: (not included)
	210-0457-00			3	NUT, keps, 6-32 x 5/16 inch
	211-0507-00			4	SCREW, 6-32 x 5/16 inch BHS
	211-0538-00			4	SCREW, 6-32 x 5/16 inch FHS phillips
46	179-0759-00			1	CABLE, harness, Channel 2
47	179-0758-00			1	CABLE, harness, Channel 1
48	179-0760-00			1	CABLE, harness, MODE switch
49	179-0797-00			2	CABLE, harness, input
50	124-0147-00			6	STRIP, ceramic, 7/16 inch x 13 notches
	- - - - - -			-	Mounting Hardware for each: (not included)
	361-0009-00			2	SPACER, nylon
51	124-0146-00			6	STRIP, ceramic, 7/16 inch x 16 notches
	- - - - - -			-	Mounting Hardware for each: (not included)
	361-0009-00			2	SPACER, nylon
52	124-0148-00			4	STRIP, ceramic, 7/16 inch x 9 notches
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
53	124-0145-00			3	STRIP, ceramic, 7/16 inch x 20 notches
	- - - - - -			-	Mounting Hardware for each: (not included)
	361-0009-00			2	SPACER, nylon

EXPLODED VIEW *(Cont'd)*

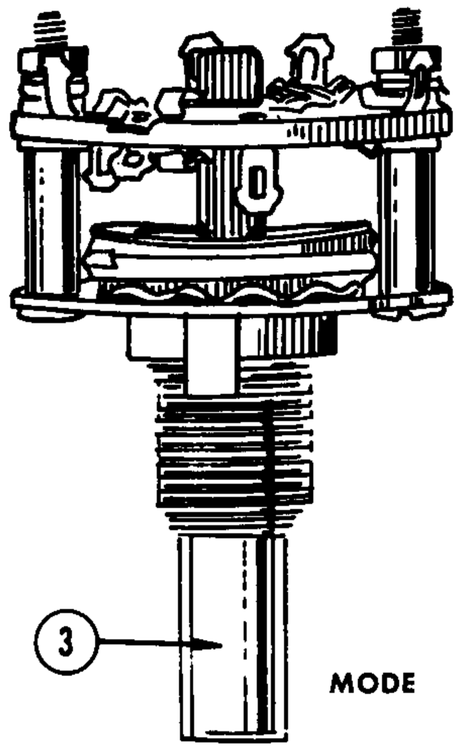
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
54	129-0006-00	X152		1	POST, connecting
	- - - - - -			-	mounting hardware: (not included w/post)
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0407-00			1	NUT, hex, 6-32 x 1/4 inch
55	384-0276-00			2	ROD, extension
56	129-0070-00			2	POST, terminal tie
57	131-0106-00			1	CONNECTOR, single contact, BNC
58	376-0029-00			2	COUPLING, shaft
	- - - - - -			-	each coupling includes:
	213-0048-00			2	SCREW, set, 4-40 x 1/8 inch HSS
59	200-0497-00			5	COVER, temperature stabilizer
60	352-0072-00			5	HOLDER, cover
61	344-0105-00			6	CLIP, test point
62	124-0148-00			2	STRIP, ceramic, 7/16 inch x 9 notches
	- - - - - -			-	mounting hardware for each: (not included w/strip)
	361-0009-00			2	SPACER, nylon
63	213-0088-00			1	SCREW, thread forming, 4-40 x 1/4 inch PHS

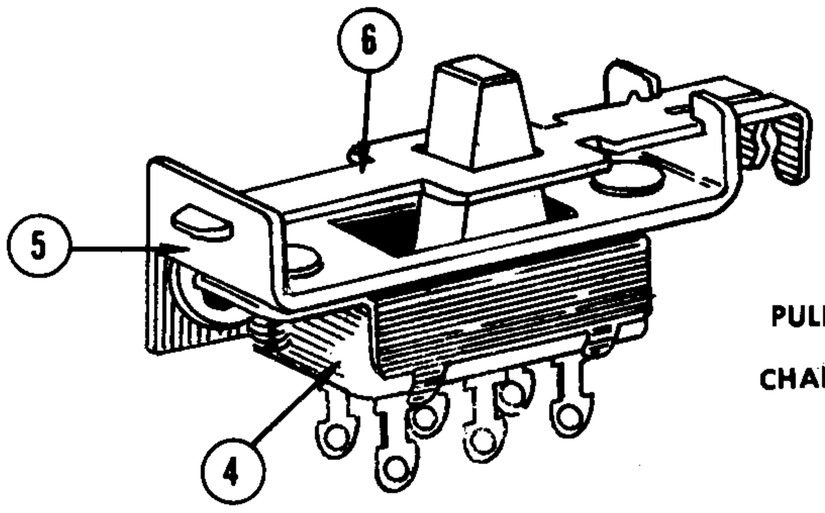
SWITCHES



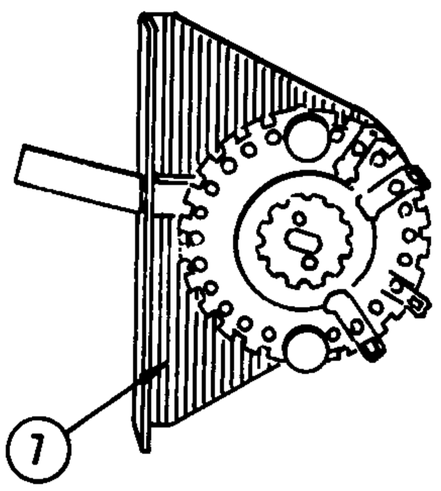


VOLTS/CM
CHANNEL 1 & 2





PULL TO INVERT
CHANNEL 1 & 2



AC-DC-GND
CHANNEL 1 & 2

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	260-0523-00			1	SWITCH, TRIGGER, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0012-00			1	LOCKWASHER, internal $^3/_8$ x $^1/_2$ inch
	210-0413-00			1	NUT, hex, $^3/_8$-32 x $^1/_2$ inch
	210-0840-00	100	429	1	LUG, solder, pot
	210-0255-00	430		1	WASHER, flat
2	262-0566-00	100	2218	2	SWITCH, VOLTS/CM, wired Channel 1 and 2
	262-0566-01	2219		2	SWITCH, VOLTS/CM, wired Channel 1 and 2
	- - - - - -			-	Each Includes:
	260-0522-00			1	SWITCH, VOLTS/CM, wired Channel 1 and 2
	- - - - - -			-	Mounting Hardware For Each: (not included)
	211-0008-00			1	SCREW, 4-40 x $^1/_4$ inch BHS
	343-0088-00	X1540		1	CLAMP, cable, size "C" (not shown)
3	260-0524-00			1	SWITCH, MODE, unwired
	- - - - - -			-	Mounting Hardware: (not included)
	210-0012-00			1	LOCKWASHER, internal $^3/_8$ x $^1/_2$ inch
	210-0413-00			1	NUT, hex, $^3/_8$-32 x $^1/_2$ inch
	210-0840-00			1	WASHER, flat
4	260-0447-00			2	SWITCH, slide PULL TO INVERT, unwired Channel 1 and 2
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, 4-40 x $^3/_{16}$ inch
5	406-0917-00			2	BRACKET, slide switch
	- - - - - -			-	Mounting Hardware For Each: not included)
	211-0504-00			2	SCREW, 6-32 x $^1/_4$ inch
6	406-0918-00			2	BRACKET, slide switch actuator
7	260-0492-00			2	SWITCH, lever AC-DC-GND, Channel 1 and 2
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0004-00			2	LOCKWASHER, internal #4
	210-0406-00			2	NUT, hex, 4-40 x $^3/_{16}$ inch
					STANDARD ACCESSORIES
	070-0376-00			2	MANUAL, instruction (not shown)

NOTES

ELECTRICAL PARTS

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description			S/N Range
		Bulbs			
B119	150-030	Neon NE 2V			
B144	150-027	Neon NE 23		UNCAL	100-1809
B144	150-0030-00	Neon NE 2V			1810-up
B219	150-030	Neon NE 2V			
B244	150-027	Neon NE 23		UNCAL	100-1809
B244	150-0030-00	Neon NE 2V			1810-up

Capacitors

Tolerance ±20% unless otherwise indicated.

Tolerance of all electrolytic capacitors as follows (with exceptions):

3V — 50V = —10%, +250%

51V — 350V = —10%, +100%

351V — 450V = —10%, +50%

C101	*285-634	.1 μf	MT		600 v	10%
C102	281-558	18 pf	Cer		500 v	
C103	281-064	.2-1.5 pf	Tub	Var		
C104A	Use 281-547	2.7 pf	Cer		500 v	10%
C104B	281-064	.2-1.5 pf	Tub	Var		
C104C	281-081	1.8-13 pf	Air	Var	800 v	
C104D	281-592	4.7 pf	Cer			±.5 pf
C105A	281-572	6.8 pf	Cer		500 v	10%
C105B	281-027	.7-3 pf	Tub	Var		
C105C	281-027	.7-3 pf	Tub	Var		
C106A	281-572	6.8 pf	Cer		500 v	10%
C106B	281-027	.7-3 pf	Tub	Var		
C106C	281-027	.7-3 pf	Tub	Var		
C107A	281-572	6.8 pf	Cer		500 v	10%
C107B	281-027	.7-3 pf	Tub	Var		
C107C	281-027	.7-3 pf	Tub	Var		
C107E	281-512	27 pf	Cer		500 v	10%
C108A	281-503	8 pf	Cer		500 v	±.5 pf
C108B	281-027	.7-3 pf	Tub	Var		
C108C	281-027	.7-3 pf	Tub	Var		
C108E	281-519	47 pf	Cer		500 v	10%
C109A	281-503	8 pf	Cer		500 v	±.5 pf
C109B	281-027	.7-3 pf	Tub	Var		
C109C, C109E	281-071	.2-1.5 pf/100 pf	Mica	Var		10%
C110A	281-503	8 pf	Cer		500 v	±.5 pf
C110B	281-027	.7-3 pf	Tub	Var		
C110C, C110E	281-069	.2-1.5 pf/200 pf	Mica	Var		10%

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C111A	281-503	8 pf	Cer		500 v	±.5 pf	
C111B	281-027	.7-3 pf	Tub	Var			
C111C C111E	281-072	.2-1.5 pf/500 pf	Mica	Var		10%	
C112A	281-503	8 pf	Cer		500 v	±.5 pf	
C112B	281-027	.7-3 pf	Tub	Var			
C112C C112E	281-073	.2-1.5 pf/1000 pf	Mica	Var		10%	
C113A	281-503	8 pf	Cer		500 v	±.5 pf	
C113B	281-027	.7-3 pf	Tub	Var			
C113C C113E	281-074	.2-1.5 pf/2000 pf	Mica	Var		10%	
C118	281-614	.0068 pf	Cer		500 v		
C123	283-079	.01 μf	Cer		250 v		100-989
C123	283-0003-00	.01 μf	Cer		150 v		990-up
C124	283-0003-00	.01 μf	Cer		150 v		X990-up
C130	285-622	.1 μf	PTM		100 v		
C131	283-079	.01 μf	Cer		250 v		
C132	281-519	47 pf	Cer		500 v	10%	
C134	283-081	.1 μf	Cer		25 v		
C159	281-577	14 pf	Cer		500 v	5%	100-1149
C159	281-0572-00	6.8 pf	Cer		500 v	10%	1150-up
C169	Use 281-0103-00	1.8-13 pf	Air	Var			
C176	Use 281-0103-00	1.8-13 pf	Air	Var			
C192	281-504	10 pf	Cer		500 v	10%	
C193	281-504	10 pf	Cer		500 v	10%	
C199	290-183	1 μf	EMT		20 v	10%	
C201	*285-634	.1 μf	MT		600 v	10%	
C202	281-558	18 pf	Cer		500 v		
C203	281-064	.2-1.5 pf	Tub	Var			
C204A	Use 281-547	2.7 pf	Cer		500 v	10%	
C204B	281-064	.2-1.5 pf	Tub	Var			
C204C	281-081	1.8-13 pf	Air	Var	800 v		
C204D	281-592	4.7 pf	Cer			±.5 pf	
C205A	281-572	6.8 pf	Cer		500 v	10%	
C205B	281-027	.7-3 pf	Tub	Var			
C205C	281-027	.7-3 pf	Tub	Var			
C206A	281-572	6.8 pf	Cer		500 v	10%	
C206B	281-027	.7-3 pf	Tub	Var			
C206C	281-027	.7-3 pf	Tub	Var			
C207A	281-572	6.8 pf	Cer		500 v	10%	
C207B	281-027	.7-3 pf	Tub	Var			
C207C	281-027	.7-3 pf	Tub	Var			
C207E	281-512	27 pf	Cer		500 v	10%	
C208A	281-503	8 pf	Cer		500 v	±.5 pf	
C208B	281-027	.7-3 pf	Tub	Var			
C208C	281-027	.7-3 pf	Tub	Var			
C208E	281-519	47 pf	Cer		500 v	10%	
C209A	281-503	8 pf	Cer		500 v	±.5 pf	
C209B	281-027	.7-3 pf	Tub	Var			

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
C209C C209E	281-071	.2-1.5 pf/100 pf	Mica	Var		10%	
C210A	281-503	8 pf	Cer		500 v	±.5 pf	
C210B	281-027	.7-3 pf	Tub	Var			
C210C C210E	281-069	.2-1.5 pf/200 pf	Mica	Var		10%	
C211A	281-503	8 pf	Cer		500 v	±.5 pf	
C211B	281-027	.7-3 pf	Tub	Var			
C211C C211E	281-072	.2-1.5 pf/500 pf	Mica	Var		10%	
C212A	281-503	8 pf	Cer		500 v	±.5 pf	
C212B	281-027	.7-3 pf	Tub	Var			
C212C C212E	281-073	.2-1.5 pf/1000 pf	Mica	Var		10%	
C213A	281-503	8 pf	Cer		500 v	±.5 pf	
C213B	281-027	.7-3 pf	Tub	Var			
C213C C213E	281-074	.2-1.5 pf/2000 pf	Mica	Var		10%	
C218	281-614	.0068 μf	Cer		500 v		
C223	283-079	.01 μf	Cer		250 v		100-989
C223	283-0003-00	.01 μf	Cer		150 v		990-up
C224	283-0003-00	.01 μf	Cer		150 v		X990-up
C230	285-622	.1 μf	PTM		100 v		
C231	283-079	.01 μf	Cer		250 v		
C232	281-519	47 pf	Cer		500 v	10%	
C234	283-081	.1 μf	Cer		25 v		
C259	281-577	14 pf	Cer		500 v	5%	100-1149
C259	281-0572-00	6.8 pf	Cer		500 v	10%	1150-up
C269	Use 281-0103-00	1.8-13 pf	Air	Var			
C271	281-519	47 pf	Cer		500 v	10%	
C276	Use 281-0103-00	1.8-13 pf	Air	Var			
C281	281-519	47 pf	Cer		500 v	10%	
C292	281-504	10 pf	Cer		500 v	10%	
C293	281-504	10 pf	Cer		500 v	10%	
C299	290-183	1 μf	EMT		20 v	10%	
C314	283-078	.001 μf	Cer		500 v		
C334	283-078	.001 μf	Cer		500 v		
C343	283-084	270 μf	Cer		1000 v	5%	
C344	283-080	.022 μf	Cer		25 v		
C348	283-088	.0011 μf	Cer		500 v	5%	
C353	283-084	270 pf	Cer		1000 v	5%	
C354	283-080	.022 μf	Cer		25 v		
C366	283-084	270 pf	Cer		1000 v	5%	
C367	283-095	56 pf	Cer		200 v	10%	
C371	283-080	.022 μf	Cer		25 v		
C382	283-080	.022 μf	Cer		25 v		
C387	283-084	270 pf	Cer		1000 v	5%	
C390	283-080	.022 μf	Cer		25 v		
C452	283-081	.1 μf	Cer		25 v		
C462	281-578	18 pf	Cer		500 v	5%	
C483	283-080	.022 μf	Cer		25 v		
C497	283-080	.022 μf	Cer		25 v		
C498	283-080	.022 μf	Cer		25 v		
C550	281-519	47 pf	Cer		500 v	10%	
C560	281-519	47 pf	Cer		500 v	10%	

Diodes

Ckt. No.	Tektronix Part No.	Description	S/N Range
D125	*152-061	Silicon Tek Spec	
D133	*152-075	Germanium Tek Spec	
D157	Use *152-0185-00	Silicon Replaceable by 1N3605	
D192	*152-075	Germanium Tek Spec	
D193	*152-075	Germanium Tek Spec	
D225	*152-061	Silicon Tek Spec	
D233	*152-075	Germanium Tek Spec	
D257	Use *152-0185-00	Silicon Replaceable by 1N3605	
D292	*152-075	Germanium Tek Spec	
D293	*152-075	Germanium Tek Spec	
D302	152-065	Silicon HD5000	
D305	152-065	Silicon HD5000	
D309	152-065	Silicon HD5000	
D312	152-065	Silicon HD5000	
D322	152-065	Silicon HD5000	
D325	152-065	Silicon HD5000	
D329	152-065	Silicon HD5000	
D332	152-065	Silicon HD5000	
D348	*152-075	Germanium Tek Spec	
D358	*152-075	Germanium Tek Spec	
D369	*152-075	Germanium Tek Spec	
D387	Use *152-0185-00	Silicon Replaceable by 1N3605	
D391	*152-075	Germanium Tek Spec	
D392	152-065	Silicon HD5000	

Inductors

L314	276-0507-00	Core, Ferramic Suppressor			X1150
L334	276-0507-00	Core, Ferramic Suppressor			X1150
L343	276-507	Core, Ferramic Suppressor			
L353	276-507	Core, Ferramic Suppressor			
L390	108-226	100 μh			
L392	*108-146	5 μh			
L434	*108-260	.1 μh			
L444	*108-260	.1 μh			
L465	*114-160	.1-.12 μh	Var	Core not replaceable	
L504	*108-211	.5 μh			
L514	*108-211	.5 μh			
L527	*108-260	.1 μh			
L554	*108-112	.3 μh			
L564	*108-112	.3 μh			
L577	*108-220	.15 μh			

Resistors

Resistors are fixed, composition, $\pm$10% unless otherwise indicated.

R102	315-470	47 Ω	1/4 w		5%	
R104C	322-610	500 k	1/4 w	Prec	1%	100-2218
R104C	322-0610-01	500 k	1/4 w	Prec	1/2%	2219-up
R104E	322-481	1 meg	1/4 w	Prec	1%	100-2218
R104E	322-0481-01	1 meg	1/4 w	Prec	1/2%	2219-up

Resistors (Cont'd)

Ckt. No.	Tektronix Part No.		Description				S/N Range
R105C	323-620	800 k	½ w		Prec	1%	100-2218
R105C	323-0620-01	800 k	½ w		Prec	½%	2219-up
R105E	321-618	250 k	⅛ w		Prec	1%	100-2218
R105E	321-0618-01	250 k	⅛ w		Prec	½%	2219-up
R106C	323-611	900 k	½ w		Prec	1%	100-2218
R106C	323-0611-01	900 k	½ w		Prec	½%	2219-up
R106E	321-617	111 k	⅛ w		Prec	1%	100-2218
R106E	321-1389-01	111 k	⅛ w		Prec	½%	2219-up
R107C	323-612	950 k	½ w		Prec	1%	100-2218
R107C	323-0612-01	950 k	½ w		Prec	½%	2219-up
R107E	321-616	52.6 k	⅛ w		Prec	1%	100-2218
R107E	321-0616-01	52.6 k	⅛ w		Prec	½%	2219-up
R108C	323-621	980 k	½ w		Prec	1%	100-2218
R108C	323-0621-01	980 k	½ w		Prec	½%	2219-up
R108E	321-615	20.4 k	⅛ w		Prec	1%	100-2218
R108E	321-0615-01	20.4 k	⅛ w		Prec	½%	2219-up
R109C	323-614	990 k	½ w		Prec	1%	100-2218
R109C	323-0614-01	990 k	½ w		Prec	½%	2219-up
R109D	315-470	47 Ω	¼ w			5%	
R109E	321-614	10.1 k	⅛ w		Prec	1%	100-2218
R109E	321-1289-01	10.1 k	⅛ w		Prec	½%	2219-up
R110C	322-625	995 k	¼ w		Prec	1%	100-2218
R110C	322-0625-01	995 k	¼ w		Prec	½%	2219-up
R110D	315-620	62 Ω	¼ w			5%	
R110E	321-613	5.03 k	⅛ w		Prec	1%	100-2218
R110E	321-0613-01	5.03 k	⅛ w		Prec	½%	2219-up
R111C	322-628	998 k	¼ w		Prec	1%	100-2218
R111C	322-0628-01	998 k	¼w		Prec	½%	2219-up
R111D	315-220	22 Ω	¼ w			5%	
R111E	321-222	2 k	⅛ w		Prec	1%	100-2218
R111E	321-0222-01	2 k	⅛ w		Prec	½%	2219-up
R112C	322-629	999 k	¼ w		Prec	1%	100-2218
R112C	322-0629-01	999 k	¼ w		Prec	½%	2219-up
R112D	315-330	33 Ω	¼ w			5%	
R112E	321-193	1 k	⅛ w		Prec	1%	100-2218
R112E	321-0193-01	1 k	⅛ w		Prec	½%	2219-up
R113C	323-481	1 meg	½ w		Prec	1%	100-2218
R113C	323-0481-01	1 meg	½ w		Prec	½%	2219-up
R113D	315-300	30 Ω	¼ w			5%	
R113E	321-612	500 Ω	⅛ w		Prec	1%	100-2218
R113E	321-0612-01	500 Ω	⅛ w		Prec	½%	2219-up
R114	323-481	1 meg	½ w		Prec	1%	100-2218
R114	323-0481-00	1 meg	½ w		Prec	½%	2219-up
R115	316-101	100 Ω	¼ w				
R116	316-104	100 k	¼ w	Var		CH 1 GRID CURRENT ZERO	
R117	311-390	25 k				5%	
R118	301-105	1 meg	½ w				
R119	316-100	10 Ω	¼ w				
R120	311-328	1 k		Var		VAR ATTEN BAL	100-359
R120	311-387	5 k		Var		VAR ATTEN BAL	360-up
R121	321-209	1.47 k	⅛ w		Prec	1%	
R122	311-387	5 k		Var		CH 1 ATTEN BAL RANGE	100-359X
R123	323-305	14.7 k	½ w		Prec	1%	X990-up
R124	302-0102-00	1 k	½ w			5%	
R125	303-153	15 k	1 w				

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R129	315-153	15 k	1/4 w			5%	
R130	308-077	1 k	3 w		WW		
R132	315-151	150 Ω	1/4 w			5%	
R133	322-225	2.15 k	1/4 w		Prec	1%	
R134	315-510	51 Ω	1/4 w			5%	
R135	321-251	4.02 k	1/8 w		Prec	1%	
R136	321-153	383 Ω	1/8 w		Prec	1%	
R138	311-169	100 Ω		Var		GAIN	
R140	311-390	25 k		Var		BASE CURRENT	
R142	321-325	23.7 k	1/8 w		Prec	1%	
R143	315-823	82 k	1/4 w			5%	
R144†	311-385	250 Ω	1/2 w	Var		VARIABLE	
R148	322-215	1.69 k	1/4 w		Prec	1%	
R149	321-117	162 Ω	1/8 w		Prec	1%	
R150	311-258	100 Ω		Var		CH 1 COM MODE CURRENT	
R151	322-097	100 Ω	1/4 w		Prec	1%	
R154	322-161	464 Ω	1/4 w		Prec	1%	
R157	321-129	215 Ω	1/8 w		Prec	1%	
R158	322-211	1.54 k	1/4 w		Prec	1%	
R159	321-097	100 Ω	1/8 w		Prec	1%	100-1149
R159	311-0461-00	250 Ω		Var		H.F. DAMPING	1150-up
R160	311-390	25 k		Var		CH 1 INV BAL	
R161	321-297	12.1 k	1/8 w		Prec	1%	
R163	321-103	115 Ω	1/8 w		Prec	1%	
R164	322-161	464 Ω	1/4 w		Prec	1%	
R165	322-202	1.24 k	1/4 w		Prec	1%	
R167	321-129	215 Ω	1/8 w		Prec	1%	
R168	322-211	1.54 k	1/4 w		Prec	1%	
R169	321-080	66.5 Ω	1/8 w		Prec	1%	
R170	321-257	4.64 k	1/8 w		Prec	1%	
R171	321-121	178 Ω	1/8 w		Prec	1%	
R174	321-081	68.1 Ω	1/8 w		Prec	1%	
R176	311-258	100 Ω		Var		CH 1 GAIN RANGE	
R178	321-223	2.05 k	1/8 w		Prec	1%	
R180	321-257	4.64 k	1/8 w		Prec	1%	
R181	321-121	178 Ω	1/8 w		Prec	1%	
R184	321-081	68.1 Ω	1/8 w		Prec	1%	
R188	321-223	2.05 k	1/8 w		Prec	1%	
R190	321-073	56.2 Ω	1/8 w		Prec	1%	
R191	321-073	56.2 Ω	1/8 w		Prec	1%	
R192	321-069	51.1 Ω	1/8 w		Prec	1%	
R193	321-069	51.1 Ω	1/8 w		Prec	1%	
R195	315-103	10 k	1/4 w			5%	
R196	311-389	2 x 10 k		Var		POSITION	
R197	315-103	10 k	1/4 w			5%	
R199	315-510	51 Ω	1/4 w			5%	

† Furnished as a unit with SW144.

R196	311-389	2 x 10 k	Var	
R197	315-103	10 k	1/4 w	
R199	315-510	51 Ω	1/4 w	

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R202	315-470	47 Ω	¼ w		5%	
R204C	322-610	500 k	¼ w	Prec	1%	100-2218
R204C	322-0610-01	500 k	¼ w	Prec	½%	2219-up
R204E	322-481	1 meg	¼ w	Prec	1%	100-2218
R204E	322-0481-01	1 meg	¼ w	Prec	½%	2219-up
R205C	323-620	800 k	½ w	Prec	1%	100-2218
R205C	323-0620-01	800 k	½ w	Prec	½%	2219-up
R205E	321-618	250 k	⅛ w	Prec	1%	100-2218
R205E	321-0618-01	250 k	⅛ w	Prec	½%	2219-up
R206C	323-611	900 k	½ w	Prec	1%	100-2218
R206C	323-0611-01	900 k	½ w	Prec	½%	2219-up
R206E	321-617	111 k	⅛ w	Prec	1%	100-2218
R206E	321-1389-01	111 k	⅛ w	Prec	½%	2219-up
R207C	323-612	950 k	½ w	Prec	1%	100-2218
R207C	323-0612-01	950 k	½ w	Prec	½%	2219-up
R207E	321-616	52.6 k	⅛ w	Prec	1%	100-2218
R207E	321-0616-01	52.6 k	⅛ w	Prec	½%	2219-up
R208C	323-621	980 k	½ w	Prec	1%	100-2218
R208C	323-0621-01	980 k	½ w	Prec	½%	2219-up
R208E	321-615	20.4 k	⅛ w	Prec	1%	100-2218
R208E	321-0615-01	20.4 k	⅛ w	Prec	½%	2219-up
R209C	323-614	990 k	½ w	Prec	1%	100-2218
R209C	323-0614-01	990 k	½ w	Prec	½%	2219-up
R209D	315-470	47 Ω	¼ w		5%	
R209E	321-614	10.1 k	⅛ w	Prec	1%	100-2218
R209E	321-1289-01	10.1 k	⅛ w	Prec	½%	2219-up
R210C	322-625	995 k	¼ w	Prec	1%	100-2218
R210C	322-0625-01	995 k	¼ w	Prec	½%	2219-up
R210D	315-620	62 Ω	¼ w		5%	
R210E	321-613	5.03 k	⅛ w	Prec	1%	100-2218
R210E	321-0613-01	5.03 k	⅛ w	Prec	½%	2219-up
R211C	322-628	998 k	¼ w	Prec	1%	100-2218
R211C	322-0628-01	998 k	¼ w	Prec	½%	2219-up
R211D	315-220	22 Ω	¼ w		5%	
R211E	321-222	2 k	⅛ w	Prec	1%	100-2218
R211E	321-0222-01	2 k	⅛ w	Prec	½%	2219-up
R212C	322-629	999 k	¼ w	Prec	1%	100-2218
R212C	322-0629-01	999 k	¼ w	Prec	½%	2219-up
R212D	315-330	33 Ω	¼ w		5%	
R212E	321-193	1 k	⅛ w	Prec	1%	100-2218
R212E	321-0193-0-	1 k	⅛ w	Prec	½%	2219-up
R213C	323-481	1 meg	½ w	Prec	1%	100-2218
R213C	323-0481-01	1 meg	½ w	Prec	½%	2219-up
R213D	315-300	30 Ω	¼ w		5%	
R213E	321-612	500 Ω	⅛ w	Prec	1%	100-2218
R213E	321-0612-01	500 Ω	⅛ w	Prec	½%	2219-up
R214	323-481	1 meg	½ w	Prec	1%	100-2218
R214	323-0481-01	1 meg	½ w	Prec	½%	2219-up
R215	316-101	100 Ω	¼ w			
R216	316-104	100 k	¼ w			
R217	311-390	25 k		Var		CH 2 GRID CURRENT ZERO
R218	301-105	1 meg	½ w		5%	
R219	316-100	10 Ω	¼ w			
R220	311-328	1 k		Var		VAR ATTEN BAL 100-359
R220	311-387	5 k		Var		VAR ATTEN BAL 360-up

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R221	321-209	1.47 k	1/8 w		Prec	1%	
R222	311-387	5 k		Var	CH 2 ATTEN BAL RANGE		100-359X
R223	323-305	14.7 k	1/2 w		Prec	1%	
R224	302-0102-00	1 k	1/2 w				X990-up
R225	303-153	15 k	1 w			5%	
R229	315-153	15 k	1/4 w			5%	
R230	308-077	1 k	3 w		WW		
R232	315-151	150 Ω	1/4 w			5%	
R233	322-225	2.15 k	1/4 w		Prec	1%	
R234	315-510	51 Ω	1/4 w			5%	
R235	321-251	4.02 k	1/8 w		Prec	1%	
R236	321-153	383 Ω	1/8 w		Prec	1%	
R238	311-169	100 Ω		Var	GAIN		
R240	311-390	25 k		Var	BASE CURRENT		
R242	321-325	23.7 k	1/8 w		Prec	1%	
R243	315-823	82 k	1/4 w			5%	
R244†	311-385	250 k	1/2 w	Var	VARIABLE		
R248	322-215	1.69 k	1/4 w		Prec	1%	
R249	321-117	162 Ω	1/8 w		Prec	1%	
R250	311-258	100 Ω		Var	CH 2 COM MODE CURRENT		
R251	322-097	100 Ω	1/4 w		Prec	1%	
R254	322-161	464 Ω	1/4 w		Prec	1%	
R257	321-129	215 Ω	1/8 w		Prec	1%	
R258	322-211	1.54 k	1/4 w		Prec	1%	
R259	321-097	100 Ω	1/8 w		Prec	1%	100-1149
R259	311-0461-00	250 Ω		Var	H. F. DAMPING		1150 up
R260	311-390	25 k		Var	CH 2 INV BAL		
R261	321-297	12.1 k	1/8 w		Prec	1%	
R263	321-103	115 Ω	1/8 w		Prec	1%	
R264	322-161	464 Ω	1/4 w		Prec	1%	
R265	322-202	1.24 k	1/4 w		Prec	1%	
R267	321-129	215 Ω	1/8 w		Prec	1%	
R268	322-211	1.54 k	1/4 w		Prec	1%	
R269	321-080	66.5 Ω	1/8 w		Prec	1%	
R270	322-197	1.1 k	1/4 w		Prec	1%	
R271	321-085	75 Ω	1/8 w		Prec	1%	
R272	321-097	100 Ω	1/8 w		Prec	1%	
R273	323-163	487 Ω	1/2 w		Prec	1%	
R274	321-081	68.1 Ω	1/8 w		Prec	1%	
R276	311-258	100 Ω		Var	CH 2 GAIN RANGE		
R278	321-223	2.05 k	1/8 w		Prec	1%	
R280	322-197	1.1 k	1/4 w		Prec	1%	
R281	321-085	75 Ω	1/8 w		Prec	1%	
R282	321-097	100 Ω	1/8 w		Prec	1%	
R283	323-163	487 Ω	1/2 w		Prec	1%	
R284	321-081	68.1 Ω	1/8 w		Prec	1%	
R286	315-120	12 Ω	1/4 w			5%	

† Furnished as a unit with SW244.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description					S/N Range
R288	321-223	2.05 k	1/8 w		Prec	1%	
R290	321-073	56.2 Ω	1/8 w		Prec	1%	
R291	321-073	56.2 Ω	1/8 w		Prec	1%	
R292	321-069	51.1 Ω	1/8 w		Prec	1%	
R293	321-069	51.1 Ω	1/8 w		Prec	1%	
R295	315-103	10 k	1/4 w			5%	
R296	311-389	2 x 10 k		Var		POSITION	
R297	315-103	10 k	1/4 w			5%	
R299	315-510	51 Ω	1/4 w			5%	
R314	315-270	27 Ω	1/4 w			5%	
R317	321-193	1 k	1/8 w		Prec	1%	100-459
R317	321-204	1.3 k	1/8 w		Prec	1%	460-up
R318	321-201	1.21 k	1/8 w		Prec	1%	
R334	315-270	27 Ω	1/4 w			5%	
R335	311-328	1 k		Var		MAIN AMP DIFF BAL	
R336	311-328	1 k	1/8 w	Var		MAIN AMP CURRENT	
R337	321-193	1 k	1/8 w		Prec	1%	100-459
R337	321-204	1.3 k	1/8 w		Prec	1%	460-up
R338	321-201	1.21 k	1/8 w		Prec	1%	
R341	315-101	100 Ω	1/4 w			5%	
R342	315-332	3.3 k	1/4 w			5%	
R343	323-125	196 Ω	1/2 w		Prec	1%	
R344	321-213	1.62 k	1/8 w		Prec	1%	
R345	322-181	750 Ω	1/4 w		Prec	1%	
R347	321-249	3.83 k	1/8 w		Prec	1%	
R351	315-101	100 Ω	1/4 w			5%	
R352	315-332	3.3 k	1/4 w			5%	
R353	323-125	196 Ω	1/2 w		Prec	1%	
R354	321-213	1.62 k	1/8 w		Prec	1%	
R355	322-181	750 Ω	1/4 w		Prec	1%	
R357	321-249	3.83 k	1/8 w		Prec	1%	
R364	323-153	383 Ω	1/2 w		Prec	1%	
R365	Use 315-153	15 k	1/4 w			5%	
R367	315-152	1.5 k	1/4 w			5%	
R369	315-682	6.8 k	1/4 w			5%	
R371	315-224	220 k	1/4 w			5%	
R373	321-289	10 k	1/8 w		Prec	1%	
R374	315-332	3.3 k	1/4 w			5%	
R375	321-161	464 Ω	1/8 w		Prec	1%	
R382	315-152	1.5 k	1/4 w			5%	
R384	322-221	1.96 k	1/4 w		Prec	1%	
R387	315-330	30 Ω	1/4 w			5%	
R389	321-069	51.1 Ω	1/8 w		Prec	1%	
R390	315-221	220 Ω	1/4 w			5%	
R391	315-221	220 Ω	1/4 w			5%	
R392	315-222	2.2 k	1/4 w			5%	
R411	321-161	464 Ω	1/8 w		Prec	1%	
R412	321-080	66.5 Ω	1/8 w		Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R413	321-145	316 Ω	1/8 w	Prec	1%	
R415	321-157	422 Ω	1/8 w	Prec	1%	
R421	321-161	464 Ω	1/8 w	Prec	1%	
R423	321-145	316 Ω	1/8 w	Prec	1%	
R425	321-157	422 Ω	1/8 w	Prec	1%	
R432	322-133	237 Ω	1/4 w	Prec	1%	
R434	321-115	154 Ω	1/8 w	Prec	1%	
R444	321-115	154 Ω	1/8 w	Prec	1%	
R450	321-109	133 Ω	1/8 w	Prec	1%	
R452	322-085	75 Ω	1/4 w	Prec	1%	
R453	321-629	5.11 k	1/8 w	Prec	1/2%	
R454	322-094	93.1 Ω	1/4 w	Prec	1%	
R455	321-630	6.81 k	1/8 w	Prec	1/2%	
R456	322-173	619 Ω	1/4 w	Prec	1%	
R457	323-137	261 Ω	1/2 w	Prec	1%	
R458	323-137	261 Ω	1/2 w	Prec	1%	
R459	322-043	27.4 Ω	1/4 w	Prec	1%	
R460	321-109	133 Ω	1/4 w	Prec	1%	
R462	315-242	2.4 k	1/4 w		5%	
R464	322-094	93.1 Ω	1/4 w	Prec	1%	
R465	321-080	66.5 Ω	1/8 w	Prec	1%	
R466	322-173	619 Ω	1/4 w	Prec	1%	
R467	323-137	261 Ω	1/2 w	Prec	1%	
R468	323-137	261 Ω	1/2 w	Prec	1%	
R481	322-193	1 k	1/4 w	Prec	1%	
R482	321-173	619 Ω	1/8 w	Prec	1%	
R483	301-151	150 Ω	1/2 w		5%	
R485	315-100	10 Ω	1/4 w		5%	
R487	315-151	150 Ω	1/4 w		5%	
R494	*310-606	67 Ω	4 w	Mica	1%	
R496	*310-606	67 Ω	4 w	Mica	1%	
R497	322-073	56.2 Ω	1/4 w	Prec	1%	
R498	322-085	75 Ω	1/4 w	Prec	1%	
R504	321-125	196 Ω	1/8 w	Prec	1%	
R514	321-125	196 Ω	1/8 w	Prec	1%	
R525	321-161	464 Ω	1/8 w	Prec	1%	
R526	321-058	39.2 Ω	1/8 w	Prec	1%	
R527	321-053	34.8 Ω	1/8 w	Prec	1%	
R529	323-170	576 Ω	1/2 w	Prec	1%	
R530	311-390	25 k		Var		CH 2 OUT DC LEVEL
R531	315-392	3.9 k	1/4 w		5%	
R532	323-181	750 Ω	1/2 w	Prec	1%	
R533	321-103	115 Ω	1/8 w	Prec	1%	
R535	321-161	464 Ω	1/8 w	Prec	1%	
R536	321-058	39.2 Ω	1/8 w	Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R539	323-170	576 Ω	½ w		Prec	1%
R541	315-820	82 Ω	¼ w			5%
R543	315-820	82 Ω	¼ w			5%
R545	321-289	10 k	⅛ w		Prec	1%
R546	311-390	25 k		Var		NORM TRIG DC BAL
R548	321-105	121 Ω	⅛ w		Prec	1%
R550	321-065	46.4 Ω	⅛ w		Prec	1%
R551	321-297	12.1 k	⅛ w		Prec	1%
R554	321-127	205 Ω	⅛ w		Prec	1%
R560	321-065	46.4 Ω	⅛ w		Prec	1%
R561	321-297	12.1 k	⅛ w		Prec	1%
R564	321-127	205 Ω	⅛ w		Prec	1%
R574	323-181	780 Ω	½ w		Prec	1%
R576	323-173	619 Ω	½ w		Prec	1%
R577	321-073	56.2 Ω	⅛ w		Prec	1%
R579	321-145	316 Ω	⅛ w		Prec	1%
R584	323-181	750 Ω	½ w		Prec	1%
R586	323-173	619 Ω	½ w		Prec	1%
R589	321-145	316 Ω	⅛ w		Prec	1%
R591	321-169	562 Ω	⅛ w		Prec	1%
R592	321-230	2.43 k	⅛ w		Prec	1%
R595	315-270	27 Ω	¼ w			5%
R597	303-221	220 Ω	1 w			5%

Switches

	Unwired	Wired			
SW101	260-492		Lever	AC-DC-GND	
SW110	260-522	*262-566	Rotary	VOLTS/CM	100-2218
SW110	260-0522-00	*262-0566-01	Rotary	VOLTS/CM	2219-up
SW144†	311-385				
SW190	260-447		Slide	PULL TO INVERT	
SW201	260-492		Lever	AC-DC-GND	
SW210	260-522	*262-566	Rotary	VOLTS/CM	100-2218
SW210	260-0522-00	*260-0566-01	Rotary	VOLTS/CM	2219-up
SW244††	311-385				

Transformers

T371	*120-273	Toroid, Bifilar 5T-10T
T390	*120-273	Toroid, Bifilar 5T-10T

Transistors

Q123	*151-103	Replaceable by 2N2219
Q133	*151-103	Replaceable by 2N2219

† Furnished as a unit with R144.

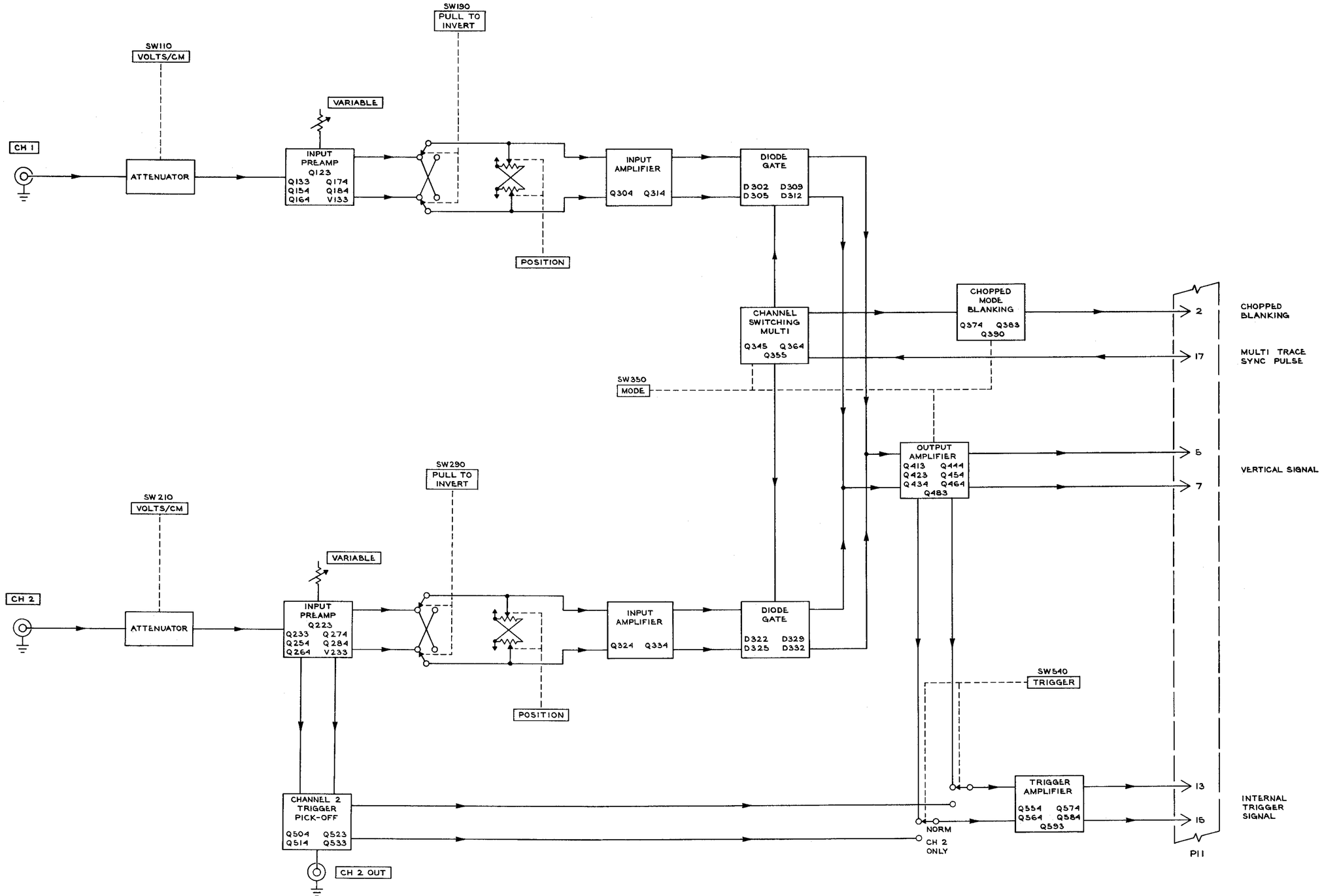
†† Furnished as a unit with R244.

Transistors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
Q154	*151-109	Selected from 2N918	
Q164	*151-109	Selected from 2N918	
Q174	*151-109	Selected from 2N918	
Q184	*151-109	Selected from 2N918	
Q223	*151-103	Replaceable by 2N2219	
Q233	*151-103	Replaceable by 2N2219	
Q254	*151-109	Selected from 2N918	
Q264	*151-109	Selected from 2N918	
Q274	*151-109	Selected from 2N918	
Q284	*151-109	Selected from 2N918	
Q304	*151-109	Selected from 2N918	
Q314	*151-109	Selected from 2N918	
Q324	*151-109	Selected from 2N918	
Q334	*151-109	Selected from 2N918	
Q345	*151-103	Replaceable by 2N2219	
Q355	*151-103	Replaceable by 2N2219	
Q364	Use *151-108	Replaceable by 2N2501	
Q374	*151-103	Replaceable by 2N2219	
Q383	*151-103	Replaceable by 2N2219	
Q390	*151-108	Replaceable by 2N2501	
Q413	*151-120	Selected from 2N2475	
Q423	*151-120	Selected from 2N2475	
Q434	*151-109	Selected from 2N918	
Q444	*151-109	Selected from 2N918	
Q454	*151-120	Selected from 2N2475	
Q464	*151-120	Selected from 2N2475	
Q483	*151-103	Replaceable by 2N2219	
Q504	*151-120	Selected from 2N2475	
Q514	*151-120	Selected from 2N2475	
Q523	*151-120	Selected from 2N2475	
Q533	*151-120	Selected from 2N2475	
Q554	*151-120	Selected from 2N2475	
Q564	*151-120	Selected from 2N2475	
Q574	*151-120	Selected from 2N2475	
Q584	*151-120	Selected from 2N2475	
Q593	*151-103	Replaceable by 2N2219	

Electron Tubes

V133	*157-080	7586	
V233	*157-080	7586	

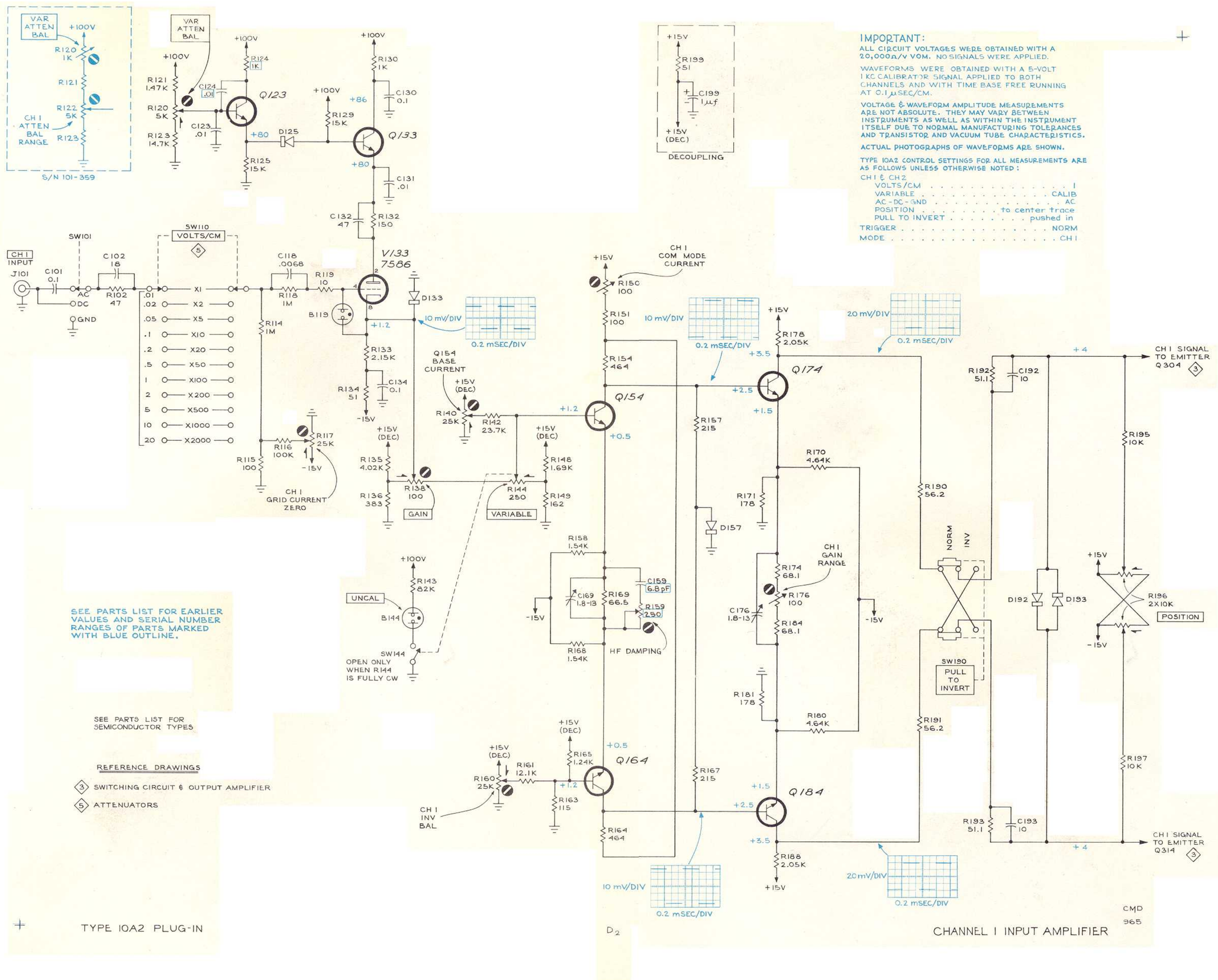


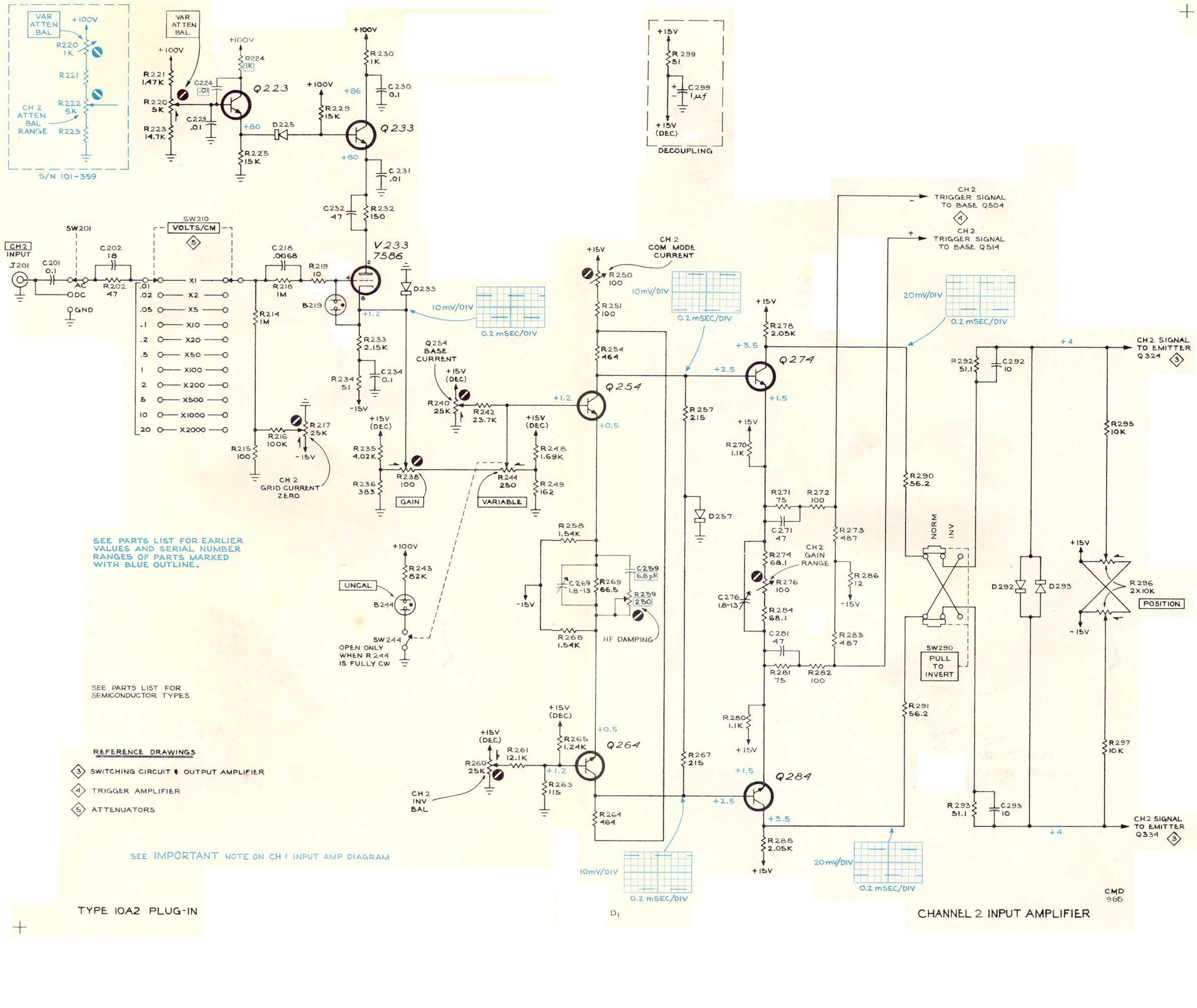
CMD 1163

TYPE 10A2 PLUG-IN

A

BLOCK DIAGRAM


VAR ATTEN BAL
+100V
R120 1K
R121
R122 5K
R123
CH 1 ATTEN BAL RANGE
S/N 101-359
R121 1.47K
R120 5K
R123 14.7K
C124 .01
C123 .01
Q123
R124 1K
+80
D125
R125 15K
+86
R129 15K
Q133
R130 1K
C130 0.1
C131 .01
C132 47
R132 150
V133 7586
D133
B119
R119 10
C118 .0068
R118 1M
10 mV/DIV
0.2 mSEC/DIV
+1.2
R133 2.15K
C134 0.1
R134 51
-15V
CH 1 INPUT
J101
C101 0.1
SW101
AC
DC
GND
C102 18
R102 47
SW110
VOLTS/CM
5
.01 X1
.02 X2
.05 X5
.1 X10
.2 X20
.5 X50
1 X100
2 X200
5 X500
10 X1000
20 X2000
R114 1M
R115 100
R116 100K
R117 25K
CH 1 GRID CURRENT ZERO
+15V (DEC)
R135 4.02K
R136 383
R138 100
GAIN
R144 250
VARIABLE
R148 1.69K
R149 162
Q154 BASE CURRENT
R140 25K
R142 23.7K
Q154
+0.5
+15V
R199 51
C199 1μf
+15V (DEC)
DECOUPLING
IMPORTANT:
ALL CIRCUIT VOLTAGES WERE OBTAINED WITH A 20,000Ω/V VOM. NO SIGNALS WERE APPLIED.
WAVEFORMS WERE OBTAINED WITH A 5-VOLT 1 KC CALIBRATOR SIGNAL APPLIED TO BOTH CHANNELS AND WITH TIME BASE FREE RUNNING AT 0.1 μSEC/CM.
VOLTAGE & WAVEFORM AMPLITUDE MEASUREMENTS ARE NOT ABSOLUTE. THEY MAY VARY BETWEEN INSTRUMENTS AS WELL AS WITHIN THE INSTRUMENT ITSELF DUE TO NORMAL MANUFACTURING TOLERANCES AND TRANSISTOR AND VACUUM TUBE CHARACTERISTICS.
ACTUAL PHOTOGRAPHS OF WAVEFORMS ARE SHOWN.
TYPE 10A2 CONTROL SETTINGS FOR ALL MEASUREMENTS ARE AS FOLLOWS UNLESS OTHERWISE NOTED:
CH 1 & CH 2
VOLTS/CM 1
VARIABLE . . . . . CALIB
AC-DC-GND . . . . . AC
POSITION . . . . . to center trace
PULL TO INVERT . . . . . pushed in
TRIGGER . . . . . NORM
MODE . . . . . CH 1
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.
SEE PARTS LIST FOR SEMICONDUCTOR TYPES
REFERENCE DRAWINGS
3 SWITCHING CIRCUIT & OUTPUT AMPLIFIER
5 ATTENUATORS
UNCAL
B144
SW144
OPEN ONLY WHEN R144 IS FULLY CW
R143 82K
R158 1.54K
C159 6.8 pF
C169 1.8-13
R169 66.5
R159 250
HF DAMPING
R168 1.54K
-15V
CH 1 INV BAL
R160 25K
R161 12.1K
R163 115
R165 1.24K
Q164
R164 464
CH 1 COM MODE CURRENT
R150 100
R151 100
R154 464
R157 215
D157
R167 215
Q174
R178 2.05K
+3.5
+2.5
+1.5
R170 4.64K
R171 178
CH 1 GAIN RANGE
R174 68.1
R176 100
C176 1.8-13
R184 68.1
R181 178
R180 4.64K
Q184
R188 2.05K
20 mV/DIV
R190 56.2
R191 56.2
NORM
INV
SW190
PULL TO INVERT
R192 51.1
C192 10
+4
CH 1 SIGNAL TO EMITTER Q304
3
R195 10K
R197 10K
D192
D193
R196 2X10K
POSITION
R193 51.1
C193 10
CH 1 SIGNAL TO EMITTER Q314
CMD 965
D2
TYPE 10A2 PLUG-IN
CHANNEL 1 INPUT AMPLIFIER



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

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DRAWINGS

- 3 SWITCHING CIRCUIT & OUTPUT AMPLIFIER
- 4 TRIGGER AMPLIFIER
- 5 ATTENUATORS

SEE IMPORTANT NOTE ON CH 1 INPUT AMP DIAGRAM

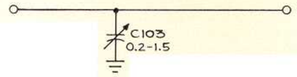
TYPE 10A2 PLUG-IN

CHANNEL 2 INPUT AMPLIFIER

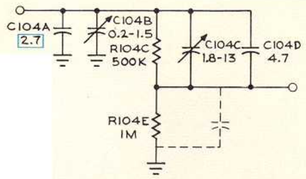
CMD 965

D1

X1



X2



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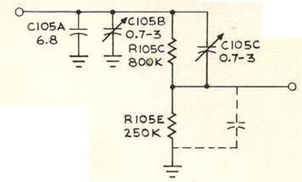

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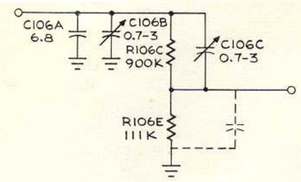

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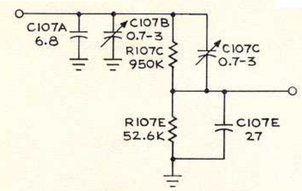
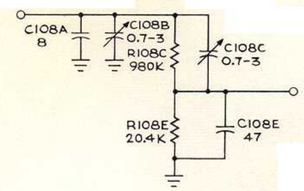


X50



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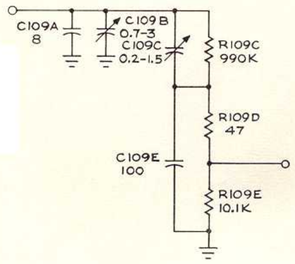
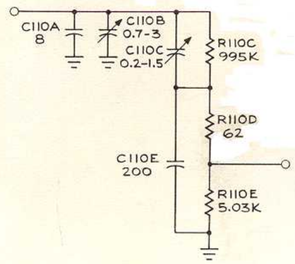
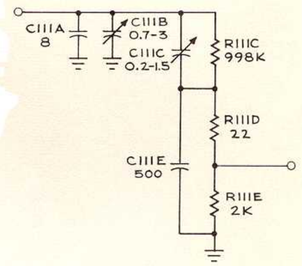


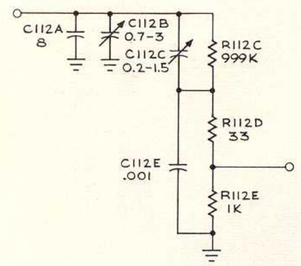
X200



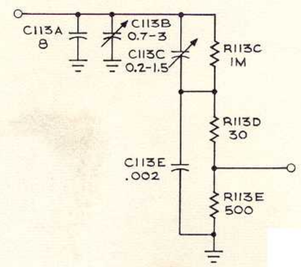
X500



X1000

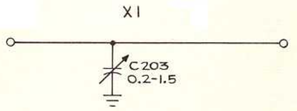


X2000

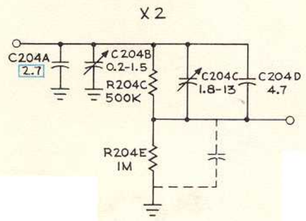


CHANNEL 1

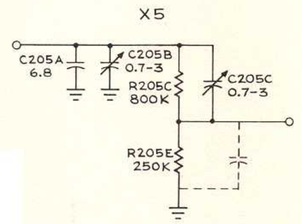
X1



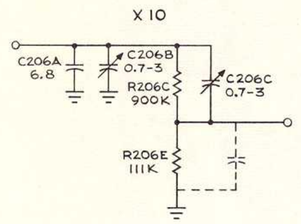
X2



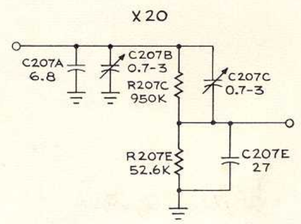
X5



X10



X20



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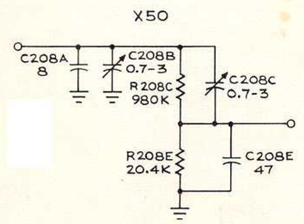

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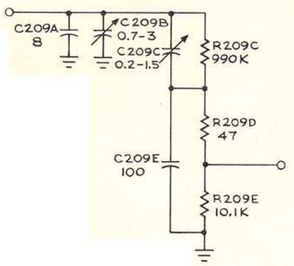

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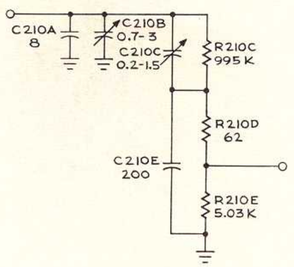

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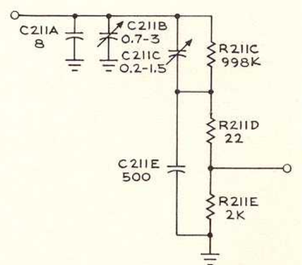

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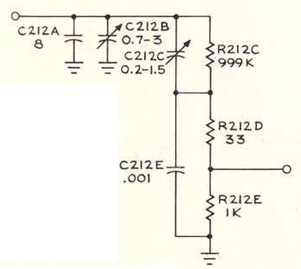
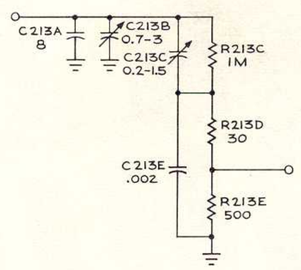


X 2000



CHANNEL 2

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

TYPE 10A2 PLUG-IN

B

DON
664

ATTENUATORS

SW350 MODE

1R 1F 1F 1R

Q304 Q314 Q324 Q334

CHANNEL 1 SIGNAL FROM R192 & R193 ①

CHANNEL 2 SIGNAL FROM R292 & R293 ②

FERRITE BEAD

D302 D305 D309 D312 D322 D325 D329 D332

R317 1.3K R318 1.21K R335 1K R336 1K R337 1.3K R338 1.21K

MAIN AMP DIFF BAL

MAIN AMP CURRENT

+15V (DEC)

Q413 Q423

R411 464 R412 66.5 R413 316 R415 422 R421 464 R423 316 R425 422

5mV/DIV 0.2 mSEC/DIV

Q434 Q444

R432 237 L434 0.1μh R434 154 L444 0.1μh

50mV/DIV 0.2mSEC/DIV

+5.1V

R450 133 L465 0.1-0.12μh R462 2.4K C462 18 R460 133

Q454 Q464

R452 75 C452 0.1 R453 5.11K R454 93.1 R455 6.81K TP453 R456 619 R457 261 R458 261 R459 27.4 R465 66.5 R468 261 R467 261 R466 619 R464 93.1

100mV/DIV 0.2mSEC/DIV

5mV/DIV 0.2 mSEC/DIV

VERTICAL SIGNAL + +9

VERTICAL SIGNAL − +9

TRIGGER SIGNAL TO TRIGGER SW540 ④

TRIGGER SIGNAL FROM COLLECTORS Q574 & Q584 ④

CH1 CH2 ALTER CHOP ADDED

R342 3.3K R352 3.3K R341 100 R351 100 R343 196 R353 196 C344 .022 C354 .022 R344 1.62K R354 1.62K R347 3.83K R357 3.83K

L343 C343 270 L353 C353 270

* 1V/DIV 0.2 μSEC/DIV

TP3450 +2.7 +9 TP355

Q345 Q355

R345 750 D348 C348 .0011 D358 R355 750

-15V (DEC) -15V (DEC)

* 500mV/DIV 0.2 μSEC/DIV

R373 10K R375 464 R374 3.3K

BLANKING AMPLIFIER Q374

T371 R371 220K C371 .022

SYNC PULSE AMPLIFIER Q364

R364 383 R365 15K C366 270 R367 1.5K C367 56

** 1V/DIV 2 μ SEC/DIV

D369 R369 6.8K

R382 1.5K C382 .022 BLANKING EF Q383

R384 1.96K R387 33 R389 51.1 D387 C387 270 L392 5μh

CHOPPED BLANKING BO Q390

T390 D391 R391 220 C390 .022 L390 100μh R390 220

* 2V/DIV 0.2 μSEC/DIV

D392 R392 2.2K CHOPPED MODE BLANKING

MULTI-TRACE SYNC PULSE

VOLTAGE SOURCE

R483 150 C483 .022 R481 1K Q483 R482 619 R485 10 TP485 R487 150

+100V +15V -15V

R494 67 R496 67 V133 V233

P11

DECOUPLING

+15V R497 56.2 C497 .022 +15V (DEC)

-15V R498 75 C498 .022 -15V (DEC)

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

REFERENCE DRAWINGS:

① CHANNEL 1 INPUT AMPLIFIER

② CHANNEL 2 INPUT AMPLIFIER

④ TRIGGER AMPLIFIER

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

WAVEFORMS & VOLTAGE READINGS WERE OBTAINED UNDER FOLLOWING CONDITIONS:

CONTROLS	WAVEFORMS	VOLTAGES	
		"UPPER" CH1	"LOWER" CH2
MODE	CH 1 * CHOP ** ALTER		

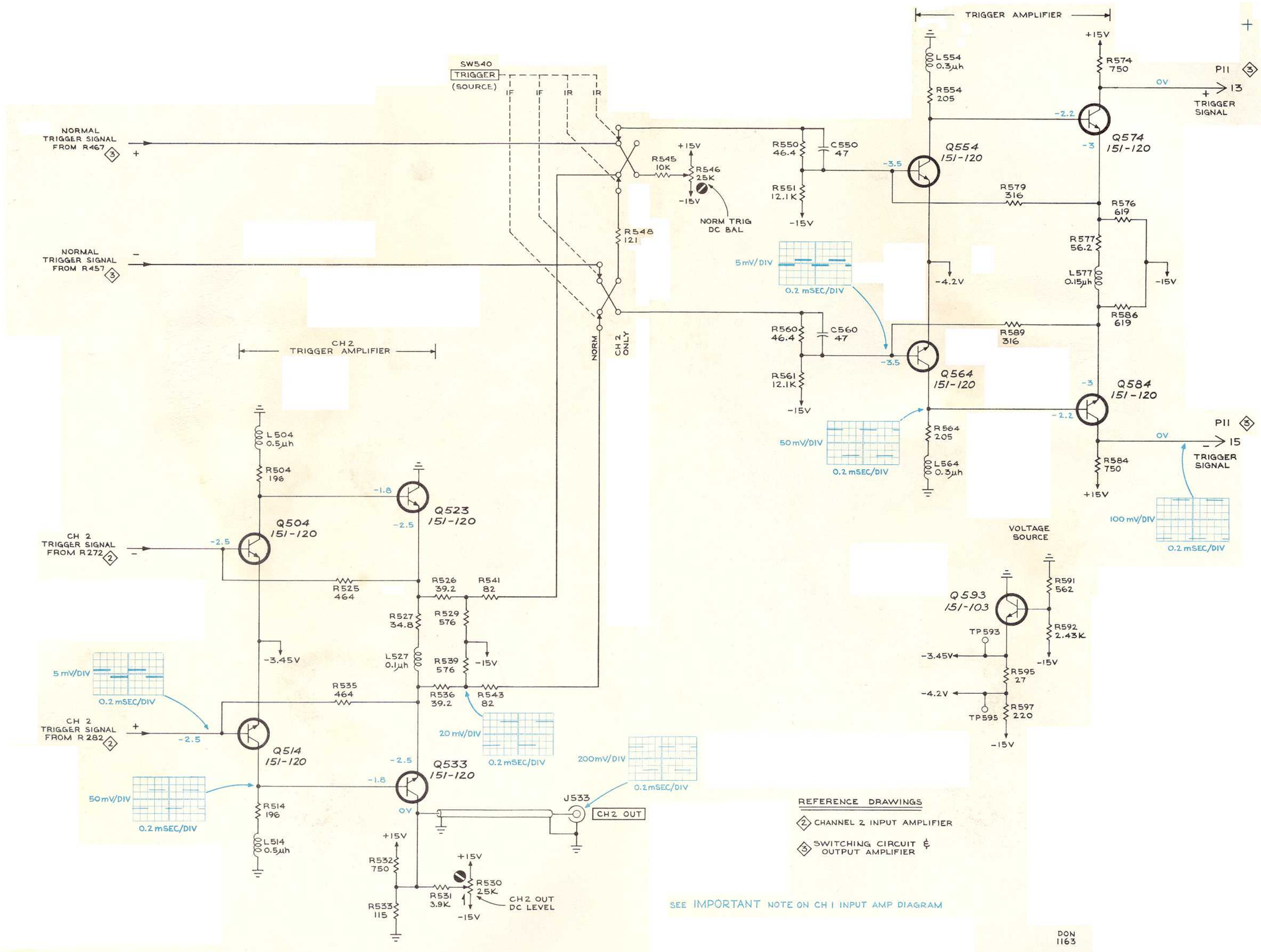
(SEE IMPORTANT NOTE ON CH 1 INPUT AMP DIAG)

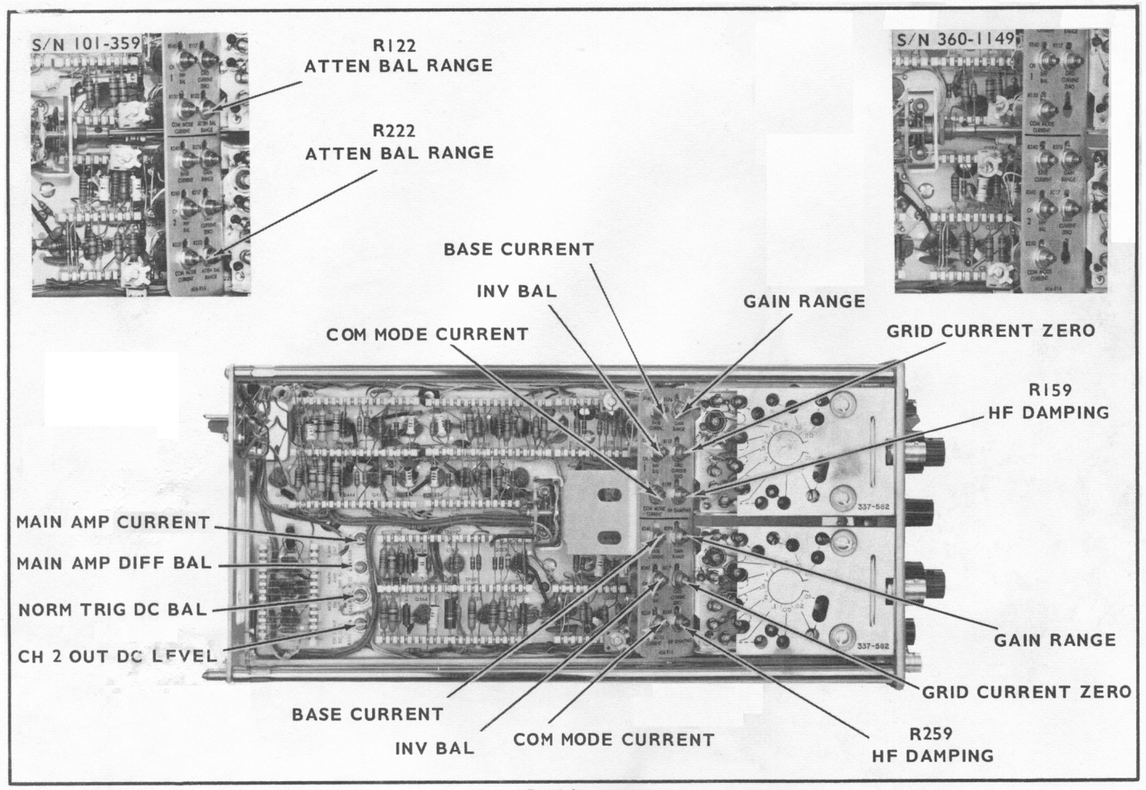
TYPE 10A2 PLUG-IN

C

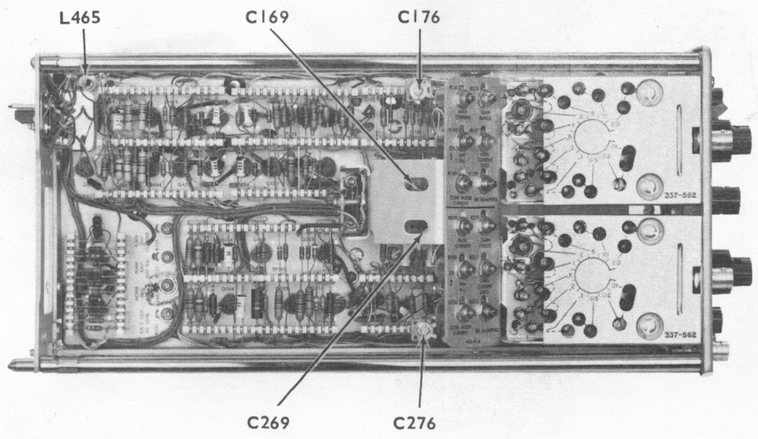
MRH 965

SWITCHING CIRCUIT & OUTPUT AMPLIFIER

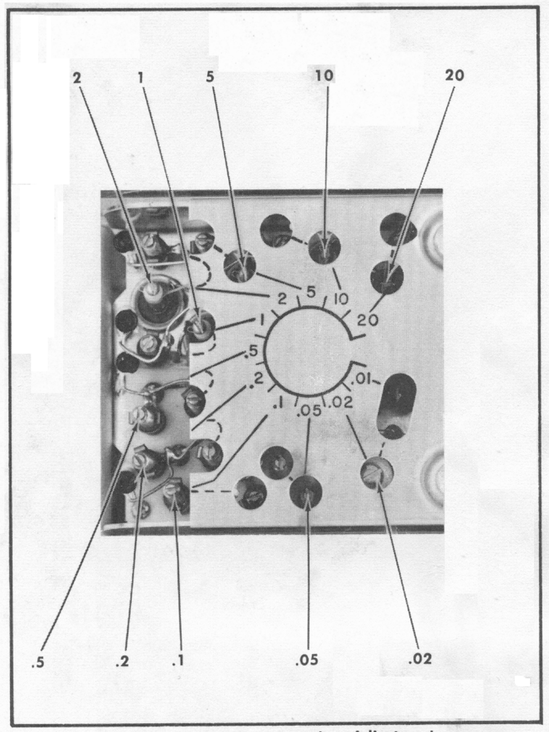

TRIGGER AMPLIFIER
SW540
TRIGGER
(SOURCE)
1F
1F
1R
1R
NORMAL TRIGGER SIGNAL FROM R467 3
+
NORMAL TRIGGER SIGNAL FROM R457 3
−
+15V
R545 10K
R546 25K
−15V
NORM TRIG DC BAL
R548 12.1
NORM
CH 2 ONLY
R550 46.4
C550 47
R551 12.1K
−15V
Q554 151-120
−3.5
L554 0.3µh
R554 205
+15V
R574 750
P11 3
0V
+ 13
TRIGGER SIGNAL
−2.2
Q574 151-120
−3
R579 316
R576 619
R577 56.2
L577 0.15µh
−15V
−4.2V
R586 619
5mV/DIV
0.2 mSEC/DIV
R560 46.4
C560 47
R561 12.1K
−15V
R589 316
−3.5
Q564 151-120
−3
Q584 151-120
−2.2
50 mV/DIV
0.2 mSEC/DIV
R564 205
L564 0.3µh
P11 3
0V
− 15
TRIGGER SIGNAL
R584 750
+15V
100 mV/DIV
0.2 mSEC/DIV
CH 2 TRIGGER AMPLIFIER
L504 0.5µh
R504 196
−1.8
Q523 151-120
−2.5
Q504 151-120
CH 2 TRIGGER SIGNAL FROM R272 2
−2.5
−
R525 464
R526 39.2
R541 82
R527 34.8
R529 576
L527 0.1µh
R539 576
−15V
−3.45V
5 mV/DIV
0.2 mSEC/DIV
R535 464
R536 39.2
R543 82
CH 2 TRIGGER SIGNAL FROM R282 2
+
−2.5
Q514 151-120
20 mV/DIV
0.2 mSEC/DIV
−2.5
Q533 151-120
−1.8
200mV/DIV
0.2mSEC/DIV
50mV/DIV
0.2 mSEC/DIV
R514 196
L514 0.5µh
0V
J533
CH2 OUT
+15V
R532 750
R531 3.9K
R530 2.5K
CH2 OUT DC LEVEL
−15V
R533 115
VOLTAGE SOURCE
Q593 151-103
R591 562
R592 2.43K
−15V
TP593
−3.45V
R595 27
−4.2V
TP595
R597 220
−15V
REFERENCE DRAWINGS
2 CHANNEL 2 INPUT AMPLIFIER
3 SWITCHING CIRCUIT & OUTPUT AMPLIFIER
SEE IMPORTANT NOTE ON CH 1 INPUT AMP DIAGRAM
DON 1163
TRIGGER AMPLIFIER
TYPE 10A2 PLUG-IN
A



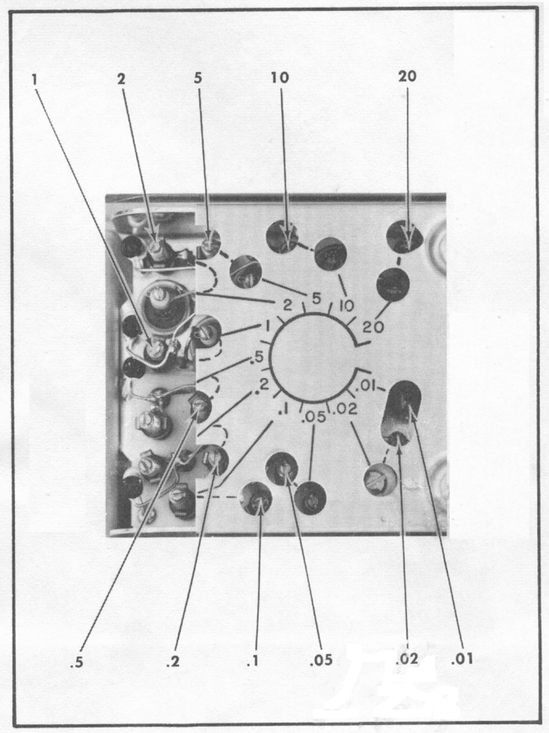
Dc Adjustments



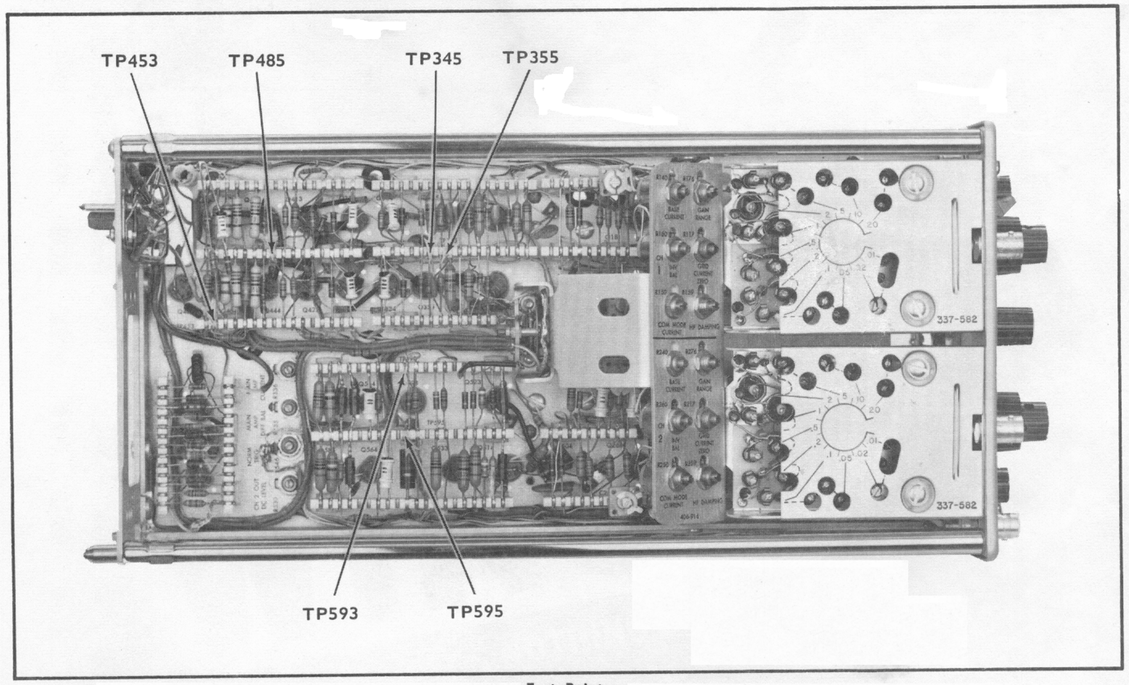
High-Frequency Compensation Adjustments



Attenuator Compensation Adjustments



Input Time-Constant Adjustments



Test Points

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.