

# INSTRUCTION MANUAL

Serial Number \_\_\_\_\_



*Tektronix, Inc.*

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070-0615-00



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

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

SERIES M MODEL 1, 2, 3



Fig. 1-1. Type 10A2A Dual-Trace Amplifier.

# SECTION 1

## CHARACTERISTICS

### Introduction

The Tektronix Type 10A2A Dual-Trace Amplifier plug-in unit provides DC to 100 megahertz vertical capabilities for the Tektronix Type 647A Oscilloscope system. The Type 10A2A contains two similar input-amplifier channels which provide calibrated deflection factors from 0.01 to 20 volts/centimeter. Either channel can be used independently to produce a single-channel display, or they can be electronically switched to produce a dual-trace display. In addition, the signals on both channels can be algebraically added to display the sum of two signals, or the two channels can be cascaded to provide a minimum deflection factor of one millivolt/division (uncalibrated). Each channel has separate input coupling, input step attenuator, variable attenuator, variable balance, gain, position and polar-

ity controls which allow each channel to be adjusted independently to produce the desired display.

The electrical characteristics which follow are divided into two categories. Characteristics listed in the Performance Requirement column are checked in the Performance Check and Calibration sections of this manual. Items listed in the Supplemental Information column are provided for reference use and do not directly reflect the measurement capabilities of this instrument. The Performance Check procedure given in Section 5 of this manual provides a convenient method of checking the Performance Requirements listed in this section. The following characteristics apply over a calibration interval of 1000 hours at an ambient temperature range of  $-30^{\circ}\text{C}$  to  $+65^{\circ}\text{C}$ , except as otherwise indicated. Warm-up time for given accuracy is 20 minutes.

Characteristics	Performance Requirement		Supplemental Information
Deflection Factors	0.01 to 20 volts/centimeter in 11 calibrated steps		Steps in 1-2-5 sequence
Variable Deflection Factor	Uncalibrated deflection factor to at least 2.5 times the VOLTS/CM switch indication. This provides a maximum uncalibrated deflection factor of at least 50 volts/centimeter in the 20 volts/centimeter position		
Attenuator Accuracy	0° C to +40° C Within $\pm 1.5\%$	$-30^{\circ}\text{C}$ to $+65^{\circ}\text{C}$ Within $\pm 2\%$	With VARIABLE control at CAL
Attenuator Accuracy of P6047 10× Probe	Within $\pm 2\%$	Within $\pm 2\%$	
Amplifier Gain Stability with Temperature			See Fig. 1-2
Bandwidth (at $-3$ dB point)			The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.
In Type 647A	DC to 100 MHz or greater	DC to 90 MHz or greater	
In Type 647	DC to 55 MHz or greater	DC to 50 MHz or greater	
Risetime (calculated)			Bandwidth and risetime performance are the same with a P6047 10× probe.
In Type 647A	3.5 nanoseconds or less	4.1 nanoseconds or less	
In Type 647	6.4 nanoseconds or less	7 nanoseconds or less	
Low-Frequency Limit with AC Coupling ( $-3$ dB point)			Approximately 1.6 Hz (0.16 Hz with 10× probe).
Input RC Characteristics			1 megohm paralleled by 20 pF in AC and DC positions of Input Coupling switches. Input RC characteristics with P6047 10× Probe are 10 megohm paralleled by 10 pF.
Maximum Input Voltage			600 volts DC + peak AC (1 kHz or less). Peak-to-peak AC not to exceed 600 V
Input Coupling Modes	AC or DC, selected by front-panel switch. Input signal is internally disconnected and input circuit grounded in GND position		Input impedance remains one megohm in GND position

Characteristics—Type 10A2A

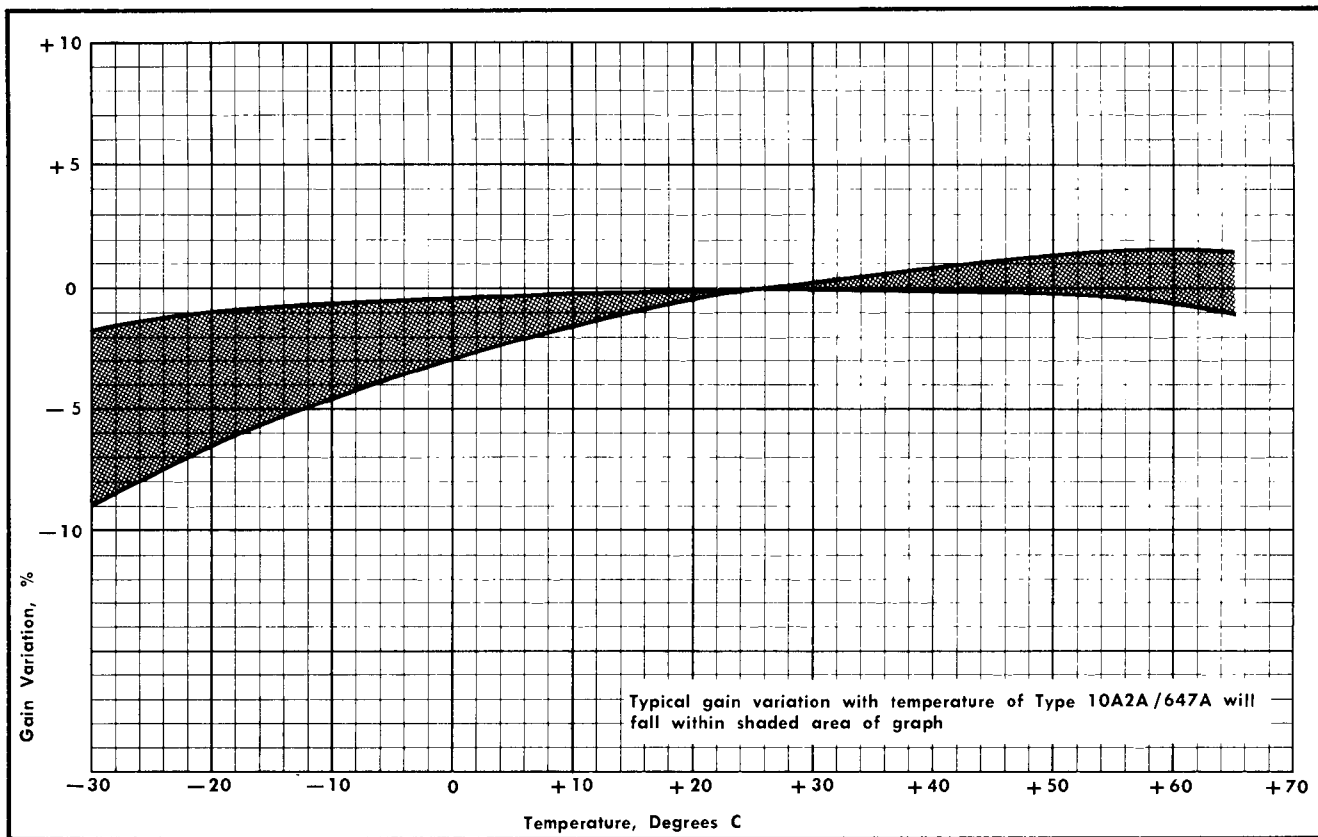


Fig. 1-2. Gain Stability with temperature of Type 10A2A and Type 647A.

Characteristics	Performance Requirement	Supplemental Information
Vertical Display Modes	Channel 1 only Channel 2 only Dual-trace, alternate between channels Dual-trace, chopped between channels Added algebraically	
DC Drift with Time		
Long term		0.5 centimeter or less/hour at 25° C
Short term		0.2 centimeter or less/minute at 25° C
DC Drift with Temperature		0.05 centimeter or less/degree C
Trace Shift Due to Input Grid Current	0.2 division or less at .01 VOLTS/CM	Equal to two nanoamps or less (adjustable to zero)
Inter-Channel Isolation		
Attenuator	10,000:1 or greater, DC to 25 MHz	
Amplifier	200:1 or greater, DC to 25 MHz	For CH 1 or CH 2 modes
Common-Mode Rejection Ratio	20:1 or greater, DC to 50 MHz, for common-mode signals less than 10 divisions in amplitude	With optimum GAIN adjustment at low frequencies. Measured at .01 volts/centimeter at 25° C
Linear Dynamic Range in Added Mode		±12 times, or greater the VOLTS/CM switch setting for 5% or less distortion
Chopped Repetition Rate	1 MHz, ±15%	
Polarity Inversion	Displayed signal from either channel can be inverted	
Channel 2 Output		
Amplitude	100 millivolts or greater/centimeter of CRT display, unterminated	
Bandwidth (at -3 dB point)	DC to 30 MHz or greater when cascaded with Channel 1	Using eight-inch BNC cable

**Characteristics—Type 10A2A**

Characteristics	Performance Requirement	Supplemental Information
DC level		Internally adjustable to zero volts
Output coupling		DC coupled
Output resistance		Approximately 100 ohms
Trigger Signal for Internal Triggering		
Trigger selection	From displayed channel(s) or from Channel 2 only	
Signal amplitude		Approximately 0.2 volt/centimeter of CRT display in NORM position of TRIGGER switch
Risetime		NORM: Typically 4 nanoseconds CH 2 ONLY: Typically 7 nanoseconds

**ENVIRONMENTAL CHARACTERISTICS**

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the electrical performance requirements given in this section following environmental test. Complete

details on environmental test procedures, including failure criteria, etc., may be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative.

Temperature		
Operating	−30° C to +65° C	
Non-operating	−55° C to +75° C	
Altitude		
Operating	15,000 feet maximum	Derate maximum operating temperature by 1° C/1000 feet change in altitude above 5000 feet
Non-operating	50,000 feet maximum	May be tested during non-operating temperature test
Humidity		
Non-operating	Five cycles (120 hours) of Mil-Std-202C, Method 106B	Exclude freezing and vibration
Vibration		
Operating and non-operating	15 minutes vibration along each of the three major axes at a total displacement of 0.025-inch peak to peak (4 g at 55 c/s) from 10-55-10 c/s in one-minute cycles. Hold at 55 c/s for three minutes on each axis	Instrument secured to vibration platform during test. Total vibration time, about 55 minutes
Shock		
Operating and non-operating	Two shocks of 20 g, one-half sine, 11 millisecond duration each direction along each major axis	Guillotine-type shocks. Total of 12 shocks
Transportation		
Package vibration	Meets National Safe Transit type of test when packaged as shipped from Tektronix, Inc. One hour vibration slightly in excess of 1 g	Package should just leave vibration surface
Package drop	30-inch drop on any corner, edge or flat surface	

**MECHANICAL CHARACTERISTICS**

Characteristic	Information
Construction	
Chassis	Aluminum alloy
Panel	Aluminum alloy with anodized finish

Characteristic	Information
Dimensions	Fits 10-series plug-in compartments of Tektronix 647-series Oscilloscopes
Connectors	BNC
Weight (without accessories)	Approximately five pounds





# SECTION 2

## OPERATING INSTRUCTIONS

### General

The Type 10A2A operates with the indicator oscilloscope and an 11-series time-base unit to form a complete oscilloscope system. To effectively use the Type 10A2A, the operation and capabilities of the instrument should be known. This section describes the operation of the front-panel controls and connectors, gives first time and general operating information and lists some basic applications for this instrument.

### Installation

The Type 10A2A is designed to operate in the vertical plug-in compartment of Tektronix 647-series Oscilloscopes. The Type 10A2A will not operate correctly if installed in the horizontal plug-in compartment. To install the Type 10A2A into the plug-in compartment, push it in as far as possible so it is seated against the front panel of the indicator oscilloscope. To remove the plug-in, pull the release bar. Grasp the plug-in behind the front panel and pull it partially out of the compartment. Then take hold of the plug-in by the support rods to remove it from the oscilloscope.

Even though the vertical gain of the indicator oscilloscope is standardized to minimize adjustment when inserting plug-ins, the gain of the Type 10A2A should be checked when it is inserted into the indicator oscilloscope to verify measurement accuracy. The adjustment procedure is given under Vertical Gain Adjustment in this section.

## FRONT-PANEL CONTROLS AND CONNECTORS

### Introduction

All controls and connectors required for the operation of the Type 10A2A are located on the front panel of the unit (see Fig. 2-1). To make full use of the capabilities of this instrument, the operator should be familiar with the function and use of each of these controls and connectors. A brief description of the function or operation of the front-panel controls and connectors follows. More detailed information is given under General Operating Information.

### Channel 1 and 2

**INPUT** Input connector for vertical deflection signal.

**Input Coupling** Selects method of coupling input signal to (AC GND DC) Input Amplifier.

**AC:** DC component of input signal is blocked. Low frequency limit ( $-3$  dB point) is about 1.6 hertz.

**GND:** Input circuit is grounded (does not ground applied signal). Input impedance remains one megohm.

**DC:** All components of the input signal are connected to the Input Amplifier.

**VAR BAL** Screwdriver adjustment to balance the Input Amplifier so there is no vertical shift of the trace as the VARIABLE control is rotated (with no signal applied).

**GAIN** Screwdriver adjustment to set gain of the channel.

**VOLTS/CM** Selects vertical deflection factor (VARIABLE control must be in CAL position for indicated deflection factor).

**VARIABLE** Provides continuously variable deflection factor to at least 2.5 times setting of VOLTS/CM switch.

**UNCAL** Light indicates when the VARIABLE control is not in the CAL position.

**POSITION** Controls vertical position of trace.

**INVERT** Switch which inverts the displayed signal when pulled out.

**CH 2 OUTPUT** Output connector providing a sample of (Channel 2 only) the signal applied to the CH 2 INPUT connector.

### Trigger and Mode Controls

**TRIGGER** Selects source of internal triggering signal.

**NORM:** Trigger signal obtained from displayed channel(s).

**CH 2 ONLY:** Trigger signal obtained from Channel 2.

**MODE** Selects the vertical mode of operation.

**CH 1:** Signal applied to the CH 1 INPUT connector is displayed.

**CH 2:** Signal applied to the CH 2 INPUT connector is displayed.

**ALT:** Dual-trace display of signal applied to both channels. Display switched at end of each sweep.

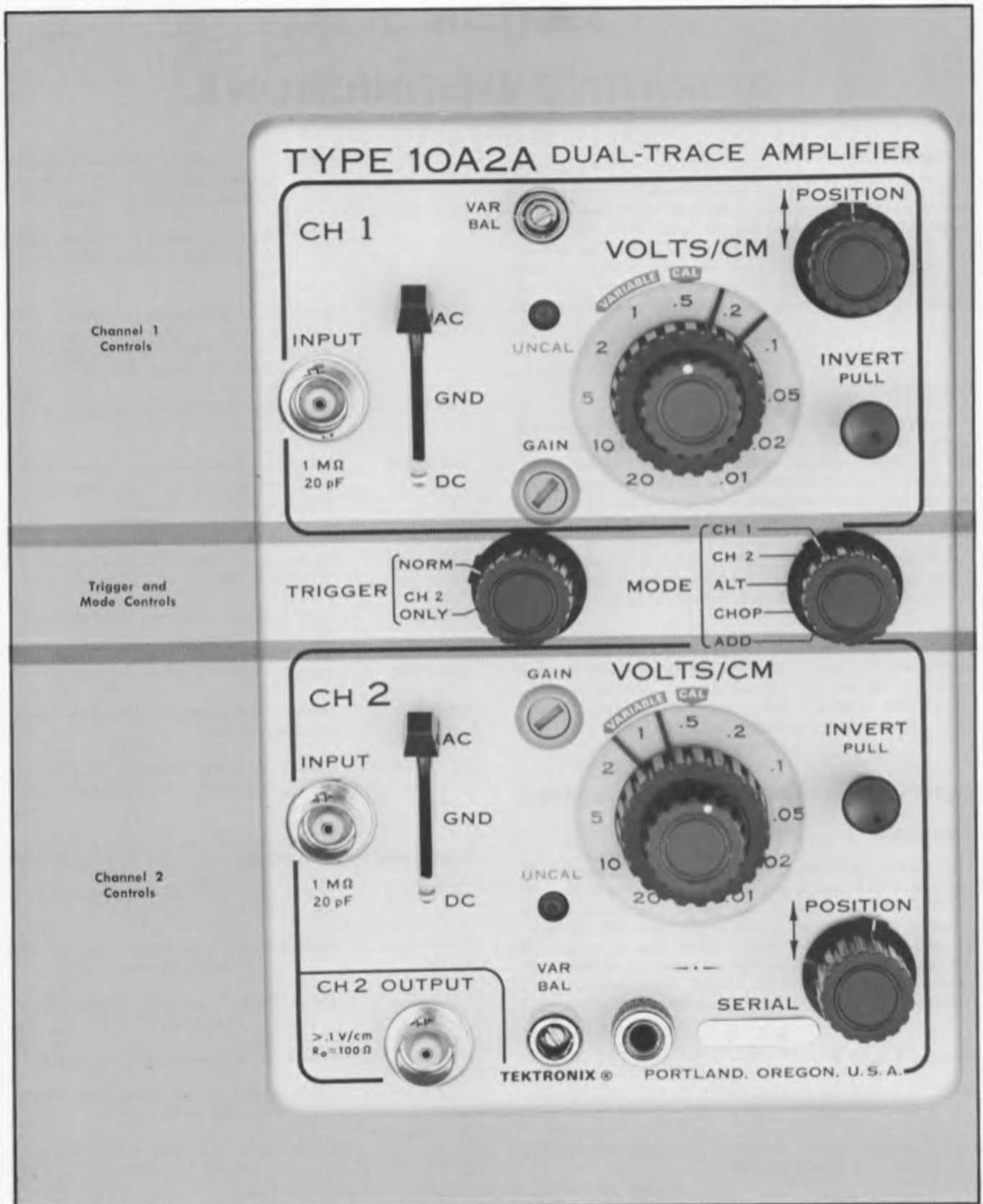


Fig. 2-1. Front-panel controls and connectors of the Type 10A2A.

**CHOP:** Dual-trace display of signal applied to both channels. Display switched between channels at a repetition rate of about one megahertz.

**ADD:** Signals applied Channel 1 and 2 are algebraically added and the algebraic sum is displayed on the CRT.

Time/Centimeter	1 millisecond
Variable	Calib
Magnifier	Off

**Indicator Oscilloscope**

Intensity	Adjust for visible display
Focus	Adjust for optimum display
Astigmatism	Adjust for optimum display
Scale Illum	As desired
Calibrator	50 millivolts
Horiz Position	Midrange

**FIRST-TIME OPERATION**

**General**

The following steps demonstrate the basic function of the controls and connectors of the Type 10A2A and also demonstrate the basic operation of this unit. It is recommended that this procedure be followed completely for familiarization with the instrument. Operation of the indicator oscilloscope and time-base unit is described in the instruction manuals for these units. The first 12 steps of this procedure describe the method of setting up the system for correct amplitude measurements. These steps may be used to set up the unit when it is installed in an oscilloscope to insure accurate measurements.

**Setup Information**

1. With the indicator oscilloscope power turned off, insert the Type 10A2A into the vertical plug-in compartment.
2. Insert an 11-series time-base unit into the right plug-in compartment.
3. Set the oscilloscope intensity control counterclockwise.
4. Connect the oscilloscope to a power source which meets its voltage and frequency requirements.
5. Turn on the oscilloscope power switch and allow about five minutes warm up.
6. Set the front-panel controls as follows:

**Type 10A2A (both channels if applicable)**

Input Coupling	GND
VOLTS/CM	.01
VARIABLE	CAL
POSITION	Midrange
INVERT	Pushed in
TRIGGER	NORM
MODE	CH 1

**Time-Base Unit**

Trigger Mode	Auto
Trigger Source	Int
Trigger Coupling	AC
Trigger Slope	+
Trigger Level	Midrange

7. Move the trace to the graticule centerline with the CH 1 POSITION control.

8. Rotate the CH 1 VARIABLE control throughout its range. If the vertical position of the trace changes, see Variable Balance in this section for the balancing procedure. Return the CH 1 VARIABLE control to CAL.

9. Set the MODE switch to CH 2. Rotate the CH 2 VARIABLE control throughout its range. If the vertical position of the trace changes, see Variable Balance in this section.

10. Connect the indicator oscilloscope calibrator output connector to both the CH 1 and CH 2 INPUT connectors using six-inch and 18-inch BNC-to-BNC patch cords. Set both Input Coupling switches to AC.

11. Center the display with the CH 2 POSITION control. The display is a square wave, five divisions in amplitude with about five cycles displayed on the screen. If the display is not five divisions in amplitude, see Vertical Gain Adjustment in this section.

12. Set the MODE switch to CH 1. Center the display with the CH 1 POSITION control. Check the display for five divisions of deflection. If the display is not five divisions, see Vertical Gain Adjustment in this section.

**Input Coupling**

13. Set the CH 1 Input Coupling switch to GND and position the trace to coincide with the graticule centerline.

14. Set the CH 1 Input Coupling switch to DC. Note that the baseline of the waveform remains at the horizontal centerline (ground reference).

15. Set the CH 1 Input Coupling switch to AC. Note that the waveform is centered about the horizontal centerline.

**Variable Volts/Centimeter**

16. Turn the CH 1 VARIABLE control throughout its range. Note that the UNCAL light comes on when the VARIABLE control is moved from the CAL position (fully clockwise). The deflection should be reduced to about two divisions in the fully counterclockwise position. Return the CH 1 VARIABLE control to CAL.

17. Set the MODE switch to CH 2. The CH 2 Input Coupling switch and VARIABLE control operate as described in steps 13 through 16.

## Operating Instructions—Type 10A2A

### Dual-Trace Operation

18. Set both VOLTS/CM switches to .02.

19. Set the MODE switch to ALT and position the Channel 1 waveform to the top half of the graticule area and the Channel 2 waveform to the bottom half of the graticule area. Turn the time-base time/centimeter switch throughout its range. Note that the display alternates between channels at all sweep rates.

20. Set the MODE switch to CHOP and the time-base time/centimeter switch to 2 microseconds. Note the switching between channels as shown by the segmented trace. Set the TRIGGER switch to CH 2 ONLY; the trace should appear more solid. Turn the time-base time/centimeter switch throughout its range. A dual-trace display is presented at all sweep rates, but unlike ALT, both channels are displayed on each sweep on a time-sharing basis. Set the time-base time/centimeter switch to 0.5 milliseconds.

### Added Mode Operation

21. Set the MODE switch to ADD. The display should be five divisions in amplitude. Note that either POSITION control moves the display.

22. Pull the CH 2 INVERT switch. The display is a straight line (if the Channel 1 and Channel 2 gain are set correctly) indicating that the algebraic sum of the two signals is zero.

23. Set either VOLTS/CM switch to .05. The square-wave display indicates that the algebraic sum of the two signals is no longer zero.

24. This completes the basic operating procedure for the Type 10A2A. Instrument operation not explained here, or operations which need further explanation are discussed under General Operating Information.

### CONTROL SETUP CHART

Fig. 2-2 shows the front-panel of the Type 10A2A. This chart can be reproduced and used as a test-setup record for special measurements, applications or procedures, or it may be used as a training aid for familiarization with this instrument.

## GENERAL OPERATING INFORMATION

### Vertical Channel Selection

Either of the input channels can be used for single-trace displays. Apply the signal to the desired INPUT connector and set the MODE switch to display the channel used. For dual-trace displays, connect the signals to both INPUT connectors and set the MODE switch to CHOP or ALT.

### Variable Balance

To check the variable balance of either channel, set the Input Coupling switch to GND and the VOLTS/CM switch to .01. Set the time-base triggering controls to produce a free-running trace and set the MODE switch to display the desired channel. Rotate the VARIABLE control throughout its range. If the trace moves vertically, adjust the front-panel VAR BAL adjustment for minimum trace shift as the VARIABLE control is rotated throughout its range.

### Vertical Gain Adjustment

To check the gain of either channel, set the VOLTS/CM switch to .01 and connect a 50-millivolt calibrator signal to the INPUT connector of the channel used. The vertical deflection should be exactly five divisions. If not, adjust the front-panel GAIN adjustment for exactly five divisions of deflection.

#### NOTE

If the gain of the two channels must be closely matched (such as for ADD mode operation), the adjustment procedure given in the Calibration section should be used.

The best measurement accuracy with probes is provided if the GAIN adjustment is made using the probe. Also; to provide the most accurate measurements, calibrate the vertical gain of the Type 10A2A at the temperature at which the measurement is to be made. This is particularly important at temperatures below 0° C (see Fig. 1-2). The temperature stability of the 647-series voltage calibrator (see 647-series Instruction Manual) is considerably better than that of the Type 10A2A/647-series vertical amplifier combination.

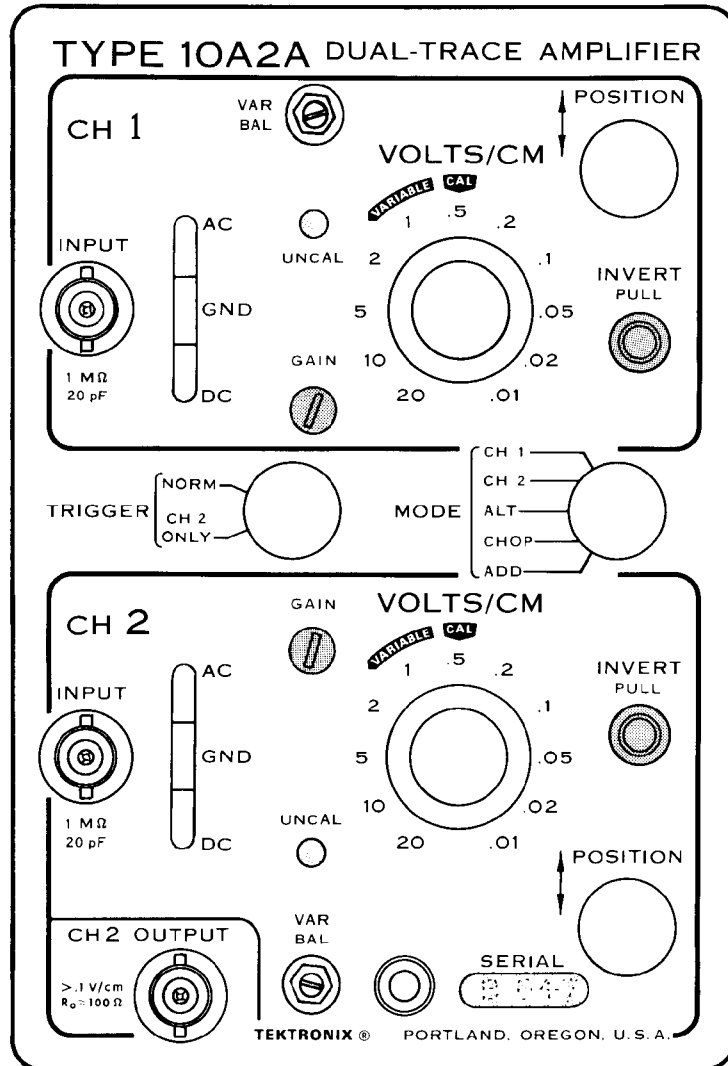
### Signal Connections

In general, probes offer the most convenient means of connecting a signal to the input of the Type 10A2A. Tektronix probes are shielded to prevent pickup of electrostatic interference. A 10× attenuator probe offers a high input impedance and allows the circuit under test to perform very close to normal operating conditions; however, a 10× probe also attenuates the input signal 10 times. The Tektronix P6045 Field Effect Transistor probe offers a high input impedance (10 megohms) paralleled by low input capacitance (about four picofarads). It also provides wide-band operation without signal attenuation. To obtain maximum bandwidth when using the probes, observe the grounding considerations given in the probe manual. The probe-to-connector adapters and the bayonet-ground tip provide the best frequency response. Remember that a ground strap only a few inches in length can produce several percent of ringing when operating at the higher frequency limit of this system. Fig. 2-3 illustrates the usable frequency range (−3 dB) of various Tektronix probes when used with the Type 10A2A. Only a few of the available probes are shown in this chart. See your Tektronix, Inc. catalog for characteristics and compatibility of other probes for this system.

Some applications may permit circuit loading with a low impedance such as 50 ohms. Full bandwidth measurements without signal attenuation are possible with high-quality coaxial cables. See the discussion on coaxial cables in this section for more information.

High-level, low-frequency signals can be connected directly to the Type 10A2A INPUT connectors with short unshielded leads or with a non-attenuating (1×) passive probe. This coupling method works best for signals below about one kilohertz and deflection factors above one volt/division. When this method is used, establish a common ground between the Type 10A2A and the equipment under test. Attempt to position the leads away from any source of

# TYPE 10A2A TEST SETUP CHART



## NOTES

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Fig. 2-2. Control setup chart for the Type 10A2A.

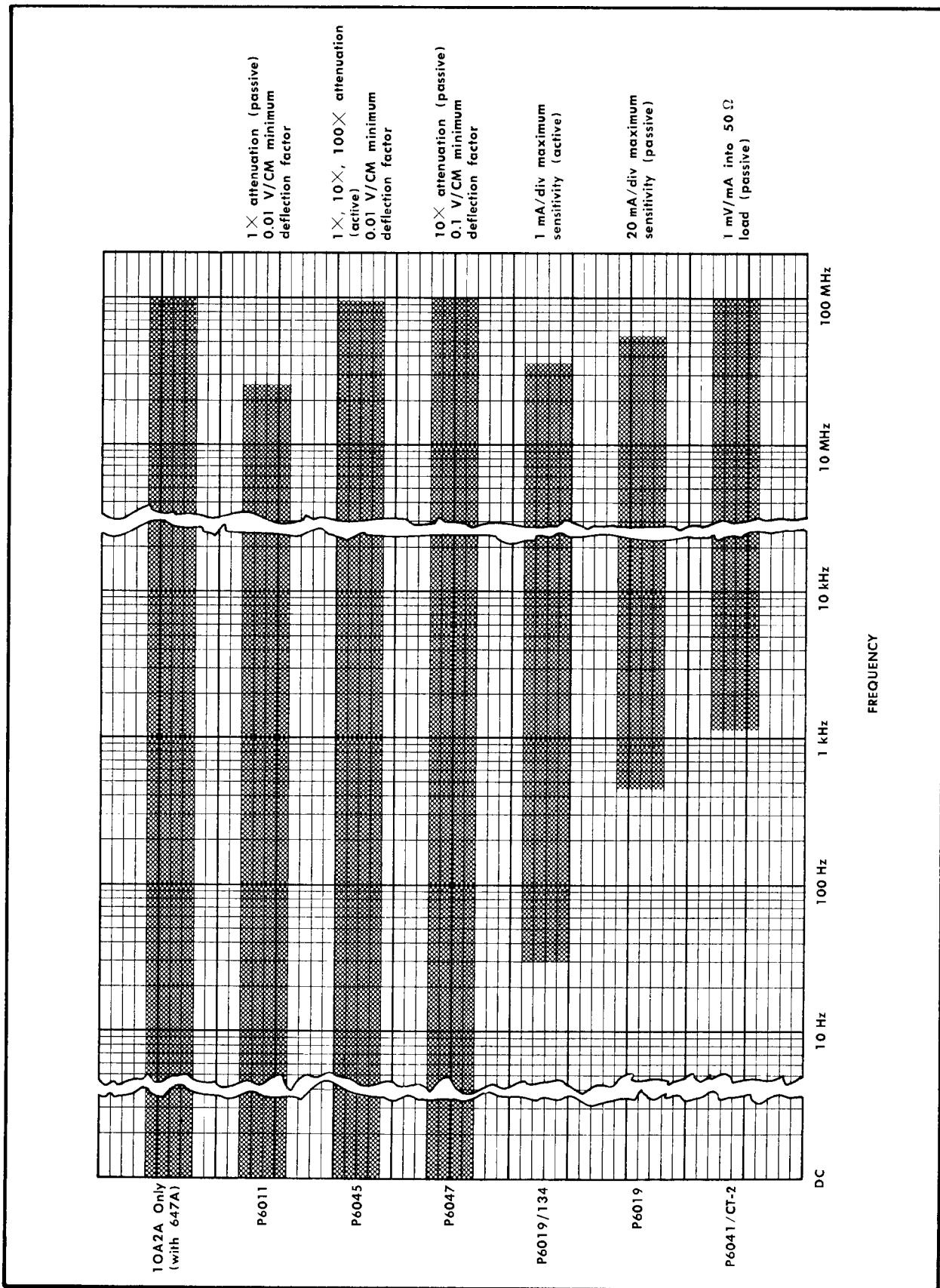


Fig. 2-3. Frequency range of signal coupling with probes.

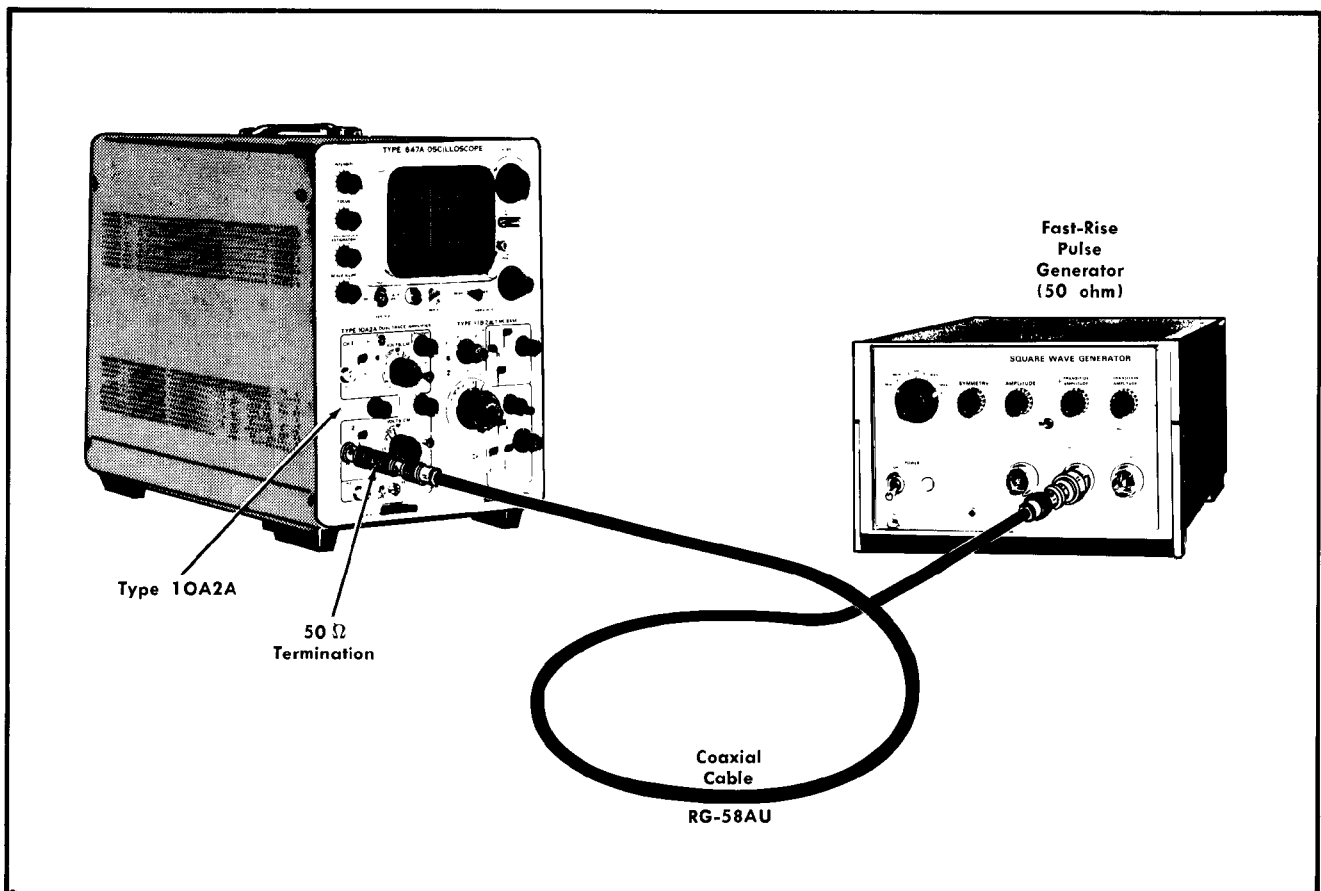


Fig. 2-4. Configuration for measuring system transient response.

interference to avoid erroneous displays. If interference is excessive with unshielded leads, use a coaxial cable or a probe.

### Loading Effect of the Type 10A2A

As nearly as possible, simulate actual operating conditions in the equipment under test. Otherwise, the equipment under test may not produce a normal signal. The 10× attenuator and field effect transistor probes mentioned previously offer the least circuit loading. See the probe instruction manual for loading characteristics of the probes.

When the signal is coupled directly to the input of the Type 10A2A, the input impedance is about one megohm paralleled by about 20 pF. When the signal is coupled to the input through a coaxial cable, the effective input capacitance depends upon the type and length of cable used. See the following discussion for information on obtaining maximum frequency response with coaxial cables.

### Coaxial Cable Considerations

The signal cables used to connect the signal to the Type 10A2A INPUT connectors have a large effect on the accu-

racy of the displayed high-frequency waveform. To maintain the high-frequency characteristics of the applied signal, low-loss coaxial cable should be used. The cable should be terminated at the Type 10A2A INPUT connector in its characteristic impedance. In some cases, it may also be necessary to terminate the cable at the source. If it is necessary to use cables with differing characteristic impedances, use suitable impedance-matching devices to provide the correct transition, with minimum loss, from one impedance to the other.

The characteristic impedance, velocity of propagation and nature of signal losses in a coaxial cable are determined by the physical and electrical characteristics of the cable. Losses caused by energy dissipation in the dielectric are proportional to the signal frequency. Therefore, much of the high-frequency information in a fast-rise pulse can be lost in only a few feet of interconnecting cable if it is not the correct type. To be sure of the high-frequency response of the system when using cables longer than about five feet, observe the transient response of the Type 10A2A and the interconnecting cable with a fast-rise pulse generator (generator risetime less than one nanosecond). Fig. 2-4 shows the method of measuring the system transient response when a signal is connected to the input of the Type 10A2A with a coaxial cable.

## Operating Instructions—Type 10A2A

Due to the high-frequency losses in coaxial cables and subsequent distortion of fast-rise pulses, the 0-50% half-amplitude risetime,  $T_0$ , is often used to measure pulse risetime instead of the conventional 10-90% measurement that is associated with amplifiers.  $T_0$  provides more accurate risetime measurements since it does not reflect the measurement errors due to coaxial distortion of the high-frequency portion of the signal.

### Input Coupling

The Channel 1 and 2 Input Coupling switches allow a choice of input coupling. The type of display desired will determine the coupling used.

The DC position can be used for most applications. However, if the DC component of the signal is much larger than the AC component, the AC position will probably provide a better display. DC coupling is preferable for displaying AC signals below about 10 hertz as they will be attenuated in the AC position.

In the AC position, the DC component of the signal is blocked by a capacitor in the input circuit. The low-frequency 3-dB point in the AC position is about 1.6 Hz. Therefore, some low-frequency distortion can be expected near this frequency limit. Distortion will also appear in non-sinusoidal waveforms which have low-frequency components.

The GND position provides a ground reference at the input of the Type 10A2A. The signal applied to the INPUT connector is internally disconnected but not grounded. The grid of the input nuxistor is at ground potential, eliminating the need to externally ground the input to establish a DC ground reference. This position can also be used to pre-charge the coupling capacitor to the average voltage of the signal applied to the INPUT connector.

To measure only the AC component of signals having both AC and DC components, take advantage of the pre-charging network incorporated in this unit. This network allows the coupling capacitor to charge to the DC source voltage when the Input Coupling switch is set to GND. The procedure for using this feature is as follows:

1. Before connecting the signal containing a DC component to the Type 10A2A INPUT connector, set the Input Coupling switch to GND. Then connect the signal to the INPUT connector.
2. Wait about one second for the coupling capacitor to charge.
3. Set the Input Coupling switch to AC. The trace (display) will remain on the screen and the AC component can be measured in the normal manner.

### Deflection Factor

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

The VARIABLE VOLTS/CM control provides variable deflection factor between the calibrated steps of the VOLTS/CM switch. The VARIABLE control extends the maximum vertical deflection factor of the Type 10A2A to at least 50 volts/centimeter (20 VOLTS/CM switch position).

### Dual-Trace Operation

**Alternate Mode.** The ALT position of the MODE switch produces a display which alternates between Channel 1 and 2 with each sweep of the CRT. Although the ALT mode can be used at all sweep rates, the CHOP mode provides a more satisfactory display at sweep rates below about 20 microseconds/division. At these slower sweep rates, alternate mode switching becomes visually perceptible.

Proper internal triggering in the ALT mode can be obtained in either the NORM or CH 2 ONLY positions of the TRIGGER switch. When in the NORM position, the sweep will be triggered from the signal on each channel. This provides a stable display of two unrelated signals, but does not indicate the time relationship between the signals. In the CH 2 ONLY position, the two signals will be displayed showing true time relationship. If the signals are not time related, the Channel 1 waveform will be unstable in the CH 2 ONLY position.

**Chopped Mode.** The CHOP position of the MODE switch produces a display which is electronically switched between channels. In general, the CHOP mode provides the best display at sweep rates slower than about 200 microseconds/division, or whenever dual-trace, single-shot phenomena are to be displayed. At faster sweep rates the chopped switching becomes apparent and may interfere with the display.

Proper internal triggering for the CHOP mode is provided with the TRIGGER switch set to CH 2 ONLY. If the NORM position is used, the sweep circuits will be triggered from the between-channel switching signal and both waveforms will be unstable. External triggering can be used to provide the same result as CH 2 ONLY triggering.

Two signals which are time-related can be displayed in the chopped mode showing true time relationship. If the signals are not time-related, the Channel 1 display will appear unstable.

Two single-shot, transient, or random signals which occur within the time interval determined by the time-base time/centimeter switch (10 times sweep rate) can be compared using the CHOP mode. To trigger the sweep correctly, the Channel 2 signal must precede the Channel 1 signal. Since the signals show true time relationship, time-difference measurements can be made.

### Channel 1 Output and Cascaded Operation

If a lower deflection factor than provided by the VOLTS/CM switch is desired, Channel 2 can be used as a wide-band preamplifier for Channel 1. Apply the input signal to the CH 2 INPUT connector. Connect the eight-inch 50-ohm BNC cable (supplied accessory) between the CH 2 OUTPUT and the CH 1 INPUT connectors and set the MODE switch to CH 1. With both VOLTS/CM switches set to .01, the deflection factor will be less than one millivolt/centimeter.



To provide a calibrated one millivolt/centimeter deflection factor, connect a 5 millivolt Calibrator signal to the CH 2 INPUT connector. Set both VOLTS/CM switches to .01. Adjust the Channel 1 VARIABLE VOLTS/CM control to produce a display exactly five divisions in amplitude. The cascaded deflection factor is determined by dividing the CH 2 VOLTS/CM switch setting by 10 (CH 1 VOLTS/CM switch and VARIABLE control remain as set above). For example, with the CH 2 VOLTS/CM switch set to .01, the calibrated deflection factor will be one millivolt/centimeter; CH 2 VOLTS/CM switch set to .02, two millivolts/centimeter, etc.

The following operating considerations and basic applications may suggest other uses for this feature.

1. If AC coupling is desired, set the Channel 2 Input Coupling switch to AC and leave the Channel 1 Input Coupling switch set to DC. When both Input Coupling switches are set to DC, DC signal coupling is provided.

2. The voltage gain from the CH 2 INPUT connector to the CH 2 OUTPUT connector is at least  $10\times$  in the .01 position, at least  $5\times$  in the .02 position and at least  $2\times$  in the .05 position.

3. The MODE and CH 2 POSITION control have no effect on the signal available at the CH 2 OUTPUT connector.

4. The Channel 2 Input Preamp can be used as an impedance matching stage with or without voltage gain. The input resistance is one megohm and the output resistance is about 100 ohms.

5. The dynamic range of the Channel 2 Input Preamp is about 20 times the CH 2 VOLTS/CM setting. The CH 2 OUTPUT signal is typically at 0 volts DC for a 0 volt DC input level.

6. If dual-trace operation is used, the signal applied to the CH 2 INPUT connector is displayed when Channel 2 is turned on. Thus, Channel 2 can be used to monitor the input signal while the amplified signal is displayed by Channel 1.

7. In special applications where the flat frequency response of the Type 10A2A is not desired, a filter inserted between the CH 2 OUTPUT and CH 1 INPUT connectors allows the oscilloscope to take on the frequency response of the filter. Combined with method 6, the input can be monitored by Channel 2 and the filtered signal displayed by Channel 1.

### Algebraic Addition

The ADD position of the MODE switch can be used to display the sum or difference of two signals, for common-mode rejection to remove an undesired signal (about 20:1 rejection up to 50 MHz) or for DC offset (applying a DC voltage to one channel to offset the DC component of a signal on the other channel).

The common-mode rejection ratio of the Type 10A2A is greater than 20:1 at 50 megahertz for signal amplitudes up to 10 times the VOLTS/CM switch setting. Rejection ratios of 100:1 can typically be achieved between DC and five megahertz by careful adjustment of the gain of either channel while observing the displayed common-mode signal.

The following general precautions should be observed when using the ADD mode.

1. Do not apply signals that exceed an equivalent of about 12 times the VOLTS/CM switch setting. For example, with a VOLTS/CM switch setting of .5, the voltage applied to that channel should not exceed about six volts. Larger voltages may distort the display.

2. Use vertical POSITION control settings which most nearly position the signal of each channel to mid-screen when viewed in either the CH 1 or CH 2 MODE switch positions. This insures the greatest dynamic range for ADD mode operation.

### BASIC APPLICATIONS

The following information describes the procedure and technique for making basic measurements with a Type 10A2A Dual-Trace Amplifier and associated time-base unit and oscilloscope. These applications are not described in detail since each application must be adapted to the requirements of the individual measurements. Familiarity with the Type 10A2A will permit these basic techniques to be applied to a wide variety of uses.

#### Peak-to-Peak Voltage Measurements—AC

To make a peak-to-peak voltage measurement, use the following procedure:

1. Connect the signal to either INPUT connector.
2. Set the MODE switch to display the channel used.
3. Set the Input Coupling switch to AC.
4. Set the VOLTS/CM switch to display about five divisions of the waveform.

#### NOTE

For low-frequency signals below about 10 hertz, use the DC position.

5. Set the time-base triggering controls to obtain a stable display. Set the sweep rate to display two or three cycles of the signal.

6. Turn the POSITION control so the lower portion of the waveform coincides with one of the graticule lines below the centerline, and the top of the waveform is within the viewing area. Move the display with the time-base position control so one of the upper peaks lies near the vertical centerline (see Fig. 2-5).

7. Measure the divisions of vertical deflection from peak to peak. Make sure the VARIABLE VOLTS/CM control is in the CAL position.

#### NOTE

This technique may also be used to make measurements between two points on the waveform rather than peak to peak.

8. Multiply the distance measured in step 7 by the VOLTS/CM switch setting. Also include the attenuation factor of the probe, if any.

## Operating Instructions—Type 10A2A

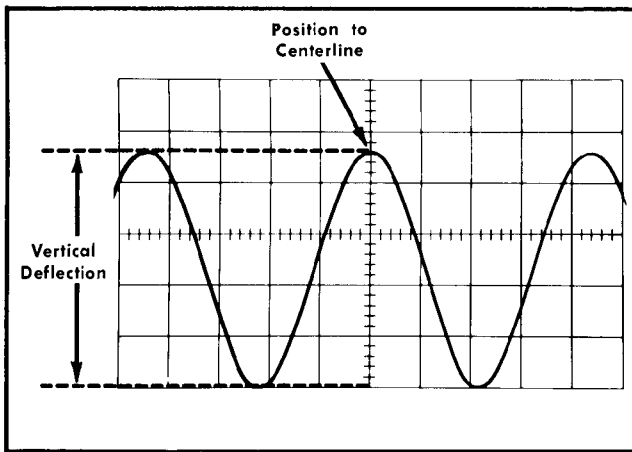


Fig. 2-5. Measuring peak-to-peak voltage of a waveform.

Example. Assume a peak-to-peak vertical deflection of 4.6 divisions (see Fig. 2-5) using a 10 $\times$  attenuator probe and a VOLTS/CM switch setting of .5.

Using the formula:

$$\text{Volts Peak to Peak} = \text{vertical deflection (divisions)} \times \text{VOLTS/CM setting} \times \text{probe attenuation factor}$$

Substituting the given values:

$$\text{Volts Peak to Peak} = 4.6 \times 0.5 \text{ V} \times 10$$

The peak-to-peak voltage would be 23 volts.

## Instantaneous Voltage Measurements—DC

To measure the DC level at a given point on a waveform, use the following procedure:

1. Connect the signal to either INPUT connector.
2. Set the MODE switch to display the channel used.
3. Set the VOLTS/CM switch to display about five divisions of the waveform.
4. Set the Input Coupling switch to GND.
5. Set the time-base triggering for automatic-mode operation.
6. Position the trace to the bottom line of the graticule or other reference line. If the voltage to be measured is negative with respect to ground, position the trace to the top line of the graticule. Do not move the POSITION control after this reference line has been established.

### NOTE

To measure a voltage level with respect to another voltage rather than ground, make the following changes in step 6: Set the Input Coupling switch to DC and apply the reference voltage to the INPUT connector. Then position the trace to the reference line.

7. Set the Input Coupling switch to DC. The ground reference line can be checked at any time by switching to the GND position.

8. Set the time-base triggering controls to obtain a stable display. Set the sweep rate to display several cycles of the signal.

9. Measure the distance in divisions between the reference line and the point on the waveform at which the DC level is to be measured. For example, in Fig. 2-6 the measurement is made between the reference line and point A.

10. Establish the polarity of the signal. If the waveform is above the reference line, the voltage is positive; below the line, negative (when the INVERT switches are pushed in).

11. Multiply the distance measured in step 9 by the VOLTS/CM switch setting. Include the attenuation of the probe, if any.

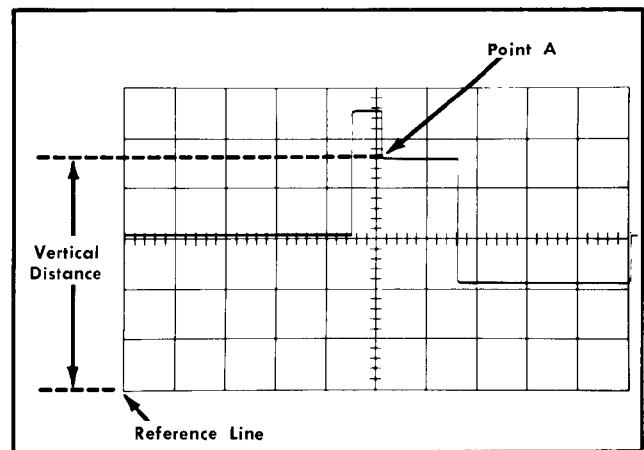


Fig. 2-6. Measuring instantaneous DC voltage with respect to a reference voltage.

Example. Assume that the vertical distance measured is 4.6 divisions (see Fig. 2-6), the waveform is above the reference line, using a 10 $\times$  attenuator probe and a VOLTS/CM switch setting of 2.

Using the formula:

$$\text{Instantaneous Voltage} = \text{vertical distance (divisions)} \times \text{polarity} \times \text{VOLTS/CM setting} \times \text{probe attenuation factor}$$

Substituting the given values:

$$\text{Instantaneous Voltage} = 4.6 \times +1 \times 2 \text{ V} \times 10$$

The instantaneous voltage would be +92 volts from the reference.

## Voltage Comparison Measurements

In some applications it may be necessary to establish a set of deflection factors other than those indicated by the

VOLTS/CM switch. This is useful for comparing signals to a reference voltage amplitude. To establish a new set of deflection factors based upon a specific reference amplitude, proceed as follows:

1. Apply the reference signal of known amplitude to either INPUT connector. Set the MODE switch to display the channel used. Using the VOLTS/CM switch and the VARIABLE control, adjust the display for an exact number of divisions. Do not move the VARIABLE VOLTS/CM control after obtaining the desired deflection.

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

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude (volts)}}{\text{deflection (divisions)} \times \text{VOLTS/CM setting}}$$

3. To establish an Adjusted Deflection Factor at any setting of the VOLTS/CM switch, multiply the VOLTS/CM switch setting by the Deflection Conversion Factor established in step 2.

$$\text{Adjusted Deflection Factor} = \text{VOLTS/CM setting} \times \text{Deflection Conversion Factor}$$

This Adjusted Deflection Factor applies only to the channel used and is correct only if the VARIABLE VOLTS/CM control is not moved from the position set in step 1.

4. To determine the peak-to-peak amplitude of a signal compared to a reference, disconnect the reference and apply the signal to the INPUT connector.

5. Set the VOLTS/CM switch to a setting that provides sufficient deflection to make the measurement. Do not re-adjust the VARIABLE VOLTS/CM control.

6. Measure the vertical deflection in divisions and determine the amplitude by the following formula:

$$\text{Signal Amplitude} = \text{Adjusted Deflection Factor} \times \text{deflection (divisions)}$$

Example. Assume a reference signal amplitude of 30 volts, a VOLTS/CM setting of 5 and a deflection of four divisions. Substituting these values in the Deflection Conversion Factor formula (step 2):

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

Then, with a VOLTS/CM switch setting of 10, the Adjusted Deflection Factor (step 3) would be:

$$\text{Adjusted Deflection Factor} = 10 \times 1.5 = 15 \text{ volts/division}$$

To determine the peak-to-peak amplitude of an applied signal which produces a vertical deflection of five divisions, use the Signal Amplitude formula (step 6):

$$\text{Signal Amplitude} = 15 \text{ V} \times 5 = 75 \text{ volts}$$

## Time-Difference Measurements

The dual-trace features of the Type 10A2A and the calibrated sweep rate of the time-base unit allow measurement of time difference between two separate events. To measure time difference, use the following procedure.

1. Set the Input Coupling switches to the desired coupling positions.

2. Set the MODE switch to either CHOP or ALT. In general, CHOP is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals. More information on determining the mode is given under Dual-Trace Operation in this section.

3. Set the TRIGGER switch to CH 2 ONLY.

4. Connect the reference signal to the CH 2 INPUT connector and the comparison signal to the CH 1 INPUT connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the INPUT connectors.

5. If the signals are of opposite polarity, pull one of the INVERT switches out to invert either display.

6. Set the VOLTS/CM switches to produce four- or five-division displays.

7. Set the time-base triggering controls for a stable display.

8. Set the sweep rate to display three or more divisions between the two waveforms.

9. Adjust the POSITION controls to center each waveform (or the points on the display between which the measurement is made) in relation to the horizontal centerline.

10. Adjust the Horizontal Position control so the Channel 2 (reference) waveform crosses the horizontal centerline at a vertical graticule line.

11. Measure the horizontal difference between the Channel 1 waveform and the Channel 2 waveform (see Fig. 2-7).

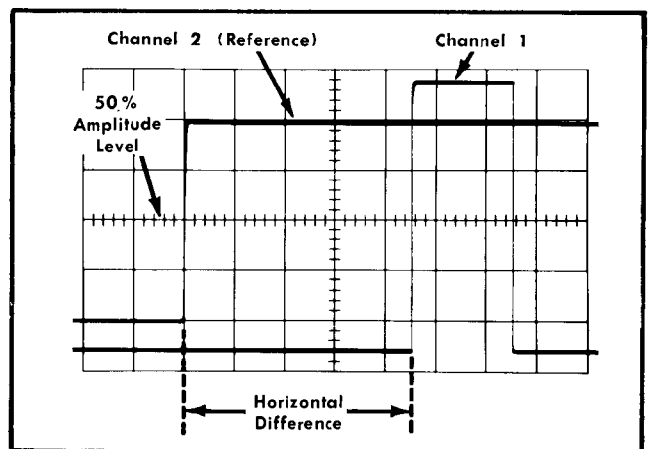


Fig. 2-7. Measuring time difference between two pulses.

## Operating Instructions—Type 10A2A

12. Multiply the measured difference by the sweep rate of the time-base unit. If sweep magnification is used, divide this answer by 10.

Example. Assume that the time-base sweep rate is 50 microseconds/division, the magnification is  $\times 10$  and the horizontal difference between waveforms is 4.5 divisions (see Fig. 2-7).

Using the formula:

$$\text{Time Delay} = \frac{\text{sweep rate} \times \text{horizontal difference (divisions)}}{\text{magnification}}$$

Substituting the given values:

$$\text{Time Delay} = \frac{50 \mu\text{s} \times 4.5}{10}$$

The time delay would be 22.5 microseconds.

## Multi-Trace Phase Difference Measurements

Phase comparison between two signals of the same frequency can be made using the dual-trace feature of the Type 10A2A. This method of phase difference measurement can be used up to the frequency limit of the vertical system. To make the comparison, use the following procedure.

1. Set the Input Coupling switches to the same position, depending on the type of coupling desired.

2. Set the MODE switch to either CHOP or ALT. In general, CHOP is more suitable for low-frequency signals and the ALT position is more suitable for high-frequency signals. More information on determining the mode is given under Dual-Trace Operation in this section.

3. Set the TRIGGER switch to CH 2 ONLY.

4. Connect the reference signal to the CH 2 INPUT connector and the comparison signal to the CH 1 INPUT connector. The reference signal should precede the comparison signal in time. Use coaxial cables or probes which have equal time delay to connect the signals to the INPUT connectors.

5. If the signals are of opposite polarity, pull one of the INVERT switches out to invert either display. (Signals may be of opposite polarity due to 180° phase difference; if so, take into account in final calculation.)

6. Set the VOLTS/CM switches and VARIABLE controls so the displays are equal and about five divisions in amplitude.

7. Set the triggering controls to obtain a stable display.

8. Set the sweep rate to display about one cycle of the waveform.

9. Move the waveforms to the center of the graticule with the POSITION controls.

10. Turn the variable sweep rate control until one cycle of the reference signal (Channel 2) occupies exactly eight divisions between the first and ninth graticule lines (see Fig. 2-8). Each division of the graticule represents 45° of the cycle ( $360^\circ \div 8 \text{ division} = 45^\circ/\text{division}$ ). The sweep rate can be stated in terms of degrees as 45°/division.

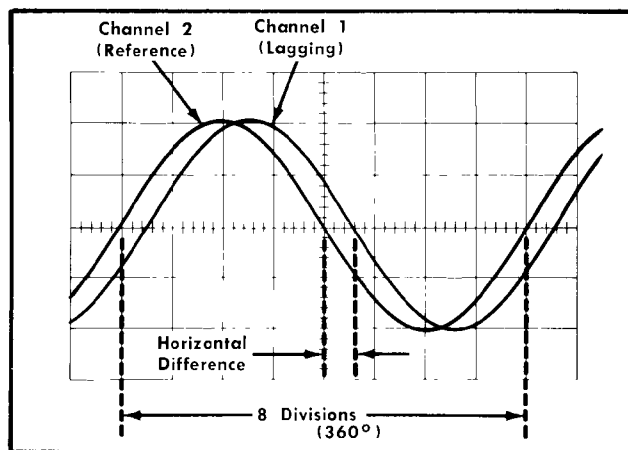


Fig. 2-8. Measuring phase difference.

11. Measure the horizontal difference between corresponding points on the waveform.

12. Multiply the measured distance (in divisions) by 45° (sweep rate in degrees/division) to obtain the exact amount of phase difference.

Example. Assume a horizontal difference of 0.6 divisions with a sweep rate of 45° as shown in Fig. 2-8.

Using the formula:

$$\text{Phase Difference} = \text{horizontal difference (divisions)} \times \text{sweep rate (degrees/div)}$$

Substituting the given values:

$$\text{Phase Difference} = 0.6 \times 45^\circ$$

The phase difference would be 27°.

## High Resolution Phase Measurements

More accurate dual-trace phase measurements can be made by increasing the sweep rate (without changing the variable sweep rate control setting). One of the easiest ways to increase the sweep rate is with the time-base magnifier. Delayed sweep magnification may also be used. The adjusted phase factor is determined by dividing the phase factor obtained previously by the increase in sweep rate.

Example. If the sweep rate were increased 10 times with the magnifier, the magnified sweep rate would be  $45^\circ \div 10 = 4.5^\circ/\text{division}$ . Fig. 2-9 shows the same signals as used in Fig. 2-8 but with the magnifier switch set to  $\times 10$ . With a horizontal difference of six divisions, the phase difference would be:

$$\text{Phase Difference} = \text{horizontal difference (divisions)} \times \text{magnified sweep rate (degrees/div)}$$

Substituting the given values:

$$\text{Phase Difference} = 6 \times 4.5^\circ$$

The phase difference would be 27°.

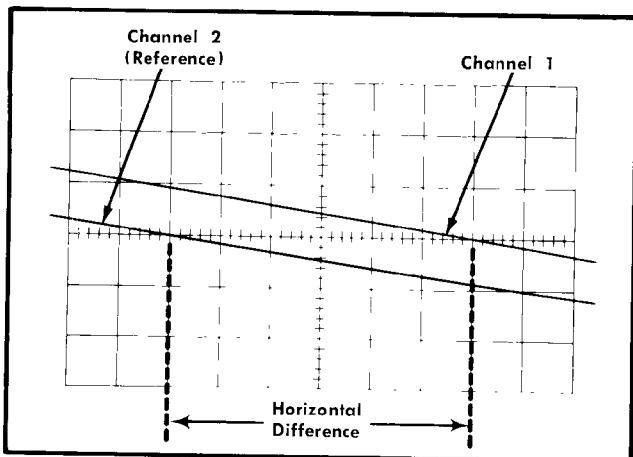


Fig. 2-9. High resolution phase-difference measurement with increased sweep rate.

### Common-Mode Rejection

The ADDED feature of the Type 10A2A can be used to display signals which contain undesirable components. These undesirable components can be eliminated through common-mode rejection. The precautions given under Algebraic Addition should be observed.

1. Connect the signal containing both the desired and undesired information to the CH 1 INPUT connector.

2. Connect a signal similar to the unwanted portion of the Channel 1 signal to the CH 2 INPUT connector. For example, in Fig. 2-10 a line-frequency signal is connected to Channel 2 to cancel out the line-frequency component of the Channel 1 signal.

3. Set both Input Coupling switches to DC (AC if DC component of input signal is too large).

4. Set the MODE switch to ALT. Set the VOLTS/CM switches so the signals are about equal in amplitude.

5. Set the TRIGGER switch to NORM.

6. Set the MODE switch to ADD. Pull the Channel 2 INVERT switch, if necessary, so the common-mode signals are of opposite polarity.

7. Adjust the CH 2 VOLTS/CM switch and VARIABLE control for maximum cancellation of the common-mode signal.

8. The signal which remains should be only the desired portion of the Channel 1 signal. The undesired signal is cancelled out.

Example. An example of this mode of operation is shown in Fig. 2-10. The signal applied to Channel 1 contains unwanted line-frequency components (Fig. 2-10A). A corresponding line-frequency signal is connected to Channel 2 (Fig. 2-10B). Fig. 2-10C shows the desired portion of the signal as displayed when common-mode rejection is used.

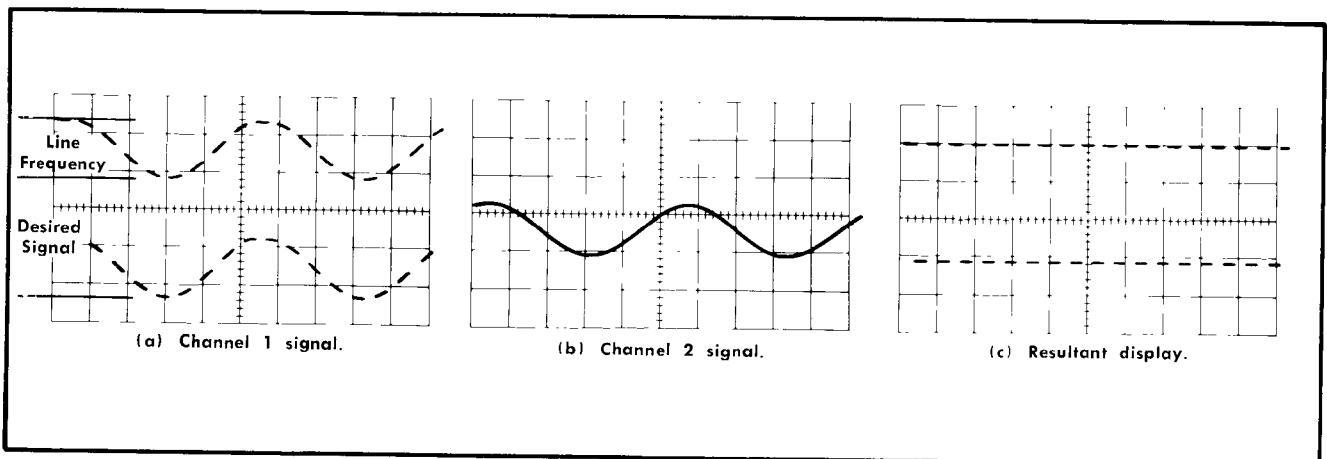


Fig. 2-10. Using the ADD feature for common-mode rejection. (A) Channel 1 signal contains desired information along with line-frequency component, (B) Channel 2 signal contains line-frequency only, (C) display using common-mode rejection.



# SECTION 3

## CIRCUIT DESCRIPTION

### Introduction

This section of the manual contains an electrical description of the circuitry used in the Type 10A2A Dual-Trace Amplifier. The description begins with a discussion of the instrument using the basic block diagram shown in Fig. 3-1. Then each circuit is described in detail using a detailed block diagram to show the interconnections between the stages in each major circuit and the relationship of the front-panel controls to the individual stages.

A complete block diagram is located in the Diagrams section at the rear of this manual. This block diagram shows the overall relationship between the circuits in this instrument. Complete schematics of each circuit are also given in the Diagrams section. Refer to these diagrams throughout the following circuit description for electrical values and circuit relationship.

### BLOCK DIAGRAM

#### General

The following block diagram is provided to aid in understanding the overall concept of the Type 10A2A before the individual circuits are discussed in detail. A basic block diagram of the Type 10A2A is shown in Fig. 3-1. Only the basic interconnections between the individual blocks are shown on this diagram. Each block in this block diagram represents a major circuit within the instrument. The number on each block refers to the circuit diagram at the rear of this manual which shows the complete circuit.

Input signals for vertical deflection on the indicator oscilloscope CRT are connected to either the Channel 1 INPUT connector or the Channel 2 INPUT connector (both for dual-trace operation). The input signals are then amplified by the Channel 1 Input Amplifier and/or the Channel 2 Input Amplifier. The VOLTS/CM switch in each Input Amplifier circuit provides the calibrated attenuation needed to display high-amplitude signals. Each Input Amplifier also includes separate position, input coupling, gain, invert, variable attenuation and balance controls. A trigger pickoff in the Channel 2 Input Amplifier circuit allows the time-base unit to be triggered from only the signal applied to Channel 2. The output of both Input Amplifier circuits is connected to the Channel Switching and Output Amplifier circuit.

The Channel Switching portion of the Channel Switching and Output Amplifier circuit selects the channel(s) to be displayed and determines the vertical mode of operation. An output signal from this circuit is connected to the indicator oscilloscope to blank out the between-channel switching transients when in the chopped mode of operation. The Output Amplifier portion of this circuit amplifies the vertical signal and provides the output to the indicator oscilloscope for vertical deflection on the CRT. A trigger-pickoff in the Output Amplifier portion provides a sample of the displayed vertical signal(s) for internal triggering. The TRIGGER switch

selects the internal trigger signal from this signal or the signal from the Channel 2 Input Amplifier. The selected signal is amplified and connected to the time-base unit through the indicator oscilloscope.

### CIRCUIT OPERATION

#### General

The following circuit analysis is written around the detailed block diagrams which are given for each major circuit. These detailed block diagrams give the names of the individual stages within the major circuits and show how they are connected together to form the major circuit. The block diagrams also show the inputs and outputs for each major circuit and the relationship of the front-panel controls to the individual stages. The circuit diagrams from which the detailed block diagrams are derived are shown in the Diagrams section of this manual. The names assigned to the individual stages on the detailed block diagrams are used throughout the following discussion.

This circuit analysis attempts to describe the electrical operation and circuit relationships in the Type 10A2A. The theory of operation for circuits which are commonly used in the electronics industry is not described in this discussion. Instead, references are given to textbooks or other source material where more complete information on these circuits can be found. Circuits which are unusual to this instrument are described in detail.

### Channel 1 Input Amplifier

#### General

Input signals for vertical deflection of the indicator oscilloscope CRT can be connected to the Channel 1 INPUT connector. The Channel 1 Input Amplifier provides control of input coupling, vertical deflection factor, balance, vertical position, polarity inversion and gain for the signal applied to the Channel 1 INPUT connector. Fig. 3-2 shows a detailed block diagram of the Channel 1 Input Amplifier circuit. A schematic of this circuit is shown on diagram 1 at the rear of this manual.

#### Input Coupling

Input signals connected to the Channel 1 INPUT connector can be AC-coupled, DC-coupled or internally disconnected. When the Input Coupling switch, SW101, is in the DC position, the input signal is coupled directly to the Channel 1 Input Attenuator stage. In the AC position, the input signal passes through a blocking capacitor, C100. This prevents the DC component of the signal from passing to the amplifier. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without the need to disconnect the applied

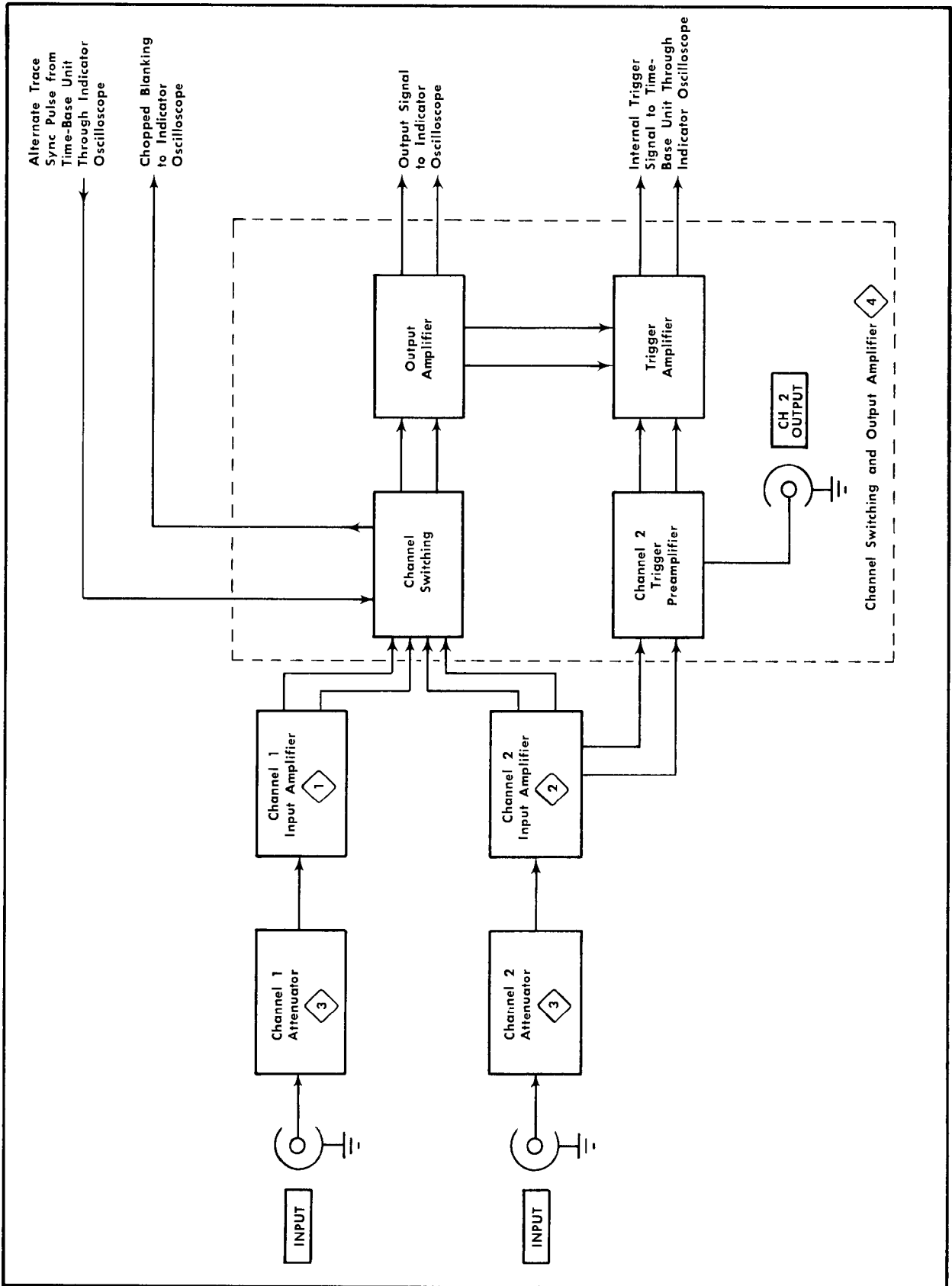


Fig. 3-1. Basic block diagram of the Type 10A2A.



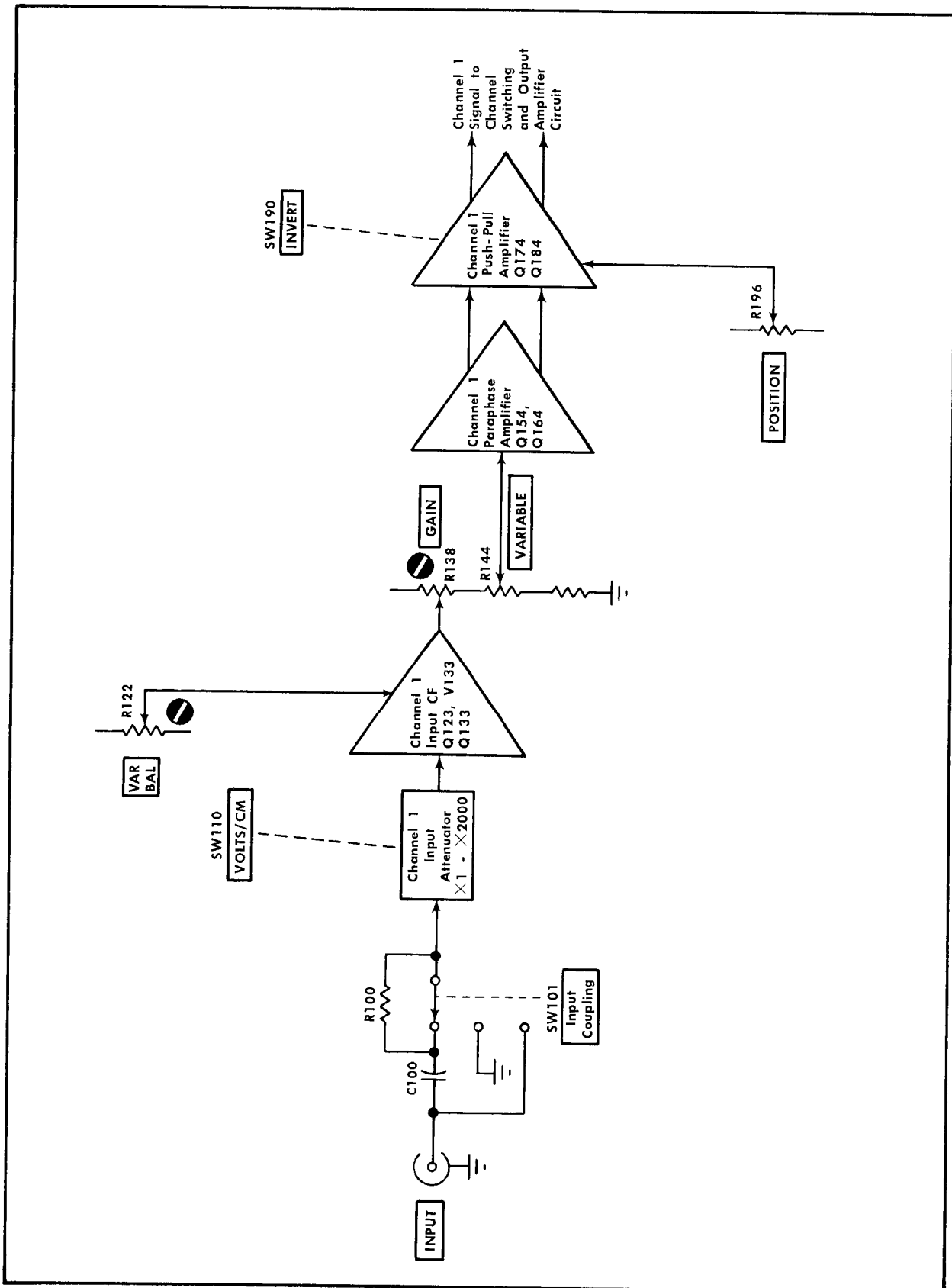


Fig. 3-2. Channel 1 Input Amplifier detailed block diagram.

## Circuit Description—Type 10A2A

signal from the INPUT connector R101 maintains the one megohm input impedance in the GND position and also allows the input capacitor, C100, to be pre-charged.

### Channel 1 Input Attenuator

The effective overall vertical deflection factor of the Type 10A2A is determined by the VOLTS/CM switch and the VARIABLE control. In all positions of the VOLTS/CM switch, the basic deflection factor of the unit is 0.01 volt/centimeter. To increase this basic deflection factor to provide the variety of deflection factors given on the front panel, precision attenuators are switched into the circuit. These attenuators are frequency compensated voltage dividers. For DC and low-frequency signals, they are resistive dividers and the voltage attenuation is determined by the resistance ratio in the attenuator. At higher frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitive voltage divider. Each attenuator contains an adjustable series capacitor to match the high-frequency attenuation to the DC attenuation and an adjustable shunt capacitor to adjust the input RC product to the correct value. Diagram 3 shows the individual attenuators used in this circuit.

In addition to providing correct attenuation at all frequencies, the Input Attenuator is designed to maintain the same input resistance (one megohm) for each setting of the VOLTS/CM switch. The variable capacitors are adjusted to maintain the same input time constant (nominally one megohm  $\times$  20 pF) at each setting of the VOLTS/CM switch.

### Channel 1 Input Cathode Follower

The Channel 1 Input Cathode Follower stage, V133, provides a high input impedance with a low impedance drive for the following stages. This stage also serves to isolate the input circuit and signal source from the remaining amplifier circuitry. R114 in the grid circuit of V133 is the input resistor. This resistor is part of the attenuation network at all VOLTS/CM switch positions. D133 provides protection for the Channel 1 Input Cathode Follower stage, and clamps the cathode at about  $-0.6$  volts during warm-up time to protect Q154 until the filament of V133 reaches normal operating temperature.

Transistor Q133 sets the operating plate voltage for V133. This voltage, in turn, is controlled by the VAR BAL adjustment, R122, at the base of Q123. The VAR BAL adjustment is set to produce a quiescent voltage level at the cathode of V133 which equals the voltage at the junction of R148-R149. Diode D125 disconnects Q133 from Q123 if a high positive input voltage is connected to the grid of V133.

The CH 1 Grid Current Zero adjustment, R117, is adjusted to offset any grid current in V133. This prevents quiescent current from flowing through the input resistor or Input Attenuator and producing a deflection when no signal is applied. The Q154 Base Current adjustment, R140, cancels the base current of Q154, when properly adjusted, so the quiescent current to Q154 from the VARIABLE control is zero. With these three controls correctly adjusted as described, the only current through the Input Attenuator and VARIABLE control is due to the applied signal. This prevents the display

trace (or DC level) from shifting when the VOLTS/CM switch is changed or VARIABLE control is rotated.

The GAIN adjustment, R138, provides variable signal-current attenuation for the output signal at the cathode of V133. The overall gain of the amplifier is set by controlling the amount of signal current which reaches the following stage. The VARIABLE control, R144, provides continuously variable uncalibrated deflection factors between the positions selected by the CH 1 VOLTS/CM switch. When the VARIABLE control is set to the CAL position (fully clockwise), maximum signal voltage reaches the base of Q154. Switch SW144, ganged with the VARIABLE control, is open and current does not flow through neon bulb B144. As the VARIABLE control is rotated counterclockwise from the CAL position, SW144 closes and the UNCAL light, B144, lights to indicate that the vertical deflection factor is uncalibrated. Also, as the VARIABLE control is rotated counterclockwise the signal voltage to Q154 is reduced.

### Channel 1 Paraphase Amplifier

Transistors Q154 and Q164 are connected as a common-emitter phase inverter (paraphase) amplifier<sup>1</sup> to convert the single-ended input signal to a push-pull output signal. The push-pull output is obtained from the single-ended input signal in the following manner: Assume that the signal voltage at the base of Q154 is increasing. This produces a corresponding increase in current through Q154 and its collector voltage goes negative. At the same time, the emitter of Q154 goes positive (more current flows through emitter resistor) and this change is connected to the emitter of Q164 through R169. As far as signal change is concerned, Q164 is connected as a grounded base stage so that it operates as the emitter-driven section of the paraphase amplifier. Then, the collector current of Q164 decreases by about the same amount as the emitter current change through the emitter resistor. Thus the single-ended input signal has been amplified and is available as a push-pull signal at the collectors of Q154 and Q164.

The CH 1 Com Mode Current adjustment, R150, establishes the collector voltage of both Q154 and Q164. This control sets the common-mode output DC current for the Channel 1 Input Amplifier. Transformer T169 provides a high impedance for common-mode signals at the emitters of Q154 and Q164 to reduce the common-mode signal components to the following stages. Adjustable capacitor C169 controls the high-frequency emitter degeneration of Q154 and Q164 to provide optimum high-frequency response from this stage. The CH 1 Inv Bal adjustment, R160, balances the DC current of this stage to provide overall DC balance for the amplifier. Balance is checked by inverting the display with the INVERT switch, SW190, and adjusting for minimum trace shift.

### Channel 1 Push-Pull Amplifier

The Channel 1 Push-Pull Amplifier stage amplifies the push-pull output from the Channel 1 Paraphase Amplifier which is connected to the bases of Q174 and Q184. Common-mode temperature compensation for this stage is provided by D157 in the base ground-return path. The voltage change across D157 with change in temperature is about

<sup>1</sup>Lloyd P. Hunter (ed.), "Handbook of Semiconductor Electronics", second edition, McGraw-Hill, New York, 1962, pp. 11-94.

equal but opposite to the voltage change across the base-emitter junction of Q174 and Q184. This minimizes any change in the common-mode output current with a change in temperature. Gain of this stage is determined by the emitter degeneration between Q174 and Q184. As the resistance between the emitters of Q174 and Q184 increases, emitter degeneration increases also, resulting in less gain. The CH 1 Gain Range adjustment, R176, varies the resistance between the emitters to set the gain of this stage so the GAIN adjustment, R138, on the front panel operates near the center of its range. Variable capacitor C172 and variable resistor R172 provide high-frequency compensation for this stage.

The INVERT switch, SW190, allows the displayed Channel 1 signal to be inverted. When the switch is pulled out, the output signal from the Channel 1 Push-Pull Amplifier is connected to the opposite input of the Common-Base Stage (in Channel Switching and Vertical Output circuit). The POSITION control, R196, provides a variable push-pull current to the next stage to control the vertical position of the display.

## Channel 2 Input Amplifier

### General

The Channel 2 Input Amplifier circuit is basically the same as the Channel 1 Input Amplifier circuit (corresponding circuit numbers are assigned in the 200-299 range). Only the differences between the two circuits are described here. Fig. 3-3 shows a detailed block diagram of the Channel 2 Input Amplifier circuit. A schematic of this circuit is shown on diagram 2 at the rear of this manual.

### Channel 2 Push-Pull Amplifier

The basic Channel 2 Push-Pull Amplifier configuration and operation is the same as for Channel 1. The only difference is that a sample of the Channel 2 signal is obtained from the emitter circuit of the Channel 2 Push-Pull Amplifier stage to provide internal triggering from the Channel 2 signal only. This sample is obtained from the junction of R272-R273 and R282-R283. The emitter resistance provided by R271-R272, R281-R282 and the input resistance of the Channel 2 Trigger Preamp stage is about the same as the resistance of R171 and R181 in the emitter circuit of the Channel 1 Push-Pull Amplifier stage. This arrangement provides similar signal response from each channel.

### Channel 2 Trigger Preamp

The internal trigger signal obtained from the Channel 2 Input Amplifier circuit is connected to the Channel 2 Trigger Preamp stage (shown on diagram 4). This stage amplifies the Channel 2 trigger signal so it is about the same amplitude as the normal trigger signal which is obtained from the Output Amplifier stage. Q504-Q523 and Q514-Q533 are connected as a push-pull amplifier stage with emitter follower output. Feedback resistors R525 and R535 set the signal voltage amplitude at the emitters of Q523 and Q533. The push-pull output signal at the emitters of Q523 and Q533 is connected to the Trigger Amplifier stage through R526-R541, R536-R543 and SW540.

An amplified sample of the Channel 2 signal at the collector of Q533 is connected to the CH 2 OUT connector. This output signal allows Channel 2 to be monitored or it can be connected to the Channel 1 INPUT connector for increased deflection factor (with reduced frequency response). The CH 2 Out DC Level adjustment, R530, sets the collector level of Q533 for a zero-volt output level with zero volts at the input of the Channel 2 Input Amplifier circuit.

## Channel Switching and Output Amplifier

### General

The Channel Switching and Output Amplifier circuit determines which of the Input Amplifier signals is displayed on the indicator oscilloscope CRT. In the ALT and CHOP positions of the MODE switch, both channels are displayed on a shared-time basis. The Output Amplifier stage provides the final amplification for the signal before it is connected to the vertical amplifier in the indicator oscilloscope. The TRIGGER switch selects between the sample of the signal applied to Channel 2 or the sample of the composite vertical signal from the Output Amplifier stage. The Trigger Amplifier stage amplifies the internal signal to the level necessary to drive the trigger circuits in the associated time-base unit. Fig. 3-4 shows a detailed block diagram of the Channel Switching and Output Amplifier circuit. A schematic of this circuit is shown on diagram 4 at the rear of this manual.

### Channel 1 and Channel 2 Common-Base Stages

The Channel 1 and Channel 2 Common-Base Stages, Q304-Q314 and Q324-Q334, provide a low impedance load for Q174 and Q184 in the Channel 1 Input Amplifier and Q274 and Q284 in the Channel 2 Input Amplifier. They also provide isolation between the Input Amplifier circuits and the Diode Gate. The output signals from the Channel 1 and 2 Common-Base Stages are connected to the Diode Gate.

### Diode Gate

The Diode Gates, consisting of four diodes each, can be thought of as switches which allow either of the Input Amplifier output signals to be displayed. D302-D305-D309-D312 control the Channel 1 output signal and D322-D325-D329-D332 control the Channel 2 output signal. These diodes are in turn controlled by the Switching Multivibrator for dual-trace displays or by the MODE switch for single-trace displays.

**CH 1.** In the CH 1 position of the MODE switch, SW350, diodes D325-D329 in the Channel 2 Diode Gate are forward biased through R351 and R353 to the +15-volt supply (see simplified diagram in Fig. 3-5). This reverse biases D322-D332 to block the Channel 2 signal so it cannot pass to the Output Amplifier stage. At the same time in the Channel 1 Diode Gate, the diodes D305-D309 are reverse biased with anode voltages of about +2.8 volts established by divider R342-R343-R344-R357 between the +15-volt and -15-volt supplies. The anodes of D302-D312 are at about +7.0 volts. Since D302-D312 are forward biased, the Channel 1 signal passes to the Output Amplifier stage.

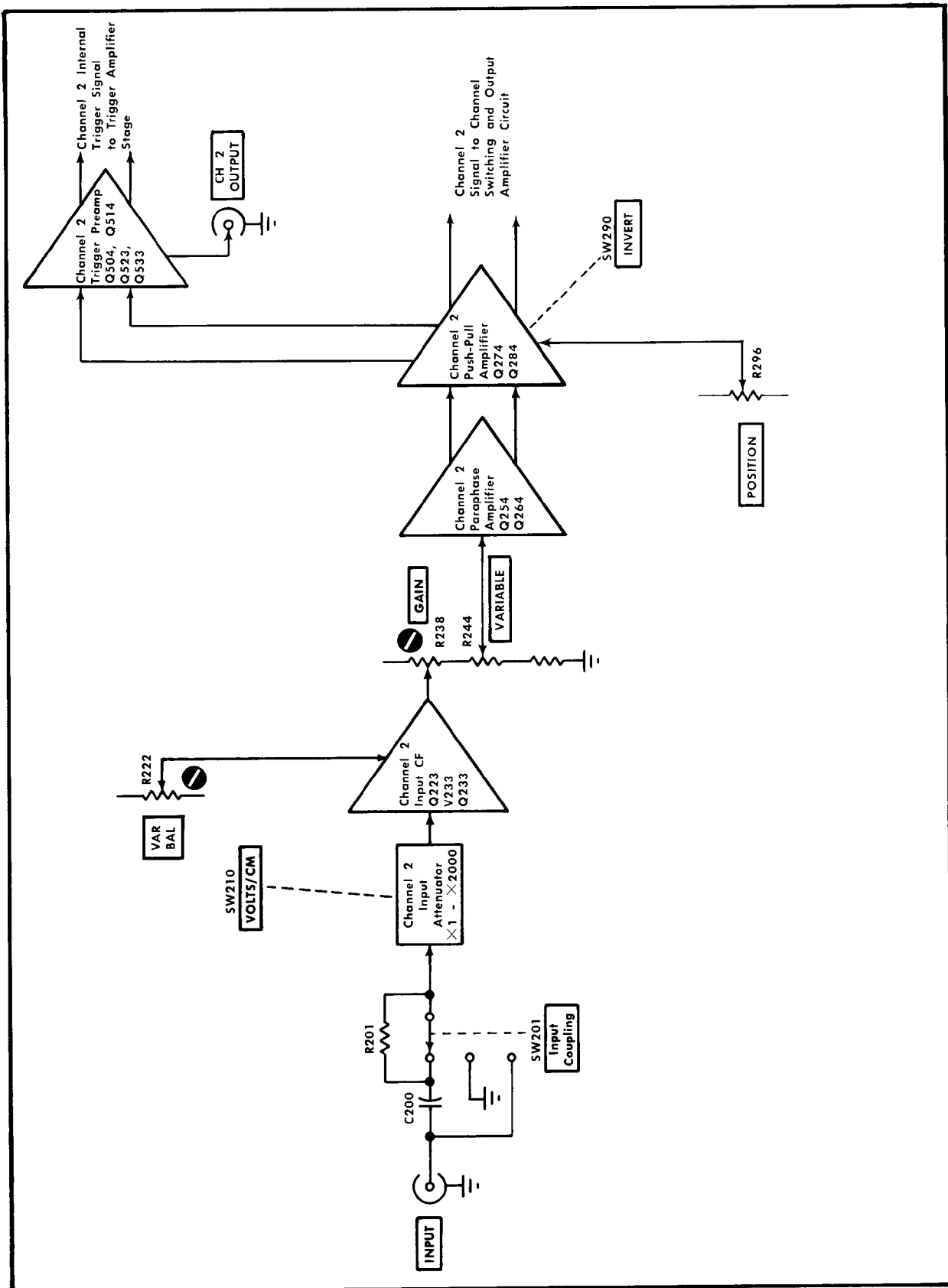


Fig. 3-3. Channel 2 Input Amplifier detailed block diagram.

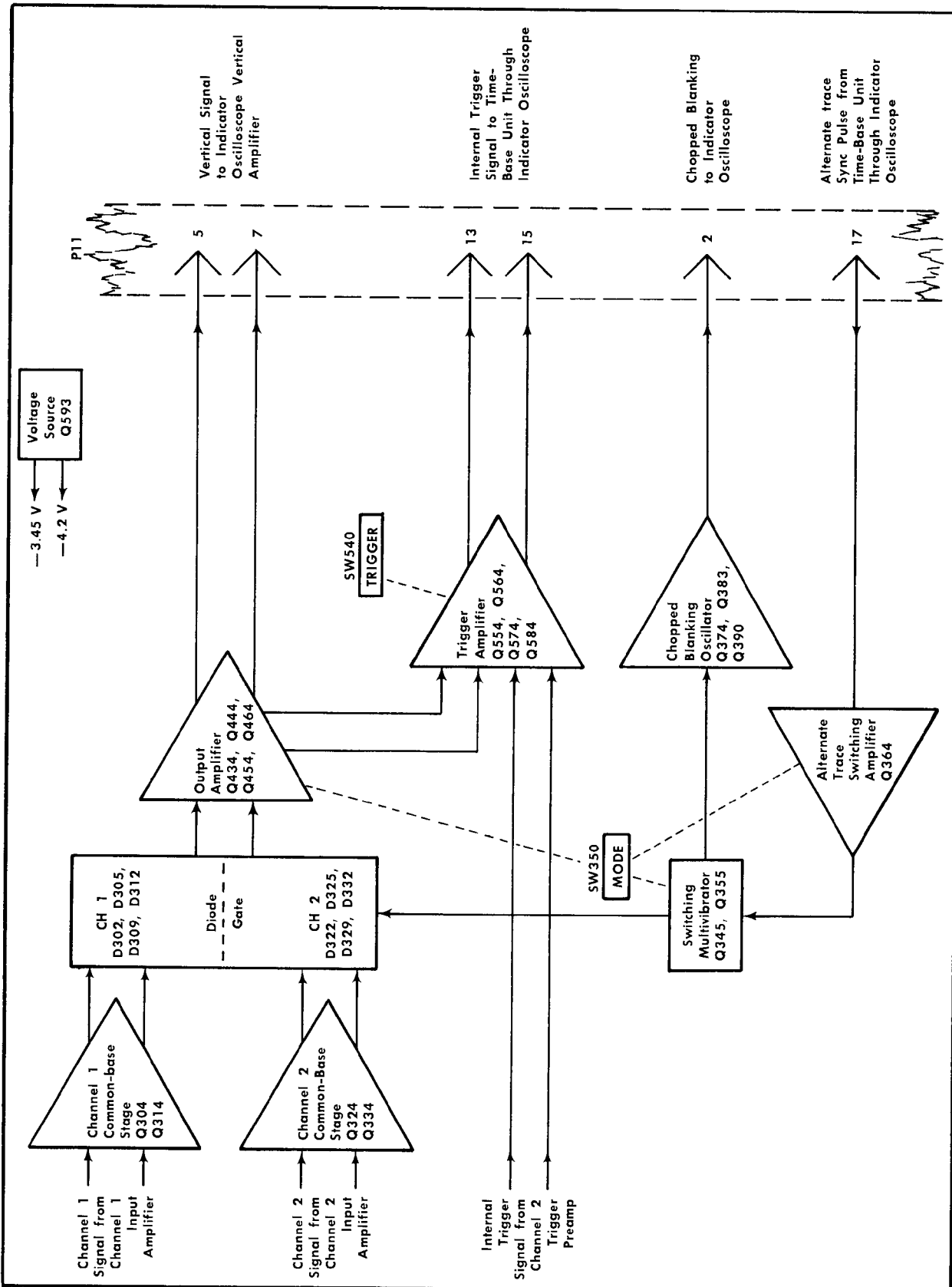


Fig. 3-4. Channel Switching and Output Amplifier detailed block diagram.

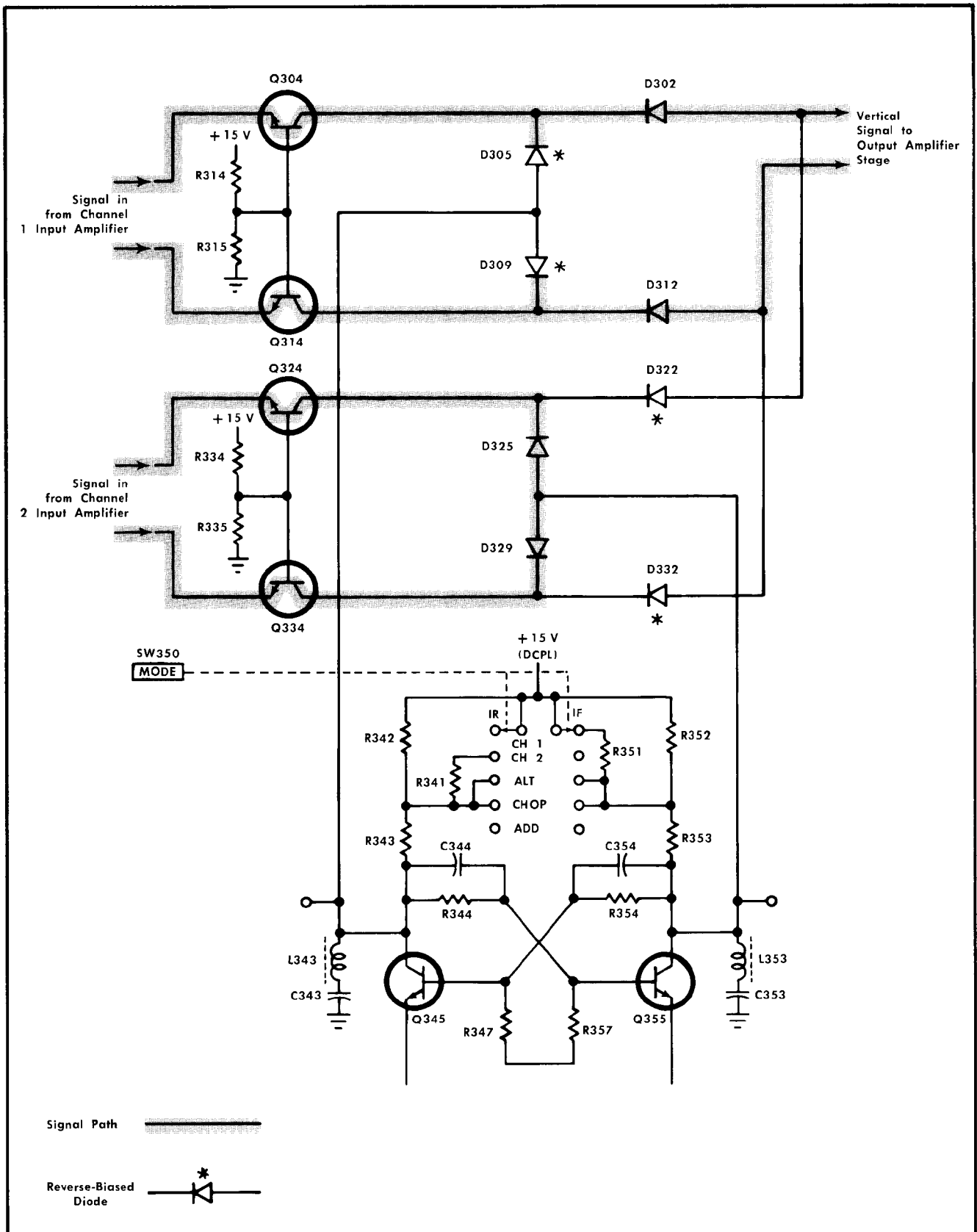


Fig. 3-5. Effect of Diode Gates on signal path (simplified diagram). Conditions shown for CH 1 position of the MODE switch.

of the transistors begins to conduct; for example Q345. Q345 reverse biases the Channel 1 shunt diodes and allows the Channel 1 signal to reach the Output Amplifier stage. The Channel 2 signal is shunted by the forward biased diodes, D325-D329.

The frequency-determining components in the CHOP mode are C348-R345-R355. Switching action occurs as follows: When Q345 is on, the base of Q355 is biased lower than the base of Q345 by the DC coupling from the collector of Q345 to the base of Q355 through divider R344-R357. When Q355 is turned off, its emitter is more positive than the emitter of Q345. Thus the emitter-base junction of Q355 is reverse biased. C348 begins to charge toward  $-15$  volts through R355 and the emitter level of Q355 goes negative. After about 0.5 microseconds, the emitter of Q355 drops negative enough to forward bias it. The collector current of Q355 results in a more negative collector voltage change and is coupled through divider R354-R347 to cut Q345 off. This switches the Diode Gate to connect the Channel 2 signal to the Output Amplifier stage. Now Q345 is held off by the base level established by divider R354-R347 and the emitter level of Q345 which was raised positive by the emitter level of Q355 coupled through C348. Again C348 begins to charge toward  $-15$  volts, but this time at the emitter of Q345 through R345. After about 0.5 microseconds, C348 charges negative enough to turn Q345 on again and the cycle is complete.

The Chopped Blanking Oscillator stage, Q374-Q383-Q390, provides an output pulse to the indicator oscilloscope CRT circuit to blank the transition between the Channel 1 trace and the Channel 2 trace. In the CHOP mode,  $-15$  volts is connected to the emitter of Q374 by the MODE switch. When the Switching Multivibrator stage changes states, the voltage across T371 momentarily increases. A positive pulse is applied to the base of Q374 to turn it on and it goes into saturation. Its collector goes negative to about  $-12$  volts and this negative voltage change is connected to the base of Q383 through R374. As the voltage across T371 collapses, Q374 turns off and is held off by the stored charge on C371 until the Switching Multivibrator changes states again.

Quiescently, Q383 is conducting and it holds blocking oscillator transistor Q390 reverse biased through R387 and R389. Diode D387 prevents the emitter level of Q390 from rising more positive than about  $+0.6$  volts. The negative-going pulse at the base of Q383, when the Switching Multivibrator changes states, turns Q383 off and its emitter starts to go negative. However, the emitter level of Q390 drops at a rate determined by the discharge of C387 through R387-R384. As the voltage across C387 drops to about  $-0.7$  volts, Q390 is forward biased and it conducts. The collector of Q390 goes negative and the feedback winding of T390 pulls the base positive to make Q390 conduct even harder. Current flows through D392 to produce a positive-going output pulse at terminal 2 of the Interconnecting Plug which is coincident with the trace switching of the Switching Multivibrator stage. Inductor L392 is the timing element which determines the width of the blocking oscillator output pulse. The positive voltage at the base of Q390 produced by the output pulse results in a current increase through L392 which is linear with time. This current increase is coupled to the collector through T390 to increase the collector current of Q390. When the collector current approaches the emitter current, the blocking oscillator regeneratively switches off.

Since the emitter level of Q390 has returned to the quiescent level of  $+0.6$  volts (Q374 and Q383 have already returned to quiescent conditions), it is reverse biased. D391 and R391 by-pass the collector winding of Q390 so the turn off current of Q390 does not produce a corresponding negative voltage at the base which would exceed the base-emitter voltage limit. The chopped blanking pulse connected to the indicator oscilloscope CRT circuit is about 1.5 milliamperes in amplitude with a duration of about 0.08 microseconds.

**ADD.** In the ADD position of the MODE switch, the Diode Gate stage allows both signals to pass to the Output Amplifier stage. The shunt diodes, D305-D309 and D325-D329, in both halves of the Diode Gate stage are reverse biased. A current equal to the DC current from one of the Input Amplifier circuits is connected into the circuit in this mode through R318 and R338 to offset the additional current delivered through both Diode Gates. The signal from both Diode Gates is connected to the Output Amplifier stage. The output signal is the algebraic sum of the signals connected to Channel 1 and Channel 2.

### Output Amplifier

The output signal from the Diode Gate stage is connected to the Output Amplifier stage, Q434-Q444-Q454-Q464. Zener diodes D318A and D318B provide a DC voltage offset to drive the base of Q434-Q444 without the corresponding signal current loss which would occur with a voltage divider. The Main Amp Diff Bal adjustment, R335, balances the quiescent base levels of Q434 and Q444 to provide a centered trace when the POSITION controls are centered. The DC level at the output of this unit is adjusted by the Main Amp Current adjustment, R336, by varying the common-mode current in the Output Amplifier.

The amplified signal at the collector of Q434 and Q444 is connected to the bases of Q454 and Q464. These transistors provide the final amplification for the signal before it is connected to the indicator oscilloscope. R450 and R460 are feed-back resistors for the combined amplifier stages, Q434-Q454 and Q444-Q464. This negative feedback sets the signal voltage amplitude at the emitters of the output transistors, Q454-Q464. The emitter-to-emitter resistor, R465, sets the signal current amplitude at the collectors of the output transistors. Fixed coil L465 and adjustable capacitor C456 provide high-frequency compensation for this stage. The Main Amp HF Damping adjustment, R462, provides high-frequency damping for the Output Amplifier. The signal at the collectors of Q454 and Q464 is connected to the vertical amplifier in the indicator oscilloscope through terminals 5 and 7 of the interconnecting plug.

The trigger signal for NORM trigger operation is obtained from the emitter circuit of Q454-Q464. A sample of the vertical deflection signal at the emitters of these transistors is connected to the Trigger Amplifier stage through dividers R457-R458 and R467-R468. The Norm Trig DC Bal adjustment, R546, adjusts the DC level of the output signal so the time-base unit triggers at the zero-volt level of the displayed signal when the trigger level control of the time-base unit is set to 0.

### Trigger Amplifier

The Trigger Amplifier stage selects the internal trigger signal from the sample of the signal applied to Channel 2 or

### Circuit Description—Type 10A2A

a sample of the composite vertical signal in the Output Amplifier stage. When the TRIGGER switch, SW540, is set to the NORM position, the internal trigger signal from the Output Amplifier stage is connected to the Trigger Amplifier. The Channel 2 Trigger Preamp output is terminated by R548. The load provided by R548 is about the same as provided by the input circuit of Q554-Q564. In the CH 2 ONLY position of the TRIGGER switch, the internal trigger signal from the Channel 2 Input Amplifier circuit is connected to the Trigger Amplifier stage. The trigger signal output from the Output Amplifier is terminated by R548 for constant loading on the Output Amplifier stage.

The Trigger Amplifier stage consists of two push-pull amplifier stages. Negative feedback from the emitters of Q574-Q584 is connected to the bases of Q554-Q564 through

resistor R579 and R589. The amplified internal trigger signal at the collectors of Q574 and Q584 is connected to the associated time-base unit through terminals 13 and 15 of the interconnecting plug.

### Voltage Source

Voltage Source transistor, Q593, provides  $-3.45$  volts to the Channel 2 Trigger Preamp stage and  $-4.2$  volts to the Trigger Amplifier stage. The base level of Q593 is set by precision voltage divider R591-R592 between the  $-15$ -volt supply and ground. This establishes the  $-3.45$ -volt level at the emitter of Q593. The  $-4.2$ -volt level is established by precision divider R595-R597 from the emitter of Q593 to the  $-15$ -volt supply.



# MAINTENANCE

## SECTION 4

### Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance or troubleshooting of the Type 10A2A.

### PREVENTIVE MAINTENANCE

#### General

Preventive maintenance consists of cleaning, visual inspection, lubrication, etc. Preventive maintenance performed on a regular basis may prevent instrument breakdown and will improve the reliability of this instrument. The severity of the environment to which the Type 10A2A is subjected will determine the frequency of maintenance. A convenient time to perform preventive maintenance is preceding recalibration of the instrument.

#### Cleaning

The Type 10A2A should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents efficient heat dissipation. It also provides an electrical conduction path.

The covers of the indicator unit minimize the amount of dust which reaches the interior of the Type 10A2A. Operation of the system without the covers in place necessitates more frequent cleaning. When the Type 10A2A is not in use, it should be stored in a protected location such as a dust-tight cabinet.

#### CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzene, toluene, xylene, acetone or similar solvents.

**Exterior.** Loose dust accumulated on the outside of the Type 10A2A can be removed with a soft cloth or small paint brush. The paint brush is particularly useful for dislodging dirt on and around the front-panel controls. Dirt which remains can be removed with a soft cloth dampened in a mild detergent and water solution. Abrasive cleaners should not be used.

**Interior.** Dust in the interior of the instrument should be removed occasionally due to its electrical conductivity under high-humidity conditions. The best way to clean the interior is to blow off the accumulated dust with dry, low-velocity air. Remove any dirt which remains with a soft paint brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips.

#### Lubrication

**General.** The reliability of potentiometers, rotary switches and other moving parts can be maintained if they are kept properly lubricated. Use a cleaning-type lubricant (e.g., Tektronix Part No. 006-0218-00) on switch contacts and the interconnecting plug. Lubricate switch detents with a heavier grease (e.g., Tektronix Part No. 006-0219-00). Potentiometers which are not permanently sealed should be lubricated with a lubricant which does not affect electrical characteristics (e.g., Tektronix Part No. 006-0220-00). This lubricant can also be used on shaft bushings. Do not over-lubricate. A lubrication kit containing the necessary lubricants and instructions is available from Tektronix, Inc. Order Tektronix Part No. 003-0342-00.

#### Visual Inspection

The Type 10A2A should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated transistors or nuvistors and heat-damaged parts. The corrective procedure for most visible defects is obvious; however, particular care must be taken if heat-damaged components are found. Overheating usually indicates other trouble in the instrument; therefore, it is important that the cause of overheating be corrected to prevent recurrence of the damage.

#### Transistor and Nuvistor Checks

Periodic checks of the transistors and nuvistors in the Type 10A2A are not recommended. The best check of transistor or nuvistor performance is its actual operation in the instrument. More details on checking transistor and nuvistor operation are given under Troubleshooting.

#### Recalibration

To assure accurate measurements, check the calibration of this instrument after each 1000 hours of operation or every six months if used infrequently. In addition, replacement of components may necessitate recalibration of the affected circuits. Complete calibration instructions are given in the Calibration section.

The calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases, minor troubles may be revealed and/or corrected by recalibration.

## TROUBLESHOOTING

### Introduction

The following information is provided to facilitate troubleshooting of the Type 10A2A if trouble develops. Information contained in other sections of this manual should be

## Maintenance—Type 10A2A

used along with the following information to aid in locating the defective component. An understanding of the circuit operation is very helpful in locating troubles. See the Circuit Description section for complete information.

### Troubleshooting Aids

**Diagrams.** Circuit diagrams are given on foldout pages in Section 9. The component number and electrical value of each component in this instrument are shown on the diagrams. Each main circuit is assigned a series of component numbers. Table 4-1 lists the main circuits in the Type 10A2A and the series of component numbers assigned to each. Important voltages and waveforms are also shown on the diagrams.

**TABLE 4-1**  
Component Numbers

Component Numbers on Diagrams	Diagram Number	Circuit
100-199	1	Channel 1 Input Amplifier
200-299	2	Channel 2 Input Amplifier
300-599	4	Channel Switching and Output Amplifier (includes Switching Multivibrator, Output Amplifier, Channel 2 Trigger Preamp and Trigger Amplifier stages)

**Switch Wafer Identification.** Switch wafers shown on the diagrams are coded to indicate the position of the wafer in the complete switch assembly. The numbered portion of the code refers to the wafer number counting from the front, or mounting end of the switch, toward the rear. The letters F and R indicate whether the front or rear of the wafer performs the particular switching function. For example, a wafer designated 2R indicates that the rear of the second wafer is used for this particular switching function.

**Wiring Color-Code.** All insulated wire and cable used in the Type 10A2A is color-coded to facilitate circuit tracing. Signal carrying leads are identified with one or two colored stripes. Voltage supply leads are identified with three stripes to indicate the approximate voltage using the EIA resistor color code. A white background color indicates a positive voltage and a tan background indicates a negative voltage. The widest color stripe identifies the first color of the code. Table 4-2 gives the wiring color code for the power-supply voltages used in the Type 10A2A.

**Resistor Color Code.** In addition to the brown composition resistors, some metal-film resistors and some wire-wound resistors are used in the Type 10A2A. The resistance values of wire-wound resistors are printed on the body of the component. The resistance values of composition resistors and metal-film resistors are color coded on the components with EIA color code (some metal-film resistors may have the value printed on the body). The color code is read starting with the stripe nearest the end of the resistor. Composition resistors have four stripes which consist of two significant figures, a multiplier and a tolerance value (see Fig. 4-1). Metal-film resistors have five stripes consisting of three significant figures, a multiplier and a tolerance value.

**TABLE 4-2**  
Power Supply Wiring Color Code

Supply	Back-ground Color	First Stripe	Second Stripe	Third Stripe
-15 volt	Tan	Brown	Green	Black
+15 volt	White	Brown	Green	Black
+100 volt	White	Brown	Black	Brown

**Capacitor Marking.** The capacitance values of common disc capacitors and small electrolytics are marked in microfarads on the side of the component body. The white ceramic capacitors used in the Type 10A2A are color coded in picofarads using a modified EIA code (see Fig. 4-1).

**Diode Color Code.** The cathode end of each glass-encased diode is indicated by a stripe, a series of stripes or a dot. For most silicon or germanium diodes with a series of stripes, the color code also indicates the type of diode and identifies the Tektronix Part Number using the resistor color code system (e.g., a diode color-coded blue-brown-gray-green indicates diode type 6185 with Tektronix Part Number 152-0185-00).

### Troubleshooting Equipment

The following equipment is useful for troubleshooting the Type 10A2A.

#### 1. Transistor Tester

Description: Tektronix Type 575 Transistor-Curve Tracer or equivalent.

Purpose: To test the semiconductors used in this instrument.

#### 2. Multimeter

Description: VTVM, 10 megohm input impedance and 0 to 500 volts range; ohmmeter, 0 to 50 megohms. Accuracy, within 3%. Test prods must be well insulated to prevent accidental shorting.

Purpose: To check operating voltages and for general troubleshooting in this instrument.

#### NOTE

A 20,000 ohms/volt VOM can be used to check the voltages in this instrument if allowances are made for the circuit loading of the VOM at high-impedance points.

#### 3. Test Oscilloscope

Description: DC to 50 MHz frequency response, 50 millivolts to 50 volts/division deflection factor. Use a 10× probe.

Purpose: To check waveforms in the instrument.

#### 4. Plug-In Extension

Description: 32-pin rigid extender. Tektronix Part No. 013-0034-00.

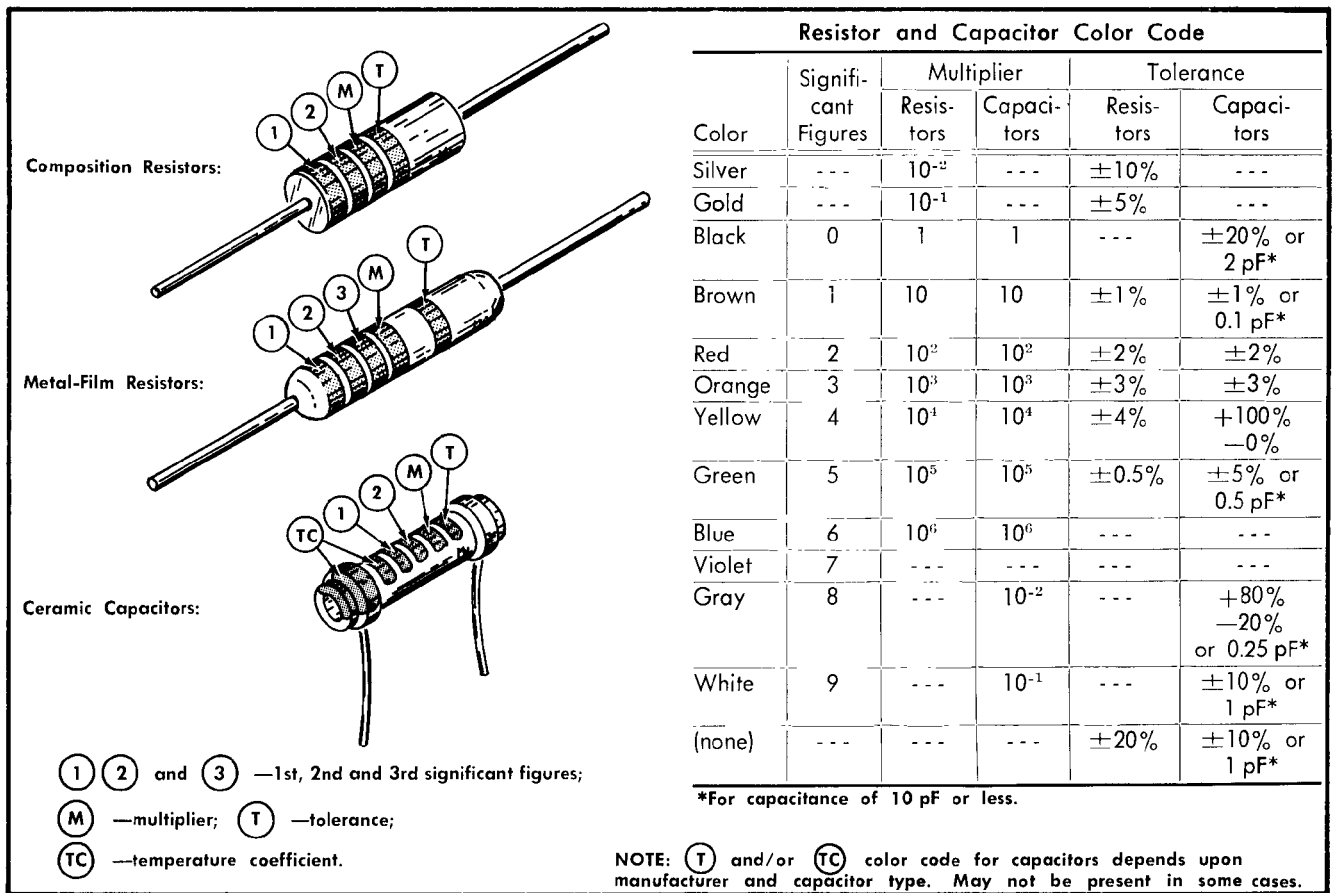


Fig. 4-1. Color-code for resistors and ceramic capacitors.

Purpose: Permits operation of the unit outside the plug-in compartment for better accessibility during troubleshooting.

### Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting. The first few checks assure proper connection, operation and calibration. If the trouble is not located by these checks, the remaining steps aid in locating the defective component. When the defective component is located, it should be replaced following the replacement procedures given under Corrective Maintenance.

**1. Check Control Settings.** Incorrect control settings can indicate a trouble that does not exist. If there is any question about the correct function or operation of any control, see the Operating Instructions section of this manual.

**2. Check Associated Equipment.** Before proceeding with troubleshooting of the Type 10A2A, check that the equipment used with this instrument is operating correctly. Check that the signal is properly connected and that the interconnecting cables are not defective. The indicator oscilloscope and time-base unit can be checked for proper operation

by substituting another vertical plug-in unit which is known to be operating properly (preferably another Type 10A2A or similar unit). If the trouble persists after substitution, the indicator oscilloscope or time-base unit are defective.

**3. Visual Check.** Visually check the portion of the instrument in which the trouble is located. Many troubles can be located by visual indications such as unsoldered connections, broken wires, damaged components, etc.

**4. Check Instrument Calibration.** Check the calibration of this instrument, or the affected circuit if the trouble exists in one circuit. The apparent trouble may only be a result of misadjustment or may be corrected by calibration. Complete calibration instructions are given in the Calibration Section of this manual.

**5. Isolate Trouble to a Circuit.** To isolate a trouble to a circuit, note the trouble symptom. The symptom often identifies the circuit in which the trouble is located. For example, incorrect Channel 1 gain indicates that the Channel 1 Input Amplifier circuit is probably at fault. When trouble symptoms appear in more than one circuit, check all affected circuits by taking voltage and waveform readings. Also check for the correct output signals at the front-panel output connector with a test oscilloscope. If the sig-

## Maintenance—Type 10A2A

nal is correct, the circuit is working correctly up to that point.

Fig. 4-2 provides a guide to aid in locating a defective circuit. This chart may not include checks for all possible defects; use steps 6 and 7 in such cases. Start from the top of the chart and perform the given checks on the left side of the page until a step is found which is not correct. Further checks and/or the circuit in which the trouble is probably located are listed to the right of this step.

After the defective circuit has been located, proceed with steps 6 and 7 to locate the defective component(s).

**6. Check Voltages and Waveforms.** Often the defective component can be located by checking for the correct voltage or waveform in the circuit. Typical voltages and waveforms are given on the diagrams.

### NOTE

Voltages and waveforms given on the diagrams are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the first diagram page.

**7. Check Individual Components.** The following procedures describe methods of checking individual components in the Type 10A2A. Components which are soldered in place are best checked by disconnecting one end. This isolates the measurement from the effects of surrounding circuitry.

**A. TRANSISTORS AND NUVISTORS.** The best check of transistor or nuvistor operation is actual performance under operating conditions. If a transistor or nuvistor is thought to be defective, it can best be checked by substituting a new component or one which has been checked previously. However, be sure that circuit conditions are not such that a replacement transistor or nuvistor might also be damaged. If substitute transistors or nuvistors are not available, test each suspected component on a dynamic tester (such as Tektronix Type 570 or 575).

**B. DIODES.** A diode can be checked for an open or shorted condition by measuring the resistance between terminals. With an ohmmeter scale having an internal source of between 800 millivolts and 3 volts, the resistance should be very high in one direction and very low when the leads are reversed.

**C. RESISTORS.** Resistors can be checked with an ohmmeter. Check the Electrical Parts List for the tolerances of the resistors used in this instrument. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

**D. INDUCTORS.** Check for open inductors by checking continuity with an ohmmeter. Shorted or partially shorted inductors can usually be found by checking the waveform response when high-frequency signals are passed through the circuit.

**E. CAPACITORS.** A leaky or shorted capacitor can best be detected by checking resistance with an ohmmeter on the highest scale. Do not exceed the voltage rating of the capacitor. The resistance reading should be high after initial

charge of the capacitor. An open capacitor can best be detected with a capacitance meter or by checking whether the capacitor passes AC signals.

**9. Repair and Readjust the Circuit.** If any defective parts are located, follow the replacement procedures given in this section. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced.

## CORRECTIVE MAINTENANCE

### General

Corrective maintenance consists of component replacement and instrument repair. Special techniques required to replace components in this instrument are given here.

### Obtaining Replacement Parts

**Standard Parts.** All electrical and mechanical part replacements for the Type 10A2A can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

### NOTE

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

**Special Parts.** In addition to the standard electronic components, some special parts are used in the Type 10A2A. These parts are manufactured or selected by Tektronix, Inc. to meet specific performance requirements, or are manufactured for Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the parts list by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

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

1. Instrument Type.
2. Instrument Serial Number.
3. A description of the part (if electrical, include circuit number).
4. Tektronix Part Number.

### Soldering Techniques

#### WARNING

Disconnect the instrument from the power source before soldering.

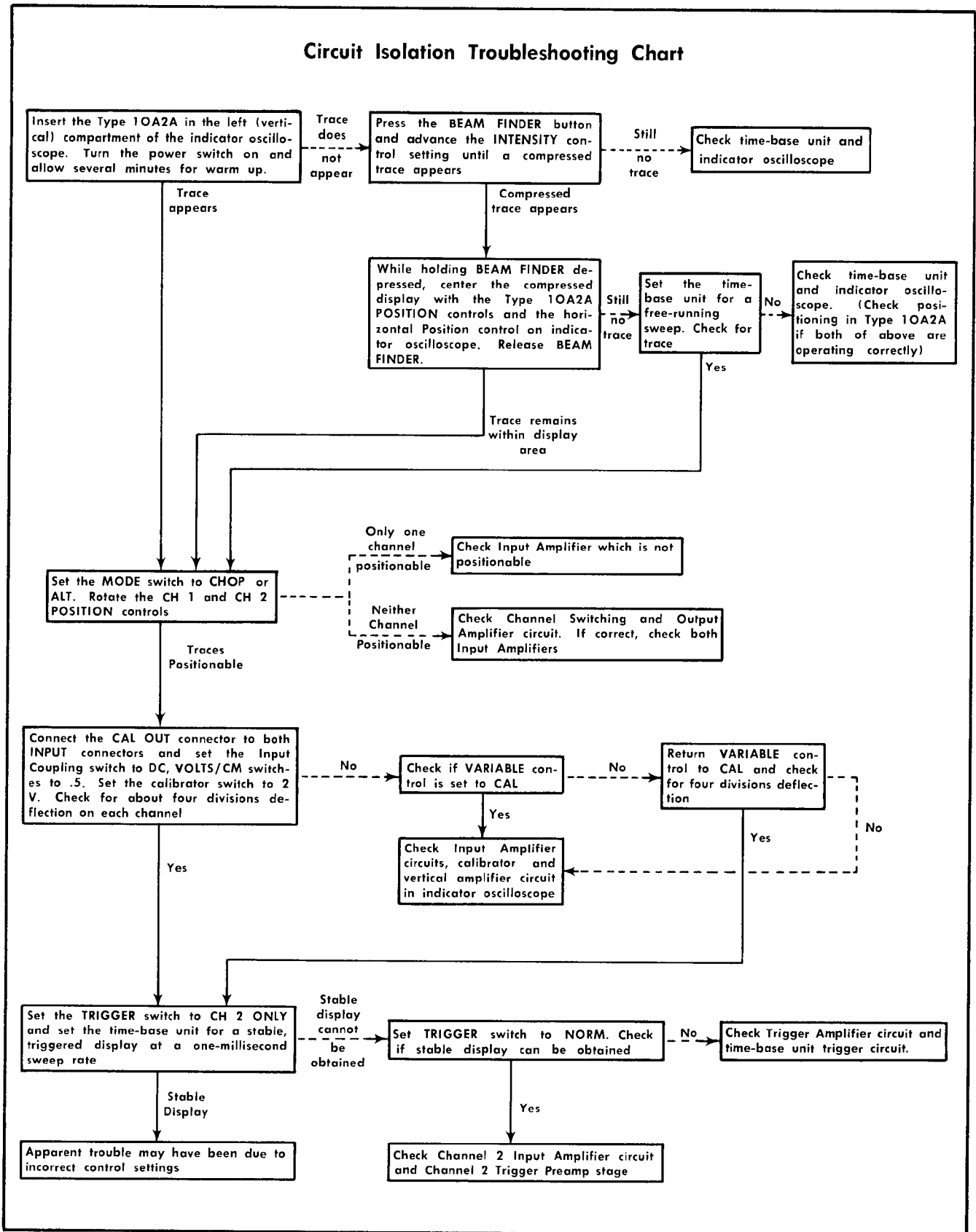


Fig. 4-2. Troubleshooting chart for Type 10A2A.

## Maintenance—Type 10A2A

**Ceramic Terminal Strips.** Solder used on the ceramic terminal strips should contain about 3% silver. Use a 40- to 75-watt soldering iron with a  $\frac{1}{8}$ -inch wide wedge-shaped tip. Ordinary solder can be used occasionally without damage to the ceramic terminal strips. However, if ordinary solder is used repeatedly or if excessive heat is applied, the solder-to-ceramic bond may be broken.

Solder containing 3% silver should be available locally, or it can be purchased from Tektronix, Inc. in one-pound rolls; order by Tektronix Part No. 251-0514-00.

Observe the following precautions when soldering to ceramic terminal strips.

1. Use a hot iron for a short time. Apply only enough heat to make the solder flow freely.
2. Maintain a clean, properly tinned tip.
3. Avoid putting pressure on the ceramic terminal strip.
4. Do not attempt to fill the terminal-strip notch with solder; use only enough solder to cover the wires adequately.
5. Clean the flux from the terminal strip with a flux-remover solvent.

**Metal Terminals.** When soldering metal terminals (e.g., switch terminals, potentiometers, etc.), ordinary 60/40 solder can be used. Use a soldering iron with a 40- to 75-watt rating and a  $\frac{1}{8}$ -inch wide wedge-shaped tip.

Observe the following precautions when soldering metal terminals:

1. Apply only enough heat to make the solder flow freely.
2. Apply only enough solder to form a solid connection. Excess solder may impair the function of the part.
3. If a wire extends beyond the solder joint, clip off the excess.
4. Clean the flux from the solder joint with a flux-remover solvent.

## Component Replacement

### WARNING

Disconnect the instrument from the power source before replacing components.

**Ceramic Terminal Strip Replacement.** A complete ceramic terminal strip assembly is shown in Fig. 4-3. Replacement strips (including studs) and spacers are supplied under separate part numbers. However, the old spacers may be re-used if they are not damaged. The applicable Tektronix Part Numbers for the ceramic strips and spacers used in this instrument are given in the Mechanical Parts List.

To replace a ceramic terminal strip, use the following procedure:

### REMOVAL:

1. Unsolder all components and connections on the strip. To aid in replacing the strip, it may be advisable to mark each lead or draw a sketch to show location of the components and connections.

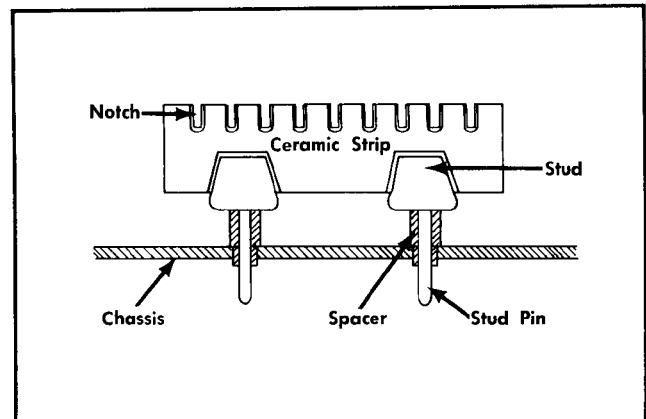


Fig. 4-3. Ceramic terminal strip assembly.

2. Pry or pull the damaged strip from the chassis. Be careful not to damage the chassis.

3. If the spacers come out with the strip, remove them from the stud pins for use on the new strip (spacers should be replaced if they are damaged).

### REPLACEMENT:

1. Place the spacers in the chassis holes.
2. Carefully press the studs of the strip into the spacers until they are completely seated. If necessary, use a soft mallet and tap lightly, directly over the stud, to seat the strip completely.
3. If the stud extends through the spacers, cut off the excess.
4. Replace all components and connections. Observe the soldering precautions given under Soldering Techniques in this section.

**Transistor and Nuistor Replacement.** Transistors and nuistors should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors or nuistors may affect the calibration of this instrument. When transistors or nuistors are replaced, check the operation of that part of the instrument which may be affected. Replacement transistors or nuistors should be of the original type or a direct replacement. Remount the transistors in the same manner as the original.

Fig. 4-4 shows the lead configurations of the transistors and nuistors used in this instrument. Notice that there are two different lead configurations for plastic-case transistors. When replacing these transistors, check the manufacturer's basing diagram for correct basing. All transistor sockets in this instrument are wired for the basing used for metal-case transistors.

**Rotary Switches.** Individual wafers or mechanical parts of rotary switches are normally not replaceable. If a switch is defective, replace the entire assembly. Replacement

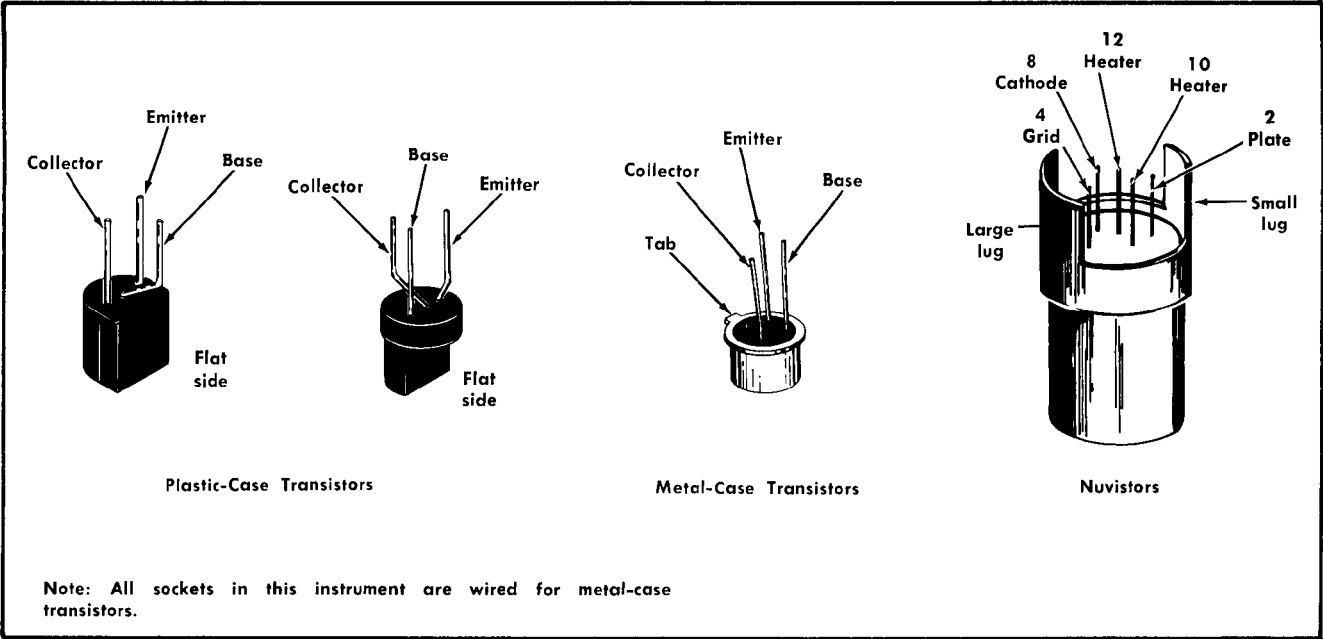


Fig. 4-4. Electrode configuration for transistors and nuvistors in this instrument (as viewed from bottom).

switches can be ordered either wired or unwired; refer to the Parts List for the applicable part numbers.

When replacing a switch, tag the leads and switch terminals with corresponding identification tags as the leads are disconnected. Then, use the old switch as a guide for installing the new one. An alternative method is to draw a sketch of the switch layout and record the wire color at each terminal. When soldering to the new switch be careful that the solder does not flow beyond the rivets of the

switch terminals. Spring tension of the switch contact can be destroyed by excessive solder.

### Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. The Performance Check procedure in Section 5 provides a quick and convenient means of checking instrument operation.

### NOTES

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# SECTION 5

## PERFORMANCE CHECK

### Introduction

This section of the manual provides a procedure for rapidly checking the performance of the Type 10A2A. This procedure checks the operation of the instrument without removing the covers or making internal adjustments. However, screwdriver adjustments which are located on the front panel are adjusted in this procedure.

If the instrument does not meet the performance requirements given in this procedure, internal checks and/or adjustments are required. See the Calibration section. All performance requirements given in this section correspond to those given in the Characteristics section.

#### NOTE

All waveforms shown in this section are actual waveform photographs taken with a Tektronix Oscilloscope Camera System.

### Recommended Equipment

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

For the most accurate and convenient performance check, special calibration fixtures are used in this procedure. These calibration fixtures are available from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. Time base plug-in. Tektronix 11-series Time Base Plug-In recommended. The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.

2. Calibration oscilloscope. Tektronix Type 647A or RM647A recommended.

3. Standard Amplitude Calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 2 millivolts to 100 volts; output signal, 1-kHz. Tektronix Calibration Fixture 067-0502-00 recommended.

4. Square-wave generator, high-rise portion; Frequency 2.5 kHz and 5 kHz; risetime, 12 ns maximum; output impedance, 600 ohms, or less (without an external termination); output amplitude, about 100 volts peak to peak unterminated.

Fast-rise portion; Frequency 400 kHz; risetime, 1 ns maximum; output impedance, 600 ohms or less (without an external termination); output amplitude, about 500 mvolts peak to peak unterminated. Tektronix Type 106 Square-Wave Generator recommended.

5. Medium frequency constant amplitude sine wave generator. Frequency, 50 kHz and 25 MHz to 100 MHz; output

amplitude, less than 40 mV to above 10 volts; amplitude regulation accuracy,  $\pm 5\%$ . Tektronix Type 191 Constant Amplitude Signal Generator recommended.

6. High frequency constant amplitude sine wave generator. Frequency, 3 MHz and 65 MHz to 108 MHz; output amplitude, 40 mV amplitude regulation accuracy  $\pm 1\%$ . Tektronix Calibration Fixture 067-0532-00 recommended.

7. Termination. Impedance, 50 ohm, accuracy;  $\pm 3\%$ ; connectors, GR one end, BNC other end. Tektronix Part No. 0171-0083-00.

8.  $5\times$  attenuator. Impedance, 50 ohm; accuracy  $\pm 2\%$  at DC and  $\pm 3\%$  at 1 GHz; connectors, GR. Tektronix Part No. 017-0079-00.

9.  $10\times$  attenuator. Impedance, 50 ohm; accuracy,  $\pm 3\%$ ; connectors, BNC. Tektronix Part No. 011-0059-00.

10. Input RC normalizer. Time constant, 1 megohm  $\times$  20 pF; attenuation,  $2\times$ ; connectors, BNC. Tektronix Part No. 011-0066-00.

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

12. Cable. Impedance, 50 ohm; length, 8 inch; connectors, BNC. Tektronix Part No. 012-0118-00.

13. Cable. Impedance, 50 ohm; length, 5 nanoseconds; connectors, GR. Tektronix Part No. 017-0502-00.

14. Cable. Impedance, 50 ohm; length, 42 inch; connectors, BNC. Tektronix Part No. 012-0057-00.

15. Dual-input coupler. Matched signal transfer to each input. Tektronix Calibration Fixture 067-0525-00.

### PERFORMANCE CHECK PROCEDURE

#### General

In the following procedure, control settings or test equipment connections should not be changed except as noted. If only a partial check is desired, refer to the preceding step(s) for setup information. Type 10A2A front-panel control titles referred to in this procedure are capitalized (e.g., VOLTS/CM).

The following procedure uses the equipment listed under Recommended Equipment. If equipment is substituted, control settings or setup may need to be altered to meet the requirements of the equipment used.

#### Preliminary Procedure

1. Install the Type 10A2A into the vertical plug-in compartment of the Type 647A.

## Performance Check—Type 10A2A

2. Install an 11-series plug-in into the horizontal plug-in compartment of the Type 647A.

3. Set the front-panel controls of the Type 10A2A, 11-series plug-in and 647A as follows:

### Type 10A2A

VOLTS/CM (both channels)	.01
VARIABLE (VOLTS/CM) (both channels)	Fully counterclockwise
POSITION (both channels)	Midrange
Input Coupling (both channels)	GND
INVERT (both channels)	Pushed in
GAIN (both channels)	180° counterclockwise from its fully clockwise position
VAR BAL (both channels)	As is
TRIGGER	NORM
MODE	CH 1

### Type 647A

Intensity	Usable display brightness
Focus	Well defined display
Astigmatism	Well defined display
Scale Illum	As desired
Calibrator	Off
Position	Midrange
Fine (Position)	Midrange

### 11-Series

Time/CM	1 ms
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

4. Connect the Type 647A directly to a power supply of appropriate voltage.

5. Set the Type 647A power to on. Allow at least 20 minutes warm up at 25°C, ±5°C, for checking the instrument to the given accuracy.

## 1. Adjust Channel 1 Variable Attenuator Balance and Check Channel 1 Invert Balance

**REQUIREMENT—Variable Attenuator Balance:** Must adjust amplifier balance so that less than 1 mm of trace shift occurs after the VARIABLE (VOLTS/CM) control is rotated from full counterclockwise to full clockwise end.

**Invert Balance:** Less than 2 cm of trace shift as INVERT switch is moved in and out.

a. Adjust the Channel 1 VAR BAL control R122 (see Fig. 5-1), to position the displayed trace at the graticule center horizontal line.

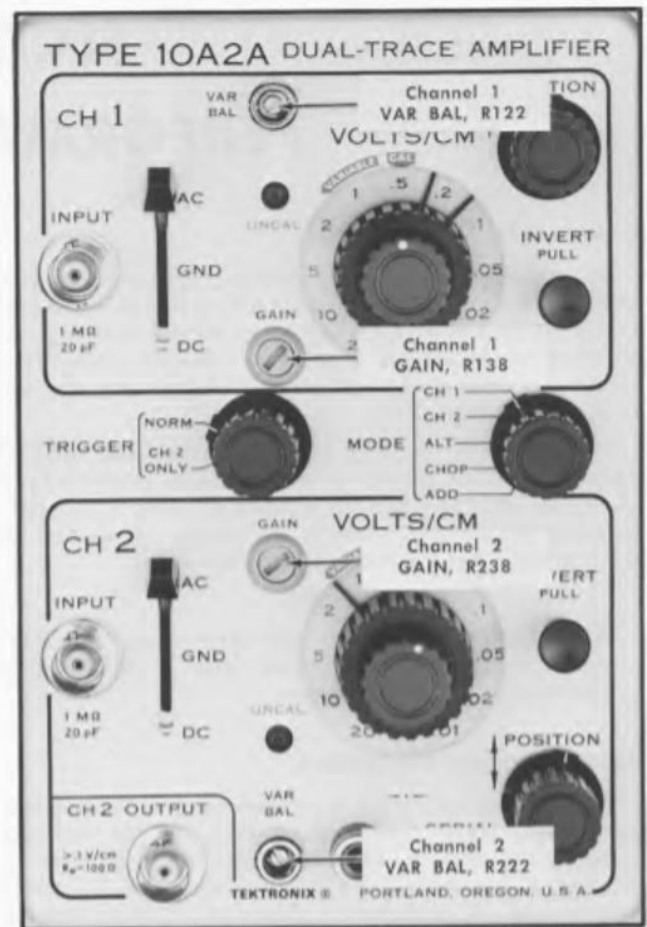


Fig. 5-1. Location of channel 1 VAR BAL control, R122 and channel 2 VAR BAL control, R222.

b. **CHECK**—Displacement of the displayed trace from graticule center after the Channel 1 VARIABLE (VOLTS/CM) control is rotated between the fully counterclockwise position and the CAL position. If the trace shifts less than 1 mm no further adjustment of the VAR BAL control is needed.

c. **ADJUST**—VAR BAL control R122 (see Fig. 5-1). Set the VARIABLE (VOLTS/CM) control fully counterclockwise and note the trace position. Then rotate the control to the CAL position and again note the position of the trace.

With the VAR BAL R122 control, move the trace back beyond its location at the fully clockwise position of the VARIABLE (VOLTS/CM) control by an amount equal to half the total trace shift. Repeat this procedure until the trace position is the same for full counterclockwise and full clockwise position of the VARIABLE (VOLTS/CM) control.

d. Set the Channel 1 VARIABLE (VOLTS/CM) control to CAL, and center the trace with the Channel 1 POSITION control.

e. Pull the Channel 1 INVERT switch.

f. **CHECK**—Trace shift; less than 2 cm as the INVERT switch is pulled.

g. Push in the INVERT switch.

## 2. Adjust Channel 2 Variable Attenuator Balance and Check Invert Balance

**REQUIREMENT**—Variable Attenuator Balance: Must adjust amplifier balance so that less than 1 mm of trace shift occurs after the VARIABLE (VOLTS/CM) control is rotated from full counterclockwise to full clockwise end.

Invert Balance: Less than 2 cm of trace shift as the INVERT switch is moved out and in.

- a. Set the Type 10A2A MODE Switch to CH 2.
- b. Adjust the Channel 2 VAR BAL control R222 (see Fig. 5-1), to position the displayed trace at the graticule center horizontal line.
- c. **CHECK**—Displacement of the displayed trace from graticule center after the Channel 2 VARIABLE (VOLTS/CM) control is rotated between the fully counterclockwise position and the CAL position. If the trace shifts less than 1 mm as the VARIABLE control is rotated, no further adjustment of the VAR BAL control is needed.
- d. **ADJUST**—VAR BAL control R222 (see Fig. 5-1). Set the VARIABLE (VOLTS/CM) control fully counterclockwise and note the trace position. Then rotate the control to the CAL position and again note the position of the trace.

With the VAR BAL, R222, control move the trace back beyond its location at the fully clockwise position of the VARIABLE (VOLTS/CM) control by an amount equal to half to total trace shift. Repeat this procedure until the trace position is the same for full counterclockwise and full clockwise position of the VARIABLE (VOLTS/CM) control.

- e. Set the Channel 2 VARIABLE (VOLTS/CM) control to CAL, and center the trace with the Channel 2 POSITION control.
- f. Pull the Channel 2 INVERT switch.
- g. **CHECK**—Trace shift; less than 2 mm as the INVERT switch is pulled.

## 3. Check Main Amplifier Differential Balance

**REQUIREMENT**—Trace must remain within 4 mm of center horizontal graticule line when channel 1 and 2 traces are positioned to the same area and the MODE switch set to ADD.

- a. Position the trace to the center graticule line with the Type 10A2A channel 2 POSITION control.
- b. Set the Type 10A2A MODE switch to CH 1.
- c. Position the trace to the center graticule line with the Type 10A2A channel 1 POSITION control.
- d. Set the Type 10A2A MODE switch to ADD and note the trace displacement from the reference position established in part c of this step.
- e. **CHECK**—Trace Displacement (noted in part d of this step); should be less than 2 mm.

## 4. Check Channel 1 Grid Current Zero

**REQUIREMENT**—Less than 2 mm trace movement as input coupling switch is changed from ground to DC.

- a. Set the Type 10A2A MODE switch to CH 1.
- b. Position the trace to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.
- c. Switch the channel 1 input coupling switch between its GND and DC positions.
- d. **CHECK**—Trace movement; there should be less than 2 mm trace movement.

## 5. Check Channel 2 Grid Current Zero

**REQUIREMENT**—No trace movement as input coupling switch is changed from ground to DC.

- a. Set the Type 10A2A MODE switch to CH 2.
- b. Position the trace to the center horizontal graticule line with the Channel 2 POSITION control.
- c. Switch the channel 2 input coupling switch between its GND and DC positions.
- d. **CHECK**—Trace movement; there should be no trace movement.

## 6. Adjust Channel 1 Gain

**REQUIREMENT**—Adjust to correct gain.

- a. Set the Type 10A2A MODE switch to CH 1 and both input coupling switches to DC.
- b. Connect the dial input coupler to the Type 10A2A Channel 1 and 2 INPUT connectors.
- c. Connect a 50 ohm coaxial cable from a standard amplitude calibrator output connector to the dual input coupler.
- d. Set the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 50 mV.
- e. Rotate the Type 10A2A channel 1 front-panel GAIN control (see Fig. 5-1) from one extreme to the other.
- f. **CHECK**—Operation; control should vary display amplitude and operate smoothly.
- g. **ADJUST**—Channel 1 GAIN control, R138 (see Fig. 5-1) for a display exactly 5 cm high.

## 7. Adjust Channel 2 Gain

**REQUIREMENT**—Adjust to correct gain.

- a. Set the Type 10A2A MODE switch to CH 2.
- b. Rotate the Type 10A2A channel 2 front-panel GAIN control (see Fig. 5-1) from one extreme to the other.
- c. **CHECK**—Operation; control should vary display amplitude and operate smoothly.
- d. **ADJUST**—Channel 2 GAIN control, R238 (see Fig. 5-1) for a display exactly 5 cm high.
- e. Set the 10A2A MODE switch to ADD and pull out the Channel 2 INVERT switch.
- f. **CHECK**—Display; should be only a trace, i.e., complete signal cancellation.

## Performance Check—Type 10A2A

g. ADJUST—Channel 2 GAIN control R238 (see Fig. 5-1), until the display consists of only a single trace, i.e., the channel 1 and 2 signals have completely cancelled each other.

### 8. Check Algebraic Add Operation

REQUIREMENT—Displayed signal must represent the algebraic sum of the channel 1 and channel 2 signals within  $\pm 2.5\%$ .

a. Change the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 20 mV.

b. Push in the Type 10A2A INVERT switch to ADD.

c. CHECK—Display amplitude; 4 cm,  $\pm 1$  mm.

### 9. Check Channel 1 Variable Volts/Cm Operation

REQUIREMENT—Must attenuate signal by at least 2.5:1. UNCAL neon should be lit when VARIABLE (VOLTS/CM) control is away from its CAL position.

a. Set the Type 10A2A MODE switch to CH 1.

b. Change the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 50 mV.

c. Rotate the Type 10A2A channel 1 VARIABLE (VOLTS/CM) control to its fully counterclockwise position.

d. CHECK—Display amplitude and operation; display amplitude must be 2 cm or less and the control should smoothly vary the amplitude.

e. CHECK—UNCAL neon; should be lit.

f. Set the Type 10A2A channel 1 VARIABLE (VOLTS/CM) control to its CAL position.

### 10. Check Channel 2 Variable Volts/Cm Operation

REQUIREMENT—Must attenuate signal by at least 2.5:1. UNCAL neon should be lit when VARIABLE (VOLTS/CM) control is away from its CAL position.

a. Set the Type 10A2A MODE switch to CH 2.

b. Rotate the Type 10A2A channel 2 VARIABLE (VOLTS/CM) control to its fully counterclockwise position.

c. CHECK—Display amplitude and operation; display amplitude must be 2 cm or less and the control should smoothly vary the amplitude.

d. CHECK—UNCAL neon; should be lit.

e. Set the Type 10A2A channel 2 VARIABLE (VOLTS/CM) control to its CAL position.

### 11. Check Channel 2 Input Coupling Switch

REQUIREMENT—Signal should center its average voltage

level near the center horizontal graticule line when the input coupling switch is set to AC. Trace should not shift more than 5 mm when input coupling switch is changed from ground to AC with a +100 volt DC input signal.

a. Set the bottom of the square-wave display to the center horizontal graticule line with the Type 10A2A channel 2 POSITION control.

b. Set the Type 10A2A channel 2 Input Coupling switch to AC.

c. CHECK—Display position; center of 5 cm square-wave display should shift down and become centered about the center graticule line.

d. Set the Type 10A2A channel 2 Input Coupling switch to GND and note the trace position.

e. Change the standard amplitude calibrator controls to produce a +100 volt DC output signal.

f. Set the Type 10A2A channel 2 Input Coupling switch to AC.

g. CHECK—Trace shift; should not shift more than 5 mm; if it does, the input coupling capacitor has too much leakage or the capacitor precharge circuit is not working.

h. Set the Type 10A2A channel 2 Input Coupling switch to DC.

i. Change the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 50 mV.

### 12. Check Channel 1 Input Coupling Switch

REQUIREMENT—Signal should center its average voltage level near the center horizontal graticule line when the input coupling switch is set to AC. Trace should not shift more than 5 mm when input coupling switch is changed from ground to AC with a +100 volt DC input signal.

a. Set the Type 10A2A MODE switch to CH 1.

b. Set the bottom of the square-wave display to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.

c. Set the Type 10A2A channel 1 Input Coupling switch to AC.

d. CHECK—Display position; center of 5 cm square-wave display should shift down and become centered about the center horizontal graticule line.

e. Set the Type 10A2A channel 1 Input Coupling switch to GND and note the trace position.

f. Change the standard amplitude calibrator controls to produce a +100 volt DC output signal.

g. Set the Type 10A2A channel 1 Input Coupling switch to AC.

h. CHECK—Trace shift; should not shift more than 5 mm. If it does, the input coupling capacitor has too much leakage or the capacitor precharge circuit is not working.

i. Disconnect the standard amplitude calibrator, the dual input coupler and the 50 ohm coaxial cable.

### 13. Check Channel 2 Output DC Level

REQUIREMENT—Output DC level should be within 150 mV of ground with Type 10A2A TRIGGER switch at NORM. With TRIGGER switch at CH 2 ONLY position, output DC level should be within 200 mV of ground.

a. Change the following Type 10A2A control settings:

VOLTS/CM (channel 1)	.1
Input Coupling (channel 1)	DC
MODE	CH 1

b. Position the trace to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.

c. Connect a 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the Type 10A2A CH 1 INPUT connector.

d. CHECK—Trace position; must not move more than 1.5 cm from the trace position established in part b of this step.

e. Set the Type 10A2A TRIGGER switch to CH 2 ONLY.

f. CHECK—Trace position; within 2 cm of trace position established in part b of this step.

g. Disconnect the 50 ohm coaxial cable.

### 14. Check Channel 2 Front-Panel Output Gain

REQUIREMENT—Output signal 100 mV or greater for each centimeter of channel 2 vertical signal deflection.

a. Set the Type 10A2A channel 1 Input Coupling switch to AC and the VOLTS/CM switch to .01.

b. Connect a 5 mV square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the Type 10A2A channel 2 INPUT connector.

c. Connect an 8 inch 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the channel 1 INPUT connector of the Type 10A2A.

d. Set the 11-series plug-in trigger level control for a stable display.

e. CHECK—Displayed signal amplitude; equal to or greater than 5 centimeters, i.e., equal to or greater than 100 mV of CH 2 OUTPUT signal per centimeter of channel 2 vertical signal deflection.

f. Disconnect the standard amplitude calibrator and both 50 ohm coaxial cables.

### 15. Check Normal Trigger DC Balance and Channel 2 Only Balance

REQUIREMENT—With 11-series plug-in trigger coupling switch set to DC, it should trigger on a 20 mV square-wave signal when the Type 10A2A TRIGGER switch is set to NORM and should trigger on a 200 mV signal when the TRIGGER switch is set to CH 2 ONLY.

a. Change the following Type 10A2A controls.

Input Coupling (channel 1)	DC
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Input Coupling (channel 2)	AC
TRIGGER	NORM
MODE	CH 2

b. Position the trace to the center graticule line with the Type 10A2A channel 2 POSITION control.

c. Connect a 2 mV square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the Type 10A2A channel 2 INPUT connector.

d. Set the 11-series plug-in trigger level control for a stable display.

e. The display should now consist of a 2 mm high square-wave signal positioned about the center graticule line.

f. Set the 11-series trigger coupling switch to DC and increase the square-wave signal from the standard amplitude calibrator until a triggered display is again observed.

g. CHECK—Signal amplitude; square-wave signal from the standard amplitude calibrator should not exceed 20 mV.

h. Set the Type 10A2A TRIGGER switch to CH 2 ONLY and depress the Type 647A beam finder switch.

i. Increase the amplitude of the square-wave signal from the standard amplitude calibrator until a triggered display is observed.

j. CHECK—Signal amplitude; square-wave signal from standard amplitude calibrator should not be greater than 0.2 volt peak to peak.

k. Disconnect the standard amplitude calibrator and the 50 ohm coaxial cable.

### 16. Check Channel 2 Attenuator Accuracy

REQUIREMENT—Correct deflection  $\pm 2\%$  for each setting of the switch.

a. Set the 11-series trigger coupling switch to AC.

b. Set the Type 10A2A channel 2 Input Coupling switch to DC and the TRIGGER switch to NORM.

c. Connect the dual input coupler to the Type 10A2A channel 1 and 2 INPUT connectors.

d. Connect a 50 ohm coaxial cable from a standard amplitude calibrator output connector to the dual input coupler.

e. Set the standard amplitude calibrator output square-wave signal to the appropriate amplitude as listed in Table 5-1.

f. Set the Type 10A2A channel 2 VOLTS/CM switch to the appropriate position listed in Table 5-1.

g. CHECK—Deflection; see Table 5-1 for correct deflection and tolerance.

### 17. Check Channel 1 Attenuator Accuracy

REQUIREMENT—Correct deflection  $\pm 2\%$  for each setting of the switch.

a. Set the Type 10A2A MODE switch to CH 1.

b. Set the standard amplitude calibrator output square-wave signal to the appropriate amplitude as listed in Table 5-1.

## Performance Check—Type 10A2A

**TABLE 5-1**  
Attenuator Accuracy Check

Square-Wave Signal Amplitude Peak to Peak	Type 10A2A VOLTS/CM Switch	Deflection and Tolerance
0.1 V	.02	5 cm, $\pm 1$ mm
0.2 V	.05	4 cm, $\pm 0.8$ mm
0.5 V	.1	5 cm, $\pm 1$ mm
1 V	.2	5 cm, $\pm 1$ mm
2 V	.5	4 cm, $\pm 0.8$ mm
5 V	1	5 cm, $\pm 1$ mm
10 V	2	5 cm, $\pm 1$ mm
20 V	5	4 cm, $\pm 0.8$ mm
50 V	10	5 cm, $\pm 1$ mm
100 V	20	5 cm, $\pm 1$ mm

c. Set the Type 10A2A channel 1 VOLTS/CM switch to the appropriate position listed in Table 5-1.

d. CHECK—Deflection; see Table 5-1 for correct deflection and tolerance.

e. Disconnect the dual input coupler, the 50 ohm coaxial cable and the standard amplitude calibrator.

### 18. Check Channel 1 Attenuator Series Compensation

REQUIREMENT—Waveform should have less than 1½% of overshoot, rounding and tilt.

a. Set the 11-series plug-in time/cm switch to .1 ms and the trigger mode switch to norm.

b. Connect a dual input coupler to the Type 10A2A channel 1 and 2 INPUT connectors.

c. Connect a 5 ns coaxial cable to the output connector of a square-wave generator.

d. Connect a 50 ohm GR to BNC termination and a 10× attenuator to the 5 ns coaxial cable.

e. Connect the unconnected end of the 10× attenuator to the dual input coupler.

f. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 5 kHz.

g. Set the 11-series plug-in time/cm switch to .1 ms and the trigger mode switch to norm, then adjust the trigger level control for a stable display.

h. CHECK—The waveform at each VOLTS/CM switch setting should have less than 1½% of overshoot, rounding and tilt.

i. Repeat parts f through h of this step for each Type 10A2A VOLTS/CM switch setting. At the 0.2 volt switch position, remove the 10× attenuator. At the 2 volt switch position, remove the 50 Ω GR to BNC termination and replace it with a GR to male BNC adapter.

### 19. Check Channel 2 Attenuator Series Compensation

REQUIREMENT—Waveform should have less than 1½% of overshoot, rounding and tilt.

a. Set the Type 10A2A MODE switch to CH 2.

b. Remove the GR to male BNC adapter from the 5 ns coaxial cable and reconnect the 50 ohm GR to BNC termination and the 10× attenuator.

c. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 5 kHz.

d. Adjust the 11-series plug-in trigger level control for a stable display.

e. CHECK—The waveform at each VOLTS/CM switch setting should have less than 1½% of overshoot, rounding and tilt.

f. Repeat parts c through e of this step for each Type 10A2A VOLTS/CM switch setting. At the 0.2 volt switch position, remove the 10× attenuator. At the 2 volt switch position, remove the 50 Ω GR to BNC termination and replace it with a GR to male BNC adapter.

g. Disconnect the 5 ns coaxial cable, the GR to BNC adapter, and the dual input coupler.

### 20. Check Channel 2 Attenuator Input Time Constants

REQUIREMENT—Waveform flatness should be uniform on all positions within 3% ( $\pm 1\frac{1}{2}\%$  of median).

a. Connect a 20 pF input RC normalizer to the Type 10A2A channel 2 INPUT connector.

b. Set the Type 10A2A channel 2 VOLTS/CM switch to .01 and the 11-series time/cm to .5 msec.

c. Connect a 5 ns coaxial cable to the output connector of a square-wave generator.

d. To the 5 ns coaxial cable connect a 50 ohm GR to BNC termination and a 10× attenuator.

e. Connect the unconnected end of the 10× attenuator to the 20 pF input RC normalizer.

f. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 2.5 kHz.

g. Adjust the 11-series plug-in trigger level control for a stable display.

h. CHECK—The waveform at each VOLTS/CM switch setting for overshoot, rounding and tilt. Waveform should be uniform on all positions within 3% ( $\pm 1\frac{1}{2}\%$  of median).

i. Repeat parts f through h of this step for each Type 10A2A VOLTS/CM switch setting. At the 0.2 volt switch setting, remove the 10× attenuator. At the 2 volt switch position remove the 50 Ω GR to BNC termination and replace it with a GR to male BNC adapter.

## 21. Check Channel 1 Attenuator Input Time Constants

REQUIREMENT—Waveform flatness should be uniform on all positions within 3% ( $\pm 1\frac{1}{2}\%$  of median).

a. Set the Type 10A2A MODE switch to CH 1 and the channel 1 VOLTS/CM switch to .01 and the 11-series time/cm to .5 msec.

b. Remove the 20 pF input RC normalizer from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.

c. Remove the GR to male BNC adapter from the 5 ns coaxial cable and reconnect the 50 ohm GR to BNC termination and the 10 $\times$  attenuator.

d. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 2.5 kHz.

e. Adjust the 11-series plug-in trigger level control for a stable display.

f. CHECK—The waveform at each VOLT/CM switch setting for overshoot, rounding and tilt. Waveform should be uniform on all positions within 3% ( $\pm 1\frac{1}{2}\%$  of median).

g. Repeat parts d through f of this step for each Type 10A2A VOLTS/CM switch setting. At the 0.2 volt switch position, remove the 10 $\times$  attenuator. At the 2 volt switch position replace the 50  $\Omega$  GR to BNC termination with a GR to male BNC adapter.

h. Disconnect the square-wave generator, the 5 ns coaxial cable, GR to male BNC adapter and the 20 pF input normalizer.

## 22. Check Alternate Trace Operation

REQUIREMENT—Type 10A2A channels should be displayed alternately.

a. Set the Type 10A2A MODE switch to ALT.

b. Set the 1-series plug-in trigger mode switch to free run.

c. CHECK—Display; one channel should be displayed, then the other alternately.

d. Set the 11-series plug-in time/cm switch to several different settings, repeating part c of this step for each switch setting.

## 23. Check Chopped Operation

REQUIREMENT—Repetition rate must be 1 MHz,  $\pm 150$  kHz and all vertical display transients should be blanked out during the switching interval.

a. Set the Type 10A2A MODE switch to CHOP.

b. Set the 11-series plug-in trigger mode switch to auto and the time/cm switch to 0.2  $\mu$ s.

c. Adjust the 11-series plug-in trigger level control for a stable display.

d. CHECK—Display repetition rate; 1 MHz,  $\pm 150$  kHz.

e. CHECK—Vertical display transients; all vertical display transients should be blanked out during the switching interval.

## 24. Check High Frequency Transient Response

REQUIREMENT—Less than 5% of overshoot, rounding, tilt or peak-to-peak ringing on a square-wave waveform.

a. Set the Type 10A2A MODE switch to CH 1.

b. Set the 11-series plug-in magnification switch to 10 times and the trigger mode switch to norm.

c. Connect the fast rise positive transition output of a square-wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 1 INPUT connector.

d. Set the square-wave generator output signal frequency to 400 kHz and adjust its output amplitude control to obtain a 4 cm high display.

e. Adjust the 11-series plug-in trigger level control for a stable display.

f. CHECK—Displayed waveform; less than 5% of overshoot, rounding, tilt, or peak-to-peak ringing (see Fig. 5-2).

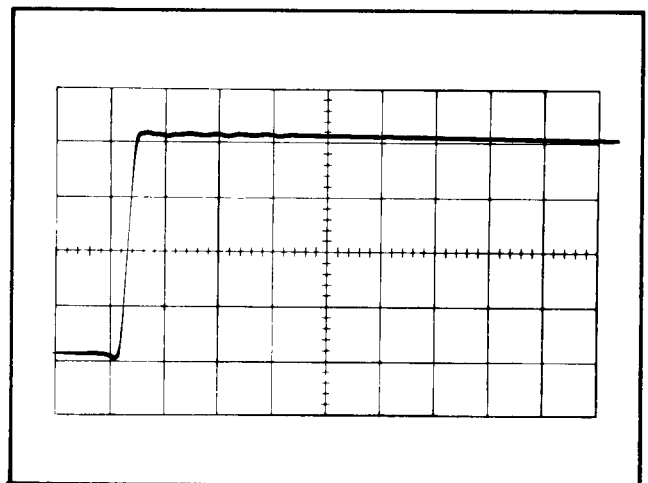


Fig. 5-2. Correctly compensated waveform.

g. Set the 1-series magnification control to 1 time and repeat part f of this step.

h. Set the Type 10A2A MODE switch to CH 2.

i. Reset the 11-series magnification control to 10 times.

j. Remove the properly terminated square-wave generator output from the Type 10A2A channel 1 INPUT connector and connect it to the channel 2 INPUT connector.

k. CHECK—Displayed waveform; less than 5% of overshoot, rounding, tilt, or peak-to-peak ringing.

l. Set the 11-series magnification control to 1 time and repeat part k of this step.

m. Reset the 11-series magnification control to 10 times.

n. Disconnect the square-wave generator.

## Performance Check—Type 10A2A

### 25A. Check Overall Bandwidth

REQUIREMENT—At least 100 MHz at  $-3$  dB.

a. Connect the output of the high frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.

b. Set the 11-series plug-in trigger mode switch to auto and the magnification switch to 1 time.

c. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).

d. Adjust the output amplitude control of the high frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.

e. Change the high frequency generator output frequency switch to its variable frequency position.

f. Increase the output of the high frequency generator until the display amplitude drops to 2.8 cm.

g. CHECK—Generator output frequency; should be at least 100 MHz; in other words,  $-3$  dB bandwidth is at least 100 MHz.

h. Disconnect the high frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.

i. Change the Type 10A2A MODE switch to CH 1.

j. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).

k. Adjust the output amplitude control of the high frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.

l. Change the high frequency generator output frequency switch to its variable frequency position.

m. Increase the output of the high frequency generator until the display amplitude drops to 2.8 cm.

n. CHECK—Generator output frequency; should be at least 100 MHz; in other words  $-3$  dB bandwidth is at least 100 MHz.

o. Disconnect the high frequency generator.

### 25B. Check Overall Bandwidth

(Alternate method which will not insure performance, but can be used as a check).

REQUIREMENT—At least 100 MHz at  $-3$  dB.

a. Connect the output of the medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.

b. Set the 11-series plug-in trigger mode switch to auto and the magnification switch to 1 time.

c. Set the medium frequency generator output frequency switch to its fixed frequency (50 kHz).

d. Adjust the output amplitude control of the high frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.

e. Change the high frequency generator output frequency switch to its variable frequency position.

f. Increase the frequency dial of the medium frequency generator to 100 MHz.

g. CHECK—Display amplitude; at least 2.8 cm of deflection must remain.

h. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.

i. Change the Type 10A2A MODE switch to CH 1.

j. Set the medium frequency generator output frequency switch to its fixed frequency (50 kHz).

k. Adjust the output amplitude control of the high frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.

l. Change the high frequency generator output frequency switch to its variable frequency position.

m. Increase the frequency dial of the medium frequency generator to 100 MHz.

n. CHECK—Display amplitude; at least 2.8 cm of deflection must remain.

o. Disconnect the medium frequency generator.

### 26. Check Channel 1 and 2 Cascaded Bandwidth

REQUIREMENT—At least 30 MHz at  $-3$  dB.

a. Connect the output of a medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.

b. Connect a short (approximately 8 inches) 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the channel 1 INPUT connector.

c. Set the medium frequency generator output frequency switch to its fixed frequency (50 kHz).

d. Set the 11-series plug-in time/cm switch to 20  $\mu$ s.

e. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.

f. Change the medium frequency generator output frequency switch to its variable frequency position.

g. Increase the frequency of the medium frequency generator until the display amplitude drops to 2.8 cm.

h. CHECK—Generator output frequency; should be at least 30 MHz; in other words,  $-3$  dB bandwidth is at 30 MHz.

i. Disconnect the medium frequency generator, the 5 ns coaxial cable and the 50 ohm GR to BNC termination.



## 27. Check Common Mode Rejection Ratio

REQUIREMENT—At least 20:1 rejection ratio at 50 MHz.

- a. Connect the output of a medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable, a 5× GR attenuator and a 50 ohm GR to BNC termination to both the Type 10A2A channel 1 and 2 INPUT connectors using a dual input coupler.
- b. Set the Type 10A2A channel 2 input coupling switch to GND.
- c. Set the medium frequency generator for an output signal frequency of 50 MHz.
- d. Set the Type 10A2A channel 1 VOLTS/CM switch to .02.
- e. Adjust the output amplitude control of the medium frequency generator to produce exactly 5 cm of CRT deflection on the Type 647A.
- f. Set the Type 10A2A channel 1 VOLTS/CM switch to .01.
- g. Change the Type 10A2A MODE switch to ADD, the channel 2 input coupling switch to DC and pull out the channel 2 INVERT switch.
- h. CHECK—Display; 5 mm or less of display amplitude, indicating a 20:1 rejection ratio.
- i. Disconnect the medium frequency generator, the 5 ns coaxial cable, the 5× GR attenuator, the 50 ohm GR to BNC termination and the dual input coupler.

## 28. Check Amplifier Inter-Channel Isolation

REQUIREMENT—Isolation ratio of at least 200:1 from DC to 25 MHz.

- a. Connect the output of a medium frequency constant amplitude sine wave generator to the Type 10A2A channel 1 INPUT connector.
- b. Set the Type 10A2A MODE switch to CH 1, the channel 1 VOLTS/CM switch to .2 and push in the channel 2 INVERT switch.
- c. Set the medium frequency generator output frequency switch to 25 MHz.
- d. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.
- e. Set the Type 10A2A MODE switch to CH 2 and the channel 1 VOLTS/CM switch to .01.
- f. CHECK—Display amplitude; 5 mm or less.

g. Disconnect the medium frequency generator from the Type 10A2A channel 1 INPUT connector and connect it to the channel 2 INPUT connector.

h. Set the Type 10A2A MODE switch to CH 1.

i. CHECK—Display amplitude; 5 mm or less.

j. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector.

## 29. Check Attenuator Inter-Channel Isolation

REQUIREMENT—Isolation ratio of at least 10,000:1 from DC to 25 MHz.

- a. Connect the output of an unterminated medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable, and a GR to male BNC adapter to the Type 10A2A channel 2 INPUT connector.
- b. Set the Type 10A2A MODE switch to CH 2, the channel 2 VOLTS/CM switch to 2.
- c. Set the medium frequency generator output frequency switch to its variable frequency position.
- d. Set the frequency dial of the medium frequency generator to 25 MHz.
- e. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.
- f. Change the Type 10A2A MODE switch to CH 1.
- g. CHECK—Display amplitude; 1 mm or less of display amplitude, indicating 10,000:1 isolation ratio.
- h. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.
- i. Set the Type 10A2A channel 2 VOLTS/CM switch to .01 and the channel 1 VOLTS/CM switch to 2.
- j. The frequency dial of the medium frequency generator should be set to 25 MHz.
- k. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.
- l. Change the Type 10A2A MODE switch to CH 2.
- m. CHECK—Display amplitude; 1 mm or less of display amplitude, indicating 10,000:1 isolation ratio.
- n. Disconnect the medium frequency generator.

This completes the performance check of the Type 10A2A. Disconnect all test equipment.



# SECTION 6

## CALIBRATION

### Introduction

Complete calibration information for the Type 10A2A is given in this section. This procedure calibrates the instrument to the performance requirements listed in the Characteristics section. To merely touch up the calibration, perform only those steps entitled "Adjust...". A short-form calibration procedure is also provided in this section for the convenience of the experienced calibrator.

The Type 10A2A should be checked, and if necessary, recalibrated, after each 1000 hours of operation, or every six months if used infrequently, to assure correct operation and accuracy. The Performance Check section of this manual provides a complete check of instrument performance without making internal adjustments. Use the performance check procedure to verify the calibration of the Type 10A2A and determine if recalibration is required.

### TEST EQUIPMENT REQUIRED

#### General

The following test equipment, or its equivalent, is required for complete calibration of the Type 10A2A (see Fig. 6-1). Specifications given are the minimum necessary for accurate calibration of this instrument. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the minimum specifications.

For the quickest and most accurate calibration, special calibration fixtures are used where necessary. All calibration fixtures listed here can be obtained from Tektronix, Inc. Order by part number through your local Tektronix Field Office or representative.

1. DC voltmeter. Minimum sensitivity, 20,000 ohms/volt; accuracy, 3%; range, 0 to 9 volts. For example Simpson Model 262.

2. Time base plug-in. Tektronix 11-series Time Base Plug-In recommended. The associated time-base unit must have compatible triggering characteristics to obtain a stable display at high frequencies. See the 11-series instruction manual.

3. Calibration oscilloscope. Tektronix Type 647A or RM647A recommended.

4. Standard Amplitude Calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 2 millivolts to 100 volts; output signal, 1-kHz. Tektronix calibration fixture 067-0502-00 recommended.

5. Square-wave generator, high-rise portion; Frequency 2.5 kHz and 5 kHz; risetime, 12 ns maximum; output impedance, 600 ohms, or less (without an external termination); output amplitude, about 100 volts peak to peak unterminated.

Fast-rise portion; Frequency 400 kHz; risetime, 1 ns maximum; output impedance, 600 ohms or less (without an external termination); output amplitude, about 500 mvolts peak to peak unterminated. Tektronix Type 106 Square-Wave Generator recommended.

6. Medium frequency constant amplitude sinewave generator. Frequency, 50 kHz and 25 MHz to 100 MHz; output amplitude, less than 40 mV to above 10 volts; amplitude regulation accuracy,  $\pm 5\%$ . Tektronix Type 191 Constant Amplitude Signal Generator recommended.

7. High frequency constant amplitude sinewave generator. Frequency, 3 MHz and 65 MHz to 100 MHz; output amplitude, 40 mV; amplitude regulation accuracy,  $\pm 1\%$ . Tektronix Calibration Fixture 067-0532-00 recommended.

8. Termination. Impedance, 50 ohm, accuracy;  $\pm 3\%$ ; connectors, GR one end, BNC other end. Tektronix Part No. 017-0083-00.

9.  $5\times$  attenuator. Impedance, 50 ohm; accuracy,  $\pm 2\%$  at DC and  $\pm 3\%$  at 1 GHz; connectors, GR. Tektronix Part No. 017-0079-00.

10.  $10\times$  attenuator. Impedance, 50 ohm; accuracy,  $\pm 3\%$ ; connectors, BNC. Tektronix Part No. 011-0059-00.

11. Input RC normalizer. Time constant, 1 megohm  $\times$  20 pF; attenuation,  $2\times$ ; connectors, BNC. Tektronix Part No. 011-0066-00.

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

13. Cable. Impedance, 50 ohm; length, 8 inch; connectors, BNC. Tektronix Part No. 012-0118-00.

14. Cable. Impedance, 50 ohm; length, 5 nanoseconds; connectors, GR. Tektronix Part No. 017-0502-00.

15. Cable. Impedance, 50 ohm; length, 42 inch; connectors, BNC. Tektronix Part No. 012-0057-00.

16. Dual-input coupler. Matched signal transfer to each input. Tektronix Calibration fixture 067-0525-00.

17. Adjustment tools (see Fig. 6-1).

Description	Tektronix Part No.
a. Insulated screwdriver, 1½-inch shaft, non-metallic.	003-0000-00
b. Plastic rod, 7½-inch long recessed metal screwdriver tips each end.	003-0003-00

### CALIBRATION RECORD AND INDEX

This short-form calibration procedure is provided to aid in checking the operation of the Type 10A2A. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristic section.

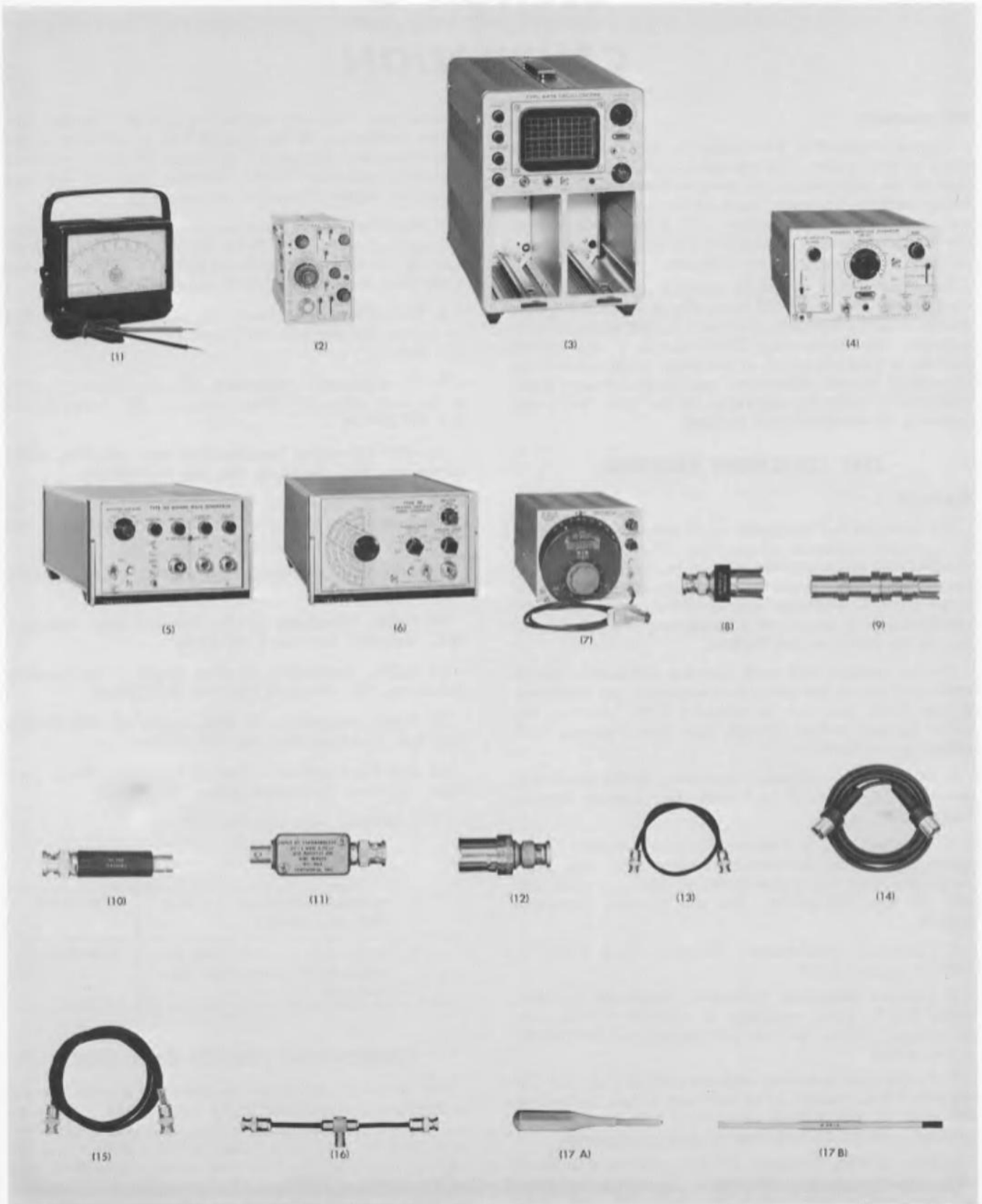


Fig. 6-1. Recommended calibration equipment.

Type 10A2A, Serial No. \_\_\_\_\_

Calibration Date \_\_\_\_\_

Calibration Technician \_\_\_\_\_

- 1. Adjust Channel 1 and 2 Common Mode Current, R150 and R250, Main Amplifier Current, R430, and Main Amplifier Differential Current, R335 (preliminary Adjustment) Page 6-6

Channel 1 Common Mode Current-Voltmeter reading between +8.0 and +8.6 volts at TP345.

Channel 2 Common Mode Current-Voltmeter reading between +8.0 and +8.6 volts at TP355.

Main Amplifier Current-Voltmeter reading of less than  $\pm 0.05$  volts at TP453 in both CH 1 and CH 2 Type 10A2A MODE switch position.

Main Amplifier Differential Current-Trace within graticule area in both CH 1 and CH 2 Type 10A2A MODE switch positions.

- 2. Adjust Channel 1 Variable Attenuator Balance, R122, Base Current, R140, and Invert Balance, R160 Page 6-7

Variable Attenuator Balance-Trace movement less than 1 mm.

Base Current-Trace movement less than 1 mm.

Invert Balance-Trace displacement less than 5 mm.

- 3. Adjust Channel 2 Variable Attenuator Balance, R222, Base Current, R240, and Invert Balance, 260 Page 6-9

Variable Attenuator Balance-Trace movement less than 1 mm.

Base Current-Trace movement less than 1 mm.

Invert Balance-Trace displacement less than 5 mm.

- 4. Adjust Channel 1 Common Mode Current, R150, Main Amplifier Differential Balance, R335, Main Amplifier Current, R430, and Channel 2 Common Mode Current, R250 Page 6-10

Channel 2 Common Mode Current-Voltmeter reading of less than 0.025 volt at TP453.

Channel 1 Common Mode Current-Voltmeter reading of less than 0.025 volt at TP453.

Main Amplifier Differential Balance-Trace displacement less than 2 mm.

Main Amplifier Current-Voltmeter reading of less than 0.025 volt at TP453.

- 5. Adjust Channel 1 Grid Current Zero, R117 Page 6-11

No trace movement as channel 1 input coupling switch moves between ground and DC.

- 6. Adjust Channel 2 Grid Current Zero, R217 Page 6-11

No trace movement as channel 2 input coupling switch moves between ground and DC.

- 7. Adjust Channel 1 Gain, R176 Page 6-12  
Exactly 5 cm.

- 8. Adjust Channel 2 Gain, R276 Page 6-13  
Exactly 5 cm.

- 9. Check Algebraic Add Operation Page 6-13  
In phase and equal amplitude signals for each channel should produce a signal twice the amplitude of the original signal.

- 10. Check Channel 1 Variable VOLTS/CM Operation Page 6-14  
Should attenuate the input signal by 2.5:1 or more.

- 11. Check Channel 2 Variable VOLTS/CM Operation Page 6-14  
Should attenuate the input signal by 2.5:1 or more.

- 12. Check Channel 2 Input Coupling Switch Page 6-14  
When input coupling switch is changed from DC to AC signal should center itself about the center graticule line.  
With +100 volts applied to the INPUT connector, the trace should not shift more than 5 mm as the input coupling switch is changed from GND to AC.

- 13. Check Channel 1 Input Coupling Switch Page 6-14  
When input coupling switch is changed from DC to AC signal should center itself about the horizontal center graticule line.  
With +100 volts applied to the INPUT connector, the trace should not shift more than 5 mm as the input coupling switch is changed from GND to AC.

- 14. Adjust Channel 2 Output DC Level, R530 Page 6-15  
CH 2 OUTPUT connector reference level within 20 mV of ground potential.  
TRIGGER switch set to CH 2 ONLY trace still within 100 mV of ground potential.

- 15. Check Channel 2 Front-Panel Output Gain Page 6-15  
The signal amplitude at the CH 2 OUTPUT connector must be at least 100 mV for each centimeter of channel 2 signal.

- 16. Adjust Normal Trigger DC Balance, R546, and Check Channel 2 Only Balance Page 6-15  
Normal Trigger DC Balance-Triggered display should be obtained with a 2 mV peak-to-peak input square-wave signal.  
Channel 2 Only Balance-Triggered display should be obtained with a 100 mV peak-to-peak input square-wave signal.

## Calibration—Type 10A2A

**Table A**

Square-Wave Signal Amplitude Peak to Peak	Type 10A2A VOLTS/CM Switch	Deflection and Tolerance
0.1 V	.02	5 cm, $\pm$ 1 mm
0.2 V	.05	4 cm, $\pm$ 0.8 mm
0.5 V	.1	5 cm, $\pm$ 1 mm
1 V	.2	5 cm, $\pm$ 1 mm
2 V	.5	4 cm, $\pm$ 0.8 mm
5 V	1	5 cm, $\pm$ 1 mm
10 V	2	5 cm, $\pm$ 1 mm
20 V	5	4 cm, $\pm$ 0.8 mm
50 V	10	5 cm, $\pm$ 1 mm
100 V	20	5 cm, $\pm$ 1 mm

**Table B**

Type 10A2A VOLTS/CM Switch	Component to Adjust For Optimum Square Corner (Series)	Component to Adjust For Optimum Flat Top (Time Constant)
.01		C103
.02	C104E	C104B
.05	C105D	C105B
.1	C106C	C106B
.2 <sup>1</sup>	C107D	C107B
.5	C108C	C108B
1	C109C	C109B
2 <sup>2</sup>	C110C	C110B
5	C111C	C111B
10	C112C	C112B
20	C113C	C113B

<sup>1</sup>Remove the 10 $\times$  attenuator.

<sup>2</sup>Remove the 50 ohm GR to BNC termination and substitute a GR to male BNC adapter in its place.

**Table C**

Type 10A2A VOLTS/CM Switch	Component to Adjust For Optimum Square Corner (Series)	Component to Adjust For Optimum Flat Top (Time Constant)
.01		C203
.02	C204C	C204B
.05	C205C	C205B
.1	C206C	C206B
.2 <sup>3</sup>	C207C	C207B
.5	C208C	C208B
2 <sup>4</sup>	C210C	C210B
5	C211C	C211B
10	C212C	C212B
20	C213C	C213B

<sup>3</sup>Remove the 10 $\times$  attenuator.

<sup>4</sup>Remove the 50 ohm GR to BNC termination and substitute a GR to male BNC adapter in its place.

- 17. Check Channel 2 Attenuator Accuracy Page 6-15  
See Table A.
- 18. Check Channel 1 Attenuator Accuracy Page 6-16  
See table for step 17 above.
- 19. Adjust Channel 1 Attenuator Series Compensations Page 6-17  
See Table B.
- 20. Adjust Channel 2 Attenuator Series Compensations Page 6-18  
See Table C.
- 21. Adjust Channel 2 Attenuator Input Time Constants Page 6-19  
See table for step 20 above.
- 22. Adjust Channel 1 Attenuator Input Time Constants Page 6-20  
See table for step 19 above.
- 23. Check Alternate Trace Operation Page 6-20  
Channels should alternate in displaying their information at all sweep rates.
- 24. Check Chopped Operation Page 6-20  
Repetition rate 1 MHz,  $\pm$ 150 kHz. All vertical display transients should be blanked out during the switching interval.
- 25. Adjust High Frequency Transient Response Page 6-21  
Must not cause more than 4% of overshoot, rounding, tilt, or peak-to-peak ringing on a square-wave waveform.
- 26A. Check Overall Bandwidth Page 6-22  
Not more than  $-3$  dB at 100 MHz.
- 26B. Check Overall Bandwidth (Alternate method which will not insure performance, but can be used as a check.) Page 6-23  
Not more than  $-3$  dB at 100 MHz.
- 27. Check Channel 1 and 2 Cascaded Bandwidth Page 6-23  
Not more than  $-3$  dB at 30 MHz.
- 28. Check Common Mode Rejection Page 6-23  
Rejection ratio of at least 20:1 at 50 MHz.
- 29. Check Amplifier Inter-Channel Isolation Page 6-24  
Ratio of at least 200:1 over a frequency range of DC to 25 MHz.
- 30. Check Attenuator Inter-Channel Isolation Page 6-24  
Isolation ratio of at least 10,000:1 over a frequency range of DC to 25 MHz.

## CALIBRATION PROCEDURE

### General

The following procedure is arranged in a sequence which allows the Type 10A2A to be calibrated with the least interaction of adjustments and reconnection of equipment. However, some adjustments affect the calibration of other circuits within the instrument. In this case, it will be necessary to check the operation of other parts of the instrument. To perform a

step without going through the prior steps, it may be necessary to confirm the performance of certain prior steps. Steps to be checked can be found at the start of the step affected.

Any needed maintenance should be performed before proceeding with calibration. Troubles which become apparent during calibration should be corrected using the techniques given in the Maintenance section.

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

In the following procedure, a test equipment setup picture is shown for each major group of adjustments and checks. Following each setup picture is a complete list of front-panel control settings for the Type 10A2A, 647A, and 11-series plug-in. To aid in locating individual controls which have been changed during complete calibration, these control names are printed in bold type. If only a partial calibration is performed, start with the nearest setup preceding the desired portion. Type 10A2A front-panel control titles referred to in this procedure are capitalized (e.g., VOLTS/CM). Internal adjustment titles are initial capitalized only (e.g., Ch 2 Grid Current Zero).

The following procedure uses the equipment listed under Equipment Required. If equipment is substituted, control settings or test equipment setup may need to be altered to meet the requirements of the equipment used.

#### NOTE

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera System.

#### Preliminary Procedure

1. Remove the left side cover from the Type 647A.
2. Install the Type 10A2A into the vertical plug-in compartment of the Type 647A.
3. Install an 11-series plug-in into the horizontal plug-in compartment of the Type 647A.
4. Set the front-panel controls of the Type 10A2A, 11-series plug-in and 647A as described below.
5. Connect the Type 647A directly to a power supply of appropriate voltage.
6. Set the Type 647A POWER switch to ON. Allow at least 20 minutes warm up at 25°C, ±5°C, for checking the instrument to the given accuracy.

#### NOTES

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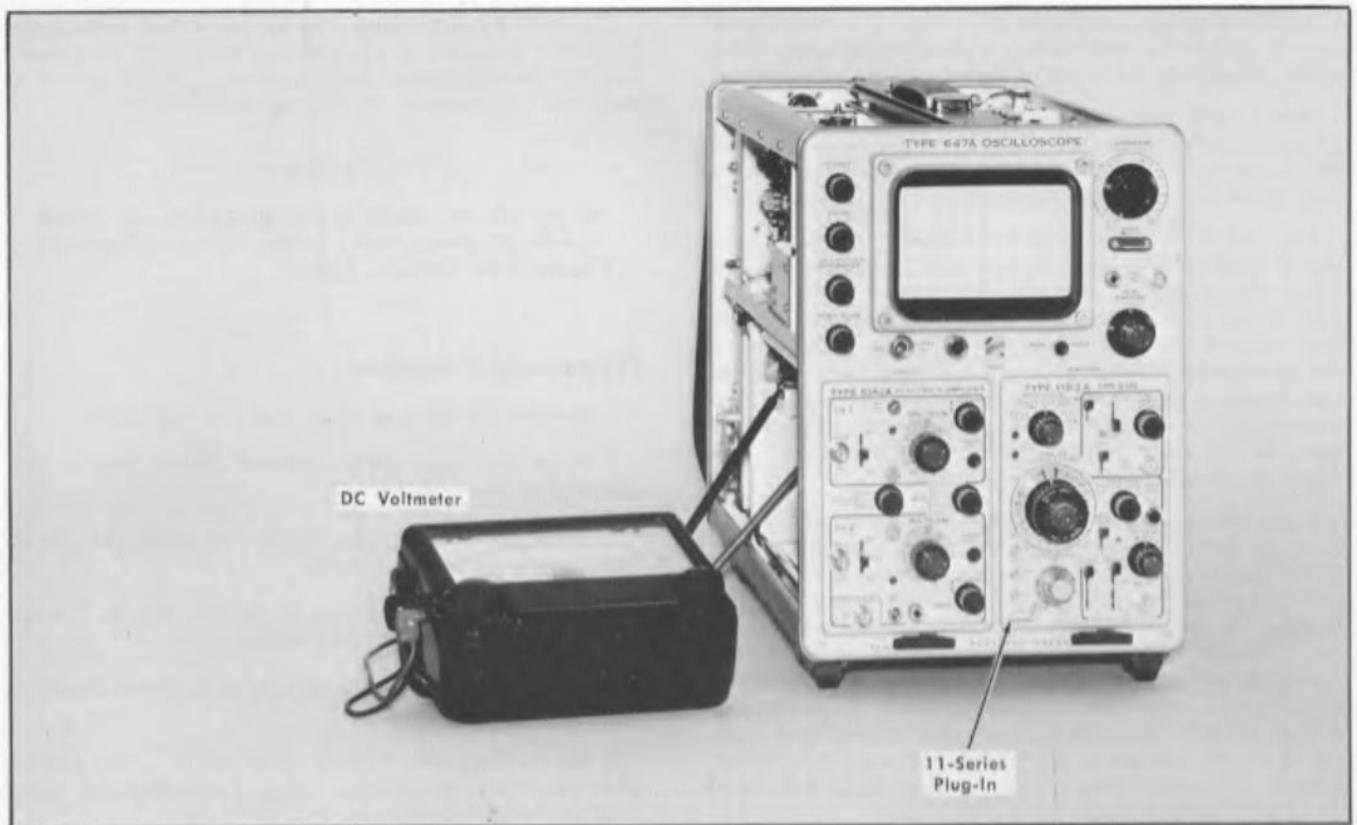


Fig. 6-2. Initial test equipment setup for steps 1 through 6.

Type 10A2A	
VOLTS/CM (both channels)	.01
VARIABLE (VOLTS/CM) (both channels)	Fully counterclockwise
POSITION (both channels)	Midrange
Input Coupling (both channels)	GND
INVERT (both channels)	Pushed in
GAIN (both channels)	180° counterclockwise from its fully clockwise position
VAR BAL (both channels)	As is
TRIGGER MODE	NORM CH 2

**Type 647A**

Intensity	Usable display brightness
Focus	Well defined display
Astigmatism	Well defined display
Scale Illum	As desired
Calibrator	Off
Position	Midrange
Fine (Position)	Midrange

11-Series	
Time/CM	1 ms
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

**1. Adjust Channel 1 and 2 Common Mode Current Main, Amplifier Current and Main Amplifier Differential Current (Preliminary Adjustment) ①**

- a. Test equipment setup is shown in Fig. 6-2.
- b. Connect a DC voltmeter between ground and TP345, see Fig. 6-3 (test point on collector of Q345).
- c. CHECK—Voltmeter reading; if voltage is between +8.0 and +8.6 volts no preliminary adjustment of Ch 1 Com Mode Current control, R150, should be made.
- d. ADJUST—Ch 1 Com Mode Current control, R150 (see Fig. 6-3) for a voltmeter reading of +8.3 volts if the voltmeter reading in part c of this step is outside the limits.
- e. Set the Type 10A2A MODE switch to CH 1.



f. Disconnect the DC voltmeter from TP345 and connect it between ground and TP355; see Fig. 6-3 (test point on collector of Q355).

g. CHECK—Voltmeter reading; if voltage is between +8.0 and +8.6 volts, no preliminary adjustment of Ch 2 Com Mode Current control, R250, should be made.

h. ADJUST—CH 2 Com Mode Current control, R250 (see Fig. 6-3), for a voltmeter reading of +8.3 volts if the voltmeter reading in part g of this step is outside the limits.

i. Disconnect the DC voltmeter from TP345 and connect it between the junction of C192 (see Fig. 6-3) and the wire going to the Type 10A2A channel 1 INVERT switch (one wire of twisted pair) and the junction between C193 (see Fig. 6-3) and the wire going to the Type 10A2A channel 1 INVERT switch (other wire of twisted pair).

j. Set the DC voltmeter to a sensitive range then adjust the Type 10A2A channel 1 VAR BAL control, R122 (see Fig. 6-4) and if necessary the Ch 1 Inv Bal control, R160 (see Fig. 6-3) until a voltmeter reading of zero volts is obtained.

h. Disconnect the DC voltmeter from the junctions in part i above and connect it between the junction of C292 (see Fig. 6-3) and the wire going to the Type 10A2A channel 2 INVERT switch (one wire of twisted pair) and the junction between C293 (see Fig. 6-3) and the wire going to the Type 10A2A channel 2 INVERT switch (other wire of twisted pair).

l. Set the DC voltmeter to a sensitive range then adjust the Type 10A2A channel 2 VAR BAL control, R222 (see Fig. 6-4) and if necessary the Ch 2 Inv Bal control, R260 (see Fig. 6-3) until a voltmeter reading of zero volts is obtained.

m. Disconnect the DC voltmeter from the junctions in part k above, and connect it between ground and TP453; see Fig. 6-3 (test point located at junction of R453 and R455).

n. Note the voltmeter reading, then set the Type 10A2A MODE switch to CH 2 and again note the voltmeter reading.

o. CHECK—Voltmeter readings; if both voltmeter readings noted in part j of this step were less than  $\pm 0.05$  volts, no preliminary adjustment of Main Amp Current control, R336 should be made.

p. ADJUST—Main Amp Current control, R336 (see Fig. 6-3) for a voltmeter reading less than  $\pm 0.05$  volts in either the CH 1 or CH 2 positions of the Type 10A2A switch. This adjustment is necessary only if the voltmeter readings noted in part n were greater than  $\pm 0.05$  volts.

q. Observe if the trace is on screen as the 10A2A MODE switch is set first to CH 1 and then the CH 2 positions.

r. CHECK—Trace positions; if trace is within the graticule area for both CH 1 and CH 2 MODE switch positions, no preliminary adjustment of Main Amp Diff Bal control, R335 should be made.

s. ADJUST—Main Amp Diff Bal control, R335 (see Fig. 6-3) so the trace is within 2 centimeters of the center horizontal graticule line, for both the CH 1 and CH 2 positions of the MODE switch.

t. If the Main Amp Diff Bal control, R335 was adjusted as in part s above, repeat parts m through s of this step.

u. Disconnect the voltmeter.

## 2. Adjust Channel 1 Variable Attenuator Balance, Base Current and Invert Balance

a. Step 1 should be checked before starting this step.

b. Set the Type 10A2A MODE Switch to CH 1 and check that channel 1 VARIABLE (VOLTS/CM) is full ccw.

c. Adjust the Channel 1 VAR BAL control R122 (see Fig. 6-4), and if necessary, the Inv Bal control R160 (see Fig. 6-3) to position the trace to the center horizontal line.

d. CHECK—Displacement of the trace from graticule center after the Channel 1 VARIABLE (VOLTS/CM) control is rotated to the CAL position. If the trace shifts less than 1 mm no further adjustment of the VAR BAL control is needed.

e. ADJUST—VAR BAL control, R122 (see Fig. 6-4). If the trace location with the VARIABLE (VOLTS/CM) control at CAL is within the graticule area proceed to sub-part 4) below. If trace is off graticule area perform all the sub parts.

1) With the VARIABLE (VOLTS/CM) control at CAL, position the trace back into the graticule area and across to the opposite extreme of the graticule by means of the VAR BAL R122 control.

2) Turn the Channel 1 VARIABLE (VOLTS/CM) control fully counterclockwise, then adjust the Inv Bal control R160 to center the trace on the graticule.

3) Turn the Channel 1 VARIABLE (VOLTS/CM) back to CAL, noting the resultant trace shift. If the trace is in the graticule area, proceed to sub-part 4). Otherwise, repeat sub-parts 1) through 3).

4) Set the VARIABLE (VOLTS/CM) control fully counterclockwise and note the trace position. Rotate the control to the CAL position and again note the position of the trace.

5) With the VAR BAL R122 control, move the trace back beyond its location at the fully counter clockwise position of the VARIABLE (VOLTS/CM) control by an amount equal to half the trace shift. Repeat this procedure until the trace position is the same for full counterclockwise and full clockwise positions of the VARIABLE (VOLTS/CM) control.

## Calibration—Type 10A2A

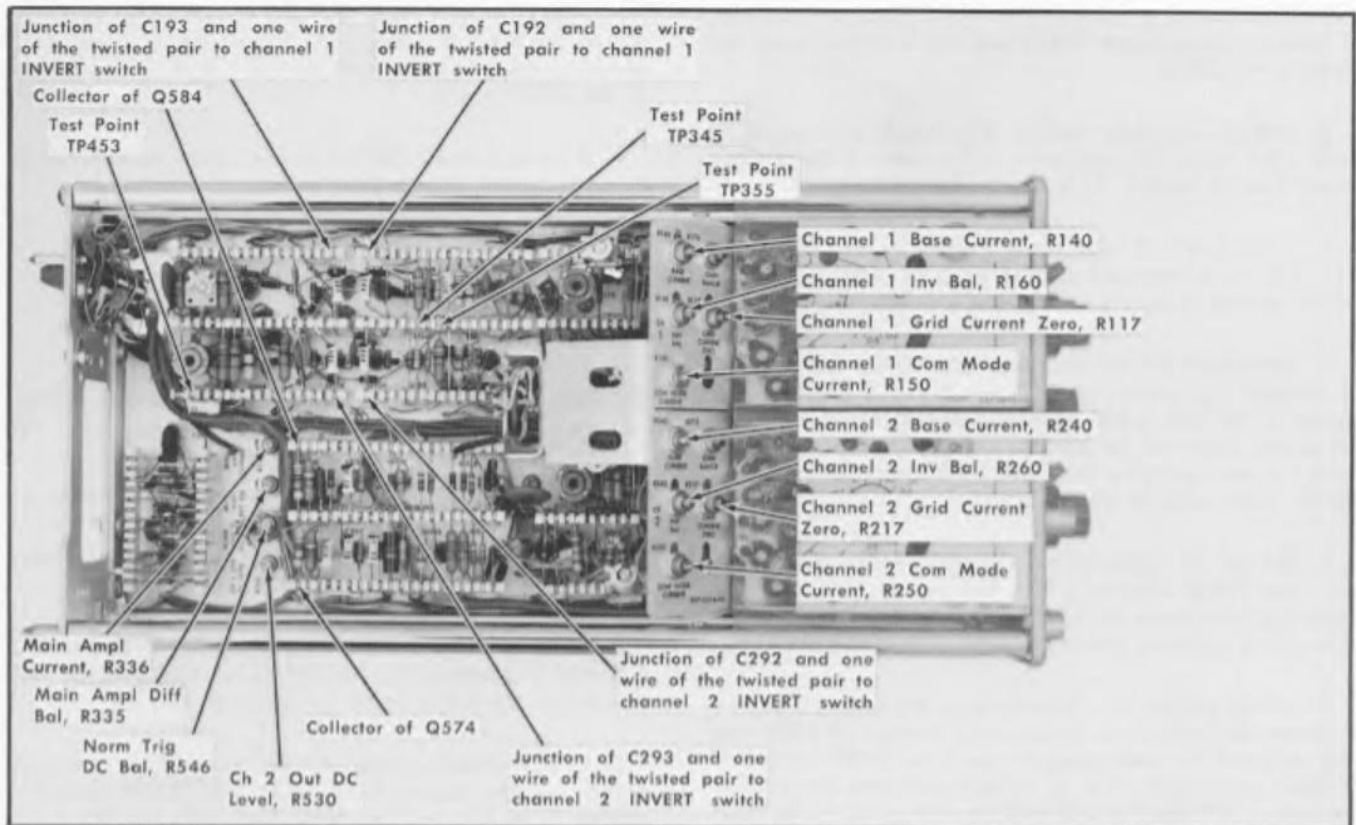


Fig. 6-3. Location of test point TP345, channel 1 Com Mode Current control, R150, test point TP355, channel 2 Com Mode Current, R250, test point TP453, Main Ampl Current control, R430, Q154 Base Current control, R140, Q254 Base Current control, R240, channel 2 Inv Bal control, R260, channel 1 Inv Bal control, R160, channel 1 Grid Current Zero control, R117, channel 2 Grid Current Zero control, R217, Main Ampl Diff Bal control, R335, channel 2 Out DC Level control, R530, collector of Q574 and Q584, Norm Trig DC Bal control, R546, junction of C193 and C192 with the channel 1 INVERT switch, and junction of C293 and C292 with the channel 2 INVERT switch.

f. With the Channel 1 VARIABLE (VOLTS/CM) control fully counterclockwise, center the trace on the graticule with the Channel 1 POSITION control.

g. Turn the VARIABLE (VOLTS/CM) control to the position (about mid-range) which causes the greatest trace shift.

h. CHECK—Trace displacement. If trace shift is less than 1 mm, no adjustment of Base Current control R140 is needed. If the shift is greater than 2 mm, proceed with the adjustment of the Base Current control as instructed in the parts to follow, then return to part d and of this step re-check the entire adjustment procedure through this point.

i. ADJUST—Base Current control R140 (see Fig. 6-3) to move the trace back past the center graticule line by an amount equal to four times the trace shift noted in part h.

### NOTE

If the trace shift noted in part h is greater than 8 mm, it will be necessary to use the Channel 1 POSITION control to keep the trace within the graticule area during adjustment of the Base Current control. If the POSITION control also lacks sufficient range, adjust Inv Bal control R160 as necessary to keep the trace within the graticule.

j. Repeat part i until trace shift is less than 1 mm as the Channel 1 VARIABLE (VOLTS/CM) control is rotated from one extreme to the other.

k. Set the Channel 1 VARIABLE (VOLTS/CM) control to CAL, and center the trace with the Channel 1 POSITION control.

l. Pull the Channel 1 INVERT switch.

m. CHECK—Trace shift. If the trace shifts less than 5 mm as the INVERT switch is pulled, no adjustment of Inv Bal control R160 (see Fig. 6-3) is necessary.

n. ADJUST—Inv Bal control R160 (see Fig. 6-3). If the trace location, when the INVERT switch is pulled, is within the graticule area proceed to sub-part 4) below. If trace is off the graticule area perform all sub-parts.

1) Push in the Channel 1 INVERT switch, and set the Channel 1 POSITION control to its mechanical center point.

2) Adjust the Inv Bal control R160 to center the trace on the graticule.

3) Pull the Channel 1 INVERT switch and note the resultant trace shift.

4) Adjust the Inv Bal control R160 to move the trace from the point of maximum displacement halfway back to the center line. Repeat this procedure, operating the INVERT switch and reducing the trace shift with the Inv Bal control progressively until there is no visible trace shift as the INVERT switch is operated.

5) Push in the INVERT switch.

**NOTE**

There is some interaction between the Inv Bal, VAR BAL and Base Current adjustments. If the operation of the INVERT control caused the trace to shift out of the graticule area originally, re-check the procedure from part d. forward.

**3. Adjust Channel 2 Variable Attenuator Balance, Base Current and Invert Balance** ①

a. Step 1 should be checked before starting this step.

b. Set the Type 10A2A MODE switch to CH 2 and check that channel 1 VARIABLE (VOLTS/CM) is full ccw.

c. Adjust the Channel 2 VAR BAL control R222 (see Fig. 6-4), and if necessary, the Inv Bal control R260 (see Fig. 6-3) to position the trace to the center horizontal line.

d. CHECK—Displacement of the trace from graticule center after the Channel 2 VARIABLE (VOLTS/CM control is rotated to the CAL position. If the trace shifts less than 1 mm no further adjustment of the VAR BAL control is needed.

e. ADJUST—VAR BAL control R222 (see Fig. 6-4). If the trace location with the VARIABLE (VOLTS/CM) control at CAL is within the graticule area proceed to sub-part 4) below. If trace is off graticule area perform all the sub-parts.

1) With the VARIABLE (VOLTS/CM) control at CAL, position the trace back into the graticule area and across to the opposite extreme of the graticule by means of the VAR BAL R222 control.

2) Turn the Channel 2 VARIABLE (VOLTS/CM) control fully counterclockwise, then adjust the Inv Bal control R260 to center the trace on the graticule.

3) Turn the Channel 2 VARIABLE (VOLTS/CM) control back to CAL, noting the resultant trace shift. If the trace is in the graticule area, proceed to sub-part 4). Otherwise, repeat sub-part 1) thru 3).

4) Set the VARIABLE (VOLTS/CM) control fully counterclockwise and note the trace position. Rotate the control to the CAL position and again note the position of the trace.

5) With the VAR BAL R222 control, move the trace back beyond its location at the fully counterclockwise position of the VARIABLE (VOLTS/CM) control by an amount equal to half the total trace shift. Repeat this procedure until the trace position is the same for full counterclockwise and full clockwise position of the VARIABLE VOLTS/CM control.

f. With the Channel 2 VARIABLE (VOLTS/CM) control fully counterclockwise, center the trace on the graticule with the Channel 2 POSITION control.

g. Turn the VARIABLE (VOLTS/CM) control to the position (about mid-range) which causes the greatest trace shift.

h. CHECK—Trace displacement. If trace shift is less than 1 mm, no adjustment of Base Current control R240 is needed. If the shift is greater than 2 mm, proceed with the adjustment of the Base Current control as instructed in the parts to follow, then return to part d of this step and re-check the adjustment procedure through this point.

i. ADJUST—Base Current control R240 (see Fig. 6-3) to move the trace back past the center line by an amount equal to four times the trace shift noted in part h.

**NOTE**

If the trace shift noted in part h is greater than 8 mm, it will be necessary to use the Channel 2 POSITION control to keep the trace within the graticule area during adjustment of the Base Current control. If the POSITION control also lacks sufficient range, adjust Inv Bal control R260 as necessary to keep the trace within the graticule.

j. Repeat part i until trace shift is less than 1 mm as the Channel 2 VARIABLE (VOLTS/CM) control is rotated from one extreme to the other.

k. Set the Channel 2 VARIABLE (VOLTS/CM) control to CAL, and center the trace with the Channel 2 POSITION control.

l. Pull the Channel 2 INVERT switch.

m. CHECK—Trace shift. If the trace shifts less than 5 mm as the INVERT switch is pulled, no adjustment of Inv Bal control R260 (see Fig. 6-3) is necessary.

n. ADJUST—Inv Bal control R260 (see Fig. 6-3). If the trace location, when the INVERT switch is pulled, is within the graticule area proceed to sub-part 4) below. If trace is off the graticule area perform all sub-parts.

1) Push in the Channel 2 INVERT switch, and set the Channel 1 POSITION control to its mechanical center point.

2) Adjust the Inv Bal control R260 to center the trace on the graticule.

3) Pull the Channel 2 INVERT switch and note the resultant trace shift.

## Calibration—Type 10A2A



Fig. 6-4. Location of channel 1 VAR BAL control, R122 and channel 2 VAR BAL control, R222.

4) Adjust the Inv Bal control R260 to move the trace from the point of maximum displacement halfway back to the center line. Repeat this procedure, operating the INVERT switch and reducing the trace shift with the Inv Bal control progressively until there is no visible trace shift as the INVERT switch is operated.

5) Push in the INVERT switch.

### NOTE

There is some interaction between the Inv Bal, VAR BAL and Base Current adjustments. If the operation of the INVERT control caused the trace to shift out of the graticule area originally, re-check the procedure from part d forward.

## 4. Adjust Channel 1 Common Mode Current, Main Amplifier Differential Balance, Main Amplifier Current and Channel 2 Common Mode Current

a. Steps 2 and 3 should be checked prior to starting this step.

b. Position the trace to the center graticule line with the Type 10A2A channel 2 POSITION control.

c. Connect a DC voltmeter between ground and TP453, see Fig. 6-3 (test point located at junction of R453 and R455).

d. CHECK—Voltmeter reading; if voltage is less than  $\pm 0.025$  volt no adjustment of Ch 2 Com Mode Current control, R250 is necessary.

e. ADJUST—Ch 2 Com Mode Current control, R250 (see Fig. 6-3) for a voltmeter reading of 0 volt. If the CH 2 Com Mode Current control, R250 can not adjust the voltage at TP453 to 0 volt, the Main Amp Current control, R430 (see Fig. 6-3) should also be adjusted.

f. Set the Type 10A2A MODE switch to ADD.

g. Position the trace to the center graticule line with the Type 10A2A channel 1 POSITION control.

h. CHECK—Voltmeter reading; if voltage is less than  $\pm 0.025$  volt no adjustment of Ch 1 Com Mode Current control, R150 is necessary.

i. ADJUST—Ch 1 Com Mode Current control, R150 (see Fig. 6-3) for a voltmeter reading of zero.

j. Set the Type 10A2A MODE switch to CH 1 and note the trace displacement from center graticule line.

k. CHECK—Voltmeter reading  $\pm 0.025$  V; if the meter reads less than  $\pm 0.025$  volt no adjustment of Main Amp Current control, R336 is necessary.

l. ADJUST—Main Amp Current, R336 (see Fig. 6-3) for a voltmeter reading of zero.

m. CHECK—Trace Displacement (noted in part j). If less than 2 mm of trace displacement is observed, no adjustment of Main Amp Diff Bal control, R335 is necessary.

n. ADJUST—Main Amp Diff Bal control, R335 (see Fig. 6-3) to return the trace to the center graticule line.

o. Set the Type 10A2A MODE switch to CH 2.

p. Position the trace to the center graticule line with the Channel 2 POSITION control.

q. CHECK—Voltmeter reading; if voltage is less than 0.025 volt no adjustment of Ch 2 Com Mode Current control, R250 is necessary.

r. ADJUST—Ch 2 Com Mode Current, R250 (see Fig. 6-3) for a voltmeter reading of zero.

s. Rotate the Type 10A2A MODE switch to CH 1, then CH 2, and finally to ADD.

t. CHECK—Trace displacement and voltmeter reading; the trace displacement from the center graticule line must not be greater than  $\pm 2$  mm, while the voltmeter reading must remain within  $\pm 0.025$  volt of zero volt.

u. Disconnect the DC voltmeter.

**5. Adjust Channel 1 Grid Current Zero ⓘ**

- a. Step 2 should be checked prior to starting this step.
- b. Set the Type 10A2A MODE switch to CH 1.
- c. Position the trace to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.
- d. Switch the channel 1 input coupling switch between its GND and DC positions.
- e. CHECK—Trace movement; there should be no trace movement.
- f. ADJUST—Ch 1 Grid Current Zero control, R117 (see Fig. 6-3) for no trace movement as part d of this step is being accomplished.

**6. Adjust Channel 2 Grid Current Zero ⓘ**

- a. Step 3 should be checked prior to starting this step.
- b. Set the Type 10A2A MODE switch to CH 2.
- c. Position the trace to the center horizontal graticule line with the Channel 2 POSITION control.
- d. Switch the channel 2 input coupling switch between its GND and DC positions.
- e. CHECK—Trace movement; there should be no trace movement.
- f. ADJUST—Ch 2 Grid Current Zero control, R217 (see Fig. 6-3) for no trace movement as part d of this step is being accomplished.

**NOTES**

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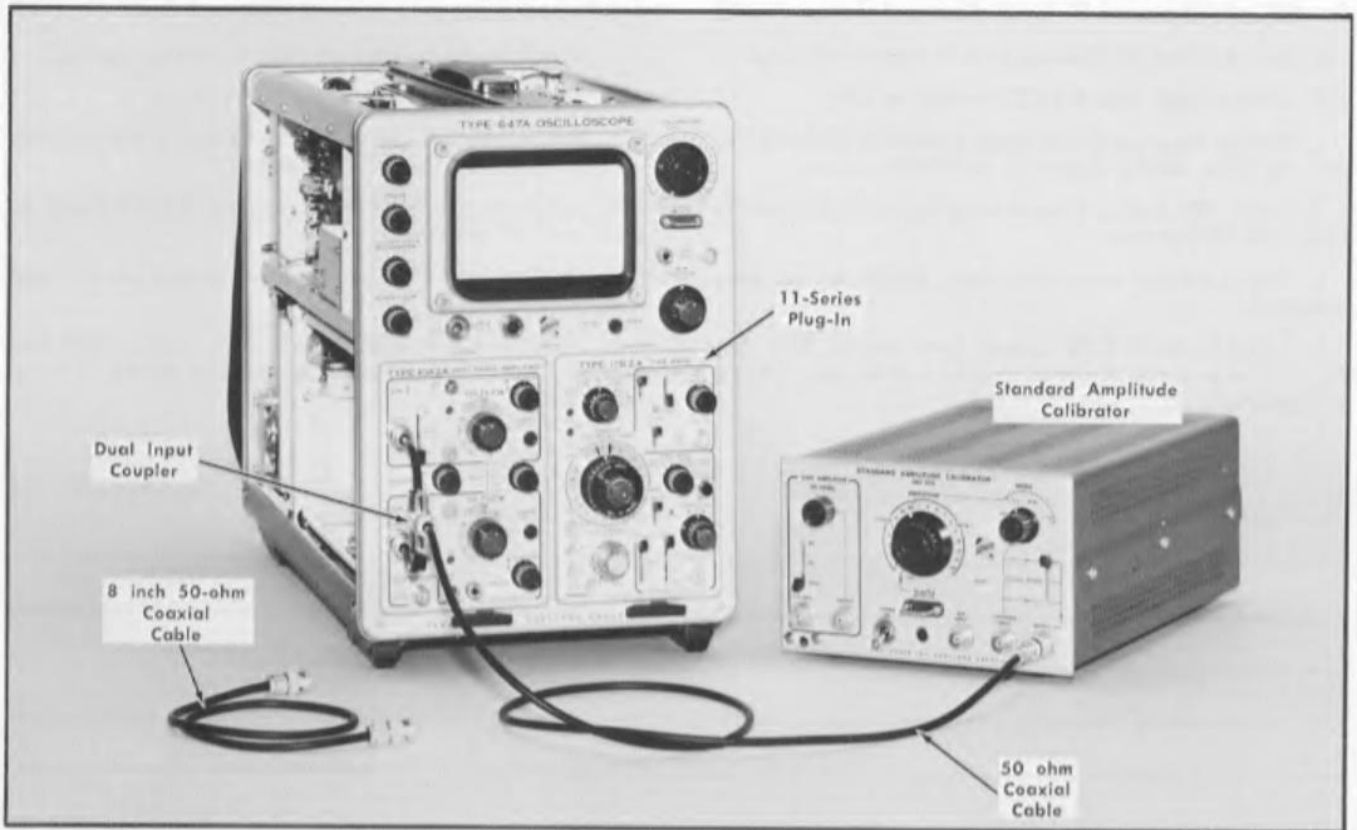


Fig. 6-5. Initial test equipment setup for steps 7 through 18.

Type 10A2A	
VOLTS/CM (both channels)	.01
VARIABLE (VOLTS/CM) (both channels)	CAL
POSITION (both channels)	Midrange
<b>Input Coupling (both channels)</b>	<b>DC</b>
INVERT (both channels)	Pushed in
GAIN (both channels)	180° counterclockwise from its fully clockwise position
VAR BAL (both channels)	As is
TRIGGER	NORM
<b>MODE</b>	<b>CH 1</b>

Type 647A	
Intensity	Usable display brightness
Focus	Well defined display
Astigmatism	Well defined display
Scale Illum	As desired
Calibrator	Off
Position	Midrange
Fine (Position)	Midrange

11-Series	
Time/Cm	1 ms
Magnification	1 time
Trigger Mode	Auto
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

## 7. Adjust Channel 1 Gain

- a. Step 2 and 4 should be checked before starting this step.
- b. Test equipment setup is shown in Fig. 6-5.
- c. Connect the dual input coupler to the Type 10A2A channel 1 and 2 INPUT connectors.
- d. Connect a 50 ohm coaxial cable from a standard amplitude calibrator output connector to the dual input coupler.
- e. Set the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 50 mV.
- f. Rotate the Type 10A2A channel 1 front-panel GAIN control (see Fig. 6-7) from one extreme to the other.

- g. CHECK—Operation; control should vary display amplitude and operate smoothly.
- h. Set the 10A2A channel 1 GAIN control 180° counterclockwise from its fully clockwise position.
- i. CHECK—Display amplitude; exactly 5 cm.
- j. ADJUST—Ch 1 Gain Range control, R176 (see Fig. 6-6) for a display exactly 5 cm high.

**NOTE**

If the Ch 1 Gain Range control, R176 will not permit the display height to be adjusted to 5 cm, but does adjust to either 4.6 cm or 5.2 cm, it is permissible to use the front-panel GAIN control, R138 for the remainder of the 5 cm adjustment.

**8. Adjust Channel 2 Gain**

- a. Steps 3 and 4 should be checked before starting this step.
- b. Set the Type 10A2A MODE switch to CH 2.
- c. Rotate the Type 10A2A channel 2 front-panel GAIN control (see Fig. 6-7) from one extreme to the other.
- d. CHECK—Operation; control should vary display amplitude and operate smoothly.
- e. Set the Type 10A2A channel 2 GAIN control 180° counterclockwise from its fully clockwise position.
- f. CHECK—Display amplitude; exactly 5 cm.
- g. ADJUST—Ch 2 Gain Range control, R276 (see Fig. 6-6) for a display exactly 5 cm high.

**NOTE**

If the Ch 2 Gain Range control, R276 will not permit the display height to be adjusted to 5 cm, but does adjust to either 4.6 cm or 5.2 cm, it is permissible to use the front-panel GAIN control, R138 for the remainder of the 5 cm adjustment.

- h. Set the Type 10A2A MODE switch to ADD and pull out the channel 2 INVERT switch.
- i. CHECK—Display; should be only a trace, i.e., complete signal cancellation.
- j. ADJUST—Ch 2 Gain Range control, R276 (see Fig. 6-6) until the display consists of only a single trace, i.e., the channel 1 and 2 signals have completely cancelled each other.

**9. Check Algebraic Add Operation**

- a. Steps 7 and 8 should be checked prior to starting this step.
- b. Change the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 20 mV.
- c. Push in the Type 10A2A Channel 1 INVERT switch.
- d. CHECK—Display amplitude; 4 cm,  $\pm 1$  mm.

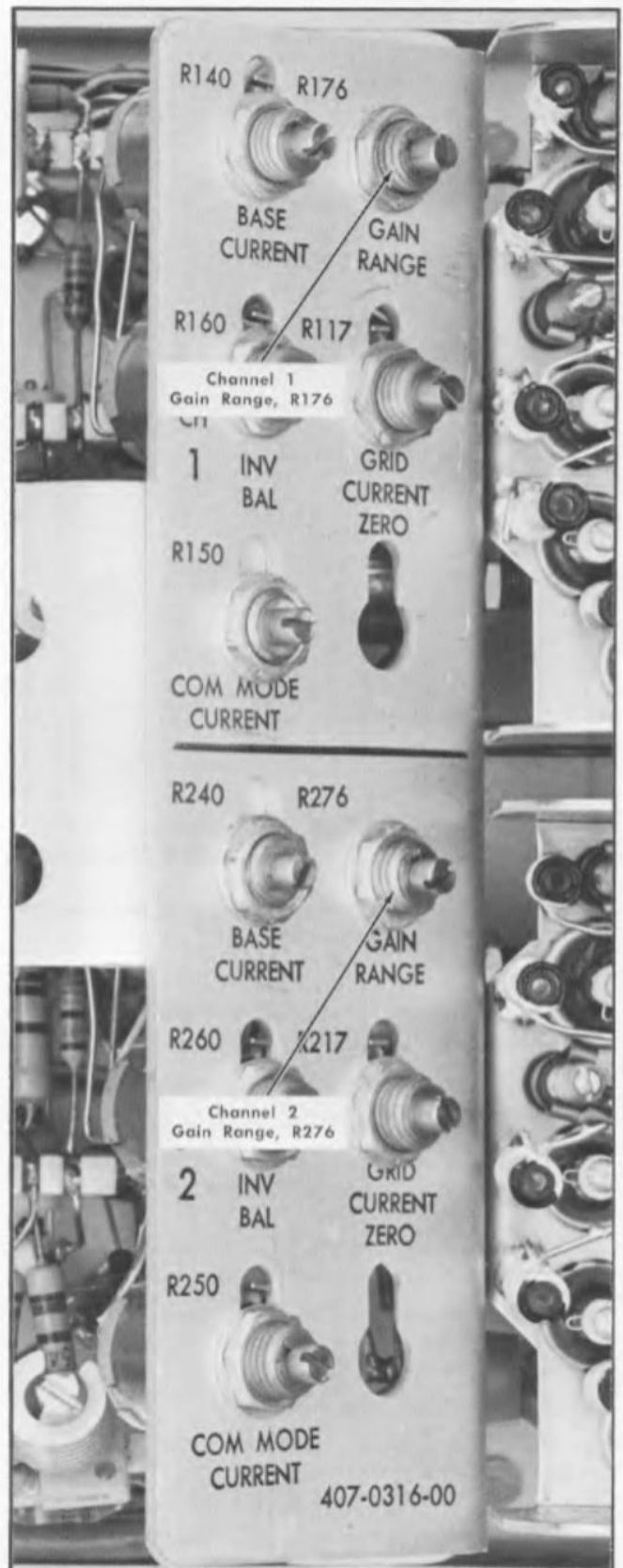


Fig. 6-6. Location of channel 1 Gain Range control, R176 and channel 2 Gain Range control, R276.



Fig. 6-7. Location of channel 1 GAIN control, R138 and channel 2 GAIN control, R238.

### 10. Check Channel 1 Variable Volts/Cm Operation

- a. Step 7 should be checked before starting this step.
- b. Set the Type 10A2A MODE switch to CH 1.
- c. Change the standard amplitude calibrator control to produce an output square-wave having an amplitude of 50 mV.
- d. Rotate the Type 10A2A channel 1 VARIABLE (VOLTS/CM) control to its fully counterclockwise position.
- e. CHECK—Display amplitude and operation; display amplitude must be 2 cm or less and the control should smoothly vary the amplitude.
- f. CHECK—UNCAL neon; should be lit.
- g. Set the Type 10A2A channel 1 VARIABLE (VOLTS/CM) control to its CAL position.

### 11. Check Channel 2 Variable Volts/Cm Operation

- a. Step 8 should be checked prior to starting this step.

- b. Set the Type 10A2A MODE switch to CH 2.
- c. Rotate the Type 10A2A channel 2 VARIABLE (VOLTS/CM) control to its fully counterclockwise position.
- d. CHECK—Display amplitude and operation; display amplitude must be 2 cm or less and the control should smoothly vary the amplitude.
- e. CHECK—UNCAL neon; should be lit.
- f. Set the Type 10A2A channel 2 VARIABLE (VOLTS/CM) control to its CAL position.

### 12. Check Channel 2 Input Coupling Switch

- a. Set the bottom of the square-wave display to the center horizontal graticule line with the Type 10A2A channel 2 POSITION control.
- b. Set the Type 10A2A channel 2 Input Coupling switch to AC.
- c. CHECK—Display position; center of 5 cm square-wave display should shift down and become centered about the center graticule line.
- d. Set the Type 10A2A channel 2 Input Coupling switch to GND and note the trace position.
- e. Change the standard amplitude calibrator controls to produce a +100 volt DC output signal.
- f. Set the Type 10A2A channel 2 Input Coupling switch to AC.
- g. CHECK—Trace shift; should not shift more than 5 mm; if it does, the input coupling capacitor has too much leakage or the capacitor precharge circuit is not working.
- h. Set the Type 10A2A channel 2 Input Coupling switch to DC.
- i. Change the standard amplitude calibrator controls to produce an output square-wave signal having an amplitude of 50 mV.

### 13. Check Channel 1 Input Coupling Switch

- a. Set the Type 10A2A MODE switch to CH 1.
- b. Set the bottom of the square-wave display to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.
- c. Set the Type 10A2A channel 1 Input Coupling switch to AC.
- d. CHECK—Display position; center of 5 cm square-wave display should shift down and become centered about the center horizontal graticule line.
- e. Set the Type 10A2A channel 1 Input Coupling switch to GND and note the trace position.



f. Change the standard amplitude calibrator controls to produce a +100 volt DC output signal.

g. Set the Type 10A2A channel 1 Input Coupling switch to AC.

h. CHECK—Trace shift; should not shift more than 5 mm. If it does, the input coupling capacitor has too much leakage or the capacitor precharge circuit is not working.

i. Disconnect the standard amplitude calibrator, the dual input coupler and the 50 ohm coaxial cable.

#### 14. Adjust Channel 2 Output DC Level ①

a. Steps 3 and 4 should be checked prior to starting this step.

b. Change the following Type 10A2A control settings:

VOLTS/CM (channel 1)	.05
Input Coupling (channel 1)	DC
MODE	CH 1

c. Position the trace to the center horizontal graticule line with the Type 10A2A channel 1 POSITION control.

d. Connect a 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the Type 10A2A CH 1 INPUT connector.

e. CHECK—Trace position; must not move more than 4 mm from the trace position established in part c of this step.

f. ADJUST—Ch 2 Out DC Level control, R530 (see Fig. 6-3) to again position the trace to the center horizontal graticule line.

g. Set the Type 10A2A TRIGGER switch to CH 2 ONLY.

h. CHECK—Trace position; within 2 cm of trace position established in part c of this step.

i. Disconnect the 50 ohm coaxial cable.

#### 15. Check Channel 2 Front-Panel Output Gain

a. Steps 7, 8 and 14 should be checked prior to starting this step.

b. Set the Type 10A2A channel 1 Input Coupling switch to AC and the VOLTS/CM switch to .01.

c. Connect a 5 mV square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the Type 10A2A channel 2 INPUT connector.

d. Connect an 8 inch 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the channel 1 connector of the Type 10A2A.

e. Set the 11-series plug-in trigger level control for a stable display.

f. CHECK—Displayed signal amplitude; equal to or greater than 5 centimeters, i.e., equal to or greater than 100

mV of CH 2 OUTPUT signal per centimeter of channel 2 vertical signal deflection.

g. Disconnect the standard amplitude calibrator and both 50 ohm coaxial cables.

#### 16. Adjust Normal Trigger DC Balance and Check Channel 2 Only Balance ①

a. Steps 2, 3, 4 and 12 should be checked before starting this step.

b. Change the following Type 10A2A controls:

Input Coupling (channel 1)	DC
Input Coupling (channel 2)	AC
TRIGGER	NORM
MODE	CH 2

c. Position the trace to the center graticule line with the Type 10A2A channel 2 POSITION control.

d. Connect a 20 mV square-wave signal from the standard amplitude calibrator through a 50 ohm coaxial cable to the Type 10A2A channel 2 INPUT connector.

e. Set the 11-series plug-in trigger level control for a stable display.

f. The display should now consist of a 2 mm high square-wave signal positioned about the center graticule line.

g. Set the 11-series trigger coupling switch to DC.

h. CHECK—Displayed signal; if display remains triggered no adjustment of the Norm Trig DC Bal control R546 is necessary.

i. ADJUST—Norm Trig DC Bal control R546 (see Fig. 6-3) until a stable display is again obtained.

j. Set the Type 10A2A TRIGGER switch to CH 2 ONLY and depress the Type 647A beam finder switch.

k. Increase the amplitude of the square-wave signal from the standard amplitude calibrator until a triggered display is observed.

l. CHECK—Signal amplitude; square-wave signal from standard amplitude calibrator should not be greater than 0.1 volt peak to peak.

m. Disconnect the standard amplitude calibrator and the 50 ohm coaxial cable.

#### 17. Check Channel 1 Attenuator Accuracy

a. Step 7 should be checked prior to starting this step.

b. Set the 11-series trigger coupling switch to AC.

c. Set the Type 10A2A channel 1 Input Coupling switch to DC and the TRIGGER switch to NORM and the MODE switch to CH 1.

d. Connect the dual input coupler to the Type 10A2A channel 1 and 2 INPUT connectors.

**Calibration—Type 10A2A**

- e. Connect a 50 ohm coaxial cable from a standard amplitude calibrator output connector to the dual input coupler.
- f. Set the standard amplitude calibrator output square-wave signal to the appropriate amplitude as listed in Table 6-1.

- g. Set the 10A2A channel 1 VOLTS/CM switch to the appropriate position listed in Table 6-1.
- h. CHECK—Deflection; see Table 6-1 for correct deflection and tolerance.

**TABLE 6-1**  
Attenuator Accuracy Check

Square-Wave Signal Amplitude Peak to Peak	Type 10A2A VOLTS/CM Switch	Deflection and Tolerance
0.1 V	.02	5 cm, $\pm 1$ mm
0.2 V	.05	4 cm, $\pm 0.8$ mm
0.5 V	.1	5 cm, $\pm 1$ mm
1 V	.2	5 cm, $\pm 1$ mm
2 V	.5	4 cm, $\pm 0.8$ mm
5 V	1	5 cm, $\pm 1$ mm
10 V	2	5 cm, $\pm 1$ mm
20 V	5	4 cm, $\pm 0.8$ mm
50 V	10	5 cm, $\pm 1$ mm
100 V	20	5 cm, $\pm 1$ mm

**18. Check Channel 2 Attenuator Accuracy**

- a. Step 8 should be checked prior to starting this step.
- b. Set the Type 10A2A MODE switch to CH 2.
- c. Set the standard amplitude calibrator output square-wave signal to the appropriate amplitude as listed in Table 6-1.
- d. Set the Type 10A2A channel 2 VOLTS/CM switch to the appropriate position listed in Table 6-1.
- e. CHECK—Deflection; see Table 6-1 for correct deflection and tolerance.
- f. Disconnect the dual input coupler, the 50 ohm coaxial cable and the standard amplitude calibrator.

**NOTES**

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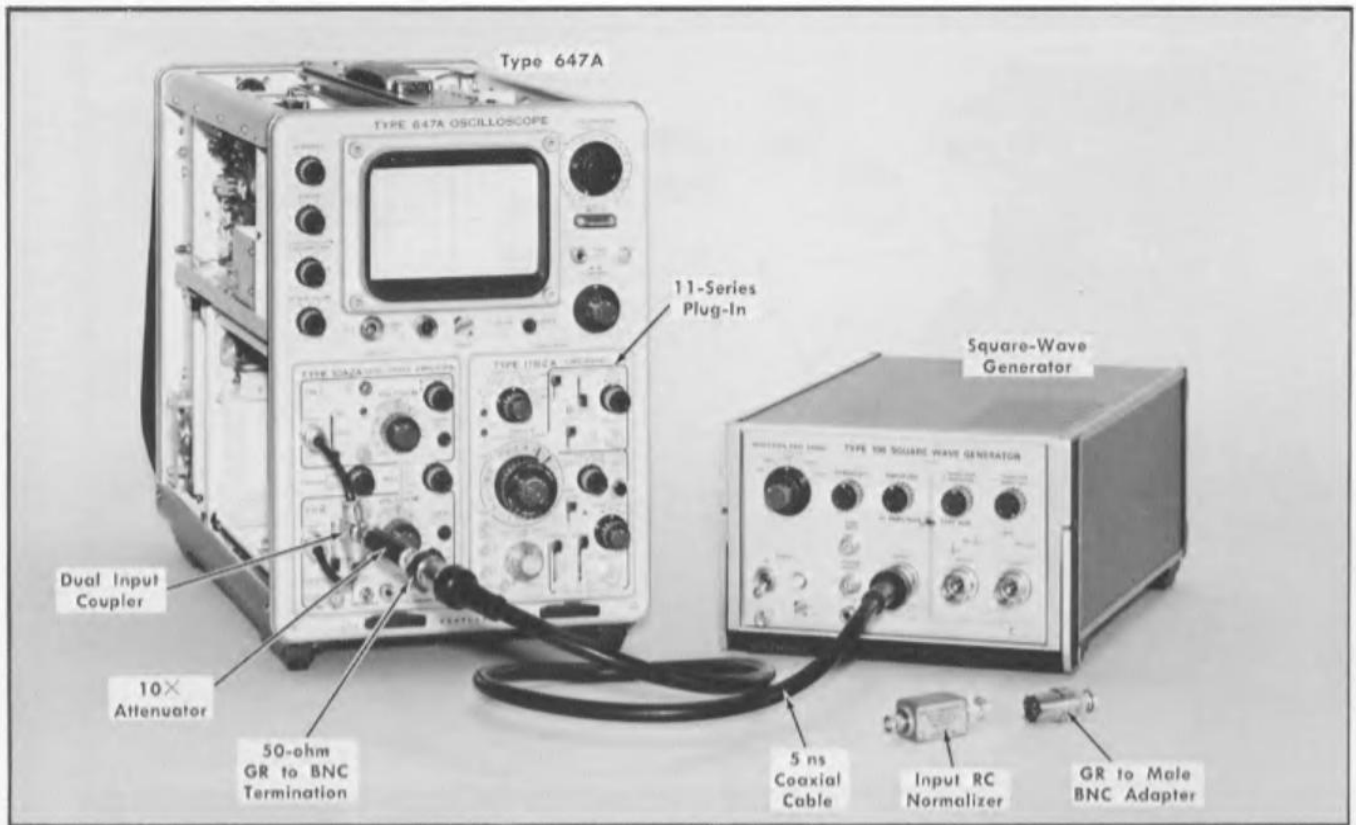


Fig. 6-8. Initial test equipment setup for steps 19 through 24.

Type 10A2A	
VOLTS/CM (both channels)	.02
VARIABLE (VOLTS/CM) (both channels)	CAL
POSITION (both channels)	Midrange
Input Coupling (both channels)	DC
INVERT (both channels)	Pushed in
GAIN (both channels)	As is
VAR BAL (both channels)	As is
TRIGGER MODE	NORM CH 1

Type 647A	
Intensity	Usable display brightness
Focus	Well defined display
Astigmatism	Well defined display
Scale Illum	As desired
Calibrator	Off
Position	Midrange
Fine (Position)	Midrange

11-Series	
Time/Cm	.1 ms
Trigger Mode	Norm

Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

### 19. Adjust Channel 1 Attenuator Series Compensations ①

- a. Step 17 should be checked prior to starting this step.
- b. Test equipment setup is shown in Fig. 6-8.
- c. Connect a dual input coupler to the Type 10A2A channel 1 and 2 INPUT connectors.
- d. Connect a 5 ns coaxial cable to the output connector of a square-wave generator.
- e. Connect a 50 ohm GR to BNC termination and a 10× attenuator to the 5 ns coaxial cable.
- f. Connect the unconnected end of the 10× attenuator to the dual input coupler.
- g. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 5 kHz.
- h. Adjust the 11-series plug-in trigger level control for a stable display.

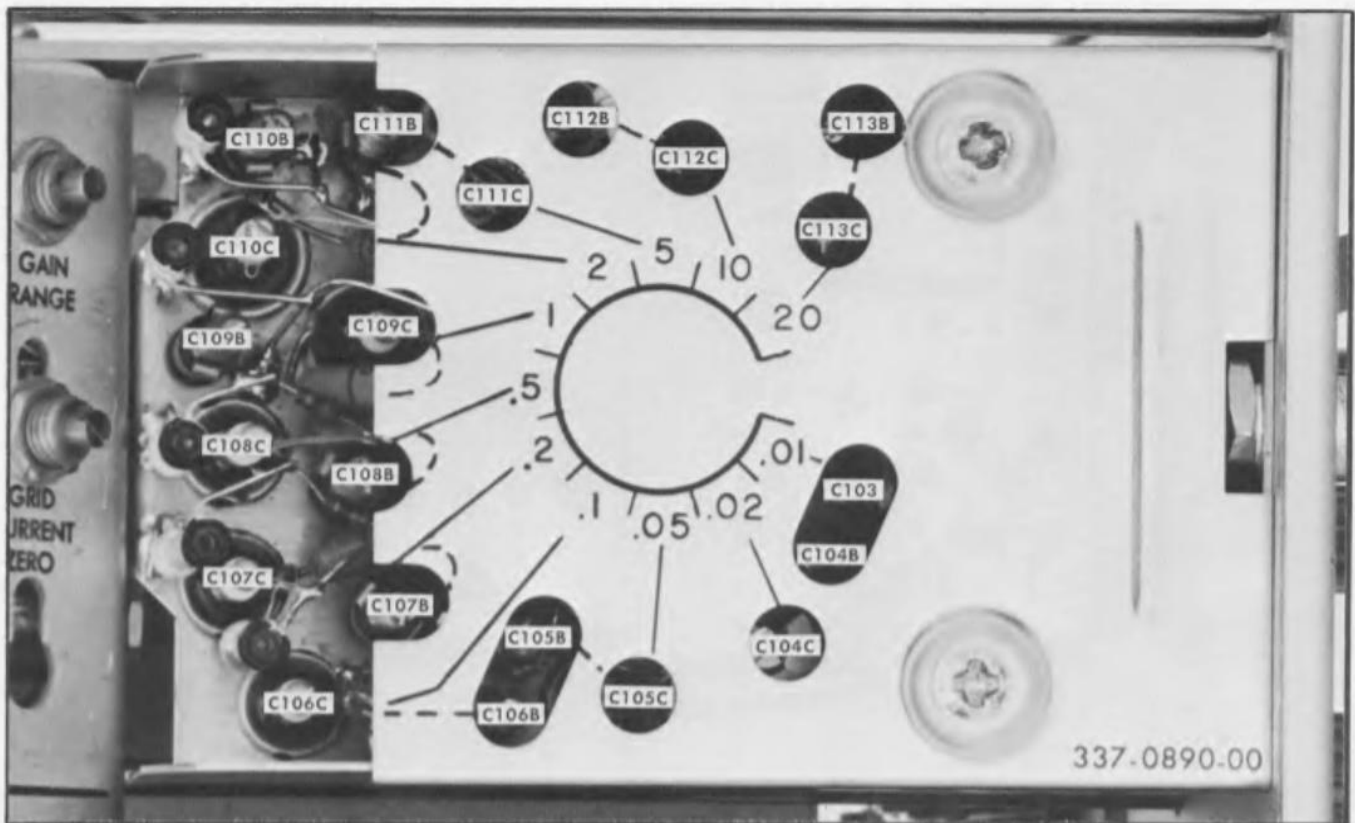


Fig. 6-9. Channel 1 attenuator input time constant adjustments.

- i. CHECK—Waveform; should have less than 1% of overshoot, rounding and tilt.
- j. ADJUST—Refer to the appropriate column in Table 6-2 and Fig. 6-9 for the component to be adjusted for an optimum square cornered square-wave having less than 1% of overshoot, rounding, and tilt.
- k. Repeat parts g through j of this step for each Type 10A2A VOLTS/CM switch setting listed in Table 6-2.

**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 series 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 not attenuator is used.

**20. Adjust Channel 2 Attenuator Series Compensations**

- a. Step 18 should be checked prior to starting this step.
- b. Set the Type 10A2A MODE switch to CH 2.
- c. Remove the GR to male BNC adapter from the 5 ns coaxial cable and reconnect the 50 ohm GR to BNC termination and the 10X attenuator.
- d. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 5 kHz.

- e. Adjust the 11-series plug-in trigger level control for a stable display.

**TABLE 6-2**  
Attenuator Adjustments

Type 10A2A VOLTS/CM Switch	Component to Adjust for Series Compensation	Component to Adjust for Input Time Constant
.01		C103
.02	C104E	C104B
.05	C105D	C105B
.1	C106C	C106B
.2 <sup>b</sup>	C107D	C107B
.5	C108C	C108B
1	C109C	C109B
2 <sup>a</sup>	C110C	C110B
5	C111C	C111B
10	C112C	C112B
20	C113C	C113B

<sup>a</sup>Remove the 10X attenuator.

<sup>b</sup>Remove the 50 ohm GR to BNC termination and substitute a GR to male BNC adapter in its place.

- f. CHECK—Waveform; should have less than 1% of overshoot, rounding and tilt.
- g. ADJUST—Refer to the appropriate column in Table 6-3 and Fig. 6-10 for the components to be adjusted for an optimum square cornered square-wave having less than 1% of overshoot, rounding and tilt.

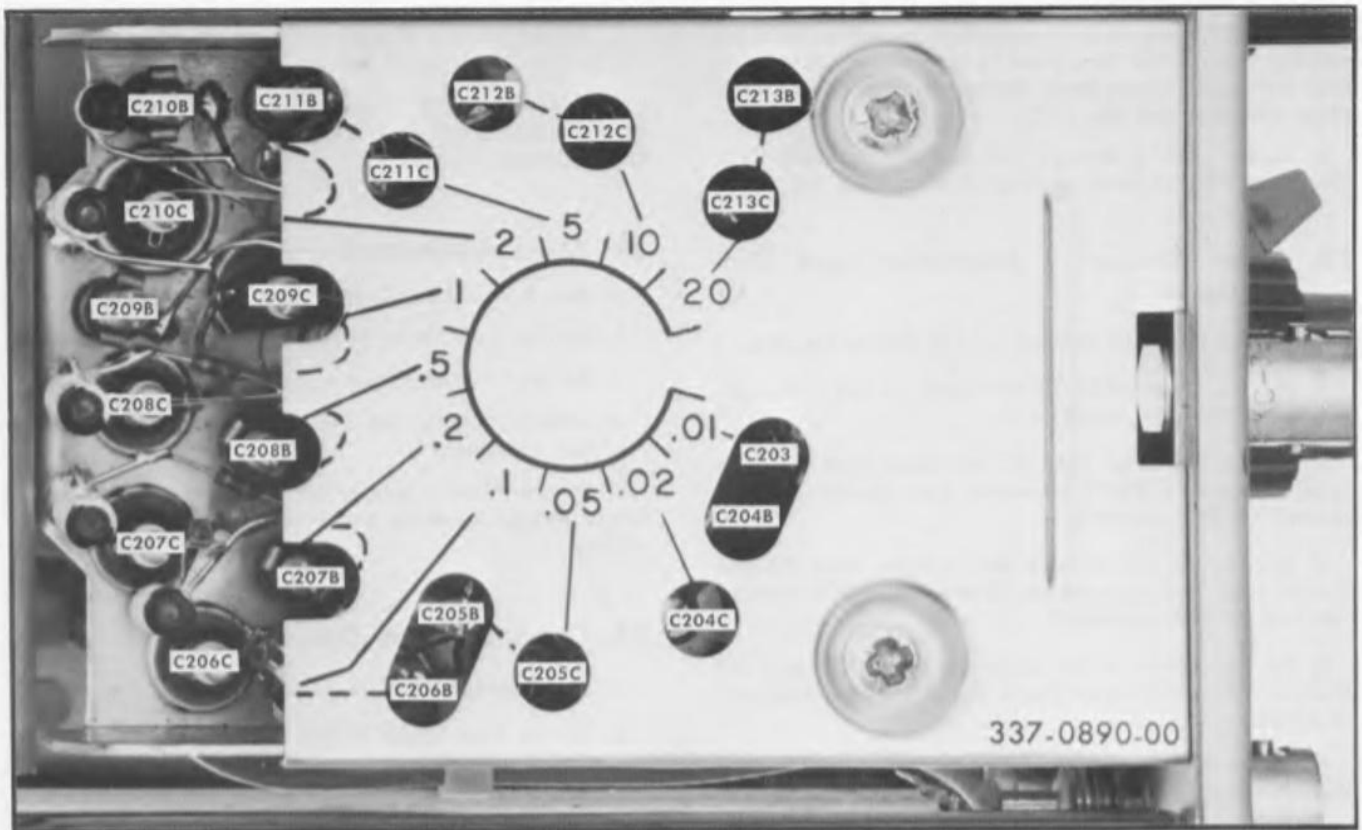


Fig. 6-10. Channel 2 attenuator input time constant adjustments.

h. Repeat parts d through g of this step for each Type 10A2A VOLTS/CM switch setting listed in Table 6-3.

i. Disconnect the 5 ns coaxial cable, the GR to BNC adapter, and the dual input coupler.

**TABLE 6-3**  
Attenuator Adjustments

Type 10A2A VOLTS/CM Switch	Component to Adjust for Series Compensation	Component to Adjust for Input Time Constant
.01		C203
.02	C204E	C204B
.05	C205D	C205B
.1	C206C	C206B
.2 <sup>†</sup>	C207D	C207B
.5	C208C	C208B
1	C209C	C209B
2 <sup>‡</sup>	C210C	C210B
5	C211C	C211B
10	C212C	C212B
20	C213C	C213B

<sup>†</sup>Remove the 10× attenuator.

<sup>‡</sup>Remove the 50 ohm GR to BNC termination and substitute a GR to BNC adapter in its place.

**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 series 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.

**21. Adjust Channel 2 Attenuator Input Time Constants**

- Step 20 should be checked prior to starting this step.
- Connect a 20 pF input RC normalizer to the Type 10A2A channel 2 INPUT connector.
- Set the Type 10A2A channel 2 VOLTS/CM switch to .01 and the 11-series time/cm to .5 ns.
- Connect a 5 ns coaxial cable to the output connector of a square-wave generator.
- To the 5 ns coaxial cable connect a 50 ohm GR to BNC termination and a 10× attenuator.
- Connect the unconnected end of the 10× attenuator to the 20 pF input RC normalizer.
- Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 2.5 kHz.
- Adjust the 11-series plug-in trigger level control for a stable display.
- CHECK—Waveform; should have less than 1% of overshoot, rounding and tilt.

**Calibration—Type 10A2A**

j. ADJUST—Refer to the appropriate column in Table 6-3 and Fig. 6-10 for the component to be adjusted for an optimum flat-topped square-wave having less than 1 % of overshoot, rounding and tilt.

k. Repeat parts g through j of this step for each Type 10A2A VOLTS/CM switch setting listed in Table 6-3.

**22. Adjust Channel 1 Attenuator Input Time Constants** ①

a. Step 19 should be checked prior to starting this step.

b. Set the Type 10A2A MODE switch to CH 1 and the channel 1 VOLT/CM switch to .01.

c. Remove the 20 pF input RC normalizer from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.

d. Remove the GR to male BNC adapter from the 5 ns coaxial cable and reconnect the 50 ohm GR to BNC termination and the 10X attenuator.

e. Set the controls of the square-wave generator so it will produce a 5 cm high square-wave signal having a frequency of 2.5 kHz.

f. Adjust the 11-series plug-in trigger level control for a stable display.

g. CHECK—Waveform; should have less than 1% of overshoot, rounding and tilt.

h. ADJUST—Refer to the appropriate columns in Table 6-2 and Fig. 6-9 for the components to be adjusted for an optimum flat topped square-wave having less than 1% of overshoot, rounding and tilt.

i. Repeat parts e through h of this step for each Type 10A2A VOLTS/CM switch setting listed in Table 6-2.

j. Disconnect the square-wave generator, the 5 ns coaxial cable, GR to male BNC adapter and the 20 pF input RC normalizer.

**23. Check Alternate Trace Operation**

a. Step 4 should be checked prior to starting this step.

b. Set the Type 10A2A MODE switch to ALT.

c. Set the 11-series plug-in trigger mode switch to free run.

d. CHECK—Display; one channel should be displayed then the other alternately.

e. Set the 11-series plug-in time/cm switch to several different settings, repeating part d of this step for each switch setting.

**24. Check Chopped Operation**

a. Step 4 should be checked prior to starting this step.

b. Set the Type 10A2A MODE switch to CHOP.

c. Set the 11-series plug-in trigger mode switch to auto and the time/cm switch to 0.2 μs.

d. Adjust the 11-series plug-in trigger level control for a stable display.

e. CHECK—Display repetition rate; 1 MHz, ±1 kHz.

f. CHECK—Vertical display transients; vertical display transients should be blanked out during the switching interval.

**NOTES**

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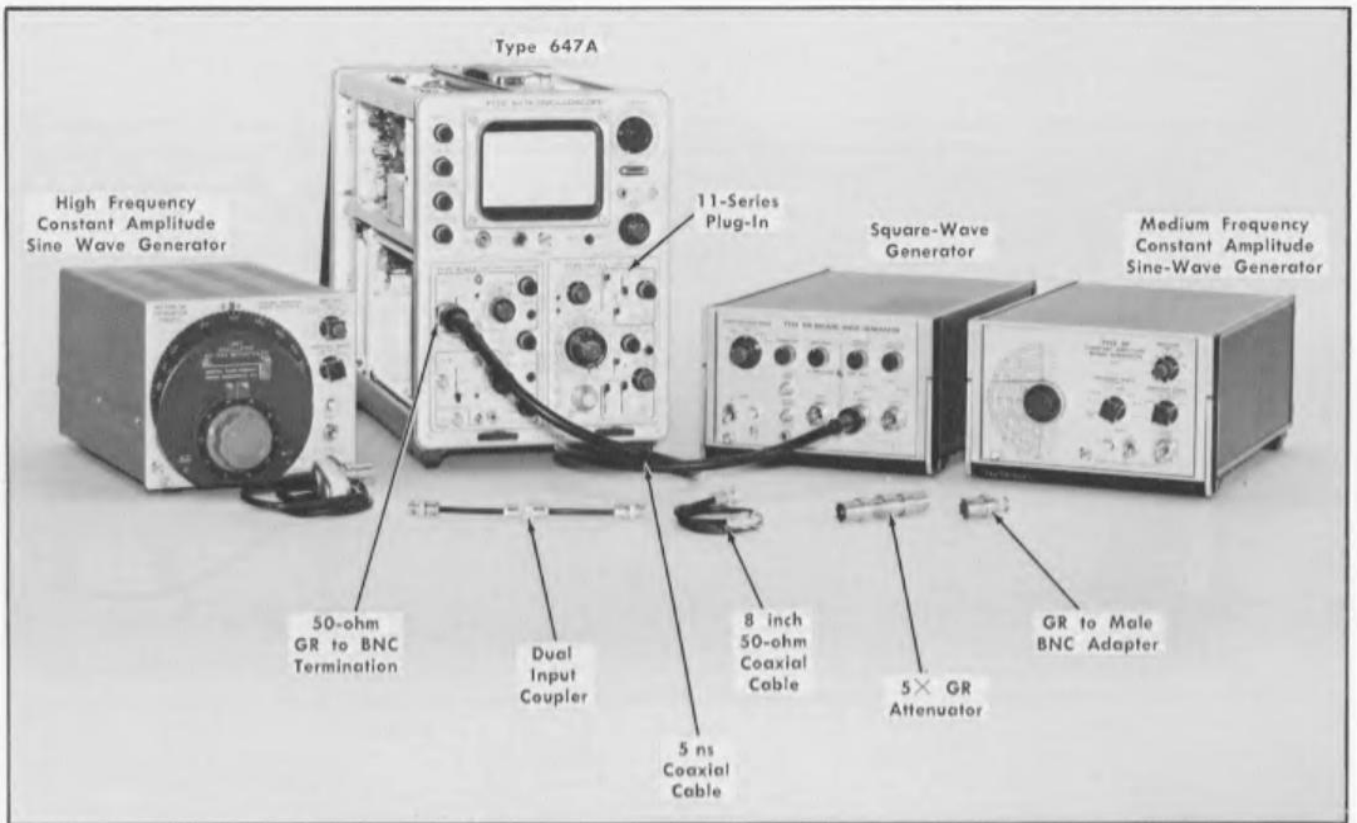


Fig. 6-11. Initial test equipment setup for steps 25 through 30.

Type 10A2A	
VOLTS/CM (both channels)	.01
VARIABLE (VOLTS/CM) (both channels)	CAL
POSITION (both channels)	Midrange
INPUT COUPLING (both channels)	DC
INVERT (both channels)	Pushed in
VAR BAL (both channels)	As is
TRIGGER	NORM
<b>Mode</b>	<b>CH 1</b>

Type 647A	
Intensity	Usable display brightness
Focus	Well defined display
Astigmatism	Well defined display
Scale Illum	As desired
Calibrator	Off
Position	Midrange
Fine (Position)	Midrange

11-Series	
Time/cm	.2 $\mu$ S
<b>Magnification</b>	<b>10 times</b>

Triggerd Mode	Norm
Trigger Slope	+
Trigger Coupling	AC
Trigger Source	Int

### 25. Adjust High Frequency Transient Response ①

- a. Steps 2, 3, 4, 7 and 8 should be checked prior to starting this step.
- b. Test equipment setup is shown in Fig. 6-11.
- c. Connect the fast rise positive transition output of the square-wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 1 INPUT connector.
- d. Set the square-wave generator output signal frequency to 400 kHz and adjust its output amplitude control to obtain a 4 cm display.
- e. Adjust the 11-series plug-in trigger level control for a stable display.
- f. CHECK—Displayed waveform; less than 4% of overshoot, rounding, tilt, or peak-to-peak ringing.

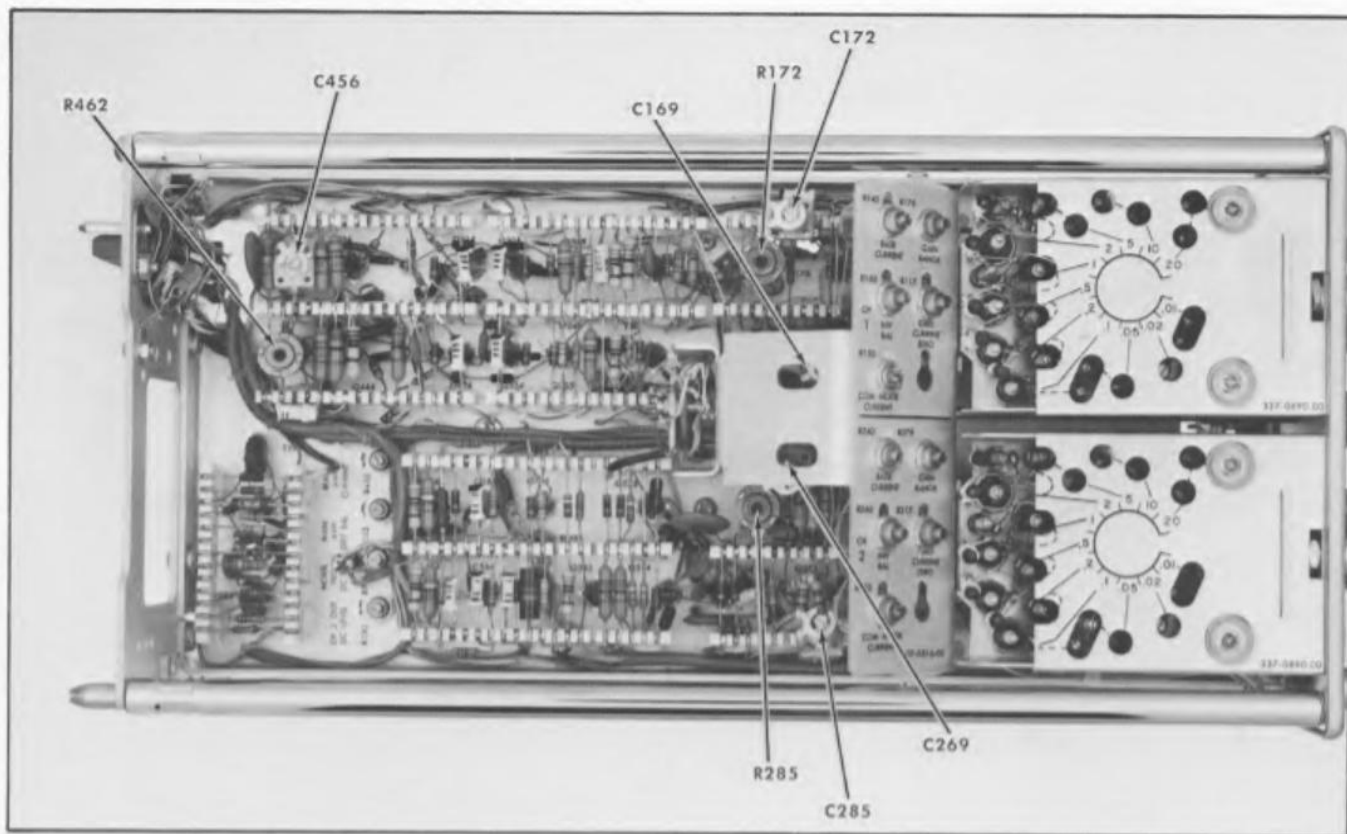


Fig. 6-12. Location of C169, C172, C269, C285, C456, R172, R285 and R462.

g. ADJUST—C169, C172, C456, R172 and R462 (see Fig. 6-12) for less than 4% overshoot, rounding, tilt, or peak-to-peak ringing on the waveform; see Fig. 6-13.

h. Set the 11-series magnification control to 1 time and repeat parts f and g of this step.

i. Set the Type 10A2A MODE switch to CH 2.

j. Reset the 11-series magnification control to 10 times.

k. Remove the properly terminated square-wave generator output from the Type 10A2A channel 1 INPUT connector and connect it to channel 2 INPUT connector.

l. CHECK—Displayed waveform; less than 4% of overshoot, rounding, tilt, or peak-to-peak ringing.

m. ADJUST—C269, C285 and R285 (see Fig. 6-12) for less than 4% overshoot, rounding, tilt, or peak-to-peak ringing on the waveform; see Fig. 6-13. If necessary, C456 and R462 (output amplifier compensations) may be readjusted so channel 2 will make the 4% performance requirement.

n. Set the 11-series magnification control to 1 time and repeat parts l and m of this step.

o. Reset the 11-series magnification control to 10 times.

p. Repeat parts c through o of this step until both channel 1 and 2 waveforms are within the 4% performance requirement.

q. Disconnect the square-wave generator.

### 26A. Check Overall Bandwidth

a. Step 25 should be checked prior to starting this step.

b. Connect the output of the high frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.

c. Set the 11-series plug-in trigger mode switch to auto and the magnification switch to 1 time.

d. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).

e. Adjust the output amplitude control of the high frequency generator until exactly 4 cm of display are obtained on the CRT of the Type 647A.

f. Change the high frequency generator output frequency switch to its variable frequency position.

g. Increase the output frequency of the high frequency generator until the display amplitude drops to 2.8 cm.

h. CHECK—Generator output frequency; should be at least 100 MHz; in other words, -3 dB bandwidth is at least 108 MHz.

#### NOTE

If unable to achieve the minimum bandwidth, readjust C169 to achieve the minimum bandwidth, then recheck step 25 before proceeding.

i. Disconnect the high frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.



- j. Change the Type 10A2A MODE switch to CH 1.
- k. Set the high frequency generator output frequency switch to its fixed frequency (3 MHz).
- l. Adjust the output amplitude control of the high frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.
- m. Change the high frequency generator output frequency switch to its variable frequency position.
- n. Increase the output of the high frequency generator until the display amplitude drops to 2.8 cm.
- o. CHECK—Generator output frequency; should be at least 100 MHz; in other words,  $-3$  dB bandwidth is at least 108 MHz.

**NOTE**

If unable to achieve the minimum bandwidth, readjust C269 to achieve the minimum bandwidth, then recheck step 25 before proceeding.

- p. Disconnect the high frequency generator.

**26B. Check Overall Bandwidth**

(Alternate method which will not insure performance, but can be used as a check).

- a. Step 25 should be checked prior to starting this step.
- b. Connect the output of the medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.
- c. Set the 11-series plug-in trigger mode switch to auto and the magnification switch to 1 time.
- d. Set the medium frequency generator output frequency switch to its fixed frequency (50 kHz).
- e. Adjust the output amplitude control of the medium frequency generator until exactly 4 cm of displays are obtained on the CRT of the Type 647A.
- f. Change the medium frequency generator output frequency switch to its variable frequency position.
- g. Increase the frequency dial of the medium frequency generator to 100 MHz.
- h. CHECK—Display amplitude; at least 2.8 cm of deflection must remain.
- i. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.
- j. Change the Type 10A2A MODE switch to CH 1.
- k. Set this medium frequency generator output frequency switch to its fixed frequency (50 kHz).
- l. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 4 cm in amplitude.
- m. Change the medium frequency generator output frequency switch to its variable frequency position.
- n. Increase the frequency dial of medium frequency generator to 100 MHz.

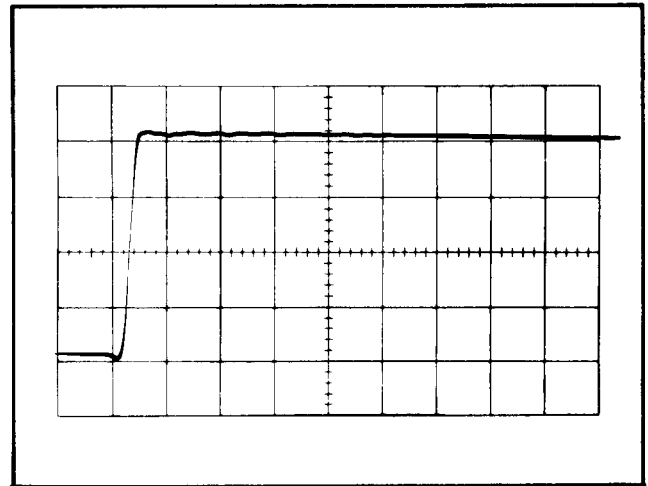


Fig. 6-13. Correctly compensated waveform.

- o. CHECK—Display amplitude; at least 2.8 cm of deflection must remain.
- p. Disconnect the medium frequency generator.

**27. Check Channel 1 and 2 Cascaded Bandwidth**

- a. Step 26 should be checked prior to starting this step.
- b. Connect the output of the medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a 50 ohm GR to BNC termination to the Type 10A2A channel 2 INPUT connector.
- c. Connect a short (approximately 8 inches) 50 ohm coaxial cable from the Type 10A2A CH 2 OUTPUT connector to the channel 1 INPUT connector.
- d. Set the medium frequency generator output frequency switch to its fixed frequency (50 kHz).
- e. Set the 11-series plug-in time/cm switch to 20  $\mu$ s.
- f. Adjust the output amplitude control of the medium frequency generator until display on the CRT of the Type 647A is exactly 4 cm in amplitude.
- g. Change the medium frequency generator output frequency switch to its variable frequency position.
- h. Increase the frequency of the medium frequency generator until the display amplitude drops to 2.8 cm.
- i. CHECK—Generator output frequency; should be at least 30 MHz; in other words,  $-3$  dB bandwidth is at least 30 MHz.
- j. Disconnect the medium frequency generator, the 5 ns coaxial cable and the 50 ohm GR to BNC termination.

**28. Check Common Mode Rejection Ratio**

- a. Steps 7, 8, 9, 25 and 26 should be checked prior to starting this step.

## Calibration—Type 10A2A

b. Connect the output of a medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable, a 5× GR attenuator and a 50 ohm GR to BNC termination to both the Type 10A2A channel 1 and 2 INPUT connectors using a dual input coupler.

c. Set the Type 10A2A channel 2 input coupling switch to GND.

d. Set the medium frequency generator for an output signal frequency of 50 MHz.

e. Set the Type 10A2A channel 1 VOLTS/CM switch to .02.

f. Adjust the output amplitude control of the medium frequency generator to produce exactly 5 cm of CRT deflection on the Type 647A.

g. Set Type 10A2A channel 1 VOLTS/CM switch to .01.

h. Change the Type 10A2A MODE switch to ADD, the channel 2 input coupling switch to DC and pull out the channel 2 INVERT switch.

i. CHECK—Display; 5 mm or less of display amplitude, indicating a 20:1 rejection ratio.

j. Disconnect the medium frequency generator, the 5 ns coaxial cable, the 5× GR attenuator, the 50 ohm GR to BNC termination and the dual input coupler.

## 29. Check Amplifier Inter-Channel Isolation

a. Steps 4, 7, 8 and 25 should be checked prior to starting this step.

b. Connect the output of the medium frequency constant amplitude sine wave generator to the Type 10A2A channel 1 INPUT connector.

c. Set the Type 10A2A MODE switch to CH 1, the channel 1 VOLTS/CM switch to .2 and push in the channel 2 INVERT switch.

d. Set the medium frequency generator for an output signal frequency of 25 MHz.

e. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.

f. Set the Type 10A2A MODE switch to CH 2 and the channel 1 VOLTS/CM switch to .01.

g. CHECK—Display amplitude; 5 mm or less.

h. Disconnect the medium frequency generator from the Type 10A2A channel 1 INPUT connector and connect it to the channel 2 INPUT connector.

i. Set the Type 10A2A MODE switch to CH 1.

j. CHECK—Display amplitude; 5 mm or less.

k. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector.

## 30. Check Attenuator Inter-Channel Isolation

a. Steps 4, 7, 8 and 25 should be checked prior to starting this step.

b. Connect the output of the unterminated medium frequency constant amplitude sine wave generator through a 5 ns coaxial cable and a GR to male BNC adapter to the Type 10A2A channel 2 INPUT connector.

c. Set the Type 10A2A MODE switch to CH 2, the channel 2 VOLTS/CM switch to 2.

d. Set the medium frequency generator output frequency switch to its variable frequency position.

e. Set the frequency dial of the medium frequency generator to 25 MHz.

f. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.

g. Change the Type 10A2A MODE switch to CH 1.

h. CHECK—Display amplitude; 1 mm or less of display amplitude, indicating 10,000:1 isolation ratio.

i. Disconnect the medium frequency generator from the Type 10A2A channel 2 INPUT connector and connect it to the channel 1 INPUT connector.

j. Set the Type 10A2A channel 2 VOLTS/CM switch to .01 and the channel 1 VOLTS/CM switch to 2.

k. The frequency dial of the medium frequency generator should be set to 25 MHz.

l. Adjust the output amplitude control of the medium frequency generator until the display on the CRT of the Type 647A is exactly 5 cm in amplitude.

m. Change the Type 10A2A MODE switch to CH 2.

n. CHECK—Display amplitude; 1 mm or less of display amplitude, indicating 10,000:1 isolation ratio.

o. Disconnect the medium frequency generator.

This completes the calibration of the Type 10A2A. Disconnect all test equipment and replace the left side panel on the Type 647A.

## ABBREVIATIONS AND SYMBOLS

A or amp	amperes	L	inductance
AC or ac	alternating current	$\lambda$	lambda—wavelength
AF	audio frequency	$\gg$	large compared with
$\alpha$	alpha—common-base current amplification factor	$<$	less than
AM	amplitude modulation	LF	low frequency
$\approx$	approximately equal to	lg	length or long
$\beta$	beta—common-emitter current amplification factor	LV	low voltage
BHB	binding head brass	M	mega or $10^6$
BHS	binding head steel	m	milli or $10^{-3}$
BNC	baby series "N" connector	M $\Omega$ or meg	megohm
X	by or times	$\mu$	micro or $10^{-6}$
C	carbon	mc	megacycle
C	capacitance	met.	metal
cap.	capacitor	MHz	megahertz
cer	ceramic	mm	millimeter
cm	centimeter	ms	millisecond
comp	composition	—	minus
conn	connector	mtg hdw	mounting hardware
$\sim$	cycle	n	nano or $10^{-9}$
c/s or cps	cycles per second	no. or #	number
CRT	cathode-ray tube	ns	nanosecond
csk	countersunk	OD	outside diameter
$\Delta$	increment	OHB	oval head brass
dB	decibel	OHS	oval head steel
dBm	decibel referred to one milliwatt	$\Omega$	ohm—ohms
DC or dc	direct current	$\omega$	omega—angular frequency
DE	double end	p	pico or $10^{-12}$
$^{\circ}$	degrees	/	per
$^{\circ}$ C	degrees Celsius (degrees centigrade)	%	percent
$^{\circ}$ F	degrees Fahrenheit	PHB	pan head brass
$^{\circ}$ K	degrees Kelvin	$\phi$	phi—phase angle
dia	diameter	$\pi$	pi—3.1416
$\div$	divide by	PHS	pan head steel
div	division	+	plus
EHF	extremely high frequency	$\pm$	plus or minus
elect.	electrolytic	PIV	peak inverse voltage
EMC	electrolytic, metal cased	plstc	plastic
EMI	electromagnetic interference (see RFI)	PMC	paper, metal cased
EMT	electrolytic, metal tubular	poly	polystyrene
$\epsilon$	epsilon—2.71828 or % of error	prec	precision
$\geq$	equal to or greater than	PT	paper, tubular
$\leq$	equal to or less than	PTM	paper or plastic, tubular, molded
ext	external	pwr	power
F or f	farad	Q	figure of merit
F & I	focus and intensity	RC	resistance capacitance
FHB	flat head brass	RF	radio frequency
FHS	flat head steel	RFI	radio frequency interference (see EMI)
Fil HB	fillister head brass	RHB	round head brass
Fil HS	fillister head steel	$\rho$	rho—resistivity
FM	frequency modulation	RHS	round head steel
ft	feet or foot	r/min or rpm	revolutions per minute
G	giga or $10^9$	RMS	root mean square
g	acceleration due to gravity	s or sec.	second
Ge	germanium	SE	single end
GHz	gigahertz	Si	silicon
GMV	guaranteed minimum value	SN or S/N	serial number
GR	General Radio	$\ll$	small compared with
$>$	greater than	T	tera or $10^{12}$
H or h	henry	TC	temperature compensated
h	height or high	TD	tunnel diode
hex.	hexagonal	THB	truss head brass
HF	high frequency	$\theta$	theta—angular phase displacement
HHB	hex head brass	thk	thick
HHS	hex head steel	THS	truss head steel
HSB	hex socket brass	tub.	tubular
HSS	hex socket steel	UHF	ultra high frequency
HV	high voltage	V	volt
Hz	hertz (cycles per second)	VAC	volts, alternating current
ID	inside diameter	var	variable
IF	intermediate frequency	VDC	volts, direct current
in.	inch or inches	VHF	very high frequency
incd	incandescent	VSWR	voltage standing wave ratio
$\infty$	infinity	W	watt
int	internal	w	wide or width
$\int$	integral	w/	with
k	kilohms or kilo ( $10^3$ )	w/o	without
k $\Omega$	kilohm	WW	wire-wound
kc	kilocycle	xmfr	transformer
kHz	kilohertz		



## PARTS ORDERING INFORMATION

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

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

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

## SPECIAL NOTES AND SYMBOLS

- ×000 Part first added at this serial number
- 00× Part removed after this serial number
- \*000-0000-00 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
- Use 000-0000-00 Part number indicated is direct replacement.
-  Screwdriver adjustment.
-  Control, adjustment or connector.

## SECTION 7 ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
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### Bulbs

B144	150-0030-00			Neon NE-2 V
B244	150-0030-00			Neon NE-2 V

### Capacitors

Tolerance  $\pm 20\%$  unless otherwise indicated.

C100	*285-0634-00			0.1 $\mu$ F	MT	600 V	10%
C101	281-0550-00			120 pF	Cer	500 V	10%
C102	281-0577-00			14 pF	Cer	500 V	5%
C103	281-0064-00			0.2-1.5 pF, Var	Tub.		
C104B	281-0064-00			0.2-1.5 pF, Var	Tub.		
C104D	281-0544-00			5.6 pF	Cer	500 V	10%
C104E	281-0103-00			1.8-13 pF, Var	Air		
C104F	281-0613-00			10 pF	Cer	200 V	10%
C105A	281-0557-00			1.8 pF	Cer	500 V	
C105B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C105B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C105C } C105D } C105C } C105D } C105E }	281-0082-00	B010100	B029999	15 pF	Mica		10%
				0.2-1.5 pF, Var	Tub.		
	281-0082-01	B030000		15 pF	Mica		10%
				0.2-1.5 pF, Var	Tub.		
	281-0544-00			5.6 pF	Cer	500 V	10%
C106A	281-0604-00	B010100	B039999	2.2 pF	Cer	500 V	$\pm 0.25$ pF
C106A	281-0529-00	B040000		1.5 pF	Cer	500 V	$\pm 0.25$ pF
C106B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C106B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C106C } C106D }	281-0083-00	B010100	B029999	0.2-1.5 pF, Var	Tub.		
				50 pF	Mica		10%
C106C } C106D }	281-0083-01	B030000		0.2-1.5 pF, Var	Tub.		
				50 pF	Mica		10%
C106E	281-0577-00			14 pF	Cer	500 V	5%
C106F	281-0658-00	B010100	B039999	6.2 pF	Cer	500 V	$\pm 0.25$ pF
C106F	281-0544-00	B040000		5.6 pF	Cer	500 V	10%
C107A	281-0544-00			5.6 pF	Cer	500 V	10%
C107B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C107B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C107C } C107D } C107C } C107D }	281-0083-00	B010100	B029999	50 pF	Mica		10%
				0.2-1.5 pF, Var	Tub.		
	281-0083-01	B030000		50 pF	Mica		10%
				0.2-1.5 pF, Var	Tub.		

Electrical Parts List—Type 10A2A

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C107E	281-0604-00			2.2 pF	Cer	500 V	±0.25 pF
C108A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C108B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C108B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C108C } C108D }	281-0083-00	B010100	B029999	0.2-1.5 pF, Var 50 pF	Tub. Mica		10%
C180C } C108D }	281-0083-01	B030000		0.2-1.5 pF, Var 50 pF	Tub. Mica		10%
C109A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C109B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C109B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C109C } C109D }	281-0071-00			0.2-1.5 pF, Var 100 pF	Tub. Mica		10%
C110A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C110B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C110B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C110C } C110D }	281-0069-00			0.2-1.5 pF, Var 200 pF	Tub. Mica		10%
C111A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C111B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C111B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C111C } C111D }	281-0072-00			0.2-1.5 pF, Var 500 pF	Tub. Mica		10%
C112A	281-0503-00	B010100	B039999	8 pF	Cer	500 V	±0.5 pF
C112A	281-0572-00	B040000		6.8 pF	Cer	500 V	10%
C112B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C112B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C112C } C112D }	281-0073-00			0.2-1.5 pF, Var 1000 pF	Tub. Mica		10%
C113A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C113B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C113B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C113C } C113D }	281-0074-00			0.2-1.5 pF, Var 2000 pF	Tub. Mica		10%
C118	283-0068-00			0.01 μF	Cer	500 V	
C123	283-0003-00			0.01 μF	Cer	150 V	
C124	283-0003-00			0.01 μF	Cef	150 V	
C130	285-0622-00			0.1 μF	PTM	100 V	
C131	283-0079-00			0.01 μF	Cer	250 V	
C132	281-0519-00			47 pF	Cer	500 V	10%
C134	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C169	281-0101-00			1.5-9.1 pF, Var	Air		
C172	281-0103-00			1.8-13 pF, Var	Air		
C173	281-0501-00	B010100	B019999	4.7 pF	Cer	500 V	±1 pF
C173	281-0529-00	B020000		1.5 pF	Cer	500 V	±0.25 pF
C178	283-0000-00			0.001 μF	Cer	500 V	
C188	283-0000-00			0.001 μF	Cer	500 V	

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description			
C192	281-0504-00			10 pF	Cer	500 V	10%
C193	281-0504-00			10 pF	Cer	500 V	10%
C199	290-0183-00			1 $\mu$ F	Elect.	35 V	10%
C200	*285-0634-00			0.1 $\mu$ F	MT	600 V	10%
C201	281-0550-00			120 pF	Cer	500 V	10%
C202	281-0577-00			14 pF	Cer	500 V	5%
C203	281-0064-00			0.2-1.5 pF, Var			
C204B	281-0064-00			0.2-1.5 pF, Var			
C204D	281-0544-00			5.6 pF	Cer	500 V	10%
C204E	281-0103-00			1.8-13 pF, Var	Air		
C204F	281-0613-00			10 pF	Cer	200 V	10%
C205A	281-0557-00			1.8 pF	Cer	500 V	
C205B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C205B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C205C } C205D }	281-0082-00	B010100	B029999	15 pF 0.2-1.5 pF, Var	Mica Tub.		10%
C205C } C205D }	281-0082-01	B030000		15 pF 0.2-1.5 pF, Var	Mica Tub.		10%
C205E	281-0544-00			5.6 pF	Cer	500 V	10%
C206A	281-0604-00	B010100	B039999	2.2 pF	Cer	500 V	$\pm 0.25$ pF
C206A	281-0529-00	B040000		1.5 pF	Cer	500 V	$\pm 0.25$ pF
C206B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C206B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C206C } C206D }	281-0083-00	B010100	B029999	0.2-1.5 pF, Var 50 pF	Tub. Mica		10%
C206C } C206D }	281-0083-01	B030000		0.2-1.5 pF, Var 50 pF	Tub. Mica		10%
C206E	281-0577-00			14 pF	Cer	500 V	5%
C206F	281-0658-00	B010100	B039999	6.2 pF	Cer	500 V	$\pm 0.25$ pF
C206F	281-0544-00	B040000		5.6 pF	Cer	500 V	$\pm 0.25$ pF
C207A	281-0544-00			5.6 pF	Cer	500 V	10%
C207B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C207B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C207C } C207D }	281-0083-00	B010100	B029999	50 pF 0.2-1.5 pF, Var	Mica Tub.		10%
C207C } C207D }	281-0083-01	B030000		50 pF 0.2-1.5 pF, Var	Mica Tub.		10%
C207E	281-0604-00			2.2 pF	Cer	500 V	$\pm 0.25$ pF
C208A	281-0503-00			8 pF	Cer	500 V	$\pm 0.5$ pF
C208B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C208B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C208C } C208D }	281-0083-00	B010100	B029999	0.2-1.5 pF, Var 50 pF	Mica		10%
C208C } C208D }	281-0083-01	B030000		0.2-1.5 pF, Var 50 pF	Tub. Mica		10%
C209A	281-0503-00			8 pF	Cer	500 V	$\pm 0.5$ pF
C209B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C209B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		

Electrical Parts List—Type 10A2A

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
C209C } C209D }	281-0071-00			0.2-1.5 pF, Var 100 pF	Tub. Mica		10%
C210A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C210B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C210B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C210C } C210D }	281-0069-00			0.2-1.5 pF, Var 200 pF	Tub. Mica		10%
C211A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C211B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C211B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C211C } C211D }	281-0072-00			0.2-1.5 pF, Var 500 pF	Tub. Mica		10%
C212A	281-0503-00	B010100	B039999	8 pF	Cer	500 V	±0.5 pF
C212A	281-0572-00	B040000		6.8 pF	Cer	500 V	10%
C212B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C212B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C212C } C212D }	281-0073-00			0.2-1.5 pF, Var 1000 pF	Tub. Mica		10%
C213A	281-0503-00			8 pF	Cer	500 V	±0.5 pF
C213B	281-0027-00	B010100	B019999	0.7-3 pF, Var	Tub.		
C213B	281-0037-00	B020000		0.7-3 pF, Var	Tub.		
C213C } C213D }	281-0074-00			0.2-1.5 pF, Var 2000 pF	Tub. Mica		10%
C218	283-0068-00			0.01 μF	Cer	500 V	
C223	283-0003-00			0.01 μF	Cer	150 V	
C224	283-0003-00			0.01 μF	Cer	150 V	
C230	285-0622-00			0.1 μF	PTM	100 V	
C231	283-0079-00			0.01 μF	Cer	250 V	
C232	281-0519-00			47 pF	Cer	500 V	10%
C234	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C259	283-0081-00			0.1 μF	Cer	25 V	+80%—20%
C269	281-0101-00			1.5-9.1 pF, Var	Air		
C271	281-0528-00			82 pF	Cer	500 V	10%
C278	283-0000-00			0.001 μF	Cer	500 V	
C281	281-0528-00			82 pF	Cer	500 V	10%
C284	281-0501-00	B010100	B019999	4.7 pF	Cer	500 V	±1 pF
C284	281-0529-00	B020000		1.5 pF	Cer	500 V	±0.25 pF
C285	281-0103-00			1.8-13 pF, Var	Air		
C288	283-0000-00			0.001 μF	Cer	500 V	
C292	281-0504-00			10 pF	Cer	500 V	10%
C293	281-0504-00			10 pF	Cer	500 V	10%
C299	290-0183-00			0.1 μF	Elect.	35 V	10%
C335	283-0084-00			270 pF	Cer	1000 V	5%
C348	283-0104-00			2000 pF	Cer	500 V	5%
C366	283-0084-00			270 pF	Cer	1000 V	5%
C367	283-0095-00			56 pF	Cer	200 V	10%



Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
C371	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C382	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C387	283-0084-00		270 pF	Cer	1000 V	5%
C390	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C434	283-0000-00		0.001 $\mu$ F	Cer	500 V	
C444	283-0000-00		0.001 $\mu$ F	Cer	500 V	
C452	283-0081-00		0.1 $\mu$ F	Cer	25 V	+80%—20%
C456	281-0099-00		1.3-5.4 pF, Var	Air		
C462	281-0512-00		27 pF	Cer	500 V	10%
C497	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C498	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C520	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C532	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C549	281-0577-00		14 pF	Cer	500 V	5%
C550	281-0564-00		24 pF	Cer	500 V	5%
C560	281-0564-00		24 pF	Cer	500 V	5%
C578	281-0558-00		18 pF	Cer	500 V	
C584	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%
C592	283-0080-00		0.022 $\mu$ F	Cer	25 V	+80%—20%

Diodes

D125	*152-0061-00	Silicon	Tek Spec
D133	*152-0075-00	Germanium	Tek Spec
D157	*152-0185-00	Silicon	Replaceable by 1N3605
D225	*152-0061-00	Silicon	Tek Spec
D233	*152-0075-00	Germanium	Tek Spec
D257	*152-0185-00	Silicon	Replaceable by 1N3605
D302	*152-0153-00	Silicon	Replaceable by 1N4244
D305	*152-0153-00	Silicon	Replaceable by 1N4244
D309	*152-0153-00	Silicon	Replaceable by 1N4244
D312	*152-0153-00	Silicon	Replaceable by 1N4244
D318A } D318B }	*153-0030-00	Zener	(matched pair)
D322	*152-0153-00	Silicon	Replaceable by 1N4244
D325	*152-0153-00	Silicon	Replaceable by 1N4244
D329	*152-0153-00	Silicon	Replaceable by 1N4244
D332	*152-0153-00	Silicon	Replaceable by 1N4244
D348	*152-0075-00	Germanium	Tek Spec
D358	*152-0075-00	Germanium	Tek Spec
D369	*152-0075-00	Germanium	Tek Spec
D387	*152-0185-00	Silicon	Replaceable by 1N3605
D391	*152-0075-00	Germanium	Tek Spec
D392	*152-0153-00	Silicon	Replaceable by 1N4244

## Electrical Parts List—Type 10A2A

### Connectors

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
P11	131-0096-00			32 contact, male
J101	131-0106-01			1 contact, female
J201	131-0106-01			1 contact, female
J533	131-0106-01			1 contact, female

### Inductors

L302	276-0528-00			Core, Ferramic Suppressor
L305	276-0528-00			Core, Ferramic Suppressor
L309	276-0528-00			Core, Ferramic Suppressor
L312	276-0528-00			Core, Ferramic Suppressor
L322	276-0528-00			Core, Ferramic Suppressor
L325	275-0528-00			Core, Ferramic Suppressor
L329	276-0528-00			Core, Ferramic Suppressor
L332	276-0528-00			Core, Ferramic Suppressor
L390	108-0226-00			100 $\mu$ H
L392	*108-0146-00			5 $\mu$ H
L465	*108-0310-00			0.09 $\mu$ H
L577	*108-0250-00			0.1 $\mu$ H
LR104	*108-0266-00			0.05 $\mu$ H (wound on a 27 $\Omega$ , 1/4 W, 5% resistor)
LR105	*108-0268-00			0.1 $\mu$ H (wound on a 36 $\Omega$ , 1/8 W, 5% resistor)
LR106	*108-0266-00			0.05 $\mu$ H (wound on a 27 $\Omega$ , 1/4 W, 5% resistor)
LR113	*108-0268-00			0.1 $\mu$ H (wound on a 36 $\Omega$ , 1/8 W, 5% resistor)
LR204	*108-0266-00			0.05 $\mu$ H (wound on a 27 $\Omega$ , 1/4 W, 5% resistor)
LR205	*108-0268-00			0.1 $\mu$ H (wound on a 36 $\Omega$ , 1/8 W, 5% resistor)
LR206	*108-0266-00			0.05 $\mu$ H (wound on a 27 $\Omega$ , 1/4 W, 5% resistor)
LR213	*108-0268-00			0.1 $\mu$ H (wound on a 36 $\Omega$ , 1/8 W, 5% resistor)
LR438	*108-0070-00			4.6 $\mu$ H (wound on a 270 $\Omega$ , 1/2 W, 5% resistor)
LR504	*108-0328-00			0.3 $\mu$ H (wound on a 220 $\Omega$ , 1/4 W, 5% resistor)
LR514	*108-0328-00			0.3 $\mu$ H (wound on a 220 $\Omega$ , 1/4 W, 5% resistor)

### Transistors

Q123	*151-0151-00	Silicon	Replaceable by 2N930
Q133	*151-0151-00	Silicon	Replaceable by 2N930
Q154	*151-0212-00	Silicon	Tek Spec
Q164	*151-0212-00	Silicon	Tek Spec
Q174	*151-0212-00	Silicon	Tek Spec
Q184	*151-0212-00	Silicon	Tek Spec
Q223	*151-0151-00	Silicon	Replaceable by 2N930
Q233	*151-0151-00	Silicon	Replaceable by 2N930
Q254	*151-0212-00	Silicon	Tek Spec
Q264	*151-0212-00	Silicon	Tek Spec
Q274	*151-0212-00	Silicon	Tek Spec
Q284	*151-0212-00	Silicon	Tek Spec
Q304	*151-0212-00	Silicon	Tek Spec
Q314	*151-0212-00	Silicon	Tek Spec
Q324	*151-0212-00	Silicon	Tek Spec

## Transistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
Q334	*151-0212-00		Silicon	Tek Spec
Q345	151-0223-00		Silicon	2N4275
Q355	151-0223-00		Silicon	2N4275
Q364	151-0223-00		Silicon	2N4275
Q374	151-0223-00		Silicon	2N4275
Q383	151-0223-00		Silicon	2N4275
Q390	151-0223-00		Silicon	2N4275
Q434	*151-0212-00		Silicon	Tek Spec
Q444	*151-0212-00		Silicon	Tek Spec
Q454	*151-0213-00		Silicon	Selected from 2N4251
Q464	*151-0213-00		Silicon	Selected from 2N4251
Q504	*151-0109-00		Silicon	Selected from 2N918
Q514	*151-0109-00		Silicon	Selected from 2N918
Q523	*151-0120-00		Silicon	Selected from 2N2475
Q533	*151-0120-00		Silicon	Selected from 2N2475
Q554	*151-0109-00		Silicon	Selected from 2N918
Q564	*151-0109-00		Silicon	Selected from 2N918
Q574	*151-0120-00		Silicon	Selected from 2N2475
Q584	*151-0120-00		Silicon	Selected from 2N2475
Q593	*151-0151-00		Silicon	Replaceable by 2N930

## Resistors

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

R100	317-0047-00	4.7 $\Omega$	$\frac{1}{8}$ W		5%
R101	315-0105-00	1 M $\Omega$	$\frac{1}{4}$ W		5%
R102	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W		5%
R104C	322-0610-01	500 k $\Omega$	$\frac{1}{4}$ W	Prec	$\frac{1}{2}\%$
R104F	317-0220-00	22 $\Omega$	$\frac{1}{8}$ W		5%
R104G	322-0481-01	1 M $\Omega$	$\frac{1}{4}$ W	Prec	$\frac{1}{2}\%$
R105C	323-0620-01	800 k $\Omega$	$\frac{1}{2}$ W	Prec	$\frac{1}{2}\%$
R105D	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R105F	321-0618-01	250 k $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R106A	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R106C	323-0611-01	900 k $\Omega$	$\frac{1}{2}$ W	Prec	$\frac{1}{2}\%$
R106E	315-0330-00	33 $\Omega$	$\frac{1}{4}$ W		5%
R106F	321-1389-01	111 k $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R107A	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R107C	323-0612-01	950 k $\Omega$	$\frac{1}{2}$ W	Prec	$\frac{1}{2}\%$
R107E	315-0470-00	47 $\Omega$	$\frac{1}{4}$ W		5%
R107F	321-0616-01	52.6 k $\Omega$	$\frac{1}{8}$ W	Prec	$\frac{1}{2}\%$
R108A	317-0560-00	56 $\Omega$	$\frac{1}{8}$ W		5%
R108C	323-0621-01	980 k $\Omega$	$\frac{1}{2}$ W	Prec	$\frac{1}{2}\%$
R108D	315-0270-00	27 $\Omega$	$\frac{1}{4}$ W		5%

Electrical Parts List—Type 10A2A

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
R108E	321-0615-01	20.4 kΩ	1/8 W Prec 1/2%
R109C	323-0614-01	990 kΩ	1/2 W Prec 1/2%
R109D	315-0470-00	47 Ω	1/4 W 5%
R109E	321-1289-01	10.1 kΩ	1/8 W Prec 1/2%
R110C	322-0625-01	995 kΩ	1/4 W Prec 1/2%
R110D	315-0620-00	62 Ω	1/4 W 5%
R110E	321-0613-01	5.03 kΩ	1/8 W Prec 1/2%
R111C	322-0628-01	998 kΩ	1/4 W Prec 1/2%
R111D	315-0220-00	22 Ω	1/4 W 5%
R111E	321-0222-01	2 kΩ	1/8 W Prec 1/2%
R112C	322-0629-01	999 kΩ	1/4 W Prec 1/2%
R112D	315-0330-00	33 Ω	1/4 W 5%
R112E	321-0193-01	1 kΩ	1/8 W Prec 1/2%
R113A	317-0390-00	39 Ω	1/8 W 5%
R113C	323-0481-01	1 MΩ	1/2 W Prec 1/2%
R113E	321-0612-01	500 Ω	1/8 W Prec 1/2%
R114	323-0481-01	1 MΩ	1/2 W Prec 1/2%
R115	316-0101-00	100 Ω	1/4 W
R116	316-0334-00	330 kΩ	1/4 W
R117	311-0390-00	25 kΩ, Var	
R118	315-0105-00	1 MΩ	1/4 W 5%
R119	317-0100-00	10 Ω	1/8 W 5%
R121	321-0209-00	1.47 kΩ	1/8 W Prec 1%
R122	311-0387-00	5 kΩ, Var	
R123	323-0305-00	14.7 kΩ	1/2 W Prec 1%
R124	302-0102-00	1 kΩ	1/2 W
R125	303-0153-00	15 kΩ	1 W 5%
R129	315-0153-00	15 kΩ	1/4 W 5%
R130	308-0077-00	1 kΩ	3 W WW
R132	315-0151-00	150 Ω	1/4 W 5%
R133	322-0225-00	2.15 kΩ	1/4 W Prec 1%
R134	315-0510-00	51 Ω	1/4 W 5%
R135	321-0251-00	4.02 kΩ	1/8 W Prec 1%
R136	321-0153-00	383 Ω	1/8 W Prec 1%
R138	311-0169-00	100 Ω, Var	
R140	311-0390-00	25 kΩ, Var	
R142	321-0325-00	23.7 kΩ	1/8 W Prec 1%
R143	315-0823-00	82 kΩ	1/4 W 5%
R144 <sup>1</sup>	311-0385-00	250 Ω, Var	
R148	322-0215-00	1.69 kΩ	1/4 W Prec 1%
R149	321-0117-00	162 Ω	1/8 W Prec 1%
R150	311-0258-00	100 Ω, Var	
R154	322-0161-00	464 Ω	1/4 W Prec 1%
R157	321-0129-00	215 Ω	1/8 W Prec 1%
R158	322-0202-00	1.24 kΩ	1/4 W Prec 1%

<sup>1</sup>Furnished as a unit with SW144.

## Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description			
R160	311-0390-00		25 k $\Omega$ , Var			
R161	321-0297-00		12.1 k $\Omega$	1/8 W	Prec	1%
R163	321-0103-00		115 $\Omega$	1/8 W	Prec	1%
R164	322-0161-00		464 $\Omega$	1/4 W	Prec	1%
R165	322-0202-00		1.24 k $\Omega$	1/4 W	Prec	1%
R167	321-0129-00		215 $\Omega$	1/8 W	Prec	1%
R168	322-0202-00		1.24 k $\Omega$	1/4 W	Prec	1%
R169	321-0077-00		61.9 $\Omega$	1/8 W	Prec	1%
R171	321-0138-00		267 $\Omega$	1/8 W	Prec	1%
R172	311-0442-00		250 $\Omega$ , Var			
R174	321-0097-00		100 $\Omega$	1/8 W	Prec	1%
R175	321-0133-00		237 $\Omega$	1/8 W	Prec	1%
R176	311-0461-00		250 $\Omega$ , Var			
R178	321-0107-00		127 $\Omega$	1/8 W	Prec	1%
R181	321-0138-00		267 $\Omega$	1/8 W	Prec	1%
R184	321-0097-00		100 $\Omega$	1/8 W	Prec	1%
R188	321-0107-00		127 $\Omega$	1/8 W	Prec	1%
R190	316-0102-00		1 k $\Omega$	1/4 W		
R192	321-0073-00		56.2 $\Omega$	1/8 W	Prec	1%
R193	321-0073-00		56.2 $\Omega$	1/8 W	Prec	1%
R195	315-0822-00		8.2 k $\Omega$	1/4 W		5%
R196	311-0389-00		2 x 10 k $\Omega$ , Var			
R197	315-0822-00		8.2 k $\Omega$	1/4 W		5%
R199	315-0510-00		51 $\Omega$	1/4 W		5%
R200	317-0047-00		4.7 $\Omega$	1/8 W		5%
R201	315-0105-00		1 M $\Omega$	1/4 W		5%
R202	315-0470-00		47 $\Omega$	1/4 W		5%
R204C	322-0610-01		500 k $\Omega$	1/4 W	Prec	1/2%
R204F	317-0220-00		22 $\Omega$	1/8 W		5%
R204G	322-0481-01		1 M $\Omega$	1/4 W	Prec	1/2%
R205C	323-0620-01		800 k $\Omega$	1/2 W	Prec	1/2%
R205D	317-0560-00		56 $\Omega$	1/8 W		5%
R205F	321-0618-01		250 k $\Omega$	1/8 W	Prec	1/2%
R206A	317-0560-00		56 $\Omega$	1/8 W		5%
R206C	323-0611-01		900 k $\Omega$	1/2 W	Prec	1/2%
R206E	315-0330-00		33 $\Omega$	1/4 W		5%
R206F	321-1389-01		111 k $\Omega$	1/8 W	Prec	1/2%
R207A	317-0560-00		56 $\Omega$	1/8 W		5%
R207C	323-0612-01		950 k $\Omega$	1/2 W	Prec	1/2%
R207E	315-0470-00		47 $\Omega$	1/4 W		5%
R207F	321-0616-01		52.6 k $\Omega$	1/8 W	Prec	1/2%
R208A	317-0560-00		56 $\Omega$	1/8 W		5%
R208C	323-0621-01		980 k $\Omega$	1/2 W	Prec	1/2%
R208D	315-0270-00		27 $\Omega$	1/4 W		5%
R208E	321-0615-01		20.4 k $\Omega$	1/8 W	Prec	1/2%

Electrical Parts List—Type 10A2A

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R209C	323-0614-01	990 k $\Omega$		1/2 W	Prec	1/2 %
R209D	315-0470-00	47 $\Omega$		1/4 W		5%
R209E	321-1289-01	10.1 k $\Omega$		1/8 W	Prec	1/2 %
R210C	322-0625-01	995 k $\Omega$		1/4 W	Prec	1/2 %
R210D	315-0620-00	62 $\Omega$		1/4 W		5%
R210E	321-0613-01	5.03 k $\Omega$		1/8 W	Prec	1/2 %
R211C	322-0628-01	998 k $\Omega$		1/4 W	Prec	1/2 %
R211D	315-0220-00	22 $\Omega$		1/4 W		5%
R211E	321-0222-01	2 k $\Omega$		1/8 W	Prec	1/2 %
R212C	322-0629-01	999 k $\Omega$		1/4 W	Prec	1/2 %
R212D	315-0330-00	33 $\Omega$		1/4 W		5%
R212E	321-0193-01	1 k $\Omega$		1/8 W	Prec	1/2 %
R213A	317-0390-00	39 $\Omega$		1/8 W		5%
R213C	323-0481-01	1 M $\Omega$		1/2 W	Prec	1/2 %
R213E	321-0612-01	500 $\Omega$		1/8 W	Prec	1/2 %
R214	323-0481-01	1 M $\Omega$		1/2 W	Prec	1 %
R215	316-0101-00	100 $\Omega$		1/4 W		
R216	316-0334-00	330 k $\Omega$		1/4 W		
R217	311-0390-00	25 k $\Omega$ , Var				
R218	315-0105-00	1 M $\Omega$		1/4 W		5%
R219	317-0100-00	10 $\Omega$		1/8 W		5%
R221	321-0209-00	1.47 k $\Omega$		1/8 W	Prec	1 %
R222	311-0387-00	5 k $\Omega$ , Var				
R223	323-0305-00	14.7 k $\Omega$		1/2 W	Prec	1 %
R224	302-0102-00	1 k $\Omega$		1/2 W		
R225	303-0153-00	15 k $\Omega$		1 W		5%
R229	315-0153-00	15 k $\Omega$		1/4 W		5%
R230	308-0077-00	1 k $\Omega$		3 W	WW	
R232	315-0151-00	150 $\Omega$		1/4 W		5%
R233	322-0225-00	2.15 k $\Omega$		1/4 W	Prec	1 %
R234	315-0510-00	51 $\Omega$		1/4 W		5%
R235	321-0251-00	4.02 k $\Omega$		1/8 W	Prec	1 %
R236	321-0153-00	383 $\Omega$		1/8 W	Prec	1 %
R238	311-0169-00	100 $\Omega$ , Var				
R240	311-0390-00	25 k $\Omega$ , Var				
R242	321-0325-00	23.7 k $\Omega$		1/8 W	Prec	1 %
R243	315-0823-00	82 k $\Omega$		1/4 W		5%
R244 <sup>2</sup>	311-0385-00	250 $\Omega$ , Var				
R248	322-0215-00	1.69 k $\Omega$		1/4 W	Prec	1 %
R249	321-0117-00	162 $\Omega$		1/8 W	Prec	1 %
R250	311-0258-00	100 $\Omega$ , Var				
R254	322-0161-00	464 $\Omega$		1/4 W	Prec	1 %
R257	321-0129-00	215 $\Omega$		1/8 W	Prec	1 %
R258	322-0202-00	1.24 k $\Omega$		1/4 W	Prec	1 %
R259	315-0100-00	10 $\Omega$		1/4 W		5%

<sup>2</sup>Furnished as a unit with SW244.

## Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R260	311-0390-00			25 k $\Omega$ , Var			
R261	321-0297-00			12.1 k $\Omega$	1/8 W	Prec	1%
R263	321-0103-00			115 $\Omega$	1/8 W	Prec	1%
R264	322-0161-00			464 $\Omega$	1/4 W	Prec	1%
R265	322-0202-00			1.24 k $\Omega$	1/4 W	Prec	1%
R267	321-0129-00			215 $\Omega$	1/8 W	Prec	1%
R268	322-0202-00			1.24 k $\Omega$	1/4 W	Prec	1%
R269	321-0077-00			61.9 $\Omega$	1/8 W	Prec	1%
R270	323-0181-00			750 $\Omega$	1/2 W	Prec	1%
R271	321-0115-00			154 $\Omega$	1/8 W	Prec	1%
R272	321-0049-00			31.6 $\Omega$	1/8 W	Prec	1%
R273	323-0163-00			487 $\Omega$	1/2 W	Prec	1%
R274	321-0097-00			100 $\Omega$	1/8 W	Prec	1%
R275	321-0149-00			348 $\Omega$	1/8 W	Prec	1%
R276	311-0461-00			250 $\Omega$ , Var			
R278	321-0107-00			127 $\Omega$	1/8 W	Prec	1%
R280	323-0181-00			750 $\Omega$	1/2 W	Prec	1%
R281	321-0115-00			154 $\Omega$	1/8 W	Prec	1%
R282	321-0049-00			31.6 $\Omega$	1/8 W	Prec	1%
R283	323-0163-00			487 $\Omega$	1/2 W	Prec	1%
R284	321-0097-00			100 $\Omega$	1/8 W	Prec	1%
R285	311-0442-00			250 $\Omega$ , Var			
R286	315-0100-00			10 $\Omega$	1/4 W		5%
R288	321-0107-00			127 $\Omega$	1/8 W	Prec	1%
R290	316-0102-00			1 k $\Omega$	1/4 W		
R292	321-0073-00			56.2 $\Omega$	1/8 W	Prec	1%
R293	321-0073-00			56.2 $\Omega$	1/8 W	Prec	1%
R295	315-0822-00			8.2 k $\Omega$	1/4 W		5%
R296	311-0389-00			2 $\times$ 10 k $\Omega$ , Var			
R297	315-0822-00			8.2 k $\Omega$	1/4 W		5%
R299	315-0510-00			51 $\Omega$	1/4 W		5%
R313	321-0193-00			1 k $\Omega$	1/8 W	Prec	1%
R314	321-0172-00			604 $\Omega$	1/8 W	Prec	1%
R317	321-0139-00			274 $\Omega$	1/8 W	Prec	1%
R318	321-0193-00			1 k $\Omega$	1/8 W	Prec	1%
R319	321-0240-00			3.09 k $\Omega$	1/8 W	Prec	1%
R333	321-0193-00			1 k $\Omega$	1/8 W	Prec	1%
R334	321-0172-00			604 $\Omega$	1/8 W	Prec	1%
R335	311-0258-00			100 $\Omega$ , Var			
R336	311-0258-00			100 $\Omega$ , Var			
R337	321-0139-00			274 $\Omega$	1/8 W	Prec	1%
R338	321-0193-00			1 k $\Omega$	1/8 W	Prec	1%
R339	321-0240-00			3.09 k $\Omega$	1/8 W	Prec	1%
R341	315-0101-00			100 $\Omega$	1/4 W		5%
R342	315-0332-00			3.3 k $\Omega$	1/4 W		5%

Electrical Parts List—Type 10A2A

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
R343	323-0125-00		196 Ω	1/2 W	Prec		1%
R344	321-0213-00		1.62 kΩ	1/8 W	Prec		1%
R345	323-0181-00		750 Ω	1/2 W	Prec		1%
R347	321-0249-00		3.83 kΩ	1/8 W	Prec		1%
R351	315-0101-00		100 Ω	1/4 W			5%
R352	315-0332-00		3.3 kΩ	1/4 W			5%
R353	323-0125-00		196 Ω	1/2 W	Prec		1%
R354	321-0213-00		1.62 kΩ	1/8 W	Prec		1%
R355	323-0181-00		750 Ω	1/2 W	Prec		1%
R357	321-0249-00		3.83 kΩ	1/8 W	Prec		1%
R364	323-0153-00		383 Ω	1/2 W	Prec		1%
R365	315-0153-00		15 kΩ	1/4 W			5%
R367	315-0102-00		1 kΩ	1/4 W			5%
R369	315-0682-00		6.8 kΩ	1/4 W			5%
R371	315-0224-00		220 kΩ	1/4 W			5%
R373	321-0289-00		10 kΩ	1/8 W	Prec		1%
R374	315-0332-00		3.3 kΩ	1/4 W			5%
R375	321-0161-00		464 Ω	1/8 W	Prec		1%
R382	315-0152-00		1.5 kΩ	1/4 W			5%
R384	322-0221-00		1.96 kΩ	1/4 W	Prec		1%
R387	315-0330-00		33 Ω	1/4 W			5%
R389	321-0069-00		51.1 Ω	1/8 W	Prec		1%
R390	315-0221-00		220 Ω	1/4 W			5%
R391	315-0221-00		220 Ω	1/4 W			5%
R392	315-0222-00		2.2 kΩ	1/4 W			5%
R431	323-0133-00		237 Ω	1/2 W	Prec		1%
R432	321-0097-00		100 Ω	1/8 W	Prec		1%
R434	321-0113-00		147 Ω	1/8 W	Prec		1%
R442	321-0097-00		100 Ω	1/8 W	Prec		1%
R444	321-0113-00		147 Ω	1/8 W	Prec		1%
R450	321-0141-00		287 Ω	1/8 W	Prec		1%
R452	323-0085-00		75 Ω	1/2 W	Prec		1%
R453	321-0257-00		4.64 kΩ	1/8 W	Prec		1%
R454	322-0094-00		93.1 Ω	1/4 W	Prec		1%
R455	321-0630-00		6.81 kΩ	1/8 W	Prec		1/2%
R457	323-0141-00		287 Ω	1/2 W	Prec		1%
R458	323-0121-00		178 Ω	1/2 W	Prec		1%
R459	323-0097-00		100 Ω	1/2 W	Prec		1%
R460	321-0141-00		287 Ω	1/8 W	Prec		1%
R462	311-0463-00		5 kΩ, Var				
R463	321-0257-00		4.64 kΩ	1/8 W	Prec		1%
R464	322-0094-00		93.1 Ω	1/4 W	Prec		1%
R465	321-0080-00		66.5 Ω	1/8 W	Prec		1%
R467	323-0141-00		287 Ω	1/2 W	Prec		1%
R468	323-0121-00		178 Ω	1/2 W	Prec		1%



Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R494	*310-0606-00		67 Ω	4 W	WW	1%
R496	*310-0606-00		67 Ω	4 W	WW	1%
R497	322-0073-00		56.2 Ω	1/4 W	Prec	1%
R498	322-0085-00		75 Ω	1/4 W	Prec	1%
R504	321-0125-00		196 Ω	1/8 W	Prec	1%
R514	321-0125-00		196 Ω	1/8 W	Prec	1%
R525	321-0161-00		464 Ω	1/8 W	Prec	1%
R526	321-0058-00		39.2 Ω	1/8 W	Prec	1%
R527	321-0053-00		34.8 Ω	1/8 W	Prec	1%
R529	323-0170-00		576 Ω	1/2 W	Prec	1%
R530	311-0390-00		25 kΩ, Var			
R531	315-0392-00		3.9 kΩ	1/4 W		5%
R532	323-0181-00		750 Ω	1/2 W	Prec	1%
R533	321-0103-00		115 Ω	1/8 W	Prec	1%
R535	321-0161-00		464 Ω	1/8 W	Prec	1%
R536	321-0058-00		39.2 Ω	1/8 W	Prec	1%
R539	323-0170-00		576 Ω	1/2 W	Prec	1%
R541	315-0820-00		82 Ω	1/4 W		5%
R543	315-0820-00		82 Ω	1/4 W		5%
R545	321-0289-00		10 kΩ	1/8 W	Prec	1%
R546	311-0390-00		25 kΩ, Var			
R548	321-0101-00		110 Ω	1/8 W	Prec	1%
R549	315-0750-00		75 Ω	1/4 W		5%
R550	321-0065-00		46.4 Ω	1/8 W	Prec	1%
R551	321-0297-00		12.1 kΩ	1/8 W	Prec	1%
R554	321-0127-00		205 Ω	1/8 W	Prec	1%
R560	321-0065-00		46.4 Ω	1/8 W	Prec	1%
R561	321-0297-00		12.1 kΩ	1/8 W	Prec	1%
R564	321-0127-00		205 Ω	1/8 W	Prec	1%
R574	323-0181-00		750 Ω	1/2 W	Prec	1%
R576	323-0173-00		619 Ω	1/2 W	Prec	1%
R577	321-0073-00		56.2 Ω	1/8 W	Prec	1%
R578	315-0120-00		12 Ω	1/4 W		5%
R584	323-0181-00		750 Ω	1/2 W	Prec	1%
R586	323-0173-00		619 Ω	1/2 W	Prec	1%
R591	321-0169-00		562 Ω	1/8 W	Prec	1%
R592	321-0230-00		2.43 kΩ	1/8 W	Prec	1%
R595	315-0270-00		27 Ω	1/4 W		5%
R597	303-0221-00		220 Ω	1 W		5%

Switches

Unwired	Wired				
SW101 260-0840-00				Lever	AC-GND-DC
SW110 260-0841-00	*262-0793-00	B010100	B029999	Rotary	VOLTS/CM
SW110 260-0841-00	*262-0793-01	B030000		Rotary	VOLTS/CM
SW144 <sup>3</sup> 311-0385-00					
SW190 260-0447-00				Slide	INVERT

<sup>3</sup>Furnished as a unit with R144.

**Electrical Parts List—Type 10A2A**

**Switches (cont)**

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc		Description
SW201	260-0840-00			Lever	AC-GND-DC
SW210	260-0841-00	*262-0793-00	B010100	Rotary	VOLTS/CM
SW210	260-0841-00	*262-0793-01	B030000	Rotary	VOLTS/CM
SW244*	311-0385-00				
SW290	260-0447-00			Slide	INVERT
SW350	260-0524-00			Rotary	MODE
SW540	260-0523-00			Rotary	TRIGGER

**Transformers**

T169	276-0507-00			Core, Ferramic Suppressor	
T269	276-0507-00			Core, Ferramic Suppressor	
T371	*120-0273-00			Toroid, 2 windings	
T390	*120-0273-00			Toroid, 2 windings	

**Electron Tubes**

V133	*157-0080-00			7586	checked
V233	*157-0080-00			7586	checked

\*Furnished as a unit with R244.

## FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear on the pullout pages immediately following the Diagrams section of this instruction manual.

## INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

*Assembly and/or Component*  
*Detail Part of Assembly and/or Component*  
*mounting hardware for Detail Part*  
*Parts of Detail Part*  
*mounting hardware for Parts of Detail Part*  
*mounting hardware for Assembly and/or Component*

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

**Mounting hardware must be purchased separately, unless otherwise specified.**

## PARTS ORDERING INFORMATION

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

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

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

Change information, if any, is located at the rear of this manual.

## ABBREVIATIONS AND SYMBOLS

For an explanation of the abbreviations and symbols used in this section, please refer to the page immediately preceding the Electrical Parts List in this instruction manual.

**INDEX OF MECHANICAL PARTS LIST ILLUSTRATIONS**

**(Located behind diagrams)**

**FIG. 1 FRONT**

**FIG. 2 CHASSIS & REAR**

# SECTION 8

## MECHANICAL PARTS LIST

FIG. 1 FRONT

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				†	1	2	3	4		5
1-1	366-0225-00			1						KNOB, charcoal—POSITION (CH 1)
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-2	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-3	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-4	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-5	131-0106-01			3						CONNECTOR, coaxial, 1 contact, BNC, w/mounting hardware
-6	348-0067-00			2						GROMMET, plastic, 5/16 inch diameter
-7	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-8	358-0075-00			1						BUSHING, resistor mounting
-9	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-10	210-0223-00			1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-11	358-0075-00			1						BUSHING, resistor mounting
-12	378-0541-00			2						FILTER, lens
-13	352-0067-00			2						HOLDER, neon
	- - - - -			-						mounting hardware for each: (not included w/holder)
-14	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch
-15	211-0109-00			1						SCREW, 4-40 x 7/8 inch, 100° csk, FHS
-16	358-0216-00			2						BUSHING, front panel
-17	384-0272-00			2						ROD, extension
-18	376-0029-00			2						COUPLING, shaft
	- - - - -			-						each coupling includes:
	213-0048-00			2						SCREW, set, 4-40 x 1/8 inch, HSS
-19	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-20	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-21	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-22	366-0220-00			1						KNOB, charcoal—MODE
	- - - - -			-						knob includes:
	213-0020-00			1						SCREW, set, 6-32 x 1/8 inch, HSS
-23	260-0524-00			1						SWITCH, unwired—MODE
	- - - - -			-						mounting hardware: (not included w/switch)
-24	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-25	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch

Mechanical Parts List—Type 10A2A

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description	1 2 3 4 5				
						1	2	3	4	5
1-26	366-0225-00			1	KNOB, charcoal—TRIGGER					
-	- - - - -			-	knob includes:					
	213-0020-00			1	SCREW, set, 6-32 x 1/8 inch, HSS					
-27	384-0668-00			1	ROD, extension					
-28	376-0052-00			1	ASSEMBLY, coupling					
-	- - - - -			-	assembly includes:					
	213-0022-00	B010100	B020289	2	SCREW, set, 4-40 x 3/16 inch, HSS					
	213-0048-00	B020290		2	SCREW, set, 4-40 x 1/8 inch, HSS					
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS					
	213-0115-00			1	SCREW, set, 4-40 x 5/16 inch, HSS					
	354-0251-00			1	RING, coupling					
	354-0261-00			1	RING, coupling					
	376-0049-00			1	COUPLING, plastic					
-29	260-0523-00			1	SWITCH, unwired—TRIGGER					
-	- - - - -			-	mounting hardware: (not included w/switch)					
-30	210-0255-00			1	LUG, solder, 3/8 inch					
	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD					
-31	210-0840-00			1	WASHER, flat, 0.390 ID x 3/16 inch OD					
-32	210-0413-00			1	NUT, hex., 3/8-32 x 1/2 inch					
-33	407-0114-00			1	BRACKET, switch					
-	- - - - -			-	mounting hardware: (not included w/bracket)					
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS					
-34	407-0316-00			1	BRACKET, variable resistor					
-	- - - - -			-	mounting hardware: (not included w/bracket)					
	211-0504-00			4	SCREW, 6-32 x 1/4 inch, PHS					
-35	131-0183-00			4	CONNECTOR, terminal feed thru					
	358-0136-00			4	BUSHING, teflon					
-36	- - - - -			2	RESISTOR, variable					
-	- - - - -			-	mounting hardware for each: (not included w/resistor)					
-37	210-0046-00			1	LOCKWASHER, internal, 1/4 ID x 0.400 inch OD					
-38	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD					
-39	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch					
-40	- - - - -			8	RESISTOR, variable					
-	- - - - -			-	mounting hardware for each: (not included w/resistor)					
-41	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD					
-42	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch					
-43	384-0275-00			1	ROD, extension, w/knob—PULL TO INVERT (CH 1)					
-44	260-0447-00			1	SWITCH, slide—PULL TO INVERT (CH 1)					
-	- - - - -			-	mounting hardware: (not included w/switch)					
-45	210-0406-00			2	NUT, hex., 4-40 x 3/16 inch					
-46	406-0917-00			1	BRACKET, slide switch					
-	- - - - -			-	mounting hardware: (not included w/bracket)					
	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS					

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y						Description
					1	2	3	4	5	
1-47	406-0918-00			1						BRACKET, slide switch actuator
-48	129-0053-00			1						ASSEMBLY, binding post
	- - - - -			-						assembly includes:
	200-0103-00			1						CAP
	355-0507-00			1						STEM, adapter
	- - - - -			-						mounting hardware: (not included w/assembly)
-49	210-0046-00			1						LOCKWASHER, internal, 1/4 ID x 0.400 inch OD
-50	210-0455-00			1						NUT, hex., 1/4-28 x 3/8 inch
-51	366-0215-01			1						KNOB, charcoal—AC-DC-GND (CH 1)
-52	260-0840-00			1						SWITCH, lever—AC-DC-GND (CH 1)
	- - - - -			-						mounting hardware: (not included w/switch)
-53	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch
-54	366-0081-00			1						KNOB, red—VARIABLE (CH 1)
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-55	384-0276-00			1						ROD, extension
	376-0050-00			1						ASSEMBLY, coupling
	- - - - -			-						assembly includes:
-56	354-0251-00			2						RING, coupling
-57	376-0046-00			1						COUPLING, plastic
	213-0022-00			4						SCREW, set, 4-40 x 3/16 inch, HSS
-58	- - - - -			1						RESISTOR, variable
	- - - - -			-						mounting hardware: (not included w/resistor)
-59	210-0223-00			1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-60	210-0940-00			1						WASHER, flat, 1/4 ID x 3/8 inch OD
-61	210-0583-00			1						NUT, hex., 1/4-32 x 5/16 inch
-62	366-0230-00			1						KNOB, charcoal—VOLTS/CM (CH 1)
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-63	262-0793-00	B010100	B029999	1						SWITCH, wired—VOLTS/CM (CH 1)
	262-0793-01	B030000		1						SWITCH, wired—VOLTS/CM (CH 1)
	- - - - -			-						switch includes:
	260-0841-00			1						SWITCH, unwired
-64	214-0456-00			1						FASTENER, plastic
	- - - - -			-						mounting hardware: (not included w/switch)
	211-0008-00			1						SCREW, 4-40 x 1/4 inch, PHS
-65	361-0056-00			2						SPACER, 1 5/32 inches long
-66	337-0890-00			1						SHIELD, attenuator
	- - - - -			-						mounting hardware: (not included w/shield)
-67	211-0504-00			2						SCREW, 6-32 x 1/4 inch, PHS
-68	384-0281-00			1						ROD, shaft, switch
-69	358-0029-00			1						BUSHING, 3/8-32 x 1/2 inch long
-70	214-0348-00			1						CASTING, attenuator
	- - - - -			-						mounting hardware: (not included w/casting)
	211-0538-00			2						SCREW, 6-32 x 5/16 inch, 100° csk, FHS

Mechanical Parts List—Type 10A2A

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † Y	1 2 3 4 5					Description
				1	2	3	4	5	
1-71	214-0350-00		1						GEAR, miter
	- - - - -		-						gear includes:
	213-0020-00		2						SCREW, set, 6-32 x 1/8 inch, HSS
-72	214-0272-00		1						GEAR, miter
	- - - - -		-						gear includes:
	213-0020-00		2						SCREW, set, 6-32 x 1/8 inch, HSS
-73	210-0839-00		1						WASHER, rippled, 1/4 ID x 7/16 inch OD
-74	129-0070-00		1						POST, terminal, insulated
-75	366-0215-01		1						KNOB, charcoal—AC-DC-GND (CH 2)
-76	260-0840-00		1						SWITCH, lever—AC-DC-GND (CH 2)
	- - - - -		-						mounting hardware: (not included w/switch)
-77	210-0586-00		2						NUT, keps, 4-40 x 1/4 inch
-78	366-0225-00		1						KNOB, charcoal—POSITION (CH 2)
	- - - - -		-						knob includes:
	213-0020-00		1						SCREW, set, 6-32 x 1/8 inch, HSS
-79	- - - - -		1						RESISTOR, variable
	- - - - -		-						mounting hardware: (not included w/resistor)
-80	210-0940-00		1						WASHER, flat, 1/4 ID x 3/8 inch OD
-81	210-0583-00		1						NUT, hex., 1/4-32 x 5/16 inch
-82	384-0275-00		1						ROD, extension, w/knob—PULL TO INVERT (CH 2)
-83	260-0447-00		1						SWITCH, slide—PULL TO INVERT (CH 2)
	- - - - -		-						mounting hardware: (not included w/switch)
-84	210-0406-00		2						NUT, hex., 4-40 x 3/16 inch
-85	406-0917-00		1						BRACKET, slide switch
	- - - - -		-						mounting hardware: (not included w/bracket)
	211-0504-00		2						SCREW, 6-32 x 1/4 inch, PHS
-86	406-0918-00		1						BRACKET, slide switch actuator
-87	366-0081-00		1						KNOB, red—VARIABLE (CH 2)
	- - - - -		-						knob includes:
	213-0004-00		1						SCREW, set, 6-32 x 3/16 inch, HSS
-88	384-0276-00		1						ROD, extension
	376-0050-00		1						ASSEMBLY, coupling
	- - - - -		-						assembly includes:
-89	354-0251-00		2						RING, coupling
-90	376-0046-00		1						COUPLING, plastic
	213-0022-00		4						SCREW, set, 4-40 x 3/16 inch, HSS
-91	- - - - -		1						RESISTOR, variable
	- - - - -		-						mounting hardware: (not included w/resistor)
-92	210-0223-00		1						LUG, solder, 1/4 ID x 7/16 inch OD, SE
-93	210-0940-00		1						WASHER, flat, 1/4 ID x 3/8 inch OD
-94	210-0583-00		1						NUT, hex., 1/4-32 x 5/16 inch



FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y	Description
		Eff	Disc		
1-95	366-0230-00			1	KNOB, charcoal—VOLTS/CM (CH 2)
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-96	262-0793-00	B010100	B029999	1	SWITCH, wired—VOLTS/CM (CH 2)
	262-0793-01	B030000		1	SWITCH, wired—VOLTS/CM (CH 2)
	- - - - -			-	switch includes:
	260-0841-00			1	SWITCH, unwired
-97	214-0456-00			1	FASTENER, plastic
	- - - - -			-	mounting hardware: (not included w/switch)
	211-0008-00			1	SCREW, 4-40 x 1/4 inch, PHS
-98	361-0056-00			2	SPACER, 1 5/32 inches long
-99	337-0890-00			1	SHIELD, attenuator
	- - - - -			-	mounting hardware: (not included w/shield)
-100	211-0504-00			2	SCREW, 6-32 x 1/4 inch, PHS
-101	343-0088-00			1	CLAMP, cable, plastic
-102	384-0281-00			1	ROD, shaft, switch
-103	358-0029-00			1	BUSHING, 3/8-32 x 1/2 inch long
-104	214-0348-00			1	CASTING, attenuator
	- - - - -			-	mounting hardware: (not included w/casting)
	211-0538-00			2	SCREW, 6-32 x 5/16 inch, 100° csk, FHS
-105	214-0350-00			1	GEAR, miter
	- - - - -			-	gear includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-106	214-0272-00			1	GEAR, miter
	- - - - -			-	gear includes:
	213-0020-00			2	SCREW, set, 6-32 x 1/8 inch, HSS
-107	210-0839-00			1	WASHER, rippled, 1/4 ID x 7/16 inch OD
-108	129-0070-00			1	POST, terminal, insulated
-109	333-0966-01			1	PANEL, front
-110	387-0784-00			1	PLATE, front sub

FIG. 2 CHASSIS & REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q					Description
			t	y	1	2	3	
2-1	441-0700-00		1					CHASSIS
-	- - - - -		-					mounting hardware: (not included w/chassis)
	210-0457-00		3					NUT, keps, 6-32 x 5/16 inch
	211-0504-00		3					SCREW, 6-32 x 1/4 inch, PHS
-2	211-0507-00		1					SCREW, 6-32 x 5/16 inch, PHS
-3	348-0067-00		12					GROMMET, plastic, 5/16 inch diameter
-4	136-0101-00		2					SOCKET, nuvistor, 5 pin
-	- - - - -		-					mounting hardware for each: (not included w/socket)
-5	213-0055-00		2					SCREW, thread forming, 2-32 x 5/16 inch, PHS
-6	136-0218-00		35					SOCKET, transistor, 3 pin
-	- - - - -		-					mounting hardware for each: (not included w/socket)
-7	354-0285-00		1					RING, transistor socket mounting
-8	200-0497-00		5					COVER, transistor
-9	352-0072-00		5					HOLDER, transistor cover
-10	210-0204-00		4					LUG, solder, DE #6
-	- - - - -		-					mounting hardware for each: (not included w/lug)
-11	213-0044-00		1					SCREW, thread forming, 5-32 x 3/16 inch, PHS
-12	210-0201-00		12					LUG, solder, SE #4
-	- - - - -		-					mounting hardware for each: (not included w/lug)
-13	213-0044-00		1					SCREW, thread forming, 5-32 x 3/16 inch, PHS
-14	426-0121-00		2					HOLDER, toroid
-15	361-0007-00		2					SPACER, plastic, 1/16 inch long
-16	- - - - -		3					RESISTOR, variable
-	- - - - -		-					mounting hardware for each: (not included w/resistor)
-17	210-0940-00		1					WASHER, flat, 1/4 ID x 3/8 inch OD
-18	210-0583-00		1					NUT, hex., 1/4-32 x 5/16 inch
-19	- - - - -		1					RESISTOR, variable
-	- - - - -		-					mounting hardware: (not included w/resistor)
-20	210-0223-00		1					LUG, solder, 1/4 ID x 7/16 inch OD, SE
-21	210-0406-00		1					NUT, hex., 4-40 x 3/16 inch

FIG. 2 CHASSIS & REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				†	Y	1	2	3		4
2-22	131-0235-00			4						CONNECTOR, terminal
	358-0136-00			4						BUSHING, teflon
-23	384-0615-00			2						ROD, spacer
	- - - - -			-						mounting hardware for each: (not included w/rod)
-24	212-0044-00			1						SCREW, 8-32 x 1/2 inch, RHS
	- - - - -									
-25	384-0615-00			2						ROD, spacer
	- - - - -			-						mounting hardware for each: (not included w/rod)
-26	214-0370-00			1						PIN, locating
	- - - - -									
-27	387-0777-00			1						PLATE, rear
-28	351-0063-00			2						GUIDE, shoe
	- - - - -			-						mounting hardware for each: (not included w/guide)
-29	211-0013-00			2						SCREW, 4-40 x 3/8 inch, PHS
-30	210-0004-00			2						LOCKWASHER, internal, #4
-31	210-0406-00			2						NUT, hex., 4-40 x 3/16 inch
	- - - - -									
-32	131-0096-00			1						CONNECTOR, 32 contact
	- - - - -			-						mounting hardware: (not included w/connector)
-31	211-0097-00			2						SCREW, 4-40 x 5/16 inch, PHS
-34	210-0586-00			2						NUT, keps, 4-40 x 1/4 inch
	- - - - -									
-35	210-0202-00			2						LUG, solder, SE #6
	- - - - -			-						mounting hardware for each: (not included w/lug)
-36	211-0504-00			1						SCREW, 6-32 x 1/4 inch, PHS
-37	210-0407-00			1						NUT, hex., 6-32 x 1/4 inch
	- - - - -									
-38	129-0006-00			1						POST, connecting, insulated
	- - - - -			-						mounting hardware: (not included w/post)
-39	210-0006-00			1						LOCKWASHER, internal, #6
-40	210-0407-00			1						NUT, hex., 6-32 x 1/4 inch
	- - - - -									
-41	124-0145-00			3						STRIP, ceramic, 7/16 inch h, w/20 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0009-00			2						SPACER, plastic, 9/32 inch long
	- - - - -									
-42	124-0146-00			6						STRIP, ceramic, 7/16 inch h, w/16 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0009-00			2						SPACER, plastic, 9/32 inch long

Mechanical Parts List—Type 10A2A

FIG. 2 CHASSIS & REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				t	Y	1	2	3		4
2-43	124-0147-00			6						STRIP, ceramic, 7/16 inch h, w/13 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0009-00			2						SPACER, plastic, 5/32 inch long
-44	124-0148-00			4						STRIP, ceramic, 7/16 inch h, w/9 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0008-00			2						SPACER, plastic, 5/32 inch long
-45	124-0148-00			2						STRIP, ceramic, 7/16 inch h, w/9 notches
	- - - - -			-						each strip includes:
	355-0046-00			2						STUD, plastic
	- - - - -			-						mounting hardware for each: (not included w/strip)
	361-0009-00			2						SPACER, plastic, 5/32 inch long
-46	344-0105-00			5						CLIP, test point
-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	179-1115-00			1						CABLE HARNESS, Channel 2





STANDARD ACCESSORIES

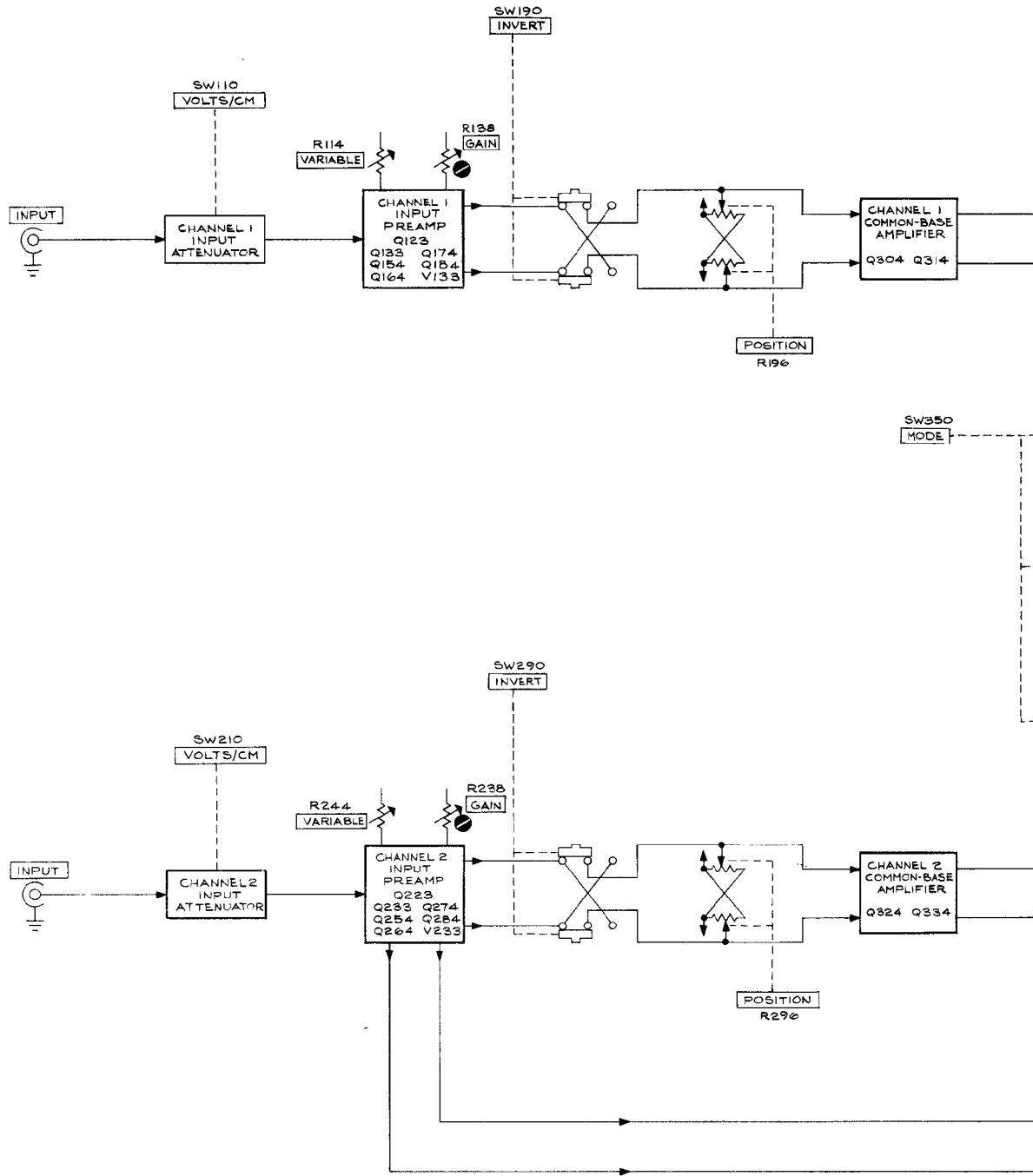
070-0615-00	2	MANUAL, instruction (not shown)
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# **SECTION 9**

## **DIAGRAMS**

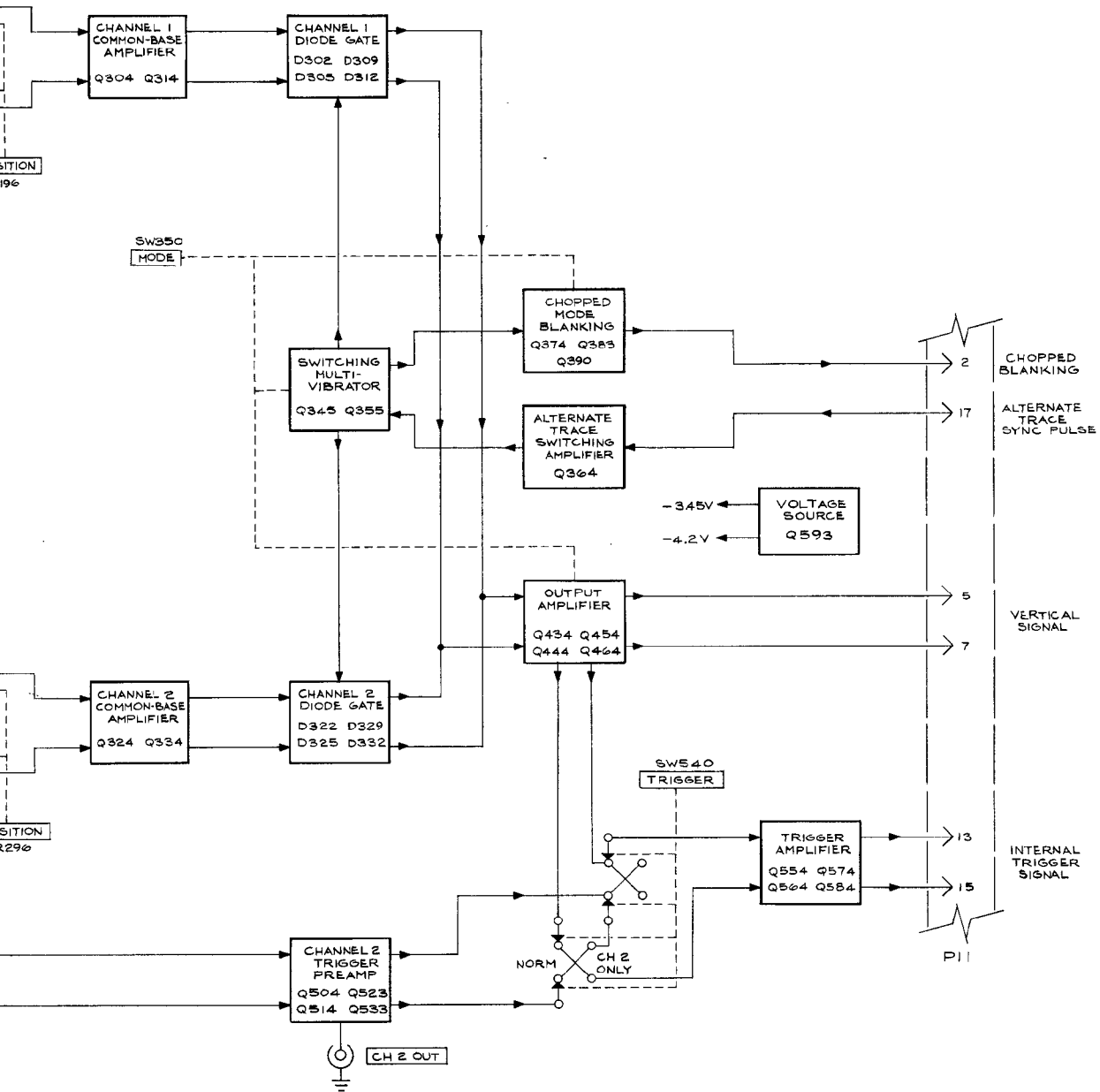
The following symbols are used on the diagrams:

	Screwdriver adjustment
	Front-, side- or rear-panel control or connector
	Clockwise control rotation in direction of arrow
	Refer to indicated diagram



TYPE 10A2A PLUG-IN

A



1266

BLOCK DIAGRAM

## VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements and waveform photographs were obtained under the following conditions unless noted otherwise on the individual diagrams:

### Test Oscilloscope (with 10× Probe)

Frequency response	DC to 50 MHz
Deflection factor (with 10× probe)	0.1 to 50 volts/division
Input impedance (with 10× probe)	10 Megohms, 7.5 pico- farads
Probe ground	Type 10A2A chassis ground
Trigger Source	External from A +Gate output connector of time-base unit to indi- cate true time relation ship between signals
Recommended type (as used for waveforms on diagrams)	Type 544 with Type 1A1 plug-in unit

### Voltmeter

Type	Nulling-type VTVM
Input impedance	10 megohms
Range	0 to 500 volts
Reference voltage	Type 10A2A chassis ground
Recommended type	Fluke Model 825A

### Type 10A2A Conditions

Line voltage of indicator oscilloscope	115 volts
Signal applied	Five-volt calibrator signal from indicator oscillo- scope for waveforms only
Trace position	Centered
Control settings	As follows except as noted otherwise on individual diagrams:

### (Both channels if applicable)

Input Coupling	DC
VOLTS/CM	1
VARIABLE	CAL
POSITION	Adjust for centered display
INVERT	Pushed in
TRIGGER	NORM
MODE	CH 1

### Indicator Oscilloscope Conditions

Intensity	Visible display
Focus	Adjust for optimum display
Astigmatism	Adjust for optimum display
Scale Illum	As desired
Calibrator	5 volts
Position (horizontal)	Midrange
Fine	Midrange

### Time-Base Unit Conditions

Coupling	AC
Source	Int
Slope	+
Level	Midrange
Trig Mode	Auto
Time/Cm	0.5 millisecond
Horiz Display	A

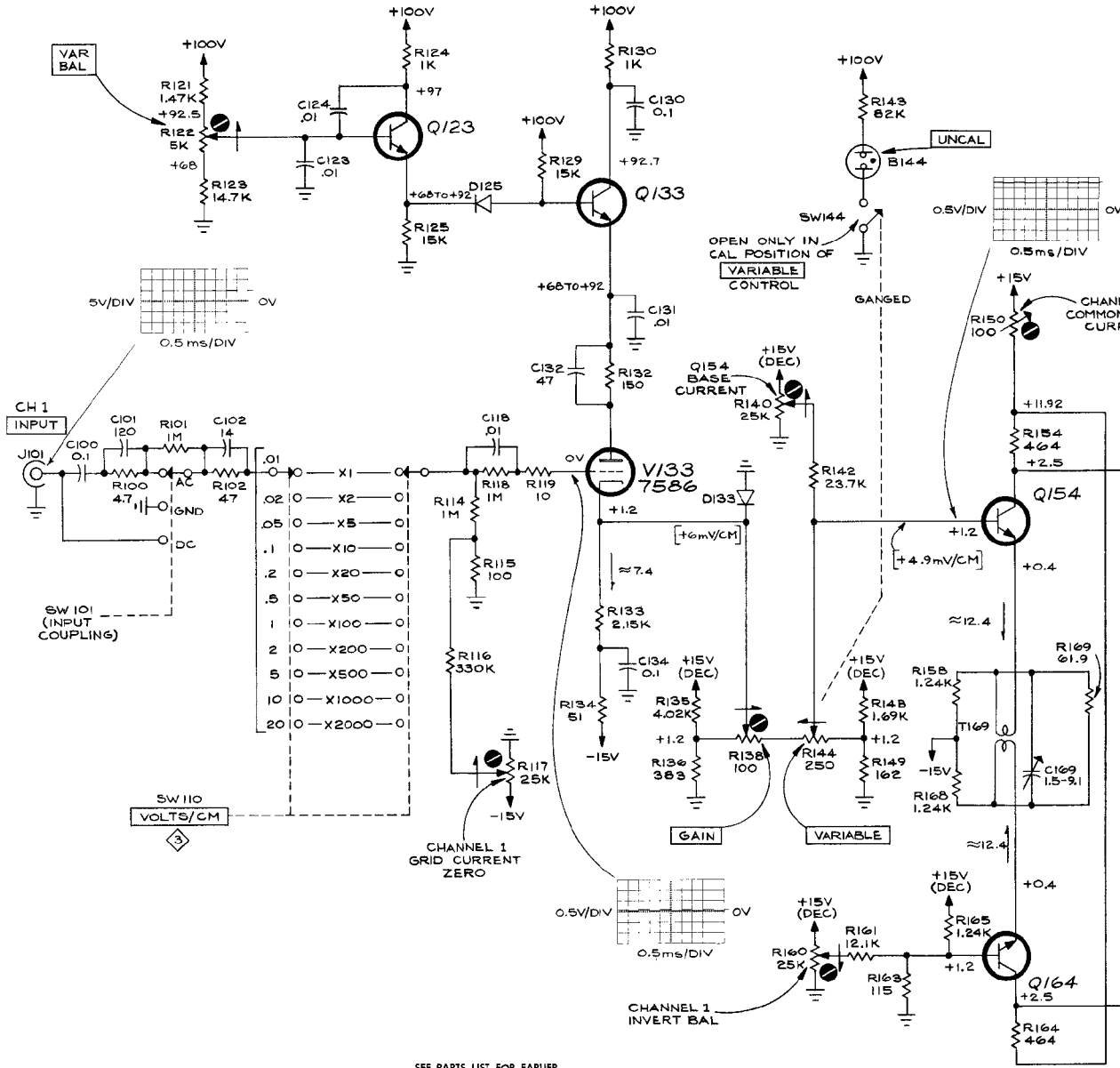
Voltages given on the diagrams are in volts, currents are in milliamps. Current flow shown in conventional current; i.e., + to -. Signal amplitudes given in volts/centimeter (in brackets) are the nominal amplitude with respect to ground. Differential amplitude is 2× the value shown. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule.

Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of differing component tolerances, internal calibration, front-panel control settings, meter loading or meter accuracy.





VOLTAGE & WAVEFORM  
CONDITIONS



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

VOLTAGES and WAVEFORMS obtained under  
conditions given on left side of this diagram,  
except as follows:  
VOLTAGES.....No signal applied

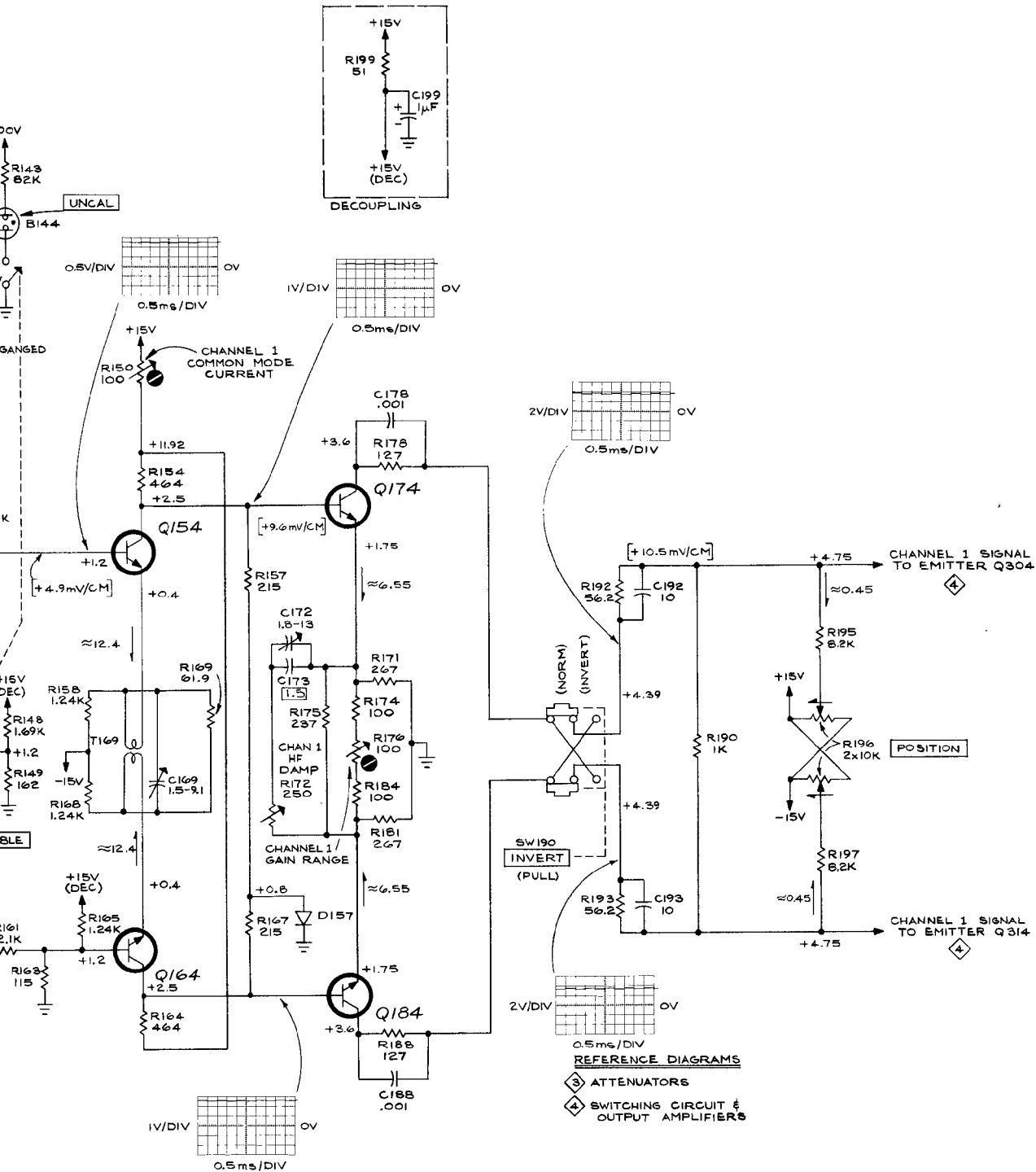
1V/DIV  
0.5ms

SEE PARTS LIST FOR  
SEMICONDUCTOR TYPE

TYPE 10A2A PLUG-IN

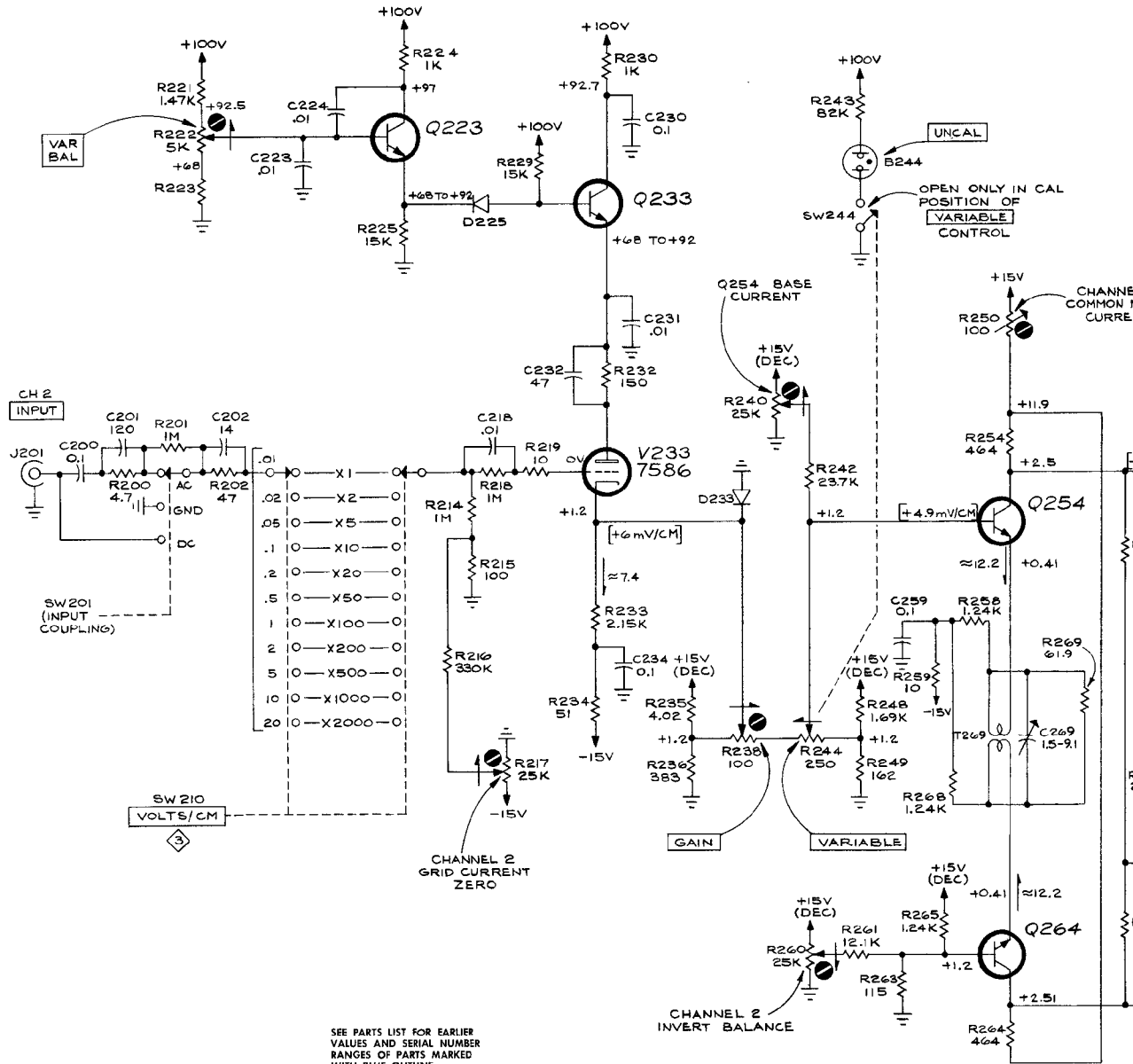
+

B



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

66T



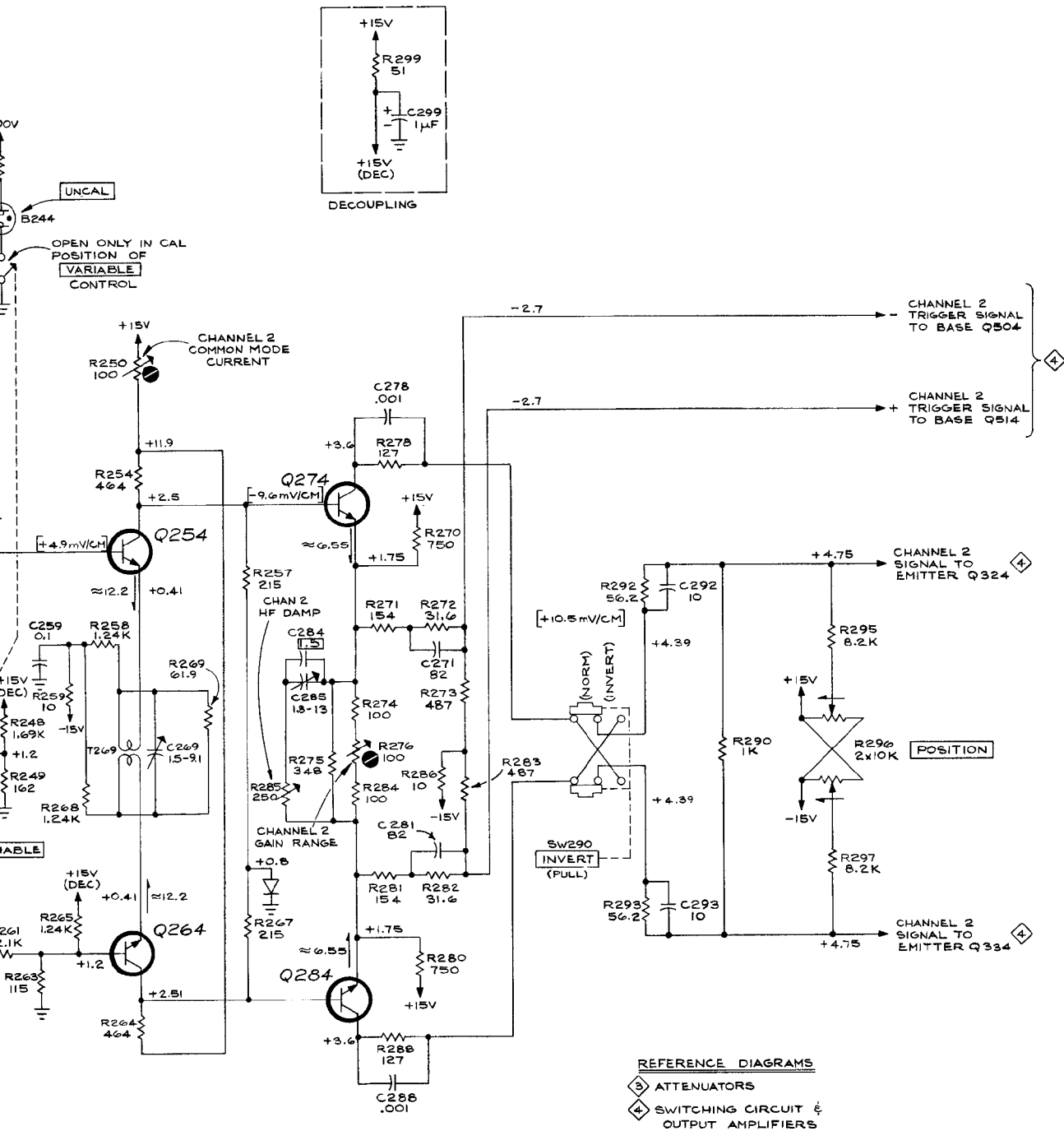
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGES obtained under conditions given on Diagram  $\diamond$ , except as follows:  
 VOLTAGES and WAVEFORMS  
 MODE.....CH 2  
 VOLTAGES only  
 .....No signal applied  
 For WAVEFORMS, see the Channel 1 Input Amplifier, Diagram  $\diamond$ .

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

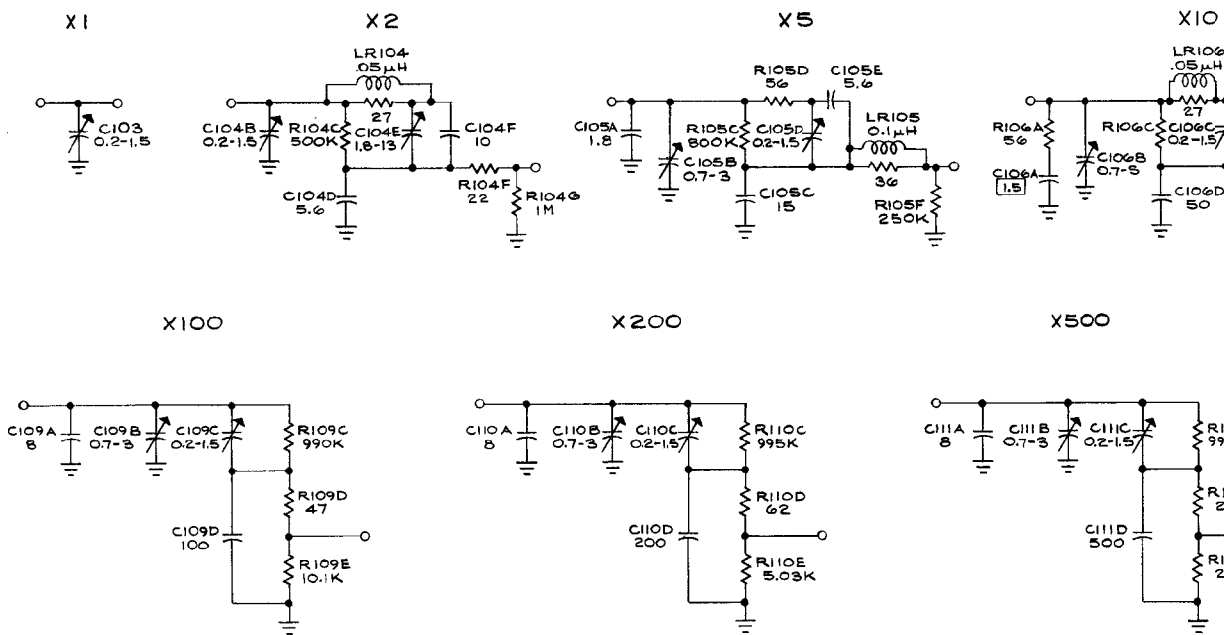
TYPE 10A2A PLUG-IN



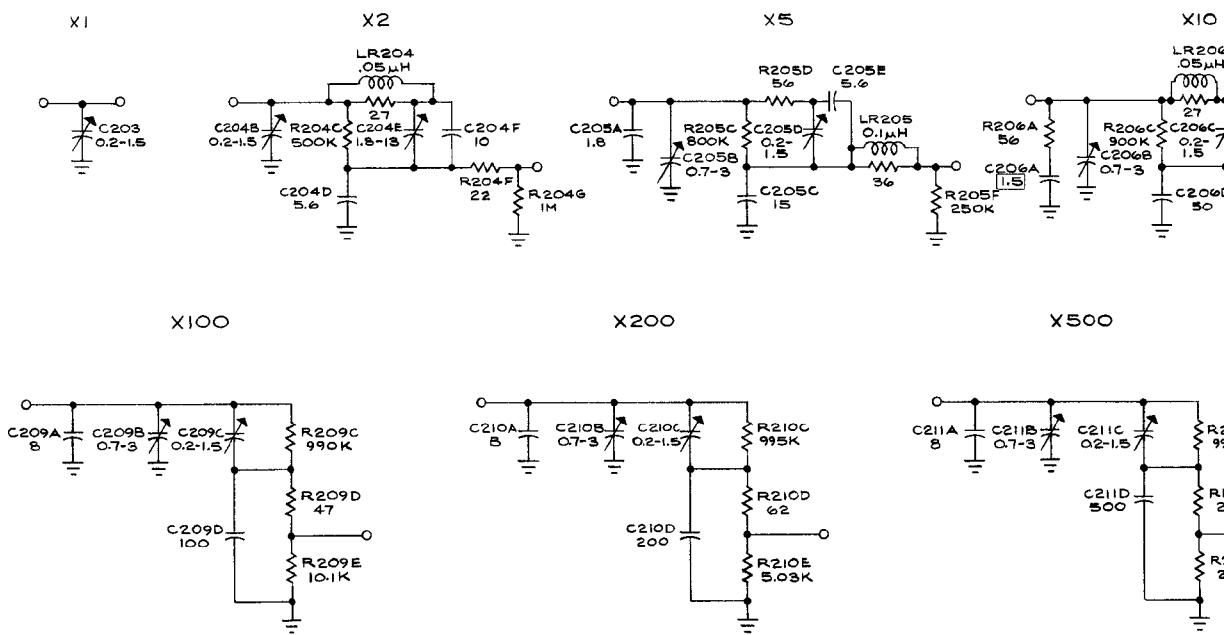


SEE PARTS LIST FOR SEMICONDUCTOR TYPES

CHANNEL 1



CHANNEL 2

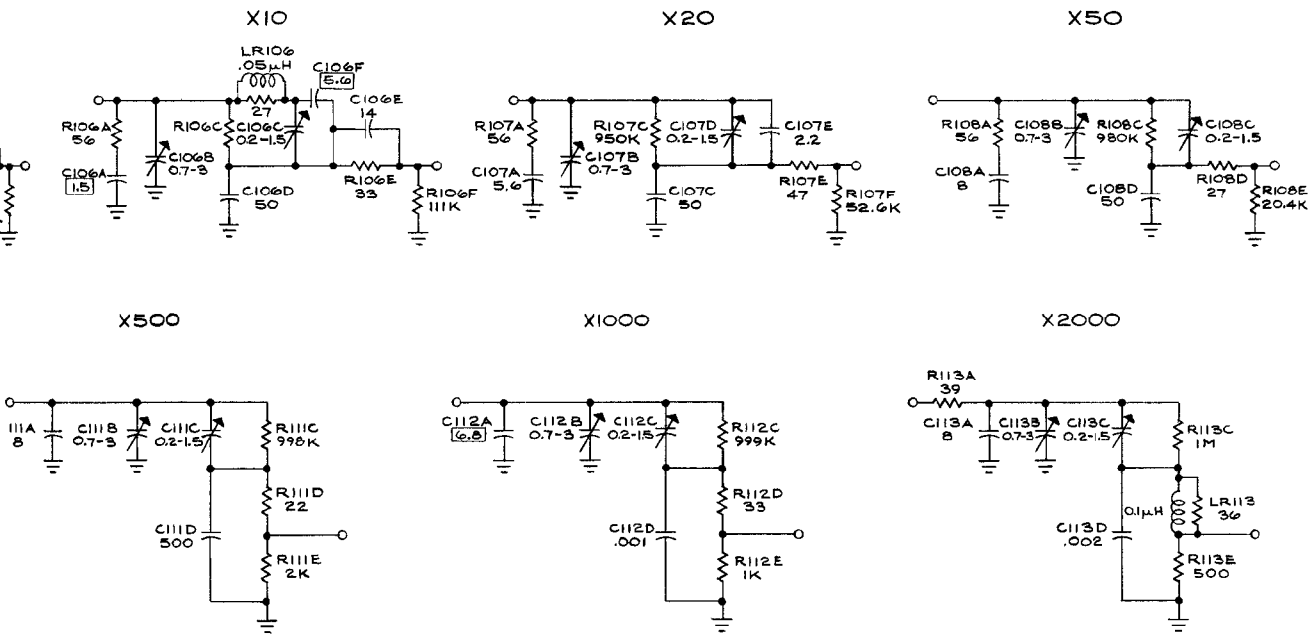


TYPE 10A2A PLUG-IN

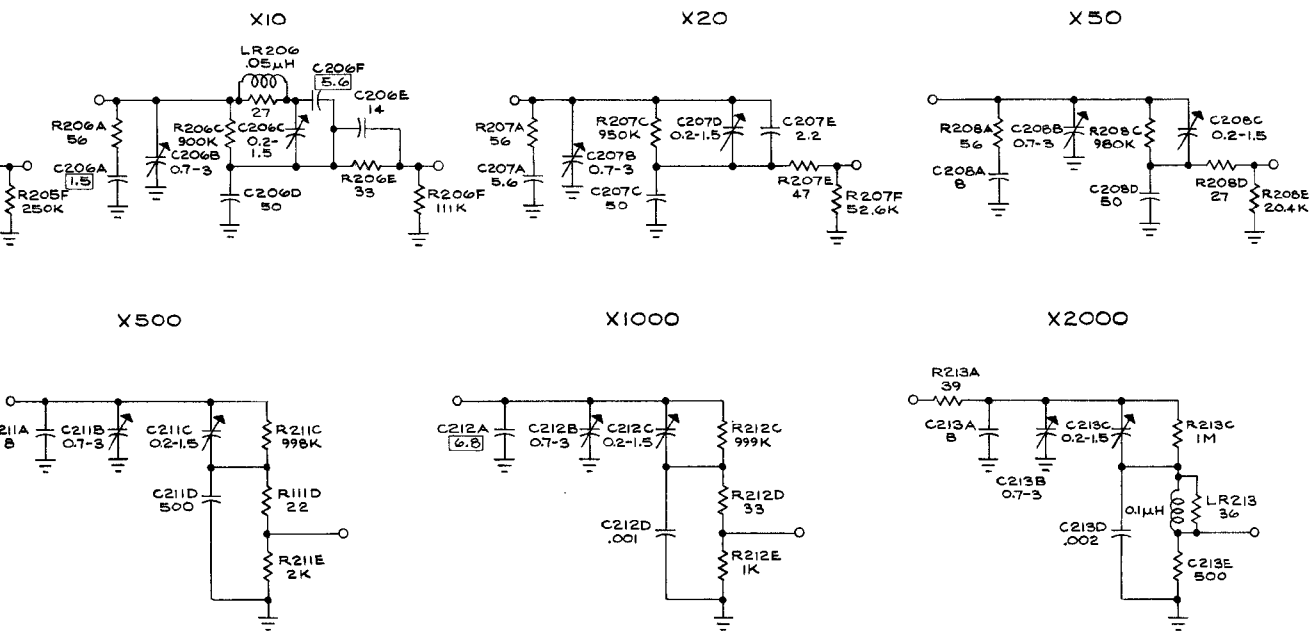
+



CHANNEL 1

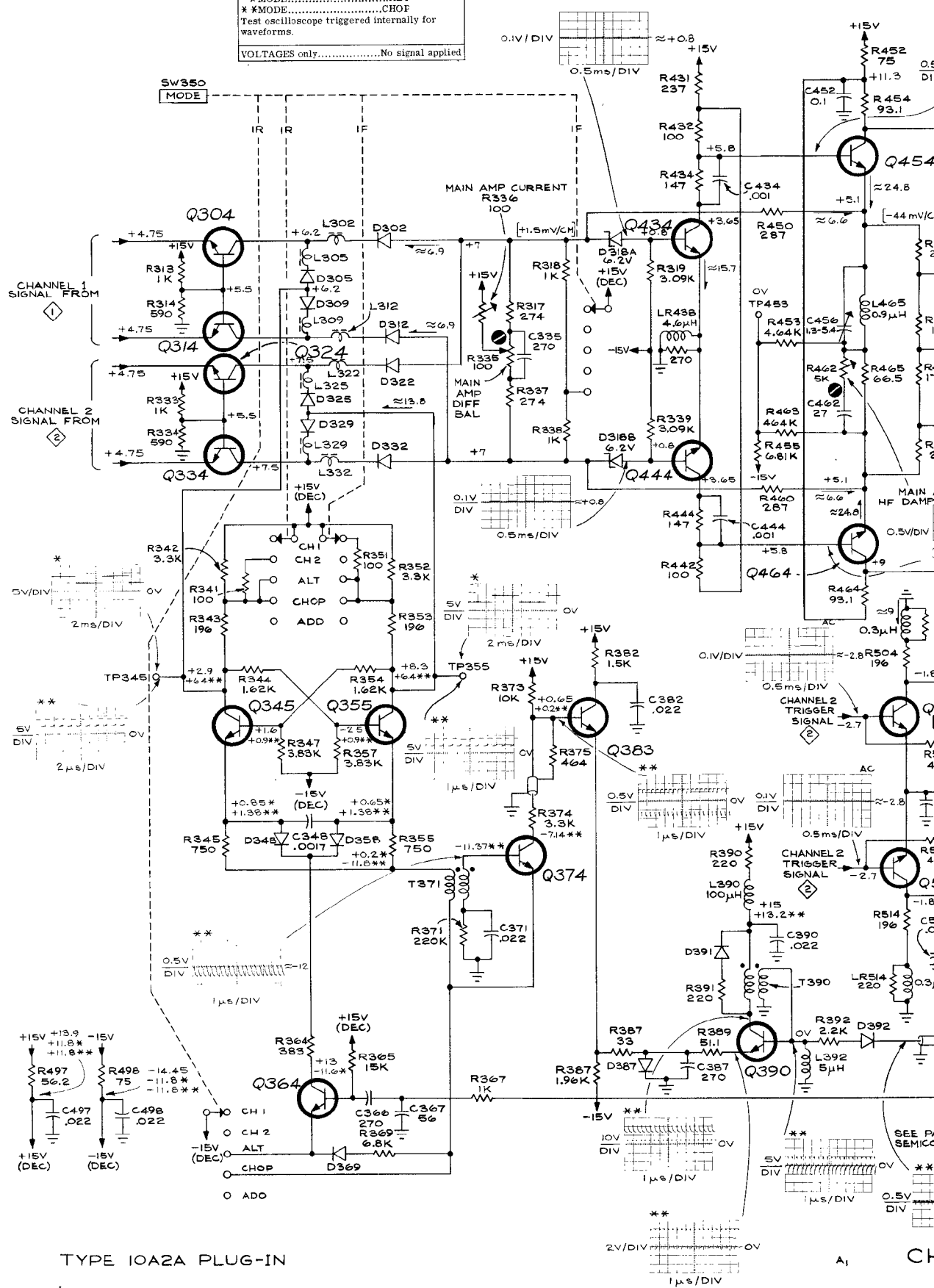


CHANNEL 2



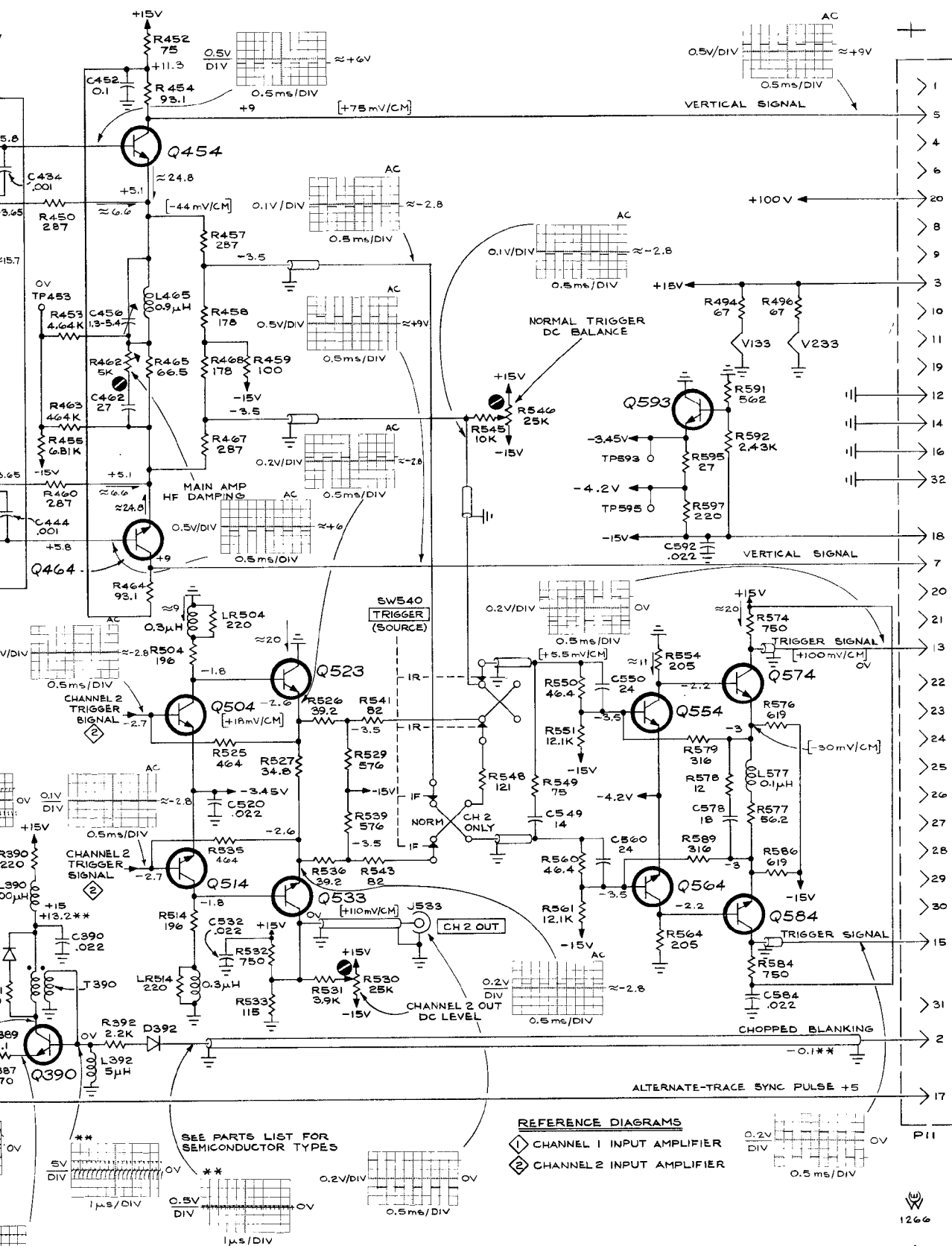
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

VOLTAGES and WAVEFORMS obtained under conditions given on Diagram  $\diamond$  except as follows:  
 VOLTAGES and WAVEFORMS:  
 \*MODE.....ALT  
 \*MODE.....CHOP  
 Test oscilloscope triggered internally for waveforms.  
 VOLTAGES only.....No signal applied



TYPE 10A2A PLUG-IN





A1 CHANNEL SWITCHING & OUTPUT AMPLIFIER ④



FIG. 1 FRONT

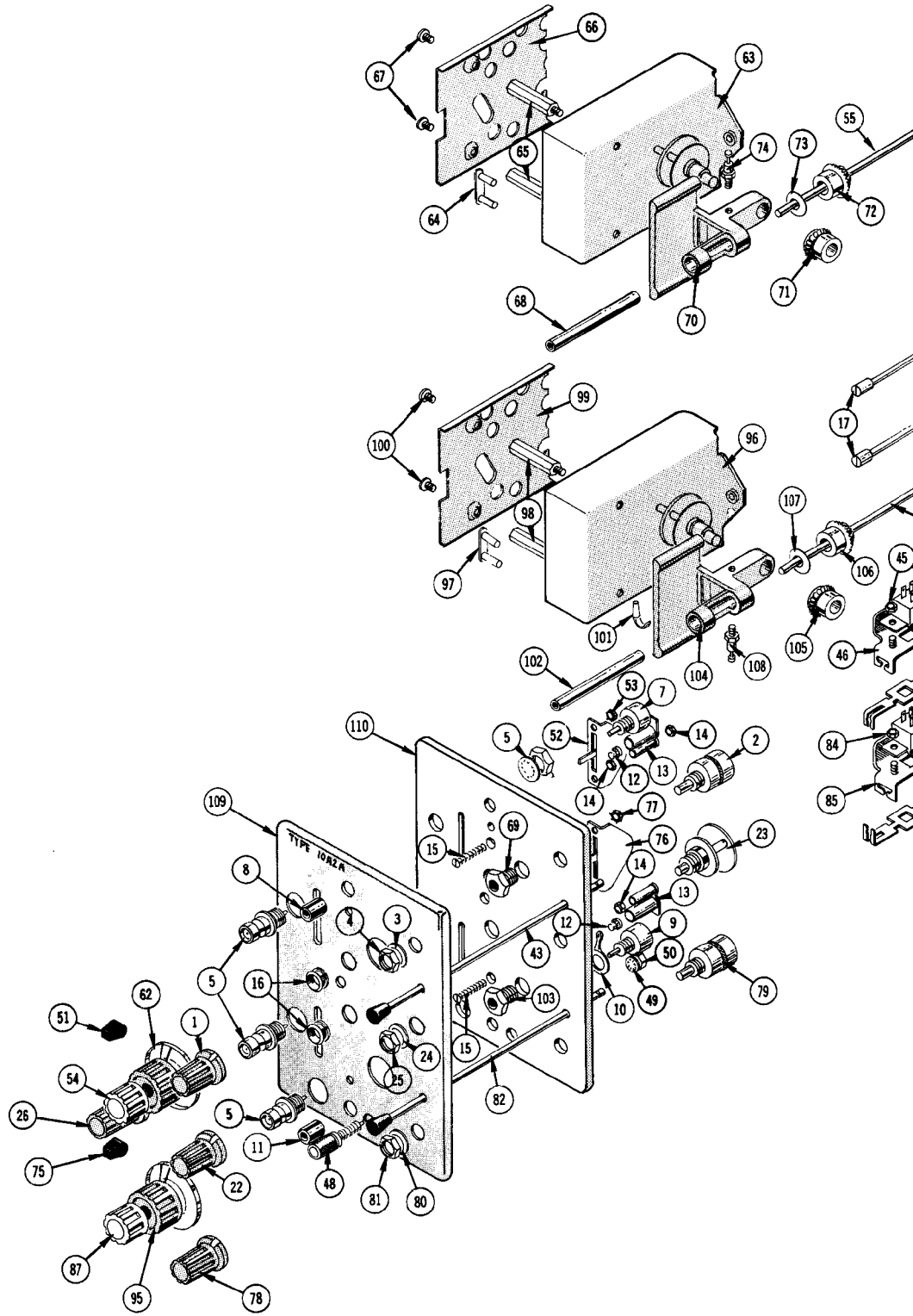
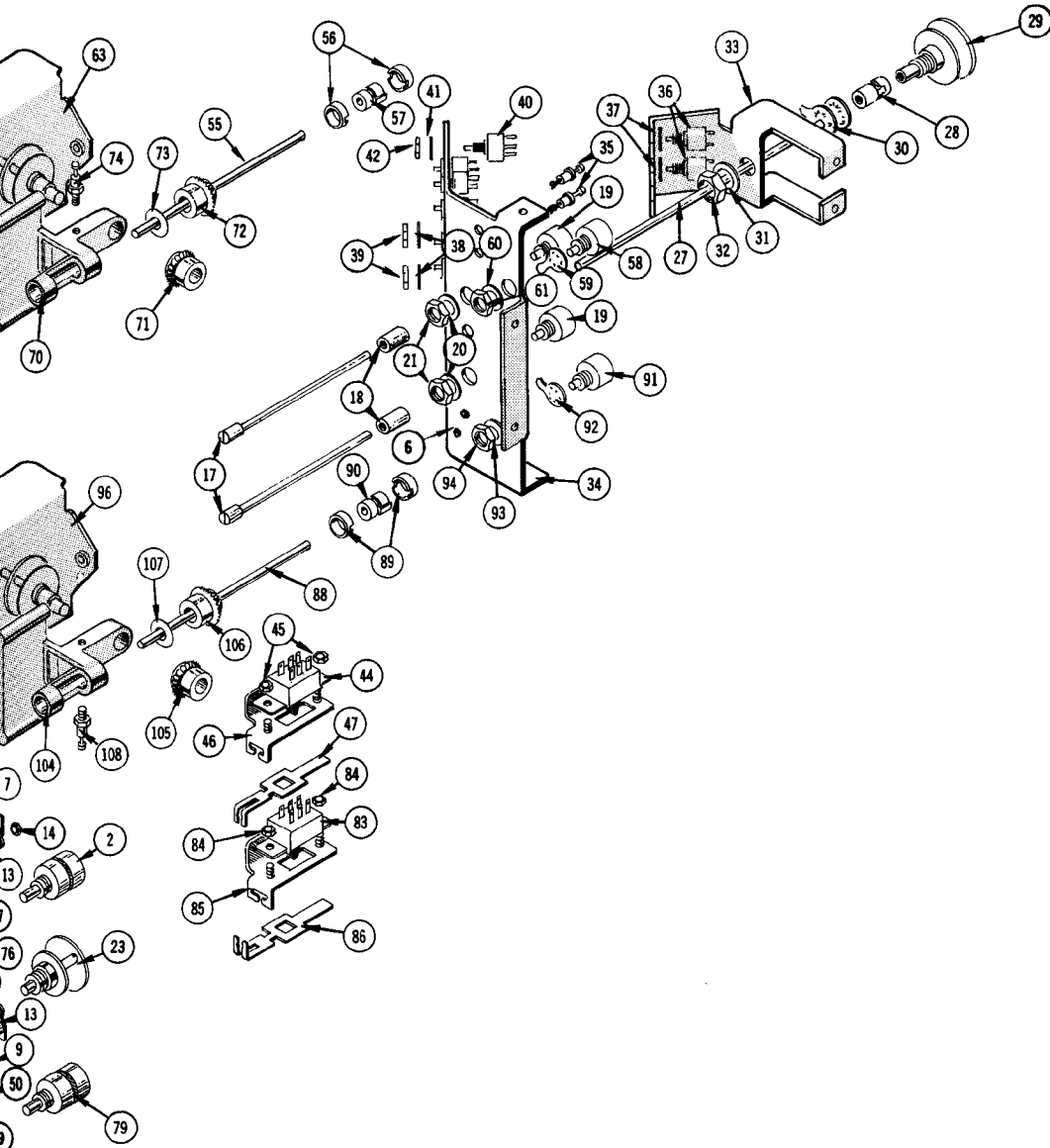


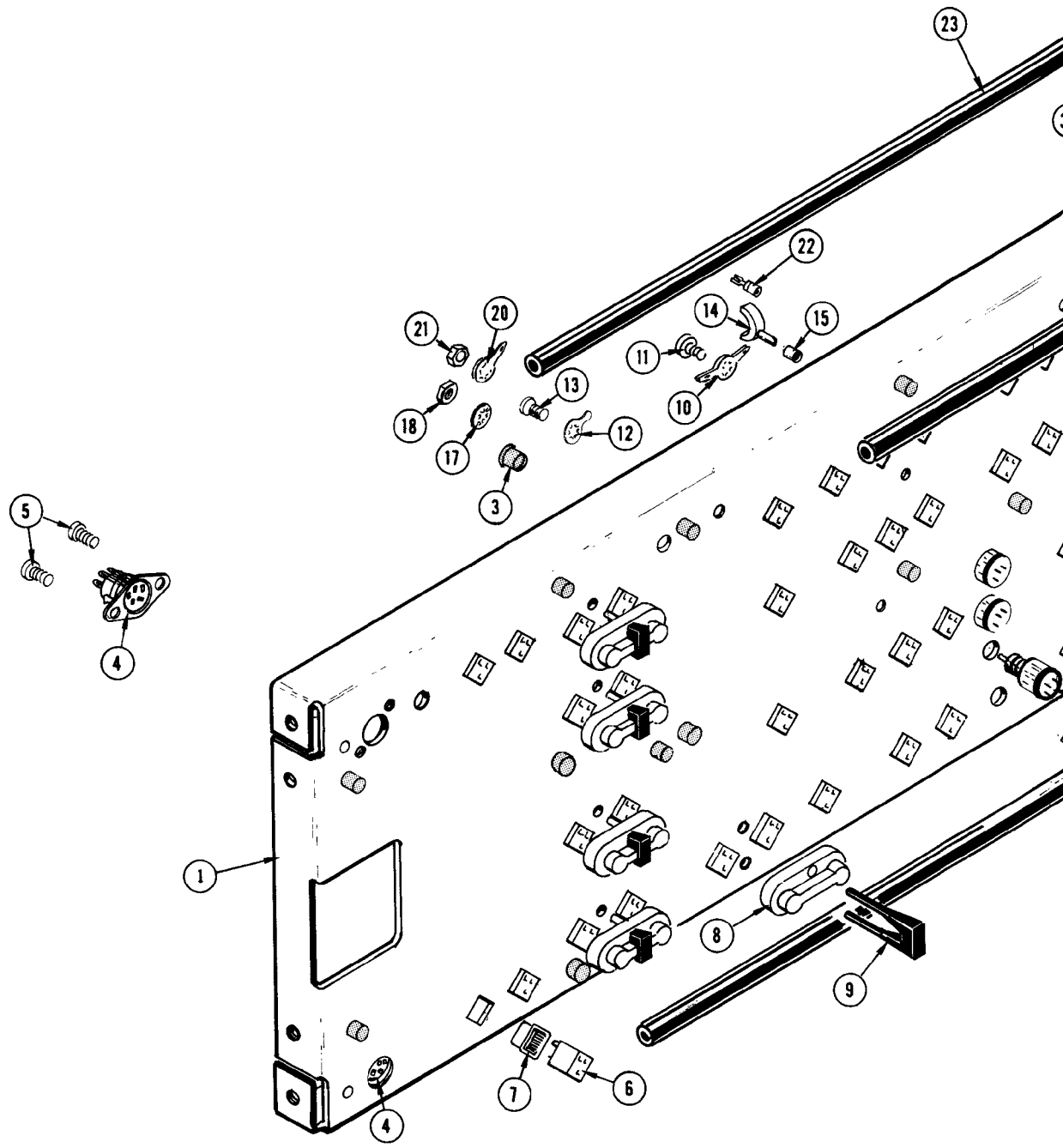
FIG. 1 FRONT

+



TYPE 10A2A DUAL-TRACE AMPLIFIER

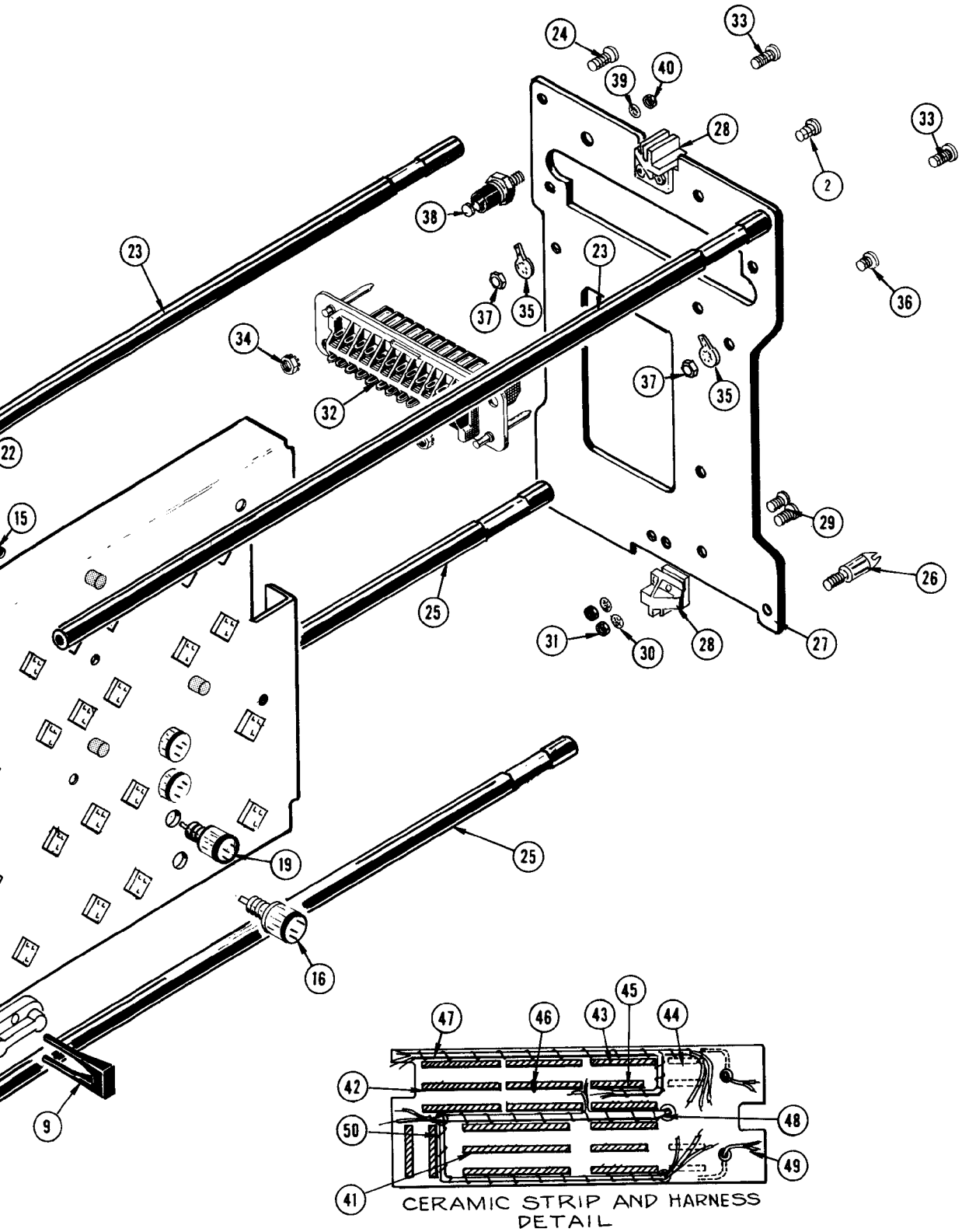
FIG. 2 CHASSIS & REAR



+<sup>A</sup>



FIG. 2 CHASSIS & REAR



TYPE 10A2A DUAL-TRACE AMPLIFIER

## **MANUAL CHANGE INFORMATION**

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

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

TYPE 10A2A

TENT SN B050570

PARTS LIST CORRECTION

CHANGE TO:

0348

283-0119-00

0.0022  $\mu$ F

Cer

200 V

TYPE 10A2A

TENT SN B040490

PARTS LIST CORRECTION

CHANGE TO:

C106A	281-0529-00	1.5 pF	Cer	500 V
C106F	281-0544-00	5.6 pF	Cer	500 V
C112A	281-0572-00	6.8 pF	Cer	500 V
C206A	281-0529-00	1.5 pF	Cer	500 V
C206F	281-0544-00	5.6 pF	Cer	500 V
C212A	281-0572-00	6.8 pF	Cer	500 V