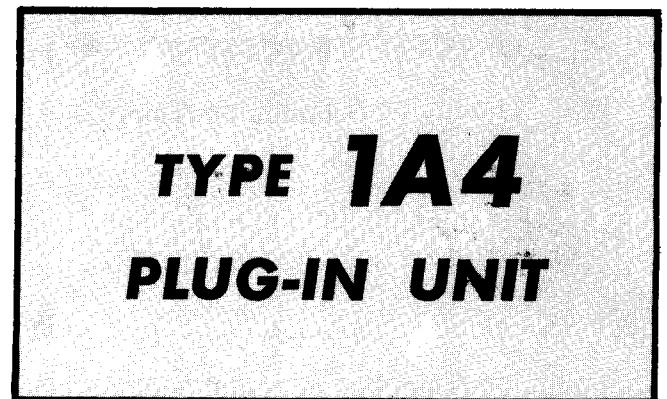


INSTRUCTION MANUAL

Serial Number _____



Tektronix, Inc.

S.W. Millikan Way ● P. O. Box 500 ● Beaverton, Oregon 97005 ● Phone 644-0161 ● Cables: Tektronix
070-0545-00



WARRANTY

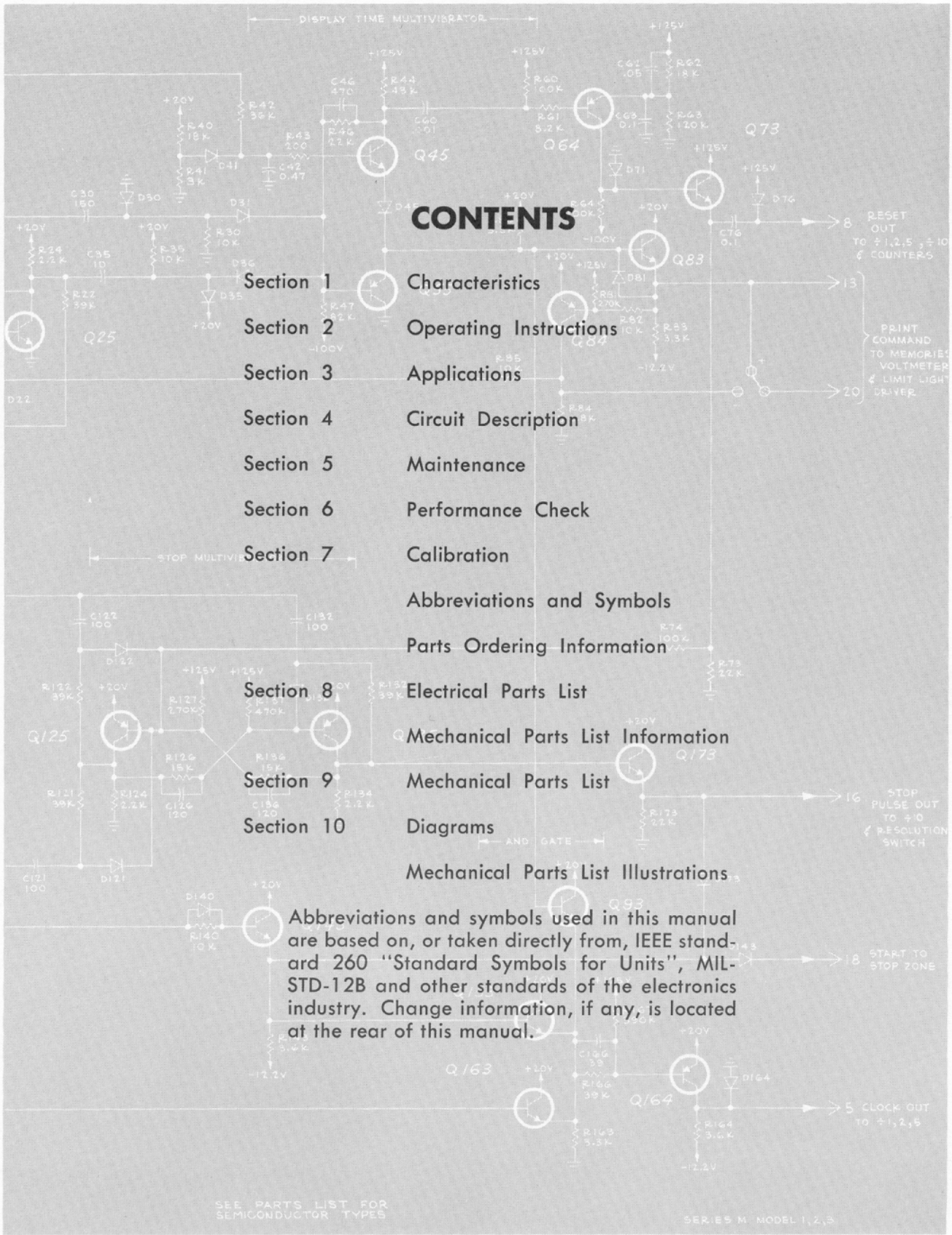
All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

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

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

Specifications and price change privileges reserved.

Copyright © 1967 by Tektronix, Inc., Beaverton, Oregon. Printed in the United States of America. All rights reserved. Contents of this publication may not be reproduced in any form without permission of the copyright owner.



CONTENTS

- Section 1 Characteristics
- Section 2 Operating Instructions
- Section 3 Applications
- Section 4 Circuit Description
- Section 5 Maintenance
- Section 6 Performance Check
- Section 7 Calibration
- Abbreviations and Symbols
- Parts Ordering Information
- Section 8 Electrical Parts List
- Section 9 Mechanical Parts List Information
- Section 10 Mechanical Parts List
- Diagrams
- Mechanical Parts List Illustrations

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 1A4 Four-Channel Amplifier.

SECTION 1

CHARACTERISTICS

Introduction

The Tektronix Type 1A4 is a four-channel 50 MHz plug-in unit designed to operate at maximum bandwidth in the Type 544, 546, 547 and 556 Oscilloscopes (including rackmounts). The unit provides four-channel operation for all 530-, 540-, 550- and 580¹-series oscilloscopes. It can also be used in conjunction with other oscilloscopes and devices through the use of a Tektronix Type 127, 132, or 133 plug-in power supply.

The Type 1A4 contains four identical fast-rise calibrated preamplifier channels. Each channel has its own input selector, attenuator, polarity and position controls which allows each display to be adjusted for optimum viewing. Basic deflection factor for each channel is 10 mV/cm.

The unique electronic switching logic of the Type 1A4 provides the versatility of two independent dual-trace units connected to the inputs of a third dual-trace unit without sacrificing bandwidth. For example, displays composed of channel 1 minus channel 2 can be chopped or alternated with channel 3 minus channel 4. As another example, the unit can be used in a "double-added" mode (channels 1 and 2 added to channels 3 and 4).

ELECTRICAL CHARACTERISTICS

The following performance requirements (center column data) apply over an ambient temperature range of 0°C to +50° C after a warm-up time of 20 minutes.

Characteristic	Performance Requirement	Supplemental Information
Deflection Factor	10 mV/cm to 20 V/cm in 11 calibrated steps for each channel.	Steps in 1-2-5 sequence.
Deflection Accuracy	Within $\pm 3\%$ of indicated deflection with VARIABLE V/CM control in the CAL (detent) position.	With gain correct at 10 mV/cm.
Added Accuracy	$\pm 1\%$ with V/CM switch set to .01.	
Variable Deflection Factor	Uncalibrated deflection factor at least 2.5 times the V/CM switch indication. This provides an uncalibrated deflection factor of at least 50 V/cm in the 20 V/cm position.	
Frequency Response (not more than -3 dB) using the Type 1A4 with Tektronix oscilloscopes: 544, 546, 547 or 556	DC to 50 MHz	
581, 581A, 585 or 585A	DC to 50 MHz with Type 81A Plug-In Adapter	DC to 33 MHz with Type 81 Plug-In Adapter
541, 541A, 543, 543A, 543B, 545, 545A, 545B or 555	DC to 33 MHz	
549	DC to 30 MHz	
551	DC to 27 MHz	
531, 531A, 533, 533A, 535 or 535A	DC to 15 MHz	
536	DC to 11 MHz	
Risetime (calculated minimum) using the Type 1A4 with Tektronix oscilloscopes:		Calculated using this formula: $\text{Risetime} = \frac{.35}{\text{Frequency}^2}$
544, 546, 547 or 556	7 ns	
581, 581A, 585 or 585A	7 ns with Type 81A Plug-In Adapter	11 ns with Type 81 Plug-In Adapter
541, 541A, 543, 543A, 543B, 545, 545A, 545B or 555	11 ns	

¹Type 81 or Type 81A Adapter is required.

²Oscilloscope/1A4 frequency at upper limit 3 dB down point.

Characteristics—Type 1A4

Characteristic	Performance Requirement	Supplemental Information
549	12 ns	
551	13 ns	
531, 531A, 533, 533A, 535 or 535A	24 ns	
536	32 ns	
Input Characteristics:		
DC Resistance		1 M Ω , $\pm 1\%$.
Capacitance		20 pF, $\pm 5\%$.
Maximum Input Voltage		600 V combined DC and peak AC.
Input Coupling Modes		AC or DC, selected by front-panel switch. GND position internally disconnects the signal and grounds the amplifier input circuit to provide a zero reference for the trace.
AC Low-Frequency Response		Typically -3 dB at 2 Hz direct. 0.2 Hz with $10\times$ probe.
Vertical Display Modes		Any two channels alternated, chopped, or added in any combination. Four channels (Channels 1 and 2 alternated, chopped, or added with Channels 3 and 4).
Chopping Repetition Rate	400 kHz, $\pm 20\%$.	To show successive 2.5 μ s (approx.) segments of each trace.
Chopped Blanking Pulse Width		0.4 to 0.8 μ s, measured at the 50% amplitude level. Chopped transient blanking occurs in all oscilloscopes except Types 536, 551, 581A and 585A.

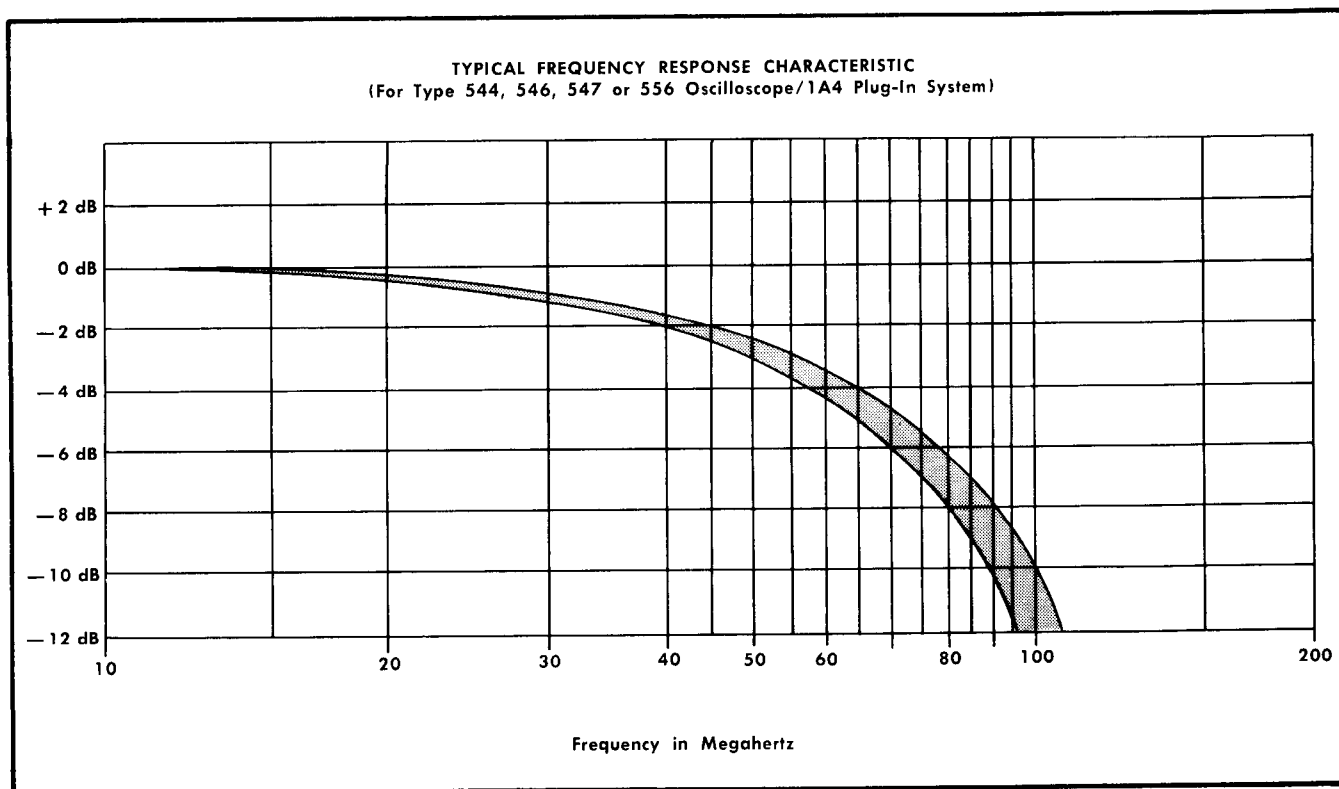


Fig. 1-2. Typical frequency response characteristic curve of the Type 1A4 for each channel when used in conjunction with the Type 544, 546, 547 or 556 Oscilloscope. A 25-ohm resistor source (generator 50-ohm output applied through a 50-ohm cable terminated in 50 ohms) was used to drive the Type 1A4.

Characteristic	Performance Requirement	Supplemental Information
Common-Mode Rejection Ratio	$\geq 20:1$ for signals from DC to 10 MHz.	Checked with 10 MHz common-mode sine-wave signals up to 10-cm in amplitude.
Polarity Inversion		Signal in any channel can be inverted.
Normal/Invert Trace Shift	< 1 cm at an ambient temperature of 25°C, $\pm 5^\circ\text{C}$.	When VAR BAL controls are adjusted for no trace shift.
Trigger Selector Balance Trace Shift	≤ 0.2 cm at an ambient temperature of 25°C, $\pm 5^\circ\text{C}$.	
Trace Drift with Time (after warm up), V/CM switch at .01		± 2 cm in any hour after a 20-minute warm up at 25°C, $\pm 5^\circ\text{C}$.
Channel Isolation:		
Attenuator	$\geq 5,000:1$ for signals from DC to 20 MHz.	
Amplifier	$\geq 50:1$ for signals from DC to 20 MHz.	
SIGNAL OUTPUT:		
Gain	≥ 0.5 V/cm of displayed signal.	SIGNAL OUTPUT connector unterminated.
Bandwidth	≤ 20 Hz to ≥ 10 MHz unterminated in all modes except chopped. ≤ 20 Hz to 500 kHz ($\pm 20\%$) in chopped mode.	With gray-on-white wire connected to pin M on the Logic board.
Output Impedance		Approximately 50 ohms.
Output Coupling		DC level: 0 V, ± 1 V at output stage and AC-coupled in preceding stages.

MECHANICAL CHARACTERISTICS

Construction Aluminum-alloy chassis with one plug-in circuit card and two circuit boards.

Finish Anodized front panel.

Operating

Temperature 0°C to +50°C.

Altitude To 15,000 feet.

ENVIRONMENTAL CHARACTERISTICS

Non-Operating

 Temperature -40°C to $+60^\circ\text{C}$.

 Altitude To 50,000 feet.

ACCESSORIES

Standard accessories supplied with this unit can be found on the last page in the Mechanical Parts List portion of the manual. For additional accessories, see the current Tektronix Inc. catalog.

SECTION 2

OPERATING INSTRUCTIONS

CONTROLS AND CONNECTORS

Introduction

A brief description of the function or operation of the Type 1A4 front- and rear-panel controls and connectors is provided here. On the front panel the controls and connectors are logically arranged so the signal path flow for each channel is from the Input connector upward. Channel 1 and 2 signal paths converge into the Ch¹ 1 & 2 MODE switch, Channel 3 and 4 signal paths converge into the Ch 3 & 4 MODE switch, and the outputs from both of these switches are then applied to the DISPLAY switch. Since the controls are arranged in this manner, the listing of the controls in this manual usually follows the same plan.

NOTE

The following Input connector and controls are identical for each channel.

Input	Signal input connector for the channel.
AC-GND-DC ²	Three-position lever switch to provide a choice of AC or DC input coupling for the applied signal. The GND position internally disconnects the signal and grounds the channel-amplifier input circuit to provide a zero reference for the trace.
V/CM	An eleven-position switch to select the calibrated deflection factors from .01 V/CM to 20 V/CM, in a 1-2-5 sequence.
VARIABLE	Varies the deflection factors between calibrated settings by at least a 2.5:1 ratio, allowing overlapping and continuously variable deflection factors from .01 V/CM to at least 50 V/CM. This control has 360° rotation and a detent position for the CAL (calibrated) position.
INVERT	When the INVERT knob is pulled outward, the display polarity is inverted with respect to the applied signal; when the INVERT knob is pushed in, the display presents the same polarity as the polarity of the applied signal.
VAR BAL	Screwdriver adjust potentiometer for varying the channel amplifier balance so the display DC level will remain stationary when turning the VARIABLE control.
POSITION	Positions the trace or display vertically on the CRT.

¹Abbreviation for "Channel".

²Can also be referred to as an Input Coupling switch.

IDENTIFY	A push-button switch that momentarily shifts the trace display upward a small amount to identify the respective channel.
GAIN	Screwdriver-adjust potentiometer for adjusting the common gain of all channels simultaneously. Compensates for slight gain variations between oscilloscopes.

Other Controls and Connector

Ch 1 & 2 MODE	A five-position 360°-rotation switch that selects the mode of operation as follows: CHANNEL 1—Displays Channel 1 only. ALT—Dual-channel alternate mode of operation (triggered electronic switching between channels during the sweep retrace interval). CHOP—Dual-channel chopped mode of operation (free-running electronic switching of channels at a rate of approximately 2 μs displayed time to 0.5 μs blanked time). ADD—Permits adding the outputs of the two channels algebraically. CHANNEL 2—Displays Channel 2 only.
Ch 3 & 4 MODE	Same as Ch 1 & 2 MODE switch but selects the mode of operation for Channels 3 and 4.
DISPLAY ³	A five-position switch that selects the type of display as follows: 1 & 2—Displays Channel 1 or 2, or 1 and 2, depending on position of Ch 1 & 2 MODE switch. ALT—Provides an alternating display between dual Channels 1 & 2 and Channels 3 & 4. A 547 TRACE SLAVING switch on the rear panel (see Fig. 2-1) provides for sweep-switching slave operation when the Type 1A4 is operated in the Type 547 Oscilloscope. When this rear-panel switch is set to LOCK, Channels 1 and 2 are slaved to A sweep and Channels 3 and 4 are slaved to B sweep. CHOP—Provides chopped operation between Channel 1 and 2 composite signal and Channel 3 and 4 composite signal. ADD—Adds the outputs of Channel 1 and 2 composite signal to Channel 3 and 4 composite signal.

³Includes a description of the 547 TRACE SLAVING switch located on the rear panel.

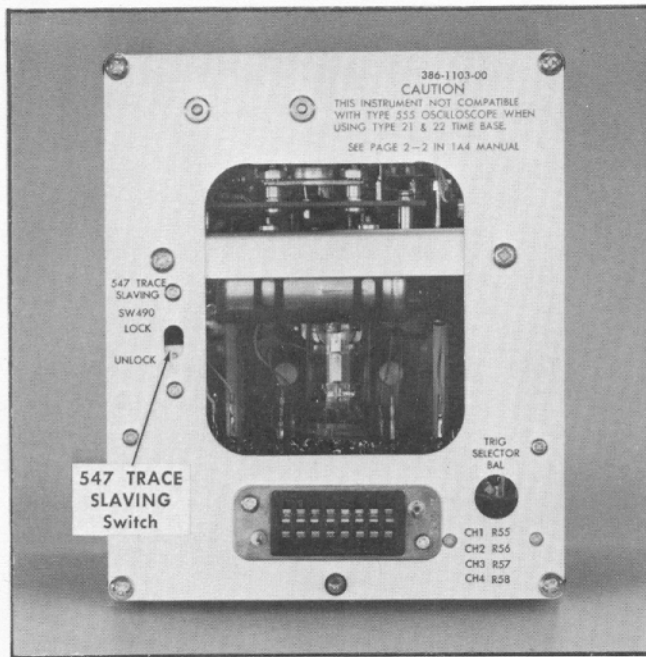


Fig. 2-1. Location of the 547 TRACE SLAVING switch. Type 1A4 rear view.

3 & 4—Displays Channel 3 or 4, or 3 and 4 depending on position of Ch 3 & 4 MODE switch.

SIGNAL & TRIGGER SOURCE

A four-position switch that selects the channel signal to be applied to the SIGNAL OUTPUT connector and to the plug-in internal trigger for oscilloscopes with plug-in trigger capabilities.

SIGNAL OUTPUT

Provides an output signal to be used for triggering purposes or cascade operation.

CAUTION

If the Type 1A4 is inserted in the upper-beam vertical plug-in compartment of a modified Type 555 Oscilloscope SN 101 to 6999 or in a Type 555 SN 7000 and up when the Type 21 and 22 Time-Base units are used instead of the Types 21A and 22A, +87 V from pin 19 in the Time-Base units is applied to pin 5 of the Type 1A4 interconnecting plug (see Fig. 2-2). This voltage will damage components in the Type 1A4 Trigger Amplifier circuit and cause the circuit to be inoperative.

In addition, the +87 V is a hazard because it is also applied to the SIGNAL OUTPUT connector. For proper Type 1A4 operation, remove the +87 V by disconnecting the white-gray wire that goes from pin 19 in the Types 21 and 22 to the ceramic terminal notch above V152.

(The Types 21A and 22A Time-Base units are compatible with the Type 1A4 and therefore do not require modification.)

FIRST-TIME OPERATION

The following procedure is a suggested method for becoming familiar with the Type 1A4 operation. This procedure assumes the oscilloscope has a 6-cm vertical scan area.

1. Set the 547 TRACE SLAVING switch to LOCK.

NOTE

To provide the best possible turn-on conditions for the unit, be sure the oscilloscope power is off before inserting the Type 1A4 in the compartment.

2. Insert the Type 1A4 into the oscilloscope plug-in compartment, tighten the securing rod (located at lower center of the front panel), and turn the oscilloscope power on.

3. Allow about 20 minutes warmup and free run the oscilloscope sweep at 0.5 ms/cm.

4. Set the Type 1A4 controls as follows:

AC-GND-DC (all)	GND
V/CM (all)	.01
VARIABLE (all)	CAL
INVERT (all)	knob pushed in
POSITION (all)	Midrange
Ch 1 & 2 MODE	CHANNEL 2
Ch 3 & 4 MODE	CHANNEL 4
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1

5. Using the Channel 2 POSITION control, position the trace about 1-cm below graticule center.

NOTE

If the trace cannot be positioned to the location as described in step 5, or if the trace shifts as the VARIABLE control is rotated counterclockwise from the CAL (detent) position, check the VAR BAL adjustment for the channel. Refer to the Variable Balance Adjustment procedure later in this section.

6. Set Ch 1 & 2 MODE switch to CHANNEL 1 and position the trace about 1 cm above graticule center. Check the VAR BAL adjustment for Channel 1 using the note described in step 5 as a guide.

7. Set the Ch 1 & 2 MODE switch to ALT and the oscilloscope Time/Cm switch to 50 ms. Observe that for each sweep cycle one channel is displayed and the other channel is shut off. Electronic switching of the channels occurs during the sweep retrace interval.

8. Set Ch 1 & 2 MODE switch to CHOP. Observe that both traces move simultaneously across the screen.

9. Set the oscilloscope Time/Cm switch to 10 μ s and adjust the oscilloscope triggering controls for +Int triggering and to obtain a stable triggered display. Notice that each trace is composed of many short-duration bits or segments with visible switching transients occurring from one trace to the other (see Fig. 2-3A).

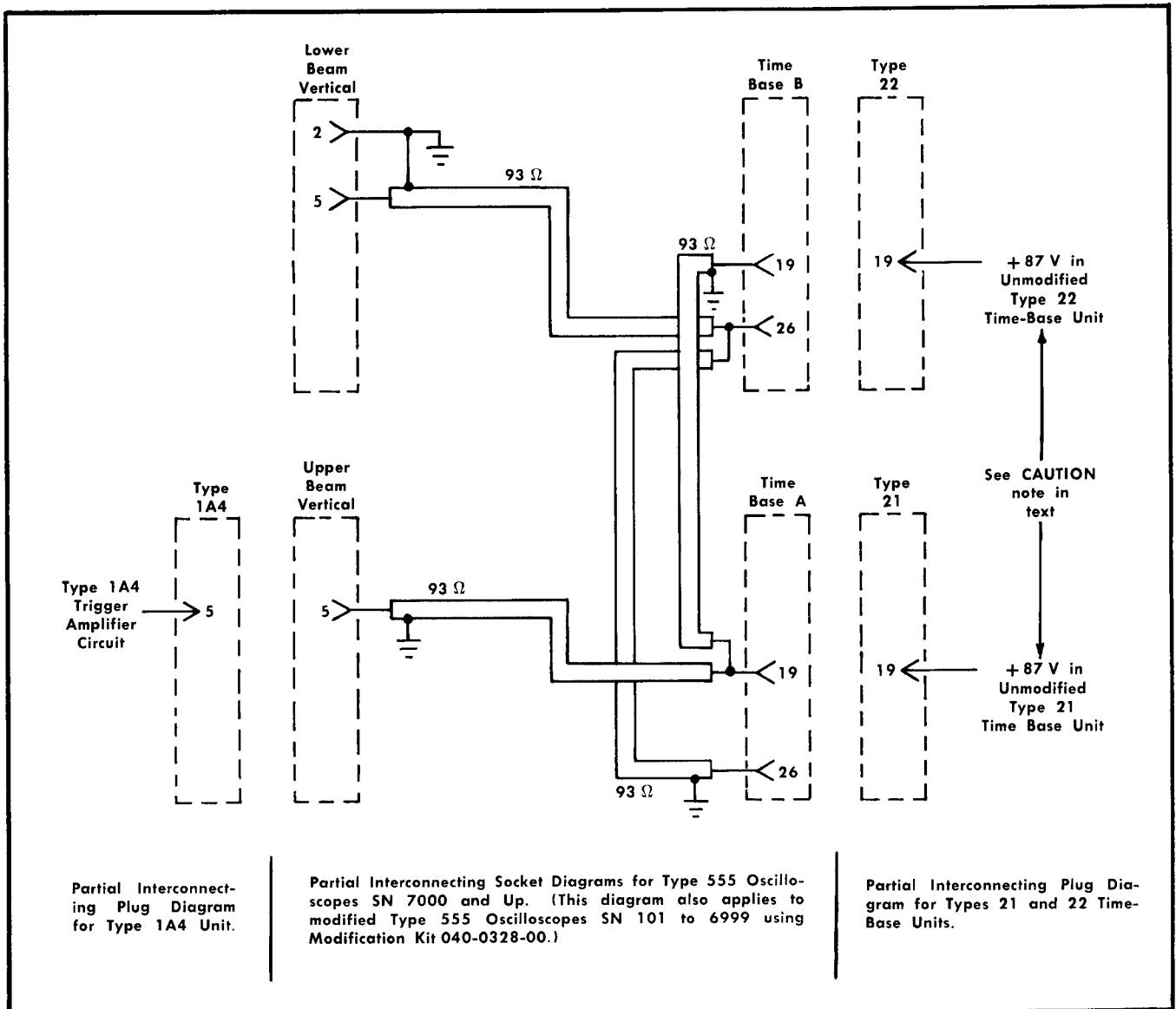


Fig. 2-2. Partial diagrams of the plug-in connectors to show why it is necessary to modify the Type 21 and 22 Time-Base units before inserting the Type 1A4 in the Type 555 upper-beam vertical plug-in compartment.

10. To see the chopped-mode switching action clearly, increase the sweep rate to $1 \mu\text{s}/\text{cm}$. Notice that Channel 1 is on for about $2.5 \mu\text{s}$ while Channel 2 is off for $2.5 \mu\text{s}$ (see Fig. 2-3B).

$$\text{Chopping Rate} = \frac{2}{\text{ON-time for Ch 1 \& 2 in } \mu\text{s}} = \frac{2}{\approx 5 \mu\text{s}} = \approx 400 \text{ kHz}$$

11. Blank out the switching transients between channels (see Fig. 2-3C) by setting the CRT Cathode Selector switch (located on the rear panel of most Tektronix oscilloscopes) to the Chopped Blanking position. Leave the switch in this position through step 26.

12. Set Ch 1 & 2 MODE switch to ADD, set the oscilloscope Time/cm to 0.5 ms, and free run the sweep.

13. Rotate the Channel 1 and 2 POSITION controls and observe that either POSITION control will move the trace.

NOTE

In the ADD position of the Ch 1 & 2 MODE switch, the DC positioning levels of both channels add; hence, if both position controls are rotated in the same direction, the trace moves twice as far as compared to the range of a single POSITION control. To keep the trace on the screen during normal operation of the unit in the ADD mode, be sure the POSITION controls are set near the centered position.

14. Set the DISPLAY switch to 3 & 4. Using steps 5 through 13 as a guide, check each position of the Ch 3 & 4 MODE switch while displaying the traces for Channels 3 and 4.

Operating Instructions—Type 1A4

Use the appropriate POSITION controls and be sure to check the VAR BAL adjustments.

15. Check that the oscilloscope Time/Cm switch is set to 0.5 ms and the sweep is free running. Set the Type 1A4 DISPLAY and both MODE switches to ALT. Set the oscilloscope Triggering Source switch to Ext to eliminate any internal triggering on the alternation of preamplifier DC levels, and allow the time base to free run at its own rate. Observe that four traces are displayed on the screen. Position the traces so they are about 1 cm apart with Channel 1 trace positioned about 2 cm above graticule center and the remaining channels positioned in succession below Channel 1.

16. Push the IDENTIFY button for each channel. The trace for each separate channel should move upward a small amount (typically about 3 mm) as the associated IDENTIFY button is pressed.

17. Set the Time/Cm to 50 ms. Observe that channels 1, 2, 3 and 4 are displayed in succession on the CRT.

18. If the Type 1A4 is being used with a Type 547 Oscilloscope, set the Horizontal Display switch to B Intens By 'A'/Alt/A-Dly'd position, set the Brightness control fully clockwise, set the Delay-Time Multiplier dial to 1.00, and set both time bases for 0.1-ms free-running sweep (check that the B Triggering Source switch is set to Ext). Set the Type 1A4 Ch 3 & 4 MODE switch to ALT. Observe that eight traces are displayed. Use the oscilloscope Trace Separation control to separate the traces so they can be easily distinguished. The sequence is as follows: Channel 1 is displayed by Time-Base B and then by Time-Base A, Channel 2 is displayed by Time-Base B and then by Time-Base A, Channel 3 is displayed by Time-Base B and then by Time-Base A, and finally Channel 4 is displayed by Time-Base B and then by Time-Base A.

19. Again, if the Type 1A4 is used with a Type 547 Oscilloscope, set the Horizontal Display switch to A/Alt/B. In this mode of operation four traces are obtained with Channels 1 and 2 locked to Time-Base A and Channels 3 and 4 locked to Time-Base B. The sequence is as follows: Channel 1 is displayed by Time-Base A, Channel 3 is displayed by Time-Base B, Channel 2 is displayed by Time-Base A and Channel 4 is displayed by Time-Base B. This mode of operation can be used advantageously when photographing a four-trace display in which two signals have a faster repetition rate than the other two. By applying the slower signals to Channels 3 and 4 and by using a slower B sweep rate, the Brightness control can be used to equalize the trace intensities so Channel 3 and 4 waveforms are about the same brightness as Channel 1 and 2 waveforms. Thus, a good photograph of all four waveforms can be obtained.

20. Returning to one time-base only oscilloscope operation (Type 547 Horizontal Display switch set to A or B), check that the Time/Cm switch is set to 0.1 ms and the Triggering Source switch is set to Ext to eliminate the internal triggers. Set the Type 1A4 Ch 3 & 4 MODE switch to CHANNEL 3. Observe that Channel 3 trace is slightly brighter than the other two traces. This is caused by the sequence as follows: Channel 1 runs once, Channel 2 runs once and Channel 3 runs twice. This mode of operation is useful when three channels are used and the faster risetime signal is applied to the channel that is running twice as often as the others. Thus, the fast-rise waveform can be displayed with improved brightness for observation and photographic purposes. Of course,

if a brighter-trace channel is not needed, the trace intensity for that channel can be returned to normal by including the 4th channel in the alternate-mode operation and positioning the unused 4th channel off the screen.

21. Set the Type 1A4 Ch 3 & 4 MODE switch to ALT, the DISPLAY switch to CHOP and check that the Ch 1 & 2 MODE switch is set to ALT. Set the oscilloscope controls so the sweep free runs at 0.2 s/cm. Notice that Channels 1 and 3 are displayed simultaneously and then Channels 2 and 4 are displayed together.

22. Increase the sweep to 10 μ s/cm. Set the oscilloscope Triggering controls for normal +Int triggered-sweep operation. Observe that each trace is composed of many short-duration bits or segments (see Fig. 2-3D).

23. Set the oscilloscope Time/Cm switch to 1 μ s to see the switching sequence clearly. Adjust the oscilloscope Triggering Level control to obtain a channel-switching sequence display such as the one shown in Fig. 2-3E.

24. Set the Ch 1 & 2 MODE switch to CHOP and the oscilloscope Time/Cm switch to 2 μ s. Adjust the Triggering Level control to obtain a stable display similar to the one shown in Fig. 2-3F. Observe that Channel 3 and 4 have twice as many segments as either Channel 1 or 2. If a similar display cannot be obtained, slight counterclockwise rotation of the oscilloscope Variable (Time/Cm) control will aid in synchronizing the Type 1A4 chopped and alternate switching action sufficiently to duplicate the triggering point. After observing the display, return the Variable (Time/Cm) control to the Calibrated position.

25. Set Ch 3 & 4 MODE switch to CHOP and observe that all four traces are chopped in sequence (see Fig. 2-3G). Use the oscilloscope Triggering Level control to select the desired triggering point.

26. Return the CRT Cathode Selector switch to the Ext CRT Cathode position.

27. Set the DISPLAY and both MODE switches to ADD. Observe that only one trace is obtained and all four POSITION controls can be used to position the trace. Also, as described in step 13 note, take into consideration that the DC positioning levels all add algebraically; therefore, to properly position the trace on the screen, all the POSITION controls should be centered and then adjusted in equal increments in the same direction to position the trace to a desired point on the screen.

28. Perform this step if the Type 1A4 is used with an oscilloscope that is capable of being internally triggered direct from the plug-in unit; that is, the oscilloscope Triggering Source switch has a Plug-In position. To demonstrate internal plug-in triggering, apply a 10-mV signal through a coaxial cable from the oscilloscope Amplitude Calibrator to the Channel 1 INPUT connector. Set the front-panel controls as follows:

Type 1A4

AC-GND-DC (Ch 1)	DC
MODE (both)	ALT
DISPLAY	ALT

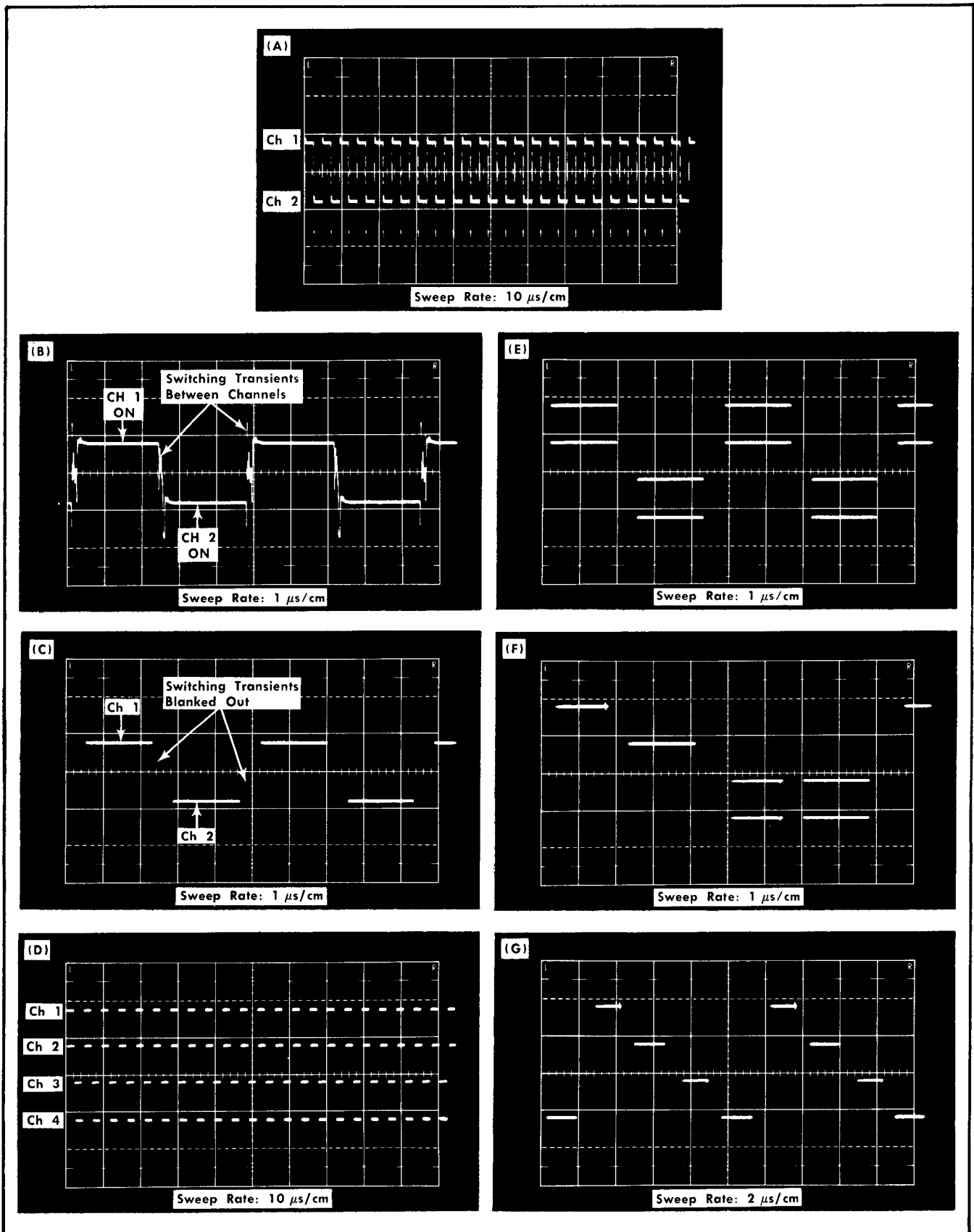


Fig. 2-3. Typical chopped mode waveforms obtained when performing the First-Time Operation procedure.

Operating Instructions—Type 1A4

Oscilloscope

Triggering:	
Level	Near 0 and knob pushed in
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Plug-In
Time/Cm	.2 mSec

Check that the remaining Type 1A4 controls are set to these positions:

AC-GND-DC (Ch 2, 3 & 4)	Gnd
V/CM (all)	.01
VARIABLE (all)	CAL
INVERT (all)	Knobs pushed in
POSITION	Traces positioned in channel sequence about 1-cm apart
SIGNAL & TRIGGER SOURCE	1

Adjust the oscilloscope Triggering Level control to obtain a stable Channel 1 display. Observe that four traces are obtained with Channel 1 displaying the calibrator signal. Now set the oscilloscope Triggering Source switch to Int and notice that a flickering display of all four traces is obtained.

29. To demonstrate external triggering from a single channel when the associated oscilloscope does not have the Plug-In triggering source feature, use the same procedure as described in step 28 with the following exceptions: Set the oscilloscope Triggering Source switch to Ext and connect a coaxial cable from the Type 1A4 SIGNAL OUTPUT connector to the oscilloscope Trigger Input connector. Return the Triggering Source switch to the Normal Internal position. This completes the First-Time Operation procedure.

Before using the Type 1A4 for accurate amplitude measurements, the front-panel master GAIN adjustment should be checked. The procedure for this adjustment and the VAR BAL adjustments are described in the instructions that follow.

Variable Balance Adjustments

If the DC balance of a channel is not properly adjusted, the CRT DC-reference-level position of the trace will shift as the VARIABLE control for that channel is rotated. In addition, severe DC imbalance can affect the gain of the channel and, hence, affect the vertical deflection factor. Therefore, the VAR BAL adjustment should always be checked first before checking the GAIN adjustment.

Though the adjustment procedure for Channel 1 is described here, the same basic procedure is used for the other channels. To properly set the DC balance, allow sufficient warm-up time (about 20 minutes) and then proceed as follows:

1. Set the front-panel controls as follows:

Type 1A4

AC-GND-DC (Ch 1)	GND
------------------	-----

V/CM (Ch 1)	.01
VARIABLE (Ch 1)	CAL
INVERT (Ch 1)	Knob pushed in
POSITION (Ch 1)	Midrange
Ch 1 & MODE DISPLAY	CHANNEL 1 1 & 2

Oscilloscope

Time/Cm	.5 mSec
Triggering	Set to free run the sweep

NOTE

If the trace is not located within ± 2 cm of graticule center after allowing a 20-minute warm-up time, preadjust the Channel 1 VAR BAL control to position the trace to the graticule center horizontal line.

The VAR BAL control for each channel is a 20-turn variable resistor that has no mechanical stops (uses a slip-clutch arrangement to prevent over-travel damage) for the adjusting screw. Clockwise rotation moves the trace upward and counterclockwise rotation moves the trace downward with the appropriate INVERT knob pushed in.

2. Rotate the Channel 1 VARIABLE control about 10° clockwise to move the control out of the CAL (detent) position. Note the direction and the distance the trace moves.

3. Return the Channel 1 VARIABLE control to the CAL position.

4. Carefully adjust the Channel 1 VAR BAL control so the trace moves in the same direction as the trace moved in step 2. Continue rotating the control until the trace moves to a point that is 1.4 times the distance noted in step 2.

5. As a final adjustment, rotate the Channel 1 VARIABLE control back and forth between the CAL and the 10° clockwise position. At the same time, adjust the VAR BAL control until there is no trace shift.

NOTE

As an alternative method replacing steps 2 through 5, proceed as follows: Rotate the VARIABLE control back (about 180° counterclockwise from the CAL detent position) and forth (clockwise toward, but not all the way back to, the detent position). If there is a trace shift, adjust the VAR BAL control for no trace shift while the VARIABLE control is rotated back and forth in the given range.

6. Return the Channel 1 VARIABLE control to the CAL position.

Gain Adjustment

The master GAIN adjustment should be checked periodically to assure the correct vertical deflection factor for all channels, particularly when the Type 1A4 is used for the first time or is moved from one oscilloscope to another. Allow about 20 minutes for instrument warm up. Be sure to

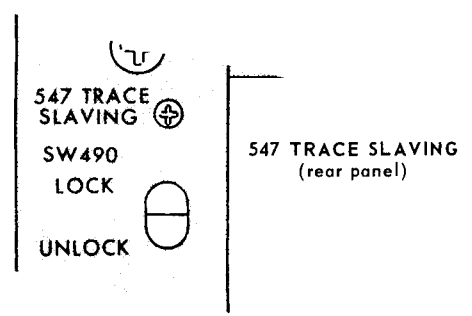
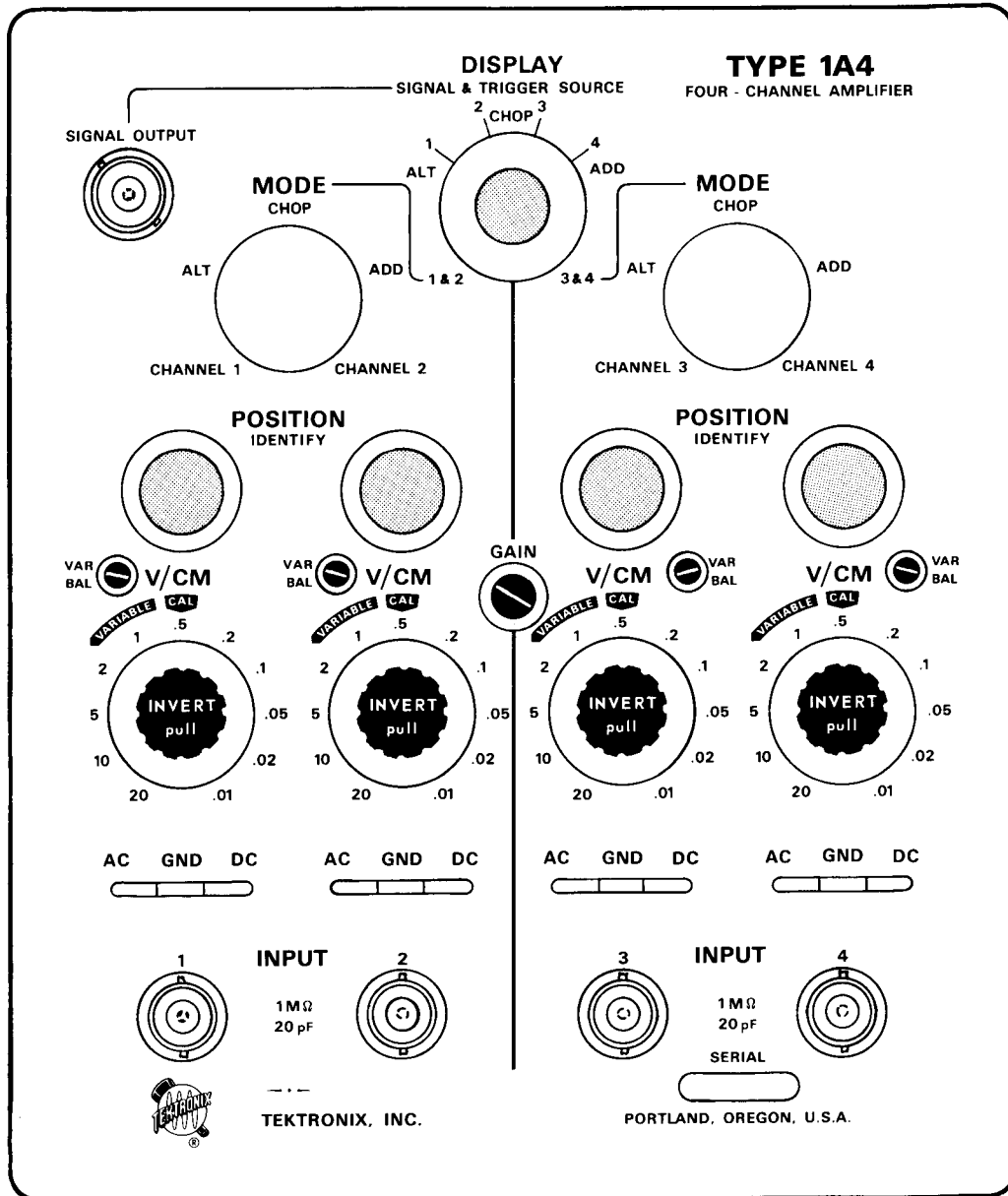


Fig. 2-4. Control setup chart.

Operating Instructions—Type 1A4

check the channel 1 VAR BAL adjustment, if you have not already done so, before checking the GAIN adjustment. Use the following procedure to check the vertical deflection factor:

1. Set the front-panel controls as follows:

Type 1A4

AC-GND-DC (Ch 1)	DC
V/CM (Ch 1)	.01
VARIABLE (Ch 1)	CAL
INVERT (Ch 1)	Knob pushed in
POSITION (Ch 1)	Midrange
Ch 1 & 2	CHANNEL 1
DISPLAY	1 & 2

Oscilloscope

Time/Cm	.1 mSec
Triggering	Set to free run the sweep

2. Apply a 50 mV peak-to-peak signal from the oscilloscope Amplitude Calibrator through a coaxial cable to the Channel 1 Input connector.

NOTE

The accuracy of the Type 1A4 deflection factors will be related directly to the amplitude accuracy of the signal used. In order for the Type 1A4 deflection factors to be within the specified $\pm 3\%$ limits, the calibrating signal must be accurate to within 0.3%. (The Tektronix Standard Amplitude Calibrator, Part No. 067-0502-00 meets the accuracy requirements.)

3. The resulting display should be exactly 5 cm in amplitude. If not, adjust the GAIN control for correct waveform

amplitude. (Use the Channel 1 POSITION control to align the display with the graticule markings.)

NOTE

If the oscilloscope being used for this procedure has a graticule height of 4 cm, use a 20 mV-signal and check for a vertical deflection of 2 cm.

If the gain of two or more channels must be closely matched (such as for ADD mode rejection), step 10 (Adjust Preamplifier Gain R77) procedure given in the Calibration section should be used.

4. Disconnect the calibrator signal.

Control Setup Chart

Fig. 2-4 shows a drawing of the Type 1A4 front panel and the 547 TRACE SLAVING switch positions. If this control setup chart is used in conjunction with a setup chart for the associated oscilloscope, both charts 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 operation of the Type 1A4/oscilloscope system.

GENERAL OPERATION

Any of the channels can be used independently by setting the DISPLAY and appropriate MODE switch to the channel(s) desired. Connect the signal to be observed to the appropriate input connector. Table 2-1 lists several methods for applying the signal to the Type 1A4. Fig. 2-5 shows a component-sequence illustration for Method 8 outlined in Table 2-1. Fig. 2-6 shows the input impedance vs frequency curves for the Type 1A4 to show that capacitive reactance (X_c) and resistance (R) decreases as frequency increases. This effect increases loading on the circuit under test as frequency increases.

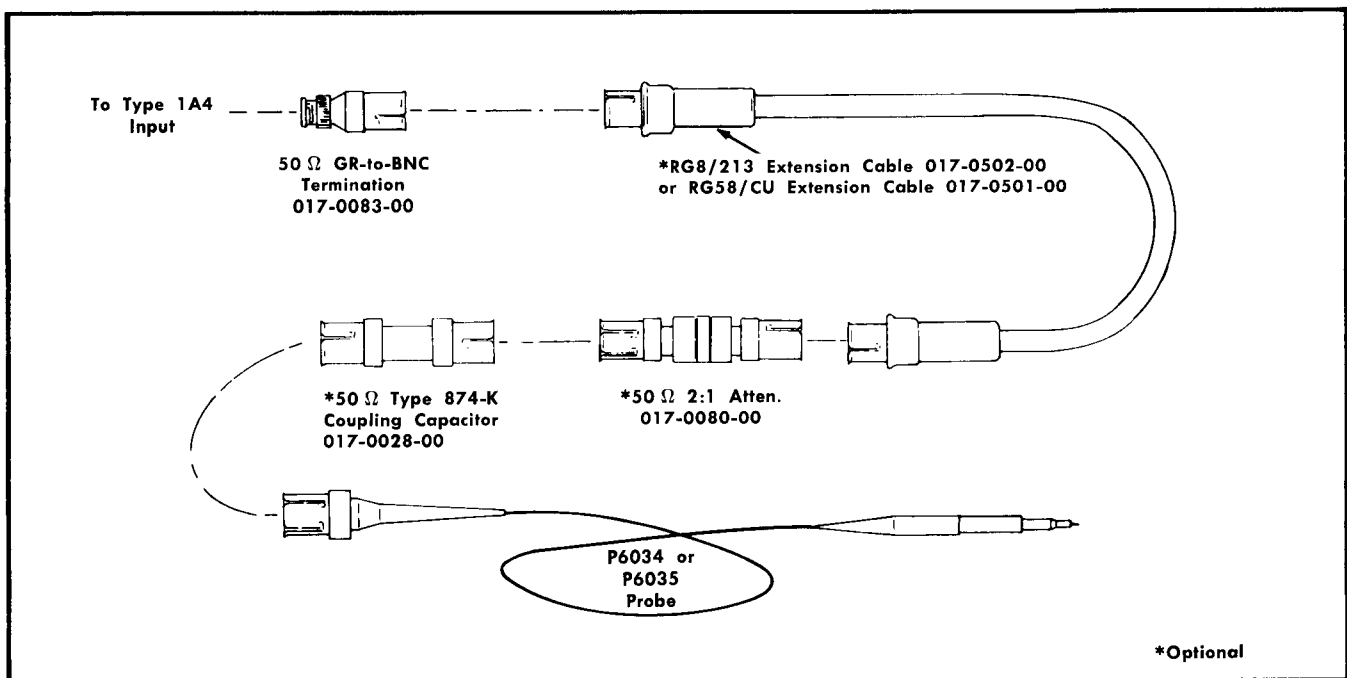


Fig. 2-5. Recommended component sequence when using the P6034 or P6035 probe. See Table 2-1.

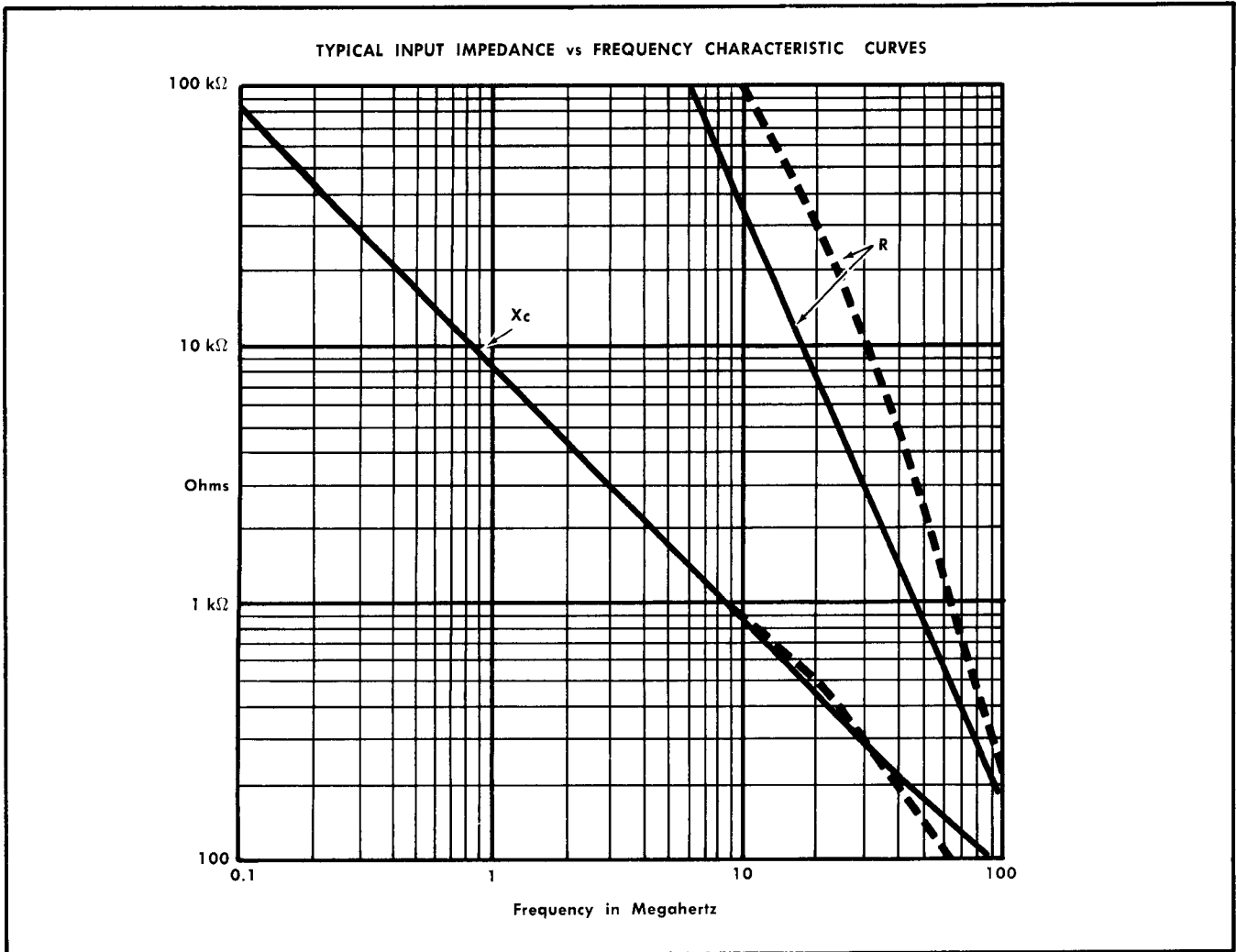


Fig. 2-6. Type 1A4 resistance and capacitive reactance vs frequency curves for each channed. Note that the input impedance (R and Xc) decreases as frequency increases. Solid lines apply to plug-in units 101 to 369 (some units were modified out of sequence); dotted lines apply to units Model No. B030370 and up.

TABLE 2-1

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading (Also see Fig. 2-6, Input Impedance Curves)	Precautions
1. Open (un-shielded) test leads.	Simplicity.	Limited frequency response. Subject to stray pickup.	BNC to banana jack adapter (103-0033-00). Two test leads.	1 MΩ and 20 pF at input, plus test leads and adapter	Stray pickup. Extreme at maximum sensitivity.
2. Unterminated coaxial cable.	Full sensitivity.	Limited frequency response. High capacitance of cable.	Coaxial cable with BNC connector(s).	1 MΩ and 20 pF plus cable capacitance.	High Capacitance loading.
3. 1X, 1MΩ probe.	Full sensitivity.	High capacitance of cable.	P6028 is 1X equipped with BNC connector.	1 MΩ and ≈ 87 pF.	High Capacitance loading.

TABLE 2-1 (cont)

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading (Also see Fig. 2-6, Input Impedance Curves)	Precautions
4. Terminated coaxial cable. Termination at Type 1A4 input.	Full sensitivity. Total Type 1A4/Oscilloscope bandwidth. Relatively flat resistive loading. Long cable with uniform response.	Presents R_o (typically 50 Ω) loading at end of coaxial cable. May need blocking capacitor to prevent DC loading or damage to termination.	Coaxial cable with BNC connector(s). R_o termination at Type 1A4 input. (BNC 50 Ω termination, 011-0049-00.)	R_o plus 20 pF at Type 1A4 end of coaxial cable can cause reflections.	Reflections from 20 pF at input. 50-ohm DC and AC loading on test point. Power limit of termination.
5. Same as 4, with coaxial attenuator at termination.	Less reflection from 20 pF at termination.	Sensitivity is reduced (increased deflection factor).	BNC coaxial attenuators.	R_o only.	50-ohm DC and AC loading on test point. Power limit of attenuator.
6. Tap into terminated coaxial system. (BNC T at Type 1A4 input.)	Permits signal to go to normal load. DC or AC coupling without coaxial attenuators.	20 pF load at tap point.	BNC T and BNC connectors on signal cables.	1 M Ω and 20 pF at tap point.	Reflections from 20 pF input.
7. 10 \times , 10 M Ω probe. 100 \times , 10 M Ω probe. 1000 \times , 100 M Ω probe.	Reduce resistance and capacitive loading, nearly full Type 1A4/Oscilloscope bandwidth.	$\times 0.1$ sensitivity. $\times 0.01$ sensitivity. $\times 0.001$ sensitivity.	P6006, P6008, P6010 are 10 \times . P6007, P6009 are 100 \times . P6015 is 1000 \times .	P6006: ≈ 7 pF, 10 M Ω . P6008: ≈ 7.5 pF, 10 M Ω . P6010: ≈ 10 pF, 10 M Ω . P6007: less than 2 pF, 10 M Ω . P6009: ≈ 2.5 pF, 10 M Ω . P6015: ≈ 3 pF, 100 M Ω .	Check probe frequency compensation. Use square-wave frequency less than 5 kHz, preferably 1 kHz.
8. 500 Ω and 5 k Ω probes (must be terminated in 50 Ω at Type 1A4 input).	Reduced capacitive loading to about 0.7 pF. Bandwidth that of Type 1A4/Oscilloscope. Probe compensation need not be adjusted, since effect is not apparent when used with the Type 1A4/Oscilloscope.	Resistive loading. $\times 0.1$ or $\times 0.01$ sensitivity. May need blocking capacitor to prevent DC loading or damage to termination. Limited low-frequency response when AC coupled: 70 kHz for P6034; 7 kHz for P6035.	P6034-10 \times . P6035-100 \times . Items in Fig. 2-5.	P6034: 500 Ω , 0.7 pF. P6035: 5 k Ω , 0.6 pF.	DC and AC loading. Voltage rating of probe.
9. Current transformer. Terminated in 50 Ω at Type 1A4. Upper bandwidth is that of Type 1A4/Oscilloscope.	Current transformer can be permanent part of test circuit. Less than 2.2 pF to test circuit chassis. Measure signal currents in transistor circuits.	RMS current rating: CT-1: 0.5 A. CT-2: 2.5 A. Sensitivity: CT-1: 5 mV/mA. CT-2: 1 mV/mA.	CT-1: Coaxial adapter with BNC termination. CT-2: Nothing extra. (Perhaps additional coaxial cable for either transformer.)	CT-1: Insertion; 1 Ω paralleled by about 5 μ H. Up to 1.5 pF. CT-2: Insertion; 0.04 Ω paralleled by about 5 μ H. Up to 2.2 pF.	Not a quick-connect device. CT-1: Low-frequency limit about 75 kHz. CT-2: Low-frequency limit about 1.2 kHz, and is 1/5 as sensitive as the CT-1.

TABLE 2-1 (cont)

Signal Coupling Methods

Method	Advantages	Limitations	Accessories Required	Source Loading (Also see Fig. 2-6, Input Impedance Curves)	Precautions
10. P6019 Current Probe with Type 134 Amplifier. System bandwidth with Type 1A4/Oscilloscope: ≈ 30 MHz.	Measure signal currents without breaking the circuit under test. Basic deflection factor: 0.2 mA/cm with Type 1A4 V/CM switch set to .01. ⁴	Low frequency limit: ≤ 12 Hz.	None if probe and amplifier are purchased with power supply as a complete set.	Insertion Z: 2.8 μ H paralleled by 0.004 Ω in series with 1.7 nH.	When changing probes, check the Low Freq. and Gain adjustments. Be sure the Type 134 Probe Selector switch is set to the proper position.
11. P6020 Current Probe with Type 134 Amplifier. System bandwidth with Type 1A4/Oscilloscope: ≈ 40 MHz.	Measure signal currents without breaking the circuit under test. Basic deflection factor: 0.2 mA/cm with Type 1A4 V/CM switch set to .01. ⁴	Low frequency limit: ≤ 100 Hz.	None if probe and amplifier are purchased with power supply as a complete set.	Insertion Z: 0.6 μ H paralleled by 0.025 Ω in series with 0.2 nH.	When changing probes, check the Low Freq. and Gain adjustments. Be sure the Type 134 Probe Selector switch is set to the proper position.

⁴Type 134 Current/Div switch is calibrated when the Type 1A4 V/CM switch is set to .05.

Use of Conventional Probes

A conventional passive attenuator probe having a standard 42-inch cable (such as those listed in Method 7 of Table 2-1) lessens both capacitive and resistive loading, but at the same time reduces sensitivity. The attenuation introduced by the probe permits measurement of signal voltages that would overscan the CRT if applied directly to the Type 1A4. However, in applying high-amplitude signal voltages to either the probe or Type 1A4, do not exceed their maximum voltage ratings. When making amplitude measurements with an attenuator probe, be sure to multiply the observed amplitude by the probe attenuation.

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

1. Set the oscilloscope Amplitude Calibrator for an output signal of suitable amplitude.
2. Place the DISPLAY and appropriate MODE switch to the settings that will select the channel that is connected to the probe.
3. Set the appropriate AC-GND-DC switch to DC.
4. Touch the probe tip to the calibrator output connector and adjust the oscilloscope controls to display several cycles of the waveform.
5. Adjust the probe compensation for best square-wave response as shown in the right-hand picture of Fig. 2-7.

NOTE

If a square-wave source other than the oscilloscope calibrator is used for compensating the probe, do

not use a repetition rate higher than 5 kHz. At higher repetition rates, the waveform amplitude appears to change as the probe is compensated. Thus, proper compensation is difficult. If the probe remains improperly compensated, transient and frequency response of the system will be poor and measurements will be inaccurate.

AC-GND-DC Switch

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

In the AC position of the switch, the DC component of the signal is blocked by a capacitor in the input circuit. The input time constant of the input circuit is about 0.1 s and the low-frequency response of the unit is about 2 Hz at -3 dB (this is equal to 70% of the calibrated display amplitude). Thus, some decrease in frequency response (droop) exists even when observing a symmetrical 60-Hz square-wave signal. If a 10 \times attenuator probe is used with the Type 1A4, the low-frequency response will be extended to about 0.2 Hz; with a 100 \times probe, low-frequency response is about 2 Hz.

Placing the AC-GND-DC switch to the GND position grounds the input circuit of the channel to provide a DC zero reference. In addition, the switch internally disconnects but does not ground the applied signal at the Input connector. The GND position of the switch eliminates the need for externally grounding the input of the unit or probe tip to establish a ground reference.

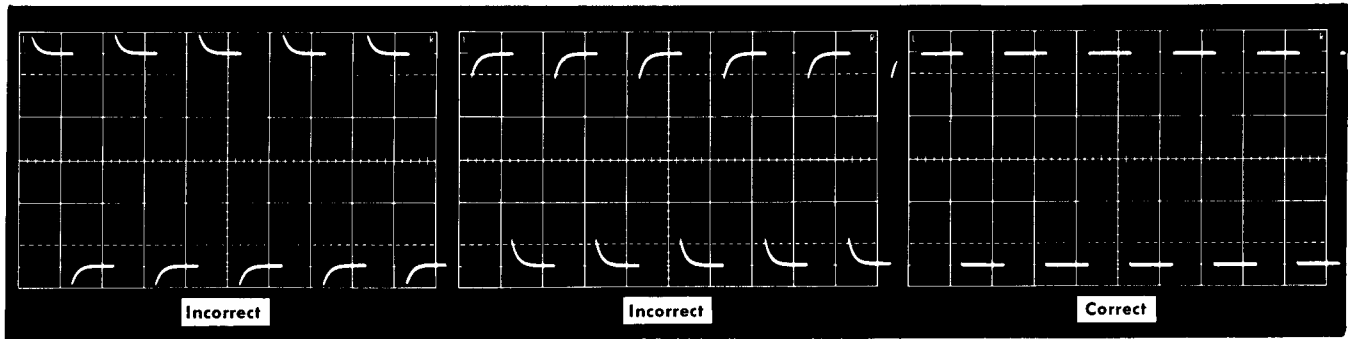


Fig. 2-7. Probe compensation waveforms using a 1-kHz calibrator signal.

V/CM Switch and VARIABLE Control

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuator factor (if any) of the probe, the setting of the V/CM switch, and the setting of the VARIABLE control. Calibrated deflection factors indicated by the V/CM switch positions apply only when the VARIABLE control is set to the CAL position. Errors in display measurements will result if the setting of this control is inadvertently moved out of the CAL (detent) position.

The range of the VARIABLE control is at least 2.5 to 1 to provide continuously variable (uncalibrated) vertical deflection factors between the calibrated settings of the V/CM switch. When the VARIABLE control is rotated slightly clockwise out of the CAL position and the V/CM switch is set to 20, the VARIABLE control extends the vertical deflection factor to at least 50 V/cm. By applying the oscilloscope calibrator voltage or any other calibrated voltage source to the Type 1A4 any specific deflection factor can be set within the range of the VARIABLE control (see Applications section, Voltage Comparison Measurements).

INVERT Switch

The INVERT switch may be used to invert the displayed waveform, particularly when using the multi-trace feature of the Type 1A4 to compare waveforms. The INVERT switch has two positions. In the normal (INVERT knob pushed in) position, the displayed waveform has the same polarity as the applied signal; that is, a positive-going pulse applied to the Type 1A4 will be displayed as a positive-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A4, the beam will move up.

In the invert (INVERT knob pulled outward) position, the displayed waveform will be inverted; that is, a positive-going pulse applied to the Type 1A4 will be inverted or displayed as a negative-going waveform on the CRT. If a positive voltage is DC coupled to the Type 1A4, the beam will move down.

MODE and SIGNAL & TRIGGER SOURCE Switches

Since Ch 1 & 2 MODE switch is similar to the Ch 3 & 4 MODE switch, only the Ch 1 & 2 MODE switch is described.

CHANNEL 1, CHANNEL 2—Single-Trace Operation

To display a single signal (referred to as single-trace operation), apply the signal to either the Channel 1 or Channel 2 Input connector, set the DISPLAY switch to 1 & 2, and set the MODE switch to the desired channel: CHANNEL 1 or CHANNEL 2.

To display a signal in one channel when the same signal or a different signal is applied to the other channel, select the signal in the channel to be displayed by setting the MODE switch to the appropriate CHANNEL 1 or CHANNEL 2 position and check that the DISPLAY switch is set to 1 & 2.

ALT, CHOP—Dual-Trace Operation

To display two signals together (dual-trace operation), apply one signal to the Channel 1 Input connector and apply the other signal to the Channel 2 Input connector. Set the DISPLAY switch to 1 & 2, set the applicable INVERT knob to the normal (pushed in) or inverted (pulled outward) position and set the MODE switch to CHOP or ALT.

In general, use the CHOP position (chopped-mode operation) with sweep rates up to about 50 $\mu\text{s}/\text{cm}$ for displaying two non-repetitive signals occurring within the sweep-time interval set by the oscilloscope Time/Cm switch. Non-repetitive signals are those signals which are single-shot, transient, or random. The CHOP position is also useful for displaying low-frequency synchronous signals. Synchronous signals are those which have the same repetition rate or are frequency related by a whole number multiple.

NOTE

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

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

1. Displaying two non-repetitive or low-frequency (below 10 kHz) synchronous signals.

To show true time and phase relationship between two non-repetitive or low-frequency synchronous signals, use chopped-mode operation. Transients as short as 0.1 ms can be well delineated or resolved. At 10 μ s/cm a 0.1-ms duration transient, for example, will contain about 100 segments in its trace. If a higher sweep rate is used, the number of segments making up each trace will be less and hence, resolution will be poorer.

To obtain a stable display, use either internal plug-in triggering direct from one of the channels, or use the external patching method. To use direct internal triggering for oscilloscopes having this capability, set the oscilloscope Triggering Source switch to the Plug-In position and set the Type 1A4 SIGNAL & TRIGGER SOURCE switch to the desired channel signal source. To use external triggering when the oscilloscope does **not** have the Plug-In triggering feature, connect

an 18-inch coaxial cable (Tektronix Part No. 012-0076-00) from the Type 1A4 SIGNAL OUTPUT connector to the oscilloscope Trigger Input connector, set the oscilloscope Triggering Source switch to Ext and set the Type 1A4 SIGNAL & TRIGGER SOURCE switch to the desired channel signal source.

CAUTION

Do not apply external voltages to the SIGNAL OUTPUT connector as this may damage the associated internal circuits. Shorting the connector to ground, however, will not cause any damage.

2. Displaying Two Asynchronous Signals.

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

TABLE 2-2

Dual-Trace Operation (DISPLAY switch set to 1 & 2)

Applied Signals (one to Channel 1 and other to Channel 2)	Type 1A4 Ch 1 & 2 MODE Switch Setting	Oscilloscope Triggering Source ⁵ Switch Setting	Oscilloscope Triggering Coupling ⁶ Switch Setting	Display shows true time relationship between signals
1. Two non-repetitive signals or two low-frequency synchronous signals (below 10 kHz). Apply reference signal to Channel 1.	CHOP	Plug-in ⁷ or Ext (connect coaxial cable from the SIGNAL OUTPUT connector to Trigger Input connector on oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject.	Yes Use sweep rates up to 50 μ s/cm. Higher sweep rates reduce resolution.
2. Two asynchronous signals, any frequency within full bandwidth of the system.	ALT	Norm Int or Int. ⁸	AC or AC Slow for frequencies below 1 kHz. AC Fast or AC LF Reject for frequencies above 1 kHz.	No
3. Two synchronous signals, 250 Hz and higher.	ALT	Plug-in ⁷ or Ext (connect coaxial cable from the SIGNAL OUTPUT connector to Trigger Input connector on oscilloscope).	AC or AC Slow or AC Fast or AC LF Reject.	Yes Apply reference signal to Channel 1.
		Norm Int or Int. ⁸	AC Fast or AC LF Reject.	No

⁵Called Slope switch on some oscilloscopes.

⁶Called Source or Mode switch on some oscilloscopes.

⁷Plug-In position is the single-channel internal trigger signal (selected by the SIGNAL & TRIGGER SOURCE switch), available at pin 5 of the Type 1A4 interconnecting plug to the oscilloscope. If your oscilloscope is not wired to permit use of this trigger source, use the Ext position and SIGNAL OUTPUT signal.

⁸Norm Int or Int switch position is the internal trigger takeoff signal from the oscilloscope vertical amplifier. In dual-trace operation this trigger is a composite of the applied signals superimposed on the DC positioning levels of the channels being electronically switched.

Operating Instructions—Type 1A4

When using alternate-mode operation and normal internal triggering, it is very important to set the oscilloscope Triggering Level control to a point where the sweep generator can trigger on the signal in one channel as it turns on, and on the signal in the other channel when it turns on. The applied signals must be of sufficient amplitude to meet the internal triggering signal amplitude requirements of the oscilloscope.

If one displayed signal has a smaller amplitude than the other, but is of adequate amplitude for internal triggering, set the Triggering Level control to a point that will assure proper triggering on the smaller amplitude signal. This can be accomplished by setting the Triggering Level control near the 0 position.

Though it may seem that stable triggering can always be obtained on asynchronous signals, there are conditions that can cause a jittery display; for example, when using the AC LF Reject triggering mode, jitter most likely occurs when attempting to trigger on high-frequency asynchronous signals that are vertically positioned apart on the screen. If jitter occurs, it can be reduced and some times eliminated by using the POSITION controls to position the displays closer together, or by superimposing them. This not only may reduce jitter, but may also increase the brightness of the display.

The reason that triggering on the oscilloscope internal trigger takeoff signal is more difficult when using multi-trace operation is that the triggering signal is a composite of the DC positioning levels and the signal in both channels. Thus, the relative position of the displays and the Triggering Coupling switch position used affect the triggering rate of the sweep and the stability of the display. In general, positioning the displays closer together and selecting a smaller value coupling capacitor in the trigger circuit (accomplished by setting the Coupling switch to AC LF Reject) aid in obtaining a bright stable display.

If chopped mode of operation is used when asynchronous signals are applied to the Type 1A4 Input connectors, one useful application is determining the zero-beat frequency of two signals. To do this, trigger on one of the channels and change the frequency of one signal until stationary displays of a number of cycles are obtained. When the displays are stable, the signals are synchronized and their relationship can be expressed as a whole number ratio.

3. Displaying two synchronous signals, 250 Hz and higher.

To show true time and phase relationship between two synchronous signals, 250 Hz and higher, use alternate mode operation and trigger on one channel only. In practice, for displaying signals between 250 Hz and 10 kHz, either alternate or chopped mode of operation can be used since this is an overlapping area, although the alternate mode is usually preferred. As a suggested procedure, apply the reference signal to Channel 1, set the Type 1A4 SIGNAL & TRIGGER SOURCE switch to 1, set the oscilloscope Triggering Source switch to Plug-In, and set the Coupling switch to AC or AC LF Reject. If the oscilloscope does not have the Plug-In position, connect an 18-inch coaxial cable from the Type 1A4 SIGNAL OUTPUT connector to the oscilloscope Trigger Input connector and set the Triggering Source switch to Ext.

In high-frequency applications where the bandwidth limit of the Type 1A4 trigger amplifier is a limiting factor, the reference trigger for the oscilloscope can be derived from external sources. If derived from the signal connected to the Type 1A4 Input connector, consider the loading effect of the oscilloscope Trigger Input connector and the interconnecting lead on the signal source. If loading is a factor, use other methods. For example, if a signal generator is used to drive the device under test and if the generator has a trigger-output connector, use the generator to externally trigger the oscilloscope. As another example, connect the cable end of an attenuator probe to the oscilloscope Trigger Input connector and connect the probe tip to the triggering source.

ADD—Algebraic Addition of Two Signals

The ADD position of the MODE switch can be used to display the sum or difference of two signals and for common-mode rejection to remove an undesired signal.

(The common-mode rejection ratio of the Type 1A4 is equal to or greater than 20:1 from DC to 10 MHz.)

During four-trace mode of operation when the DISPLAY switch is set to ADD, channel 1 is algebraically adding to channel 3 and channel 2 is algebraically adding to channel 4 using these modes:

- (1) Adding two chopping pairs (both MODE switches set to CHOP).
- (2) Adding two alternating pairs (both MODE switches set to ALT).

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

1. Do not exceed the input voltage rating of the Type 1A4.
2. Do not apply signals that will exceed an equivalent of about 12 times the V/CM switch setting. For example, with a V/CM switch setting of .2, the voltage applied to that channel should not exceed about 2.4 volts. Larger voltages may distort the display.
3. Use Type 1A4 POSITION control settings which most nearly position the signal of each channel to mid-screen when viewing each channel separately. This will insure the greatest dynamic range for ADD mode of operation.

DISPLAY Switch

The DISPLAY switch increases the versatility of the Type 1A4 because it provides the additional switching modes needed to make Channels 1 and 2 alternate, chop or add with Channels 3 and 4. Thus, the Type 1A4 has the versatility of two dual-trace units connected to a third unit. The basic information given for the MODE and SIGNAL & TRIGGER SOURCE switches also applies to the DISPLAY switch.

Selecting the Trigger Amplifier Bandwidth

The Type 1A4 has provisions for selecting the Trigger Amplifier bandwidth and hence, the bandwidth of the channel trigger signal source and the signal applied to the SIGNAL OUTPUT connector. There are three choices and these are made by moving a gray-on-white wire to one of the

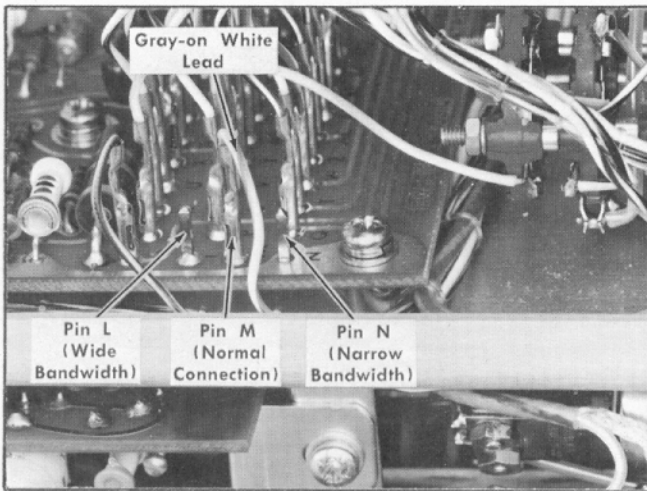


Fig. 2-8. Selecting the Trigger Amplifier bandwidth by connecting the gray-on-white wire to the desired square-pin connector.

square-pin connectors shown in Fig. 2-8. These connectors are located on the top side of the plug-in unit behind the Ch 1 & 2 MODE switch.

The three choices are as follows:

1. Switch controlled connection pin "M". This is the normal connection and the one used when the unit was shipped from the factory. If this connection is used, bandwidth of the Trigger Amplifier is controlled by the MODE and DISPLAY switches. In all positions of these switches except the CHOP position, bandwidth is ≤ 20 Hz to ≥ 10 MHz unterminated; in the CHOP positions, bandwidth is ≤ 20 Hz to 500 kHz ($\pm 20\%$). Upper bandwidth for the CHOP positions is decreased to attenuate the high-frequency components of the chopped-mode switching transients. Wide-bandwidth triggering is usually not needed during chopped mode of operation because the unit will probably be used for displaying low-frequency signals.

2. Wide bandwidth connection pin "L". If this connection is used, the Trigger Amplifier bandwidth is ≤ 20 Hz to ≥ 10 MHz unterminated in all positions of the MODE and DISPLAY switches. This connection is most useful if full bandwidth triggering in all modes of operation is desired, even when using the chopped mode.

3. Narrow bandwidth connection pin "N". When using this connection, the Trigger Amplifier bandwidth is ≤ 20 Hz to 500 kHz ($\pm 20\%$) in all positions of the MODE and DISPLAY switches. This connection is most useful in applications where it is desirable to attenuate the high-frequency components of the Type 1A4 trigger or SIGNAL OUTPUT connector signal.

Changing the Trigger Amplifier Bandwidth

For special applications when using chopped-mode of operation with the gray-on-white connected to pin M (see Fig. 2-8), it may be desirable to change the upper-limit frequency response of the Trigger Amplifier from 500 kHz to some other limit. This can be accomplished by changing the

value of C142 located on the Trigger Amplifier board (see Fig. 2-9). Table 2-3, for example, gives the bandwidth when C142 is changed to the values indicated.

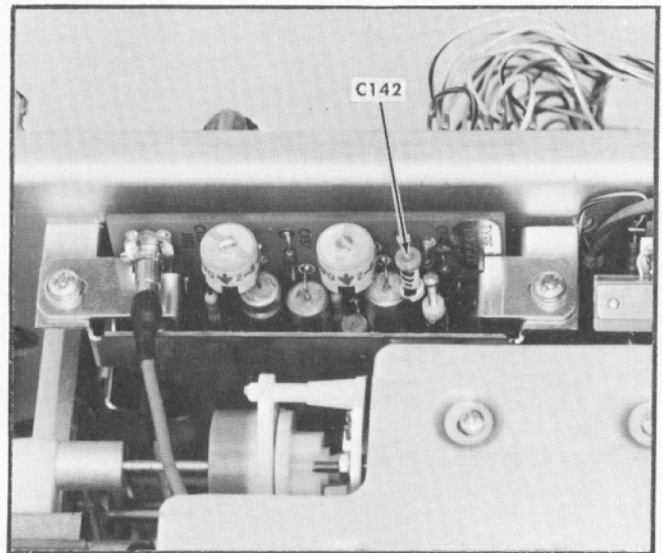


Fig. 2-9. Location of C142 on the Trigger Amplifier board.

TABLE 2-3

C142	Trigger Amplifier Bandwidth ⁹ (-3 dB)
47 pF	≤ 20 Hz to ≈ 240 kHz
100 pF	≤ 20 Hz to ≈ 120 kHz
200 pF	≤ 20 Hz to ≈ 60 kHz

Cascaded Operation

If a plug-in unit having a sensitivity greater than 10 mV/cm is not readily available, the Type 1A4 sensitivity can be increased by using cascaded operation. This is accomplished by applying the signal from the SIGNAL OUTPUT connector through a coaxial jumper cable to another channel. The amplified signal can then be displayed on the CRT.

Cascaded operation provides a gain of at least 50 through the Trigger Amplifier to the SIGNAL OUTPUT connector. Thus, a deflection factor of 200 μ V/cm or less can be obtained when the V/CM switches for both channels are set to .01 and the VARIABLE control for the second channel is set to CAL. If a low-pass filter such as the one shown in Fig. 2-10 and described later is used, performance in the more sensitive V/CM switch positions can be improved.

In general, cascaded operation is most useful for displaying signals from approximately 20 Hz to 1 MHz. When observing high-frequency signals (above 1 MHz) and aberrations on the displayed waveform are present, consider the possibility that these aberrations can be caused by using cascaded operation. Such aberrations can be tolerated, however, if the advantages of higher sensitivity are more important. (If high-frequency response and a deflection fac-

⁹For chopped-mode operation when the gray-on-white wire is connected to pin M.

Operating Instructions—Type 1A4

tor less than 10 mV/cm are the desired objectives, use two or more channels in the added mode as described in the Applications section.)

If an oscilloscope without the plug-in triggering source feature is used during cascaded operation and a BNC T connector is used for connecting the signal from the SIGNAL OUTPUT connector to the oscilloscope Trigger Input connector, consider that this additional cable connection will cause reflections that affect high-frequency response.

When displaying low-frequency signals, about 15 mV of line-related residual ripple will be present at the SIGNAL OUTPUT connector. Allowance for this ripple must be made; otherwise erroneous measurements will be obtained. Consider, for example, that this residual ripple will be present when examining power-supply voltage ripple in a device-under-test.

Fig. 2-10 shows how to construct a low-pass filter that limits the Trigger Amplifier high-frequency response to about 100 kHz. The components are mounted in an accessory housing to provide adequate shielding and a convenient method for making connections. The accessory housing (similar in appearance to item 9 in the Calibration section of this manual) can be purchased without electrical components by using the following description when ordering: Coupler, test set with BNC connector, Tektronix Part No. 011-0081-00.

Using the filter as shown in Fig. 2-10 and Channel 1 and 2, the following procedure is suggested:

1. Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 1 & 2)	AC
V/CM (Ch 1 & 2)	.01
VARIABLE (Ch 2)	CAL
INVERT (Ch 2)	Pushed in
POSITION (Ch 2)	Midrange
Ch 1 & 2 MODE	CHANNEL 2
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1

Oscilloscope

Triggering	+Int, Line, AC, Auto Stability
Time/Cm	5 mSec

2. Connect the low-pass filter to the Channel 2 Input connector.

3. Connect a 50-ohm coaxial cable from the SIGNAL OUTPUT connector to the low-pass filter.

4. Apply a 1-mV peak-to-peak 1 kHz amplitude calibrator signal through a coaxial cable to the Channel 1 Input connector.

5. Set the Channel 2 VARIABLE (V/CM) control so the display is exactly 5 cm in amplitude. Channel 2 in the Type 1A4 is now calibrated for a vertical deflection factor of 200

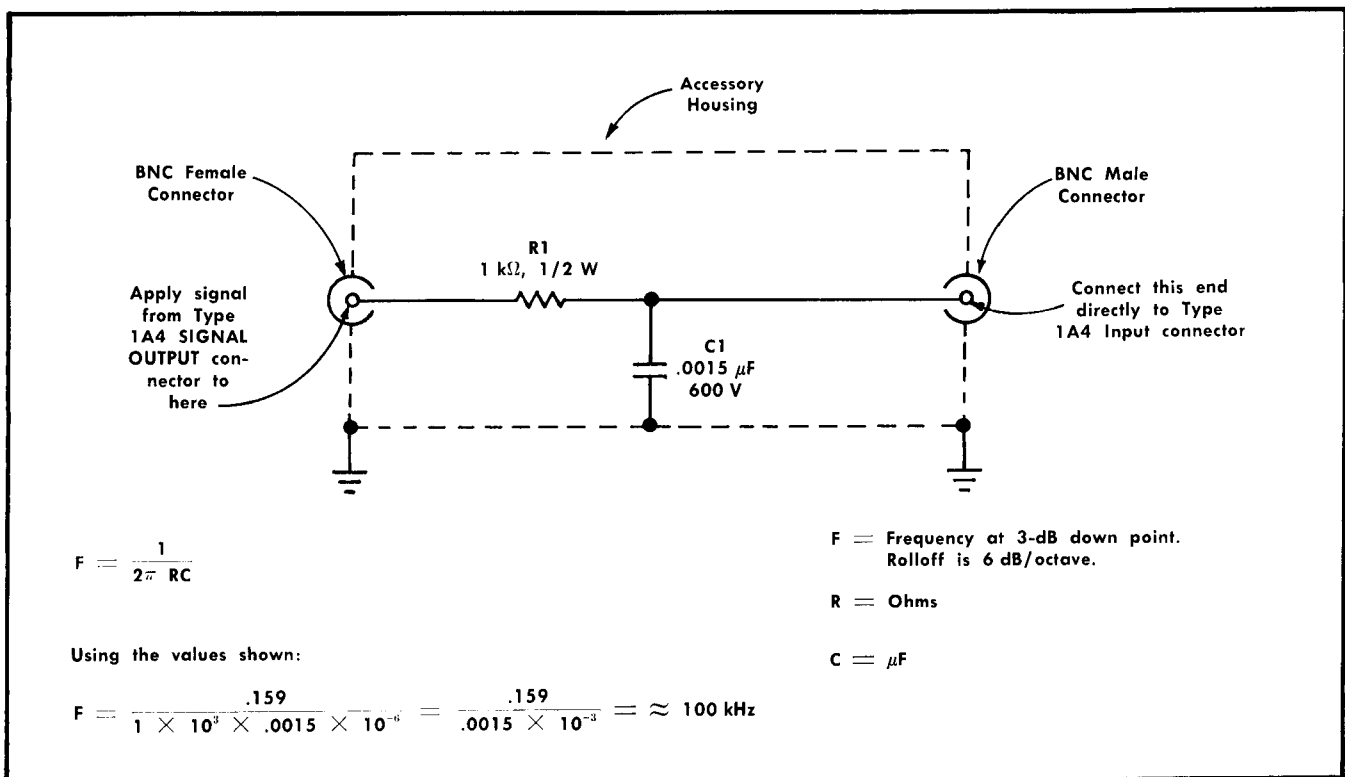


Fig. 2-10. Constructing a low-pass filter.

$\mu\text{V}/\text{cm}$ with the Channel 2 V/CM switch set to .01. To maintain this basic calibrated sensitivity, do not change the Channel 1 V/CM switch or the Channel 2 VARIABLE control settings while using the remaining Channel 2 controls.

6. Disconnect the 1-mV calibrator signal. Use Table 2-4 to obtain the desired vertical deflection factor and apply the signal to be measured to the Channel 1 Input connector. Set the oscilloscope triggering and time-base controls to obtain a stable display at the desired sweep rate.

TABLE 2-4

Actual Vertical Deflection Factor	Channel 2 V/CM Switch Position
200 $\mu\text{V}/\text{cm}$.01
400 $\mu\text{V}/\text{cm}$.02
1 mV/cm	.05
2 mV/cm	.1
4 mV/cm	.2

SECTION 3

APPLICATIONS

Introduction

This section of the manual describes procedures and techniques for making basic measurements with the Type 1A4 and a Type 547 Oscilloscope. When only one channel is involved, the step-by-step procedures use Channel 1 as the example. If more than one channel is involved, the reference signal is applied to Channel 1.

NOTE

Although Channel 1 is used as the example in these procedures, any of the other channels can be used in the same manner by applying the signal to the desired channel and using the applicable front-panel controls. All the procedures assume the Type 1A4 is used with an oscilloscope that has 6-cm usable scan area, such as the Type 547. If the Type 1A4 is used with an oscilloscope which provides a usable scan other than 6 cm, interpret the procedure accordingly.

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

AC Component Voltage Measurements

To measure the AC component of a waveform using a single channel, namely Channel 1 as an example, use the AC position of the Input Coupling switch. In this position, only the AC component of the input signal will be displayed on the CRT. (However, if the AC component of the input signal is very low in frequency, use the DC position of the switch providing no DC component is present.)

To make the peak-to-peak voltage measurement, the following procedure is suggested.

1. Set the applicable Type 1A4 controls as follows:

AC-GND-DC (Ch 1)	AC
VARIABLE (Ch 1)	CAL
POSITION (Ch 1)	Midrange
Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	1 & 2

2. Preset the Channel 1 V/CM switch to a suitable deflection factor. (Use a deflection factor that will enable an on-screen display to be obtained when performing step 3.)

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

4. Set the oscilloscope triggering controls for normal internal triggering and set the Time/Cm switch so several cycles of the waveform are displayed.

5. Use the Channel 1 POSITION control to vertically position the waveform to a point in the graticule area that permits easy measurement of the waveform. For example,

position the waveform so that the negative peaks coincide with one of the lower graticule lines and one of the positive peaks lies near the graticule center vertical line (see Fig. 3-1).

6. Measure the vertical deflection in cm from peak to peak on the waveform.

NOTE

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

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

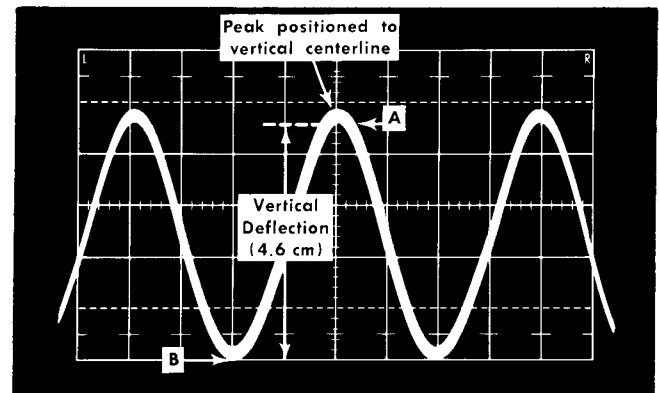


Fig. 3-1. Measuring peak-to-peak voltage of a waveform.

Example. Assume a peak-to-peak vertical deflection of 4.6 cm (see Fig. 3-1) when using a 10× attenuator probe and a V/CM switch setting of .5.

Using the formula:

$$\text{Peak to Peak Volts} = \text{vertical deflection in cm} \times \text{V/CM setting} \times \text{factor probe attenuator}$$

Substituting the given values:

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

The peak-to-peak voltage is 23 V.

Instantaneous Voltage Measurements—DC

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

Applications—Type 1A4

- Set the applicable Type 1A4 controls as follows:

AC-GND-DC (Ch 1)	GND
VARIABLE (Ch 1)	CAL, knob pushed in
POSITION (Ch 1)	Midrange
Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	1 & 2

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

3. If the voltage is positive with respect to ground, use the Channel 1 POSITION control to position the trace to the bottom line of the graticule or other reference line. If the voltage 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 3. Set Channel 1 AC-GND-DC switch to DC. Apply the reference voltage to the reference line. Remove the reference voltage and proceed to step 5.

- Set the Channel 1 AC-GND-DC switch to DC. The ground reference line can be checked at any time by switching to the GND position.

5. Preset the Channel 1 V/CM switch to a suitable deflection factor. (Use a deflection factor that will enable an on-screen display to be obtained when performing step 6.)

6. Apply the signal, preferably through a coaxial cable or an attenuator probe (avoid the use of unshielded leads), to the Channel 1 Input connector.

7. Set the oscilloscope triggering controls for normal internal triggering and to obtain a stable display. Set the Time/Cm switch to a setting that will display the desired waveform.

8. Measure the vertical distance in cm between the reference line and the point on the waveform at which the DC level is to be measured. For example, in Fig. 3-2 the measurement is made between the reference line and point A.

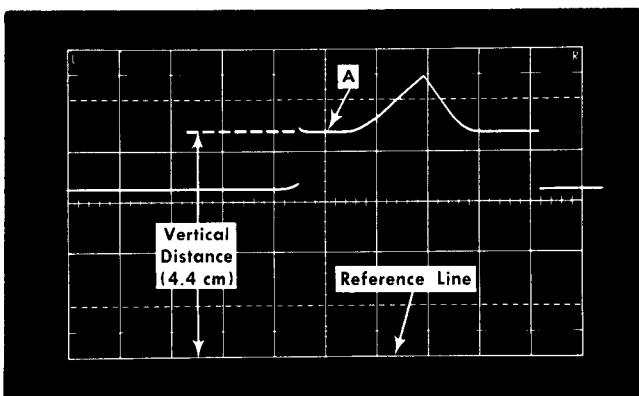


Fig. 3-2. Measuring instantaneous DC voltage with respect to a reference.

9. Establish the polarity of the signal. If the waveform is above the reference line, the voltage is positive; below the line, negative.

Example. Assume that the vertical distance measured is 4.4 cm (see Fig. 3-2) above the reference line when using a 10× attenuator probe and a V/CM switch setting of 2. Using the formula:

$$\text{Instantaneous Voltage} = \begin{matrix} \text{vertical} \\ \text{distance} \\ \text{in cm} \end{matrix} \times \begin{matrix} \text{polarity} \\ \times \end{matrix} \begin{matrix} \text{V/CM} \\ \text{setting} \end{matrix} \times \begin{matrix} \text{probe} \\ \text{attenuation} \\ \text{factor} \end{matrix}$$

Substituting the given values:

$$\text{Instantaneous Voltage} = 4.4 \times +1 \times 2 \times 10$$

The instantaneous voltage is +88 V.

Voltage Comparison Measurements

In some applications, it may be necessary to establish a set of deflection factors other than those indicated by the V/CM switch. This is useful for comparing signals to a known reference voltage amplitude. To establish a new set of vertical deflection factors based upon a known specific reference amplitude, proceed as follows:

- Set the applicable Type 1A4 controls as follows:

AC-GND-DC (Ch 1)	AC or DC, whichever is desired
POSITION (Ch 1)	Midrange
Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	1 & 2

- Apply the reference signal of known amplitude to the Channel 1 Input connector.

3. Using the Channel 1 V/CM switch and the VARIABLE control, adjust the display for an exact number of graticule divisions in cm. Do not move the VARIABLE control after obtaining the desired deflection.

4. Divide the amplitude of the reference signal (in volts) by the product of the deflection in cm (established in step 3) and the V/CM switch setting. This is the Deflection Conversion Factor.

$$\text{Deflection Conversion Factor} = \frac{\text{reference signal amplitude in volts}}{\text{deflection in cm} \times \text{V/CM setting}}$$

5. To establish an Adjusted Deflection Factor at any setting of the V/CM switch, multiply the V/CM switch setting by the Deflection Conversion Factor established in step 4.

$$\text{Adjusted Deflection Factor} = \begin{matrix} \text{V/CM} \\ \text{setting} \end{matrix} \times \begin{matrix} \text{Deflection} \\ \text{Conversion} \\ \text{Factor} \end{matrix}$$

This Adjusted Deflection Factor applies only to the channel used and is correct only if the VARIABLE control is not moved from the position set in step 3.

6. To determine the peak-to-peak amplitude of a signal compared to a reference, disconnect the reference and apply the signal to the Channel 1 Input connector.

7. Set the V/CM switch to a setting that will provide sufficient deflection to make the measurement. Do not readjust the Channel 1 VARIABLE control.

8. Measure the vertical deflection in cm and determine the amplitude by the following formula:

$$\text{Signal Amplitude} = \frac{\text{Adjusted Deflection}}{\text{Factor}} \times \text{deflection in cm}$$

Example. Assume a reference signal amplitude of 30 V, a V/CM setting of 5 and a vertical deflection of 4 cm. Substituting these values in the Deflection Conversion Factor formula (step 4):

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

Then, with a V/CM switch setting of 10, the Adjusted Deflection Factor (step 5) would be:

$$\frac{\text{Adjusted Deflection}}{\text{Factor}} = 10 \times 1.5 = 15 \text{ V/cm}$$

To determine the peak-to-peak amplitude of an applied signal which produces a vertical deflection of 5 cm, use the Signal Amplitude formula (step 8):

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

Time-Difference Measurements

The calibrated sweep rate of the oscilloscope and the multi-trace feature of the Type 1A4 allow measurement of time difference between two or more separate events. To measure time difference between two pulses using Channels 1 and 2 as an example, use the following procedure.

1. Set the DISPLAY switch to 1 & 2.

2. Set Channel 1 and 2 AC-GND-DC switches to identical settings; either AC or DC, depending on the type of coupling desired.

3. Set the Ch 1 & 2 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 "ALT, CHOP—Dual-Trace Operation" in Section 2, Operating Instructions.

4. Set the oscilloscope Triggering Source switch to Int Plug-In and set the Type 1A4 SIGNAL & TRIGGER SOURCE switch to 1.

5. Connect the reference signal to Channel 1 Input connector and the comparison signal to the Channel 2 Input connector. The reference signal should precede the comparison signal in time. (If extremely short delays are being measured, use coaxial cables or probes which have equal time delay).

6. Set the Channel 1 and 2 V/CM switches to produce 2- to 5-cm vertical deflection displays.

7. Set the oscilloscope Triggering Level control to obtain a stable display.

NOTE

If the waveforms are of opposite polarity, pull the Channel 2 INVERT knob outward to invert the Channel 2 waveform.

8. Set the oscilloscope Time/Cm switch for a sweep rate which shows sufficient horizontal distance between the two waveforms so a measurement can be made.

9. Adjust the Channel 1 and 2 POSITION controls to center each waveform (usually the 50% amplitude points on the rising portion of the waveforms) in relation to the graticule center horizontal line.

10. Adjust the oscilloscope Horizontal Position control so the Channel 1 (reference) waveform crosses the graticule center horizontal line at a vertical graticule line.

11. Measure the horizontal difference between the Channel 1 waveform and the Channel 2 waveform (see Fig. 3-3).

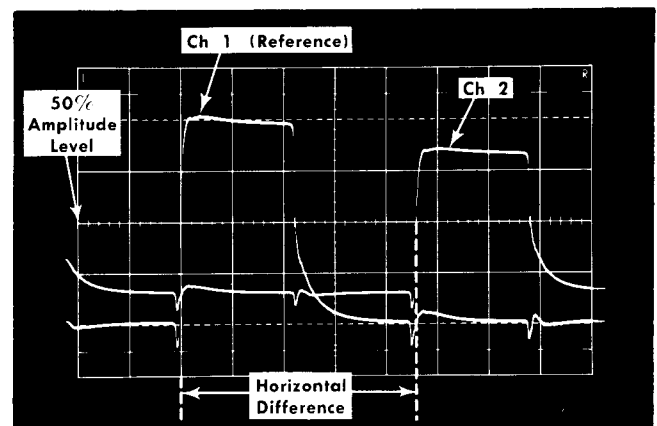


Fig. 3-3. Measuring the time difference between two pulses.

12. Multiply the measured difference by the setting of the oscilloscope Time/Cm switch. If sweep magnification is used, divide this answer by the amount of magnification.

Example. Assume that the Time/Cm switch is set to 0.2 μSec , the Sweep Magnifier switch is set to $\times 10$ and the horizontal difference between waveforms is 4.6 cm (see Fig. 3-3).

Using the formula:

$$\text{Time Difference} = \frac{\text{V/CM setting} \times \text{horizontal difference in cm}}{\text{magnification}}$$

Substituting the given values:

$$\text{Time Difference} = \frac{0.2 \times 4.6}{10}$$

The time difference between the two pulses is 0.092 μs .

Pulse-Delay Measurements

The wide bandwidth of the Type 1A4 when used in a 50 MHz oscilloscope/Type 1A4/probe system is particularly useful for performing pulse-delay measurements in computers or for checking the characteristics of tapped delay lines. Using all four channels of the unit, pulse degradation of the waveform if any, can be easily detected by simultaneously making comparisons of the signal at various test points along the delay line with the source or reference signal. This application is very similar to the Time-Difference Measurements described previously except that all four channels are used to display the fast-rise pulse waveforms. Since the time-difference between waveforms is very short, a fast sweep rate and alternate-mode operation must be used.

To measure pulse delay, use the following procedure:

1. Set the MODE DISPLAY switches to ALT.
2. Set the SIGNAL & TRIGGER SOURCE switch to 1 and the oscilloscope Triggering Source switch to Plug-In.
3. Set the AC-GND-DC switches to identical settings; either AC or DC, depending on the type of coupling desired.
4. Set the VARIABLE controls to CAL and check that the INVERT knobs are pushed in.
5. Connect the reference signal to Channel 1 Input connector and the successive signals to be compared to each of the remaining channel Input connectors in succession so incremental delay can be easily identified and measured. Use coaxial cables or probes which have equal time delay when applying the signals to the Input connectors.
6. Set the V/CM switches to produce 1- to 2-cm vertical deflection displays.
7. Set the oscilloscope Triggering Level control to obtain a stable display consisting of all four waveforms.

NOTE

If any waveform is of opposite polarity, pull the INVERT knob outward for that channel to invert the waveform.

8. Adjust the POSITION controls to separate the displays and to center each waveform (50% amplitude point on the rising portion of the waveform) on its own graticule horizontal line (see Fig. 3-4A).
9. Set the oscilloscope Time/Cm switch for a sweep rate which shows sufficient horizontal distance between the 50% amplitude points of the waveforms so measurements can be easily made.
10. Adjust the oscilloscope Horizontal Position control so the Channel 1 (reference) waveform at the 50% level crosses its own graticule horizontal line at a vertical graticule line (see Fig. 3-4B).
11. Measure the horizontal difference between the Channel 1 waveform and each of the other waveforms (see Fig. 3-4B).

NOTE

If desired, each measurement can be made using the Time-Difference method as shown in Fig. 3-3. By setting the SIGNAL & TRIGGER SOURCE switch

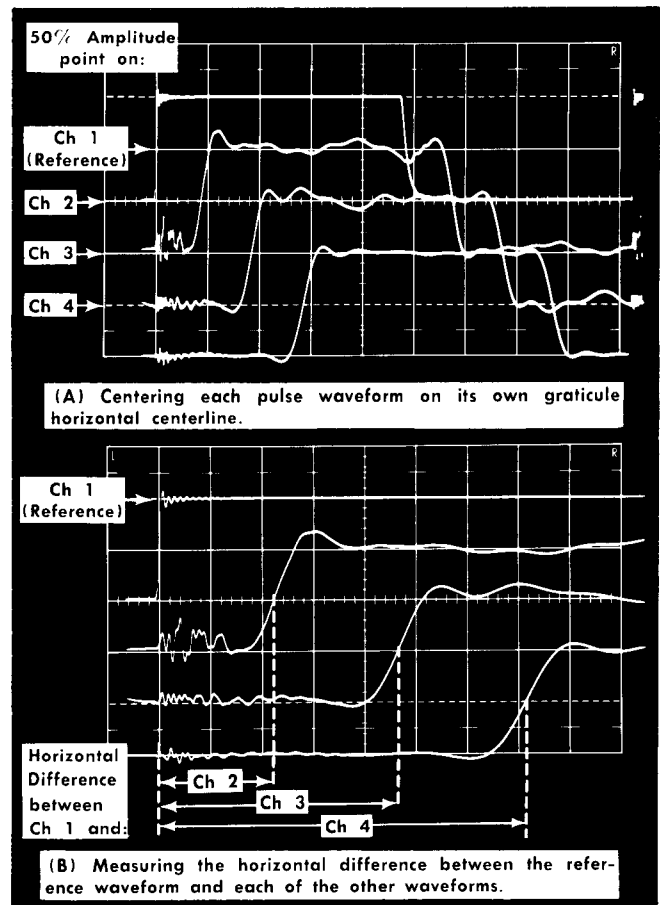


Fig. 3-4. Waveforms obtained when checking the characteristics of a tapped delay line.

to a different channel, time difference between the signal in that channel and another can be measured. The non-applicable waveforms can also be switched off by setting the appropriate AC-GND-DC switches to GND until it is necessary to display them.

12. Multiply the measured difference for each channel by the setting of the oscilloscope Time/Cm switch. If sweep magnification is used, divide this answer by the amount of magnification. For an example to show how this is done, refer to step 12 in the Time-Difference Measurements procedure previously described.

Multi-Trace Phase Difference Measurements

Phase comparisons between two or more signals of the same frequency can be made using the multi-trace feature of the Type 1A4. To make phase comparisons between four signals, proceed as follows:

1. Set all the AC-GND-DC switches to the same position—all AC or all DC, depending on the type of coupling desired.
2. Set the SIGNAL & TRIGGER SOURCE switch to 1 and set all the POSITION controls to midrange.
3. Set the MODE and DISPLAY switches to the same positions—CHOP or ALT. In general, CHOP is more suitable for

displaying low-frequency signals and the ALT position is more suitable for high-frequency signals. More information on determining the mode is given under "ALT, CHOP—Dual-Trace Operation" in Section 2, Operating Instructions.

4. Apply the reference signal to the Channel 1 Input connector; apply the signals to be compared to the other channels. Use coaxial cables or probes which have equal time delay to connect the signals to the Input connectors.

5. Set the oscilloscope Triggering Source switch to Norm Int and use the other Triggering controls to obtain a stable display of all four waveforms.

6. Set the V/CM switches and the VARIABLE controls so the waveforms are equal and about 6 cm in amplitude. If necessary, readjust the oscilloscope Triggering Level control to maintain a stable display.

7. Set the Time/CM switch to a sweep rate which displays about 1 cycle for the waveforms.

8. Move the waveforms to the center of the graticule area with the Type 1A4 POSITION controls.

9. Set the oscilloscope Triggering Source switch to Plug In. Turn the Variable Time/CM control until 1 cycle of the reference signal (Channel 1) occupies exactly 9 cm horizontally (see Fig. 3-5). Each cm of the graticule represents 45° of the cycle ($360^\circ \div 8 \text{ cm} = 45^\circ/\text{cm}$). This is the phase factor.

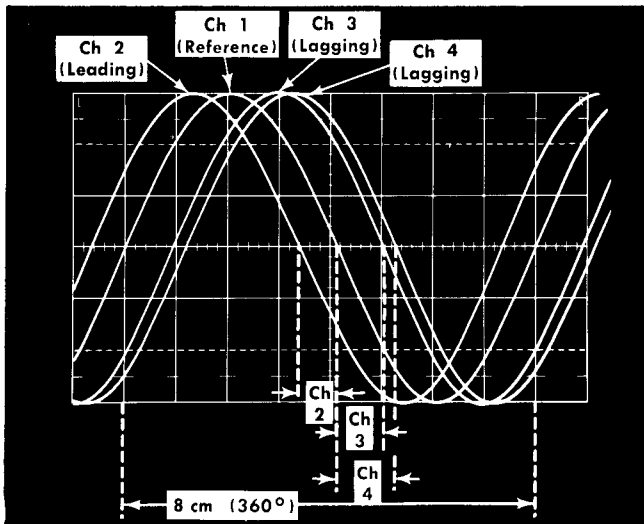


Fig. 3-5. Measuring phase difference.

10. Measure the horizontal difference between corresponding points on the waveforms; that is, between the Channel 1 waveform and each of the other waveforms as shown in Fig. 3-5. Note whether the waveform to be compared is leading or lagging. To make each phase difference measurement easier, the non-applicable waveforms can be switched off by setting the AC-GND-DC switches to GND until it is necessary to display them.

Example. Assume a horizontal difference of 0.73 cm between Channel 1 and 2 waveforms with a phase factor of 45° per cm as shown in Fig. 3-5.

Using the formula:

$$\text{Phase Difference} = \frac{\text{horizontal difference in cm}}{\text{phase factor}}$$

Substituting the given values:

$$\text{Phase Difference} = 0.73 \times 45^\circ$$

The phase difference is 32.85°. (Channel 2 waveform leads Channel 1 waveform by 32.85°.)

More Accurate Phase Measurements. More accurate multi-trace phase measurements can be made by increasing the sweep rate (without changing the oscilloscope Variable Time/CM control setting). One of the easiest ways to increase the sweep rate is with the oscilloscope Sweep Magnifier switch. 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 Sweep Magnifier, the adjusted phase factor would be $45^\circ \div 10 = 4.5^\circ/\text{cm}$. Fig. 3-6 shows the Channel 1 and 2 signal as was used in Fig. 3-5, but with the Sweep Magnifier switch set to $\times 10$. With a horizontal difference of 7.3 cm, the phase difference is:

$$\text{Phase Difference} = \frac{\text{horizontal difference in cm}}{\text{adjusted phase factor}}$$

Substituting the given values:

$$\text{Phase Difference} = 7.3 \times 4.5^\circ$$

The Phase difference is 32.85°

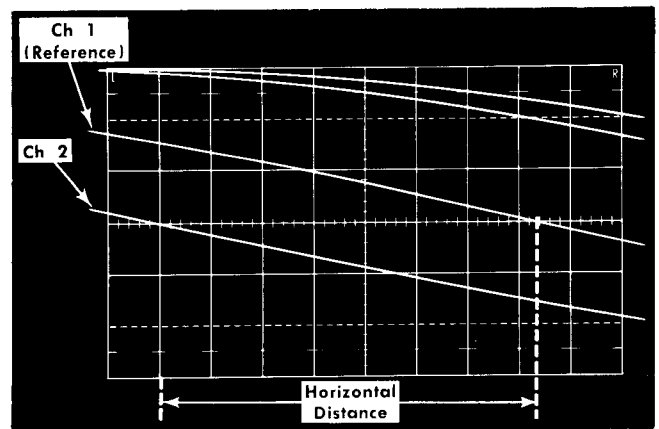


Fig. 3-6. Accurate phase-difference measurement with increased sweep rate.

Adding Fast-Rise Signals

The Type 1A4 is useful for adding low-amplitude fast-rise signals so the higher-amplitude added signal can be easily observed on the CRT. Since the Type 1A4 has wide bandwidth and good transient response, the added signal will be a faithful reproduction of the applied signal. To demonstrate this capability, a fast-rise square wave was displayed on the CRT using a single channel as shown in Fig. 3-7A. Two

Applications—Type 1A4

channels added is shown in Fig. 3-7B and four channels added is shown in Fig. 3-7C. The following paragraphs describe the procedure in greater detail.

To obtain Fig. 3-7A waveform, the Type 1A4 controls were set as follows:

Channel 1 controls

AC-GND-DC	DC
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Near midrange
Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	1 & 2

A fast-rise 10-kHz signal from a Type 106 Square-Wave Generator was applied through a 2× attenuator, 50-ohm coaxial cable and a 50-ohm in-line termination to the Channel 1 Input connector. The generator output was set to produce a 4-cm display amplitude as shown in Fig. 3-7A.

Next, the 2× attenuator was replaced by a 10× attenuator and a dual-input connector was inserted between the 50-ohm termination and the Channel 1 & 2 Input connectors. With the 10-kHz signal applied to Channel 1 and 2 simultaneously, the Type 1A4 controls were set as follows:

Channel 1 & 2 controls

AC-GND-DC	DC
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Near midrange
Ch 1 & 2 MODE	ADD
DISPLAY	1 & 2

The generator output was readjusted to produce a 4-cm Channel 1 & 2 added display as shown in Fig. 3-7B.

Finally, two more dual-input connectors were used to apply the same fast-rise 10-kHz signal to all four channels simultaneously. The Type 1A4 controls were set as follows:

All Channels

AC-GND-DC	DC
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Near midrange

Ch 1 & 2 MODE	ADD
Ch 3 & 4 MODE	ADD
DISPLAY	ADD

The generator output was readjusted to obtain a 4-cm 4-channel added display as shown in Fig. 3-7C.

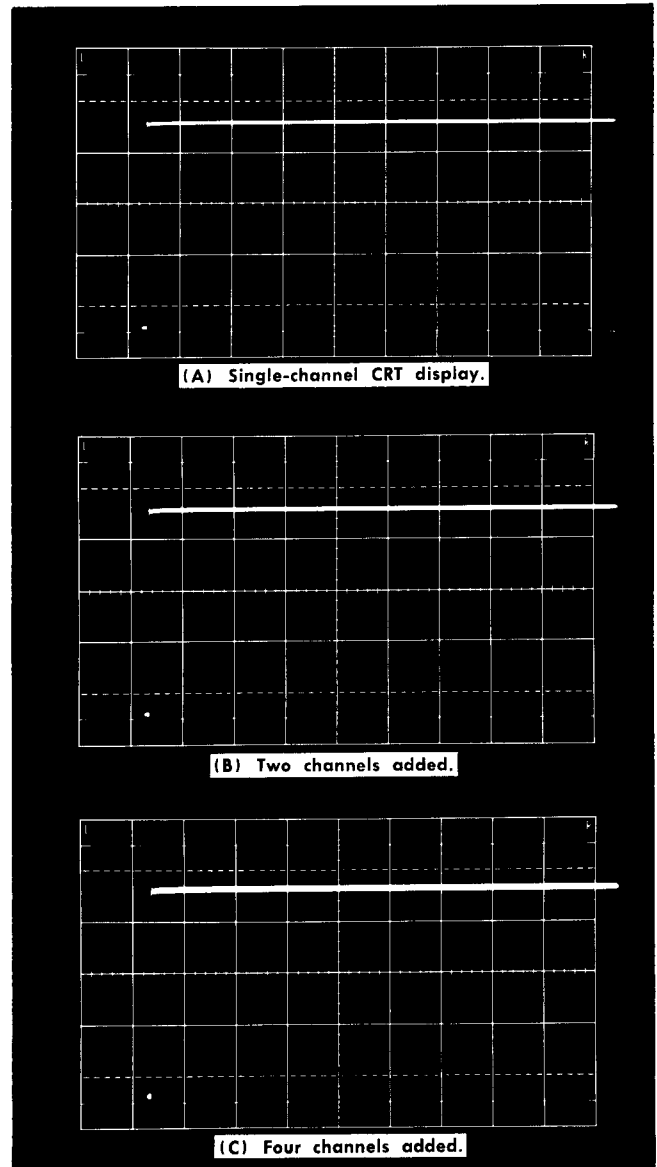


Fig. 3-7. Typical fast-rise waveforms obtained when comparing the added-mode displays to a single-channel display. Sweep rate: 1 μ s/cm.

SECTION 4

CIRCUIT DESCRIPTION

BLOCK DIAGRAM

The Type 1A4 Four-Channel Amplifier Plug-In Unit consists of four identical Input Amplifiers, a common Output Amplifier, an Output Level Regulator, a Trigger Amplifier, a Channel Switching Logic circuit and a Power Supply. When following this description, use the Block Diagram located on the pullout page in the last section of this manual.

All four channels are identical. Each channel has its own Input Coupling (AC-GND-DC) switch, Attenuator, Input Amplifier and POSITION control. Other components not shown on the Block Diagram and not mentioned here will be described in the Circuit Analysis portion of this section.

The Attenuator and Input Amplifier circuits for each channel are electrically and mechanically the same. They are constructed and wired to form a complete subassembly so one channel subassembly can be easily removed or replaced without disturbing the others. Since the subassemblies are identical, they can be interchanged without regard for the channel numbering system indicated on the front panel.

When signals are applied to the Type 1A4 Input connectors, a portion of the signal is taken off from each of the Input Amplifiers for application to the SIGNAL & TRIGGER SOURCE switch. This switch selects the channel signal that will be applied to the Trigger Amplifier circuit for amplification and for use as a trigger signal source.

The amplified trigger signal from the Trigger Amplifier is applied to the SIGNAL OUTPUT connector and to pin 5 of the 16-pin interconnecting plug. The trigger signal at pin 5 is applied internally to the oscilloscope Triggering Source switch in oscilloscopes which are wired to use this source.

The signal from each Input Amplifier is applied to an electronic switch controlled by the Channel Switching Logic circuit. The electronic switch (shown as a SPDT switch for each pair of channels on the Block Diagram) selects the channel signal that will be applied to a third electronic switch. The third electronic switch passes the selected channel signal to the Output Amplifier. From the Output Amplifier the signal is applied to pins 1 and 3 of the interconnecting plug for application to the oscilloscope vertical amplifier.

To regulate the current that each channel needs as it is switched into the circuit, particularly when switching to the added mode of operation, an Output Level Regulator circuit is provided. This circuit senses the output for any current change and feeds this change back to the input of the Output Amplifier. When the correct amount of current is supplied, the average output level at pins 1 and 3 is maintained at 67.5% of the oscilloscope's non-decoupled +100 V supply.

There are three binaries (multivibrators) in the Logic circuit; each binary controls one of the electronic switches.

The mode of operation for these binaries is set by the MODE and DISPLAY switches. If the oscilloscope used with the Type 1A4 has the alternate sweep switching feature, as does the Type 547, the oscilloscope sends an alternate-sweep switching slave pulse via pin 7 of the interconnecting plug to the Display Multivibrator (Q435, Q445). During A/Alt/B mode of operation when the Type 1A4 547 TRACE SLAVING switch is set to LOCK, the slave pulse locks channels 1 and 2 with Time-Base A and locks channels 3 and 4 with Time-Base B to provide completely isolated dual-sweep displays. During B-Intens-By-'A'/Alt/A-Dly'd mode of operation, the alternate sweep switching feature of the oscilloscope permits an 8-trace display to be obtained as the four channels are displayed alternately by each time base.

When using the Type 1A4 in the alternate mode (do not confuse the plug-in alternate mode with the Type 547 alternating time-base modes), the associated oscilloscope (regardless of type) sends an alternate trace sync pulse through pin 8 of the interconnecting plug to the Type 1A4 Logic circuit. Purpose of this pulse is to switch the channels of the plug-in unit during the sweep retrace interval. Thus, the channels in use can be displayed alternately.

For chopped mode of operation in the Type 1A4, the unit sends chopped-blanking pulses via pin 16 of the interconnecting plug to the oscilloscope CRT circuit. The purpose of these pulses is to blank the chopped-mode switching transients that occur during the switching time between channels so each channel display appears as an independent sampled display of the input signal. (Not applicable for Type 536, 551, 581A and 585A Oscilloscopes.)

Lastly, the Type 1A4 contains its own regulated power supply to provide +12.1 V and -15 V to the various circuits requiring these voltages. The remaining voltages that are listed in the Power Supply block originate from the oscilloscope power supplies and these voltages are applied to the Type 1A4 via pins 9, 10, 11, 13, 14 and 15 of the 16-pin interconnecting plug (see Power Supply schematic diagram).

CIRCUIT ANALYSIS

Introduction

The following circuit analysis of the Type 1A4 is keyed to the schematic diagrams located in the last section of this manual. Each schematic diagram has been assigned a reference diagram number in a diamond frame. These diagrams should be referred to for electrical values and relationships. In addition, refer to the simplified diagrams provided in this portion of the manual.

NOTE

Voltages given in this circuit analysis are not absolute, but are approximate. Measurements were

Circuit Description—Type 1A4

obtained using a 20,000 Ω/V DC VOM. All voltages are given with respect to ground unless indicated otherwise. Rising and falling portions of photographed waveforms were "touched up" to show entire waveshape. For alternate mode waveforms, 10-kHz signals were applied to all four channels for triggering purposes. Approximately the same number of switching cycles can be displayed on the test oscilloscope by free-running the sweep at 0.1 ms/cm.

Ch 1 Input Amplifier 1 and Attenuators 2

NOTE

Since all the Input Amplifiers are identical, the following description of the Channel 1 Input Amplifier applies to all.

Input Coupling

Input signals applied to the INPUT connector can be AC-coupled, DC-coupled or internally disconnected. When the AC-GND-DC switch SW1 is placed in the DC position, the input signal is coupled through network C2 and R2 directly to the input attenuator. The network is a parasitic suppressor to dampen parasitic oscillations at the higher frequencies. Such oscillations are usually caused by the inductive component of an external circuit connected to the INPUT connector.

In the AC position, the input signal is passed through a blocking capacitor, C1. This prevents the DC component of the signal from passing to the Input Amplifier. The GND position opens the signal path and grounds the input circuit of the Source Follower Q53A. This provides a ground reference for the trace without the need to remove the signal from the INPUT connector or disconnect the probe tip from a test point.

Input Attenuator

The Input Source Follower Q53A stage requires an input signal of 0.01 V, peak-to-peak, applied to its gate to produce one cm of calibrated peak-to-peak deflection on the CRT. In order to satisfy this condition, and to make the unit provide calibrated deflection factors for a wide range of input voltages, precision attenuation networks can be switched into the input circuitry by means of the V/CM switch SW25. The voltage-attenuation ratios of these networks are $\times 1$, $\times 2$, $\times 5$, $\times 10$ and $\times 100$.

When the V/CM switch is set to the .01 position, the input signal is coupled without attenuation to the gate of Q53A. For the other settings of the V/CM switch, the attenuation networks are switched into the circuit, either singly or two in series, so that the signal at the gate of Q53A is always 0.01 V for each cm of CRT deflection.

The attenuators are frequency compensated RC voltage dividers, and the attenuation factor at low frequencies can be expressed in a general manner as follows:

$$\text{Attenuation Factor} = \frac{\text{total divider resistance (including R45)}}{\text{grounded-leg resistances (includes R45)}}$$

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

$$\text{Attenuation Factor} = \frac{(R32)(R45) + (R32)(R34) + (R34)(R45)}{(R34)(R45)} = 2$$

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

For high-frequency signals, the impedance of the capacitors is low in comparison to the resistance of the circuit and the attenuators become capacitive voltage dividers. For these frequencies, the attenuation factor is similar to the resistance case, except that the capacitive reactances are the dominant factors involved. A variable capacitor in each attenuator, such as C32 in the $\times 2$ attenuator (see Fig. 4-1), provides a method for adjusting the capacitive reactance ratios equal to the resistance ratios.

The variable capacitor at the input to each attenuator, such as C31 (see Fig. 4-1), provides a means for adjusting the input capacitance of the attenuator to a normal value of 20 pF when using a 20 pF input RC normalizer as a reference. Similarly, C26 provides a method for normalizing the input time constant when the V/CM is set to the straight-through input position. In addition, to providing the same input capacitance for each position of the V/CM switch, the resistance values used in the attenuators are chosen to provide an input resistance of 1 M Ω for each setting of the V/CM switch. Thus, an attenuator probe, when connected to the INPUT connector of the Type 1A4, will work into the same time constant regardless of the V/CM switch position.

Input Source Follower Q53A

Q53A is a field-effect transistor (FET) which presents a high-impedance, low-capacitance load to the input circuit, and isolates the input from the remaining stages. R44 in the gate circuit of Q53A is a parasitic suppressor. Resistor R45 is the input resistor and is also part of the attenuation network in all positions of the V/CM switch above .01.

A network consisting of C46, R46, D46A and D46B form a protection circuit in Q53A gate circuit. The resistive component R46 limits the steady-state current in the event a negative or positive-going overload signal is inadvertently applied to the INPUT connector. Since the resistance alone will deteriorate the high-frequency AC response for normal-amplitude signals, C46 is added to pass the high frequencies around R46.

During the interval while a positive-going overload signal is applied to the Type 1A4, D46B conducts and limits the voltage of +12.6 V at the gate element of Q53A. If the overload signal is negative going, D46A will conduct to keep the gate from going more negative than -15.6 V. During the negative-going overload, Q53A will be driven into cutoff and D71 will conduct. D71 prevents Q53A source and Q73 base from going more negative than -0.6 V, thus minimizing the time taken for the amplifier to recover when the overload is removed.

DC Balance Source Follower Q53B

The DC Balance Source Follower Q53B provides proper DC balance drive to the base of Q84 via transistor Q83. This is accomplished by using DC coupling between the stages and by adjusting the VAR BAL control R60 so there is no current flow between the emitters of Q74 and Q84 under no signal conditions. No current flow between emitters is evident when

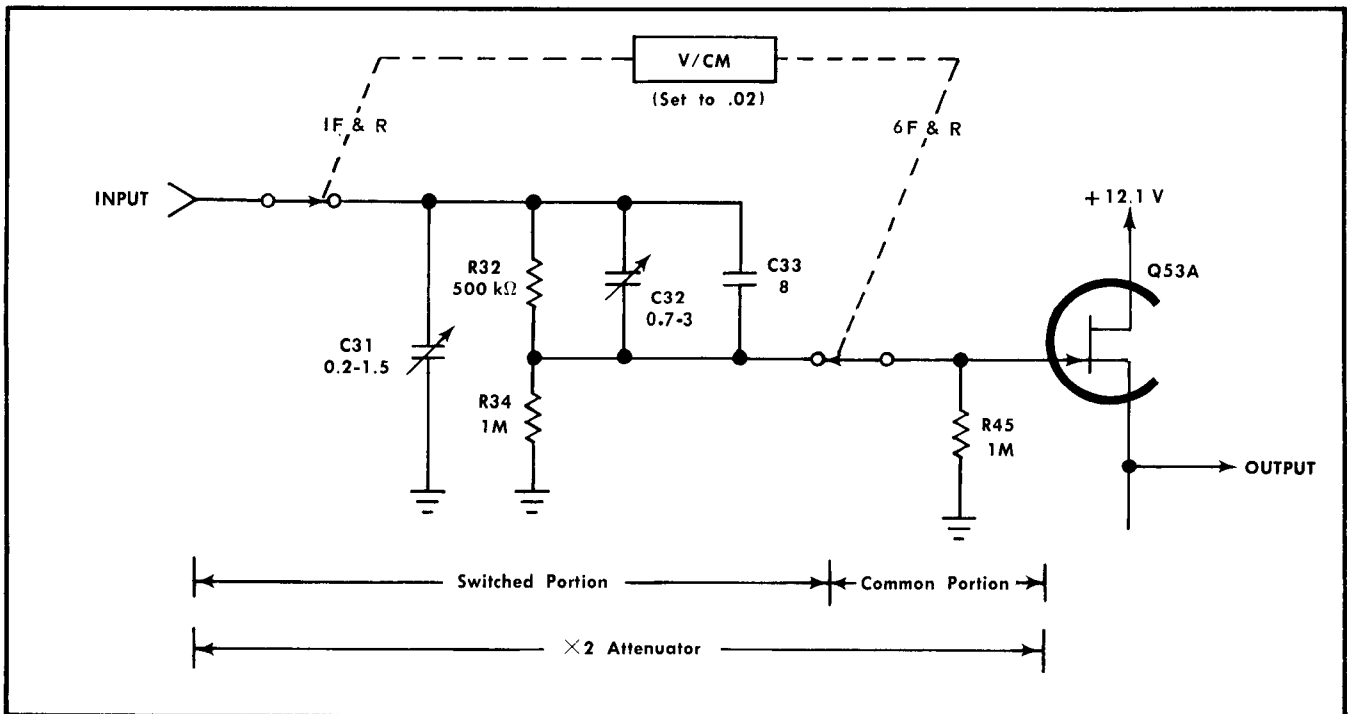


Fig. 4-1. Simplified diagram of the input circuit showing the main components involved when calculating the $\times 2$ attenuation factor.

the trace on the CRT does not shift vertically as the VARIABLE control R75 is rotated back and forth.

R61 is a voltage dropping resistor for R60, and determines the range of adjustment. Capacitors C60 and C64 bypass any fast voltage fluctuations to ground. Gate-to-source junction bias is set by the voltage divider consisting of R62, R63 and the adjusted portion of R60. R66 is the source load resistor for Q53B. R81 is a parasitic suppressor for the DC balance currents applied to the base of Q83.

Q53B and Q83 with associated circuitry have another important function. These stages are a balancing circuit for Q53A and Q73 to assure DC stability. Power-supply variations and changes in ambient temperature will affect both sides of the circuit equally since the circuit is symmetrical. Thus, any signals generated in the circuit due to these effects will arrive in phase at the bases of Q74 and Q84 and therefore will cancel.

Input Emitter Follower, Q73 and Q83

In addition to providing a means of balancing out power-supply and ambient-temperature variations as explained previously, Q73 and Q83 provide low-impedance drive to the Paraphase Amplifier stage, Q74 and Q84.

The input signal at the source element of Q53A is applied through R71, a parasitic suppressor, to the base of Q73. From the emitter of Q73 the signal is applied directly to the base of Q74 for amplification. The DC balance current is applied via Q53B and Q83 to the base of Q84.

A plastic cover is placed over Q73 and Q83 to minimize the effects of ambient temperature variations. For this same reason a plastic cover is also installed on Q74 and Q84.

Paraphase Amplifier, Q74 and Q84

The remaining stage in the Channel 1 Input Amplifier circuitry is an emitter-coupled paraphase amplifier consisting of Q74 and Q84 with associated components. This stage converts the single-ended input signal to push-pull. Gain of the stage is controlled by the VARIABLE control R75 and the PREAMP GAIN control R77 in the common emitter circuit. These variable potentiometers vary the emitter degeneration. Maximum gain occurs with minimum resistance between the two emitters. During calibration, the PREAMP GAIN control is set to obtain .01 V/cm calibrated deflection factor when the V/CM switch is set to .01 and the VARIABLE control is set to CAL.

The VAR BAL control R60 (via Q53B and Q83) sets the DC level on the base of Q84 so that no current flows between the emitters of Q74 and Q84 under no signal conditions. This insures that there is no ground reference shift of the trace when the VARIABLE control is turned.

Trigger Amplifier

Transistors Q114, Q124, Q134, Q143 and Q144 with associated components comprise the Trigger Amplifier circuitry. Each amplifier stage is an operational amplifier using a resistor as the main feedback element. Total voltage gain of the complete Trigger Amplifier, as measured between the source element of Q53A and the output at the collector of Q143, is a minimum of 50.

The SIGNAL & TRIGGER SOURCE switch SW100 in the base circuit of Q114 indirectly selects the channel signal that will be used as the signal and trigger source for application to the base circuit of Q114. Diodes are used for direct signal switching to avoid using long signal-carrying

Circuit Description—Type 1A4

leads to SW100. When Channel 1 is selected, for example, diode D101 is disconnected from the -15-V supply. As a result, D101 is reverse-biased and diode D105 is forward biased to allow the signal to pass from the source of Q53A through R53 and the forward-conducting diode D105 to the base of Q114.

For the remaining channels, the opposite occurs; that is, D102, D103 and D104 are connected to the -15-V supply and so they are forward biased. Diodes D106, D107 and D108 are reverse biased. Hence, the reverse-biased diodes in Channels 2, 3 and 4 prevent the signal in their respective channels from reaching the Trigger Amplifier. Refer to the Ch 1 Input Amplifier schematic diagram to see the diode voltages and polarities.

Whenever the SIGNAL & TRIGGER SOURCE switch is used for switching to one of the channel signals, a slight change in current will occur through R53 as the associated diodes are switched off and on. As a result, a small voltage change will occur at the source of Q53A and this will cause the trace to shift position on the CRT. To restore the trace to its original position, a TRIG SELECTOR BAL adjustment is provided for each channel. Using Channel 1 as an example, the normal procedure for adjusting the TRIG SELECTOR adjustment R55 is as follows: Set the SIGNAL & TRIGGER SOURCE switch to 2 and position the Channel 1 trace to graticule center. Set the SIGNAL & TRIGGER SOURCE switch to 1 and adjust R55 to return the trace to graticule center.

AC coupling is used between stages in the Trigger Amplifier to prevent amplifying the DC component of the signal in this high-gain circuit. An amplified DC component in a DC-coupled amplifier can drive succeeding stages into the limits of their dynamic operating range, thus seriously affecting the output signal amplitude and waveshape.

Series RC high-frequency peaking is used in the base circuits of Q124, Q134 and Q144; two are adjustable by means of C117 and C137, and one peaking network is fixed. The peaking network located in the base circuit of Q134 is fixed, because it affects the square wave in the same area as the network used in the base circuit of Q124. Hence, C117 provides sufficient range of adjustment for high-frequency compensation in that area.

Transistors Q144 and Q143 work together as an output stage for the Trigger Amplifier. Purpose of the stage is to provide low-impedance drive for the SIGNAL OUTPUT connector J149 and pin 5 of the interconnecting plug. The output impedance at J149 is 50 ohms and at pin 5 it is 93 ohms. C147 and R147 comprise a high-frequency peaking network; C147 is the adjustable component. Zener diode D143 provides a 6-V offset drop between the collector of Q144 and the base of Q143 to enable Q143 emitter to operate about 0.6 V to 0.7 V above ground.

D145 is a temperature compensating diode for the stage and also provides sufficient voltage drop to lower the output DC level of J149 and pin 5 to about ground. Diode D142 is a switching diode that is controlled by the MODE and DISPLAY switches when wired as shown on the schematic diagram. In all positions of these switches except the CHOP positions, D142 is reverse biased and the effect of C142 in the circuit can be considered negligible. Thus, bandwidth of the Trigger Amplifier is $\leq 20\text{ Hz}$ to $\geq 10\text{ MHz}$, unterminated. However, if the DISPLAY switch or either

MODE switch is set to CHOP, D142 becomes forward biased because its cathode voltage is lowered when the junction of R140 and C140 is grounded via the switch position. D142 connects C142 from the collector to the base of Q144. C142 provides negative feedback at high frequencies to the base of Q144. This feedback causes rolloff in the response of the amplifier and thus lowers the high frequency response from $\geq 10\text{ MHz}$ to 500 kHz, $\pm 20\%$, terminated or unterminated.

Output Amplifier 3

This circuit analysis describes the circuits that appear on the Output Amplifier schematic diagram. The circuit description starts at the left side of the diagram which includes a portion of the Input Amplifier circuitry for each channel. Since all channels are identical, Channel 1 is the only channel described.

Channel 1 Circuitry

Resistors R301 and R302, connected in each line coming from the collectors of Q74 and Q84 in the Ch 1 Input Amplifier circuit, provide thermal balancing for the transistors. The resistors keep the transistors operating at nearly constant power when the channel signal is coupled through the series diodes (D306, D309, D341 and D344) to the Output Amplifier. The manner in which these diodes are turned on is described later in this section. C301 and C302 offset the time constant developed between the resistors and the stray capacitance.

The INVERT switch SW300 inverts the displayed polarity of the signal. With the switch pushed in, a positive voltage change at the Channel 1 INPUT connector deflects the electron beam of the oscilloscope upward. With the switch pulled outward, the switch reverses the signal leads to the diode switch so a positive voltage change at the INPUT connector deflects the electron beam downward.

T300 is a bifilar transformer which lowers the common-mode gain of the amplifier at high frequencies. Use of the transformer contributes toward stable operation in the amplifier by suppressing tendencies for a wideband amplifier to oscillate.

The POSITION control, R305, is a dual-section potentiometer that varies the differential currents in the collector circuit of transistors Q74 and Q84. The differential currents act as positioning signals superimposed on the signal currents from the transistors. When the POSITION control is set to electrical center, no current flows in either leg. When the POSITION control is moved to either end from center, a change of at least 0.9 V differentially occurs at pins 1 and 3 of the interconnecting plug to the oscilloscope. This voltage range corresponds to at least 9 cm positioning range for the upward movement and at least 9 cm positioning range for the downward movement of the trace from electrical center.

The IDENTIFY switch SW305 is a pushbutton switch that, when pressed, inserts a small value of resistance in one side of the POSITION control circuitry and removes an equal value of resistance in the other side of the same circuitry. As a result, the differential currents in the push-pull circuit are changed sufficiently to cause the trace to shift upward about 3 mm on the CRT. This amount of trace shift provides a convenient means for identifying the channel

that is being displayed without the need for moving the POSITION control or using some other less convenient method.

Diode Switches

Assuming Channel 1 is the only channel being used, the Channel 1 push-pull signal consisting of the applied signal and DC positioning currents are fed through forward-biased series diodes D306, D309, D341 and D344 to the emitter circuit of Q344 and Q354. Fig. 4-2A is a simplified drawing that uses heavy lines to show the signal paths. Typical voltages are given to show diode biasing.

Each diode switch consists of four diodes that act like a double-pole double-throw switch. The Ch 1 diode switch, for example, can be turned on as shown in Fig. 4-2A by reverse biasing the shunt diodes (D307 and D308) and forward biasing the series diodes (D306 and D309). This is accomplished by applying +5.2 V from the Ch 1 & 2 Multivibrator to the junction of the shunt diodes. The +5.2 V at the shunt diode anodes is lower than the voltages at the cathodes so the shunt diodes are reverse biased. The series diodes, however, are forward biased by the +8 V at the anodes with respect to the +7.3-V at the cathodes, so the signal passes through these series diodes to the Ch 1 & 2 diode switch.

The Ch 1 & 2 diode switch operates in the same manner as the Ch 1 diode switch. The switching voltage for the Ch 1 & 2 diode switch comes from the Display Multivibrator. With the voltages applied to the switch as shown in Fig. 4-2A, shunt diodes D342 and D343 are reverse biased; series diodes D341 and D344 are forward biased so the Channel 1 signal passes through the series diodes to the Output Amplifier.

Fig. 4-2B shows the signal paths and diode biasing conditions when Channel 2 only operation is used. Note that the Ch 1 diode switch is turned off so Channel 1 signal goes to a common-mode point at the junction of shunt diodes D307 and D308. Channel 2 signal, however, passes through the turned-on Ch 1 & 2 diode switch to the Output Amplifier. Fig. 4-2C shows the signal paths and diode biasing conditions when Channels 1 and 2 are turned off. The signal from the Channel 3 & 4 diode switch is allowed to pass to the Output Amplifier. The voltages for this illustration (Fig. 4-2C) were obtained by setting the Ch 1 & 2 MODE switch to CHANNEL 1, the DISPLAY switch to 3 & 4, and the Ch 3 & 4 MODE switch to either CHANNEL 3 or CHANNEL 4.

Output Amplifier

The Output Amplifier consists of Q344, Q354, V374, Q384 and Q394 with associated components and circuitry. The Output Level Regulator, consisting of Q363, Q373 and Q374, is also part of the Output Amplifier circuit but will be described later as a separate topic. To follow the signal through the Output Amplifier, this description follows the signal single-endedly through Q344, V374A and Q384.

Transistor Q344 is current driven by the signal and positioning currents from the collector circuit of Q84. Thus, the voltage swing at the emitters is relatively small, due to the low impedance.

V374A operates as a grounded-grid amplifier with its cathode current driven by Q344. The tube elevates the

+13.2-V DC level at the collector of Q344 to about +65 V at the plate. This +65-V level is raised to about +67.5 V at the collector of Q384 and pin 3 of the interconnecting plug. The +67.5-V level is the correct voltage necessary for operating the vertical amplifier in the oscilloscope. Actually, however, the voltage at pin 3 is 67.5% of the oscilloscope's +100 V non-decoupled regulated supply and this percentage voltage is set accurately by means of the OUTPUT DC LEVEL control R360 in the Output Level Regulator circuit.

The plate impedance of V374A can be looked upon as the input impedance of an operational amplifier consisting of V374A and Q384 with R376 being used as the feedback resistor. R375 is the load resistor. Transistor Q384 is a high-frequency transistor that has low input capacitance to maintain circuit stability and to provide wide bandwidth response.

High-frequency compensation networks are provided in the collector circuit of Q384 and Q394. These are: C395, R395, C396, R396, C397 and R397. The time constants of these networks act against the impedance of R393 and R394 to produce the proper step response when the time constants are correctly adjusted according to the sequence given in the Calibration procedure.

A master GAIN control, R379, is provided in the Output Amplifier, so that all four channels do not have to be set individually every time the Type 1A4 is taken out of one oscilloscope and plugged into another. When adjusted, R379 varies the cathode degeneration and thus the gain of the stage. In the Calibration procedure for the Type 1A4, R379 is set to midrange and the PREAMP GAIN control R97 in each channel is adjusted to obtain the correct deflection factor.

Output Level Regulator

Transistors Q363, Q373 and Q374 with associated components form the Output Level Regulator circuit. The purpose of this circuit is to sense any change in output voltage level of the Output Amplifier and provide the correct amount of feedback to restore the output to its original level. This is accomplished by connecting the common-mode point at the junction of R374, R375 and R382 to the base of Q374. Any change in average voltage at pins 1 and 3 will also appear at the common-mode point.

This change in average output voltage is compared to the voltage at the base of Q373. If the voltage at the base of Q374 is not the same as the voltage at the base of Q373, current through Q374 changes and this change is applied to the junction of R345 and R355 in the emitter circuits of Q344 and Q354. This method of feedback restores the output voltage to its original level, which is 67.5% of the oscilloscope's non-decoupled 100-V supply.

The voltage at the base of Q373 is set by means of the OUTPUT DC LEVEL control R360 and transistor Q363. The control is connected in a divider network with R361 and R362. Transistor Q363 converts the high impedance of the divider network into a low impedance for driving the base of Q373. Comparator transistors Q373 and Q374 are capable of handling a wide range of current variations demanded by the different modes of operation. For example, in single-channel mode of operation a certain amount of common-mode current flows through the emitters of Q344 and Q354. In add mode of operation, this current is increased

Circuit Description—Type 1A4

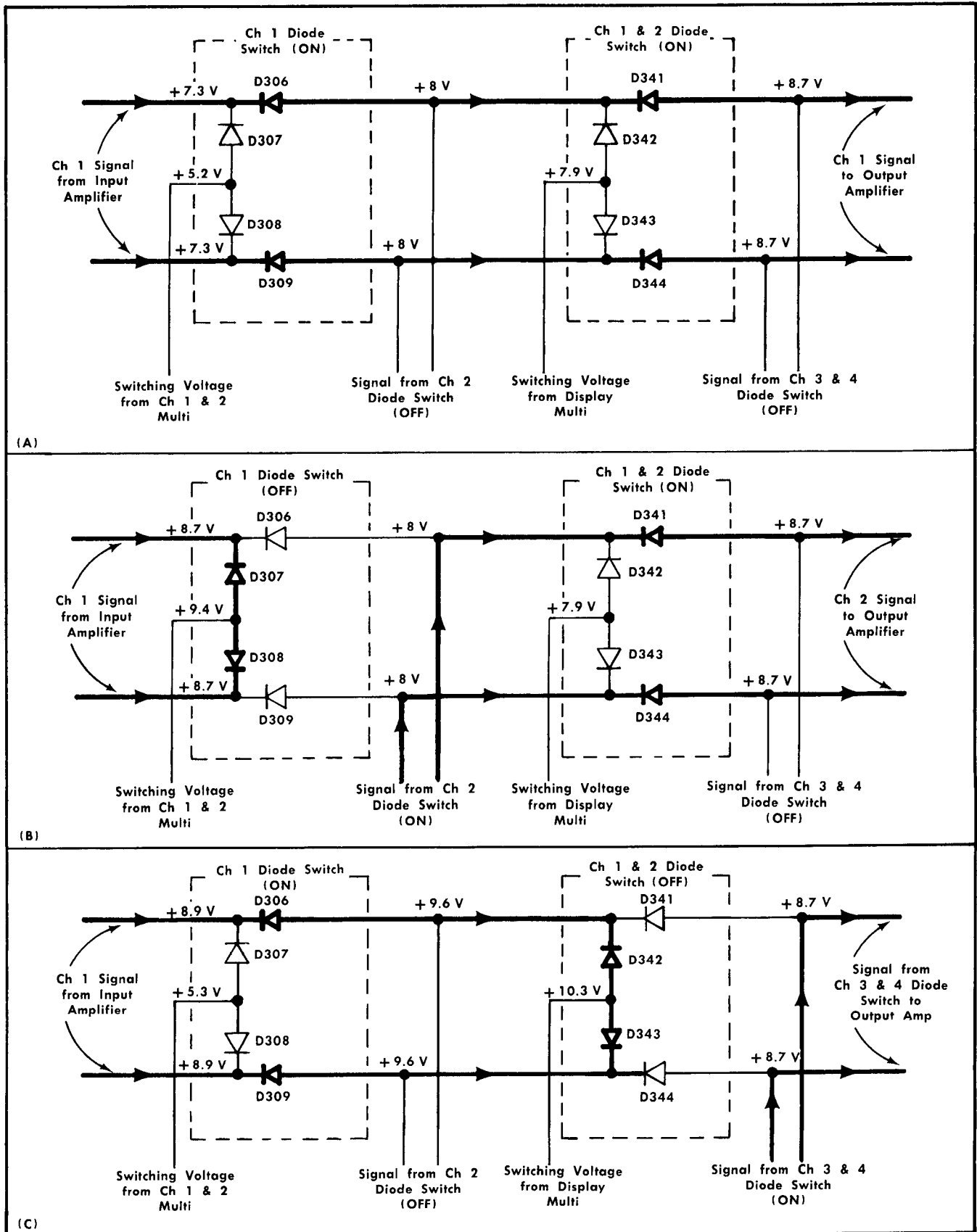


Fig. 4-2. Simplified drawings showing how Ch 1 and Ch 2 diode switches control the signal paths for Channel 1 and 2. Drawing (A) shows Channel-1-only operation, (B) shows Channel-2-only operation, and (C) shows Channel 1 and 2 turned off while Ch 3 & 4 diode switch is turned on. Heavy lines show signal path.

because more diode switches are turned on. Q374 supplies this extra current through R345 and R355.

Capacitor C374 controls the response time of the regulator circuit so its speed is appropriate for the operating modes encountered in the Type 1A4; particularly, when using the chopped mode.

1 Channel Switching Logic 4

Introduction

The various combined settings of the Type 1A4 MODE and DISPLAY switches provide many different modes of operation. When some of these modes are combined with the alternate-sweep feature of the Type 547 Oscilloscope, the system can be locked together to display multi-channel signals at two different sweep rates. Since the versatility of the system makes possible so many different operating modes, it is beyond the scope of this manual to describe all of them. Therefore, some modes are analyzed with the intention that this will present a basis for understanding the other modes.

Block diagrams are provided in this portion of the manual to show the various interconnections between blocks and to point out all the signals that go to and from the blocks. Table 4-1 summarizes the circuit configurations. Knowing these circuit arrangements in advance should be helpful when reference to a configuration is made in the description.

TABLE 4-1
Basic Circuit Configurations

Circuit	Configuration
Multivibrators ² Each multivibrator is basically a bistable circuit or binary. Configurations are set by the MODE and DISPLAY switches.	Three stable states and one bistable: 1. "A" side ON, "B" side OFF. 2. "A" side OFF, "B" side ON. 3. Both sides OFF. 4. Bistable circuit—Base-triggered from Blocking Oscillator through steering diodes.
Blocking Oscillators ² Configuration for Q420 and Q460 is controlled by associated transistors, Q423 and Q463. Configuration for Q450 is set directly by DISPLAY and MODE switches.	Two states: 1. Triggered. 2. Free-running.
Blocking Oscillator Control Transistors, Q423 and Q463. Configurations are set by the MODE and DISPLAY	Two stable states and one active state: 1. ON. 2. OFF.

¹Also referred to as the "Logic circuit" in this manual.

²Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms", McGraw-Hill, New York, 1965. Refer to pp. 362-389 for more information about multivibrators and pp. 597-621 for information concerning blocking oscillators.

switches.	3. Active. Driven ON or OFF by lockout signal from the appropriate collector in Display Multi (Q435 and Q445).
Chopped Blanking Pulse Amplifier, Q504.	Active. Conducts when positive-going pulses are applied.
Alternate Trace Sync Pulse Amplifier, Q493 and Q494. Stable states of Q493 are set by MODE and DISPLAY switches. Q493 is active in the ALT positions only.	Two stable states for Q493: 1. Active. Conducts when positive-going alternate-trace sync pulses are applied. 2. Inactive. Does not conduct when pulses are applied. Q494 is active. Driven into conduction by negative-going pulses from Q493 when Q493 operates in the active state only.

Schematic diagrams of the Channel 1 & 2 Logic circuits are provided in this section to show the circuit configurations in detail. These circuits are similar to the Logic circuits associated with the Display Multivibrator and the Ch 3 & 4 Multivibrator. There is one exception. The Display B. O. (Blocking Oscillator) Q450 configuration is not controlled by a control transistor but is set directly by the MODE and DISPLAY switches. Schematics of the Chopped Blanking Pulse Amplifier and Alternate Trace Sync Pulse Amplifier are also provided in this section since a description of these circuits is necessary when describing the switching circuits for Channels 1 and 2. Circuit values for the components can be found by referring to the schematic diagram pull-out pages at the rear of the manual. All information supplied in this portion of the manual is useful for troubleshooting purposes if proper allowance is made for variations in voltage and waveform amplitudes between units.

The description begins with the CHANNEL 2 position of the Ch 1 & 2 MODE switch and then proceeds to each of the other positions of the switch before going to the more complex modes of operation.

Channel 2 Only Operation

Block Diagram (see Fig. 4-3) and Diode Switches (Fig. 4-4). In this mode of operation the Ch 1 & 2 Multivibrator is set to operate in this stable state: Q405 is on and Q415 is off. Q405 applies +9.4 V to the anode junction of Ch 1 shunt diodes, D307 and D308. This voltage turns on the shunt diodes and reverse biases the series diodes, D306 and D309, to stop the Channel 1 signal.

Q415 applies +5.2 V to the Ch 2 shunt diodes, D317 and D318. This voltage reverse biases the shunt diodes and permits the series diodes, D316 and D319, to be forward biased. The forward-biased Ch 2 series diodes allow the Channel 2 signal to go on to the Ch 1 & 2 diode switch.

With the DISPLAY switch set to 1 & 2, the Display Multivibrator is set to operate in this stable state: Q435 is on and Q445 is off. Q445 applies +7.9 V to the Ch 1 & 2 shunt

Circuit Description—Type 1A4

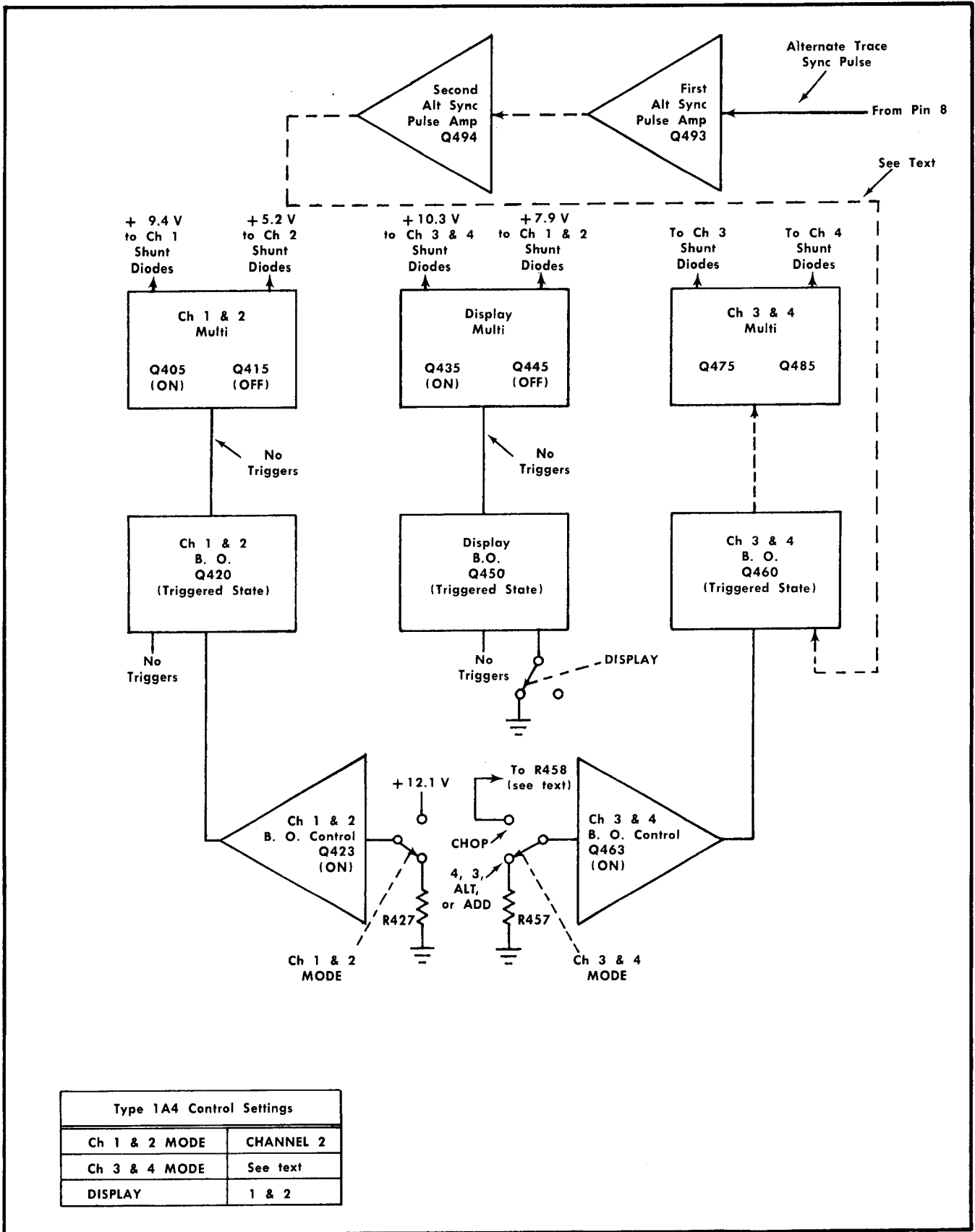


Fig: 4-3. Simplified block diagram of the Logic circuit set for Channel 2 only operation.

diodes, D342 and D343. This voltage reverse biases the shunt diodes and permits the Ch 1 & 2 series diodes to become forward biased so the Channel 2 signal passes through the Ch 1 & 2 diode switch to the Output Amplifier.

Q435 applies +10.3 V to the Ch 3 & 4 shunt diodes, D352 and D353. This voltage forward biases the shunt diodes and reverse biases the Ch 3 & 4 series diodes, D351 and D354. As a result, the Ch 3 & 4 diode switch is turned off to stop any signals coming from Channel 3 and/or 4.

During Channel 2 only operation, the state of the Ch 3 & 4 Multivibrator can be changed by means of the Ch 3 & 4 MODE switch. However, the Channel 1 and 2 display is not affected because the Ch 3 & 4 diode switch is held off by the Display Multivibrator.

Referring to Fig. 4-3 block diagram, it is important to explain the action of the circuits associated with the Ch 3 & 4 Multivibrator when the Ch 3 & 4 MODE switch is set to each of its positions while the DISPLAY switch is set to 1 & 2. Note that for all positions of the Ch 3 & 4 MODE

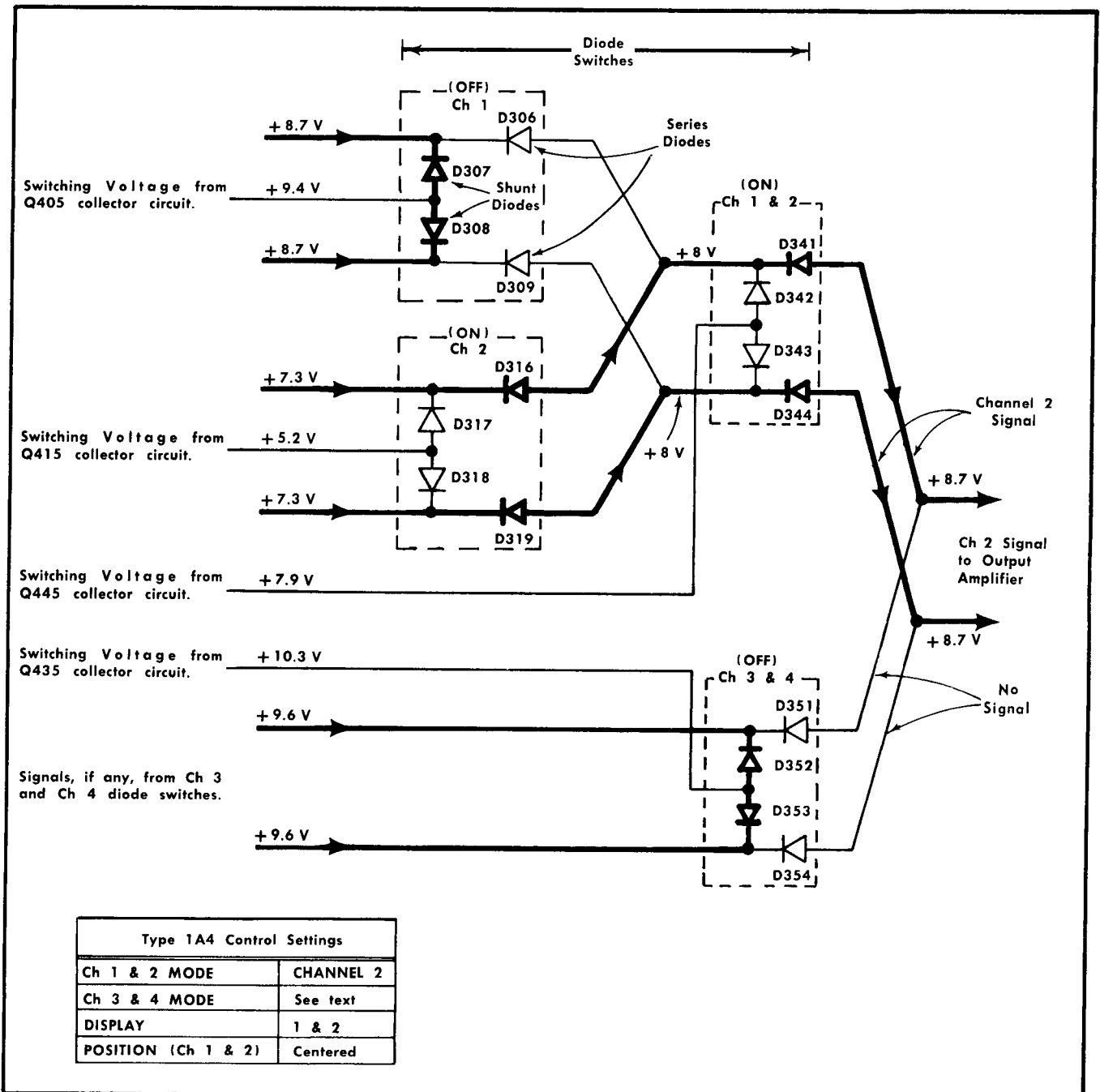


Fig. 4-4. Simplified diagram of the diode switches during Channel 2 only operation. Channel 2 signal passes through the Ch 2 and Ch 1 & 2 diode switches to the Output Amplifier.

Circuit Description—Type 1A4

switch, the Ch 3 & 4 B. O. Control transistor, Q463, is turned on and this places the Ch 3 & 4 B. O. Q460 in a triggered state. Q463 is turned on by connecting the transistor to R457 or R458. Both of these resistors are the same value and go to ground. The reason for connecting Q463 to R458 during the CHOP position is to place Q460 in a triggered state instead of a free-running state while the DISPLAY switch is set to 1 & 2. (The free-running state is the normal configuration when chopped-mode operation is used but since the Type 1A4 is set for Channel 2 only operation, the B. O. for Ch 3 & 4 is deliberately prevented from free running because the blanking pulses from Q504 will interfere with the Channel 2 display. Thus, to prevent Q460 from free running and applying pulses to Q504 at this time, Q460 is placed in a triggered state and no triggers are applied to Q460.)

In the ALT position the Ch 3 & 4 MODE switch places the First Alternate Sync Pulse Amplifier, Q493, in the active state so the alternate trace sync pulses can be amplified by Q493 and Q494 for application to Q460. The B. O. Q460 is triggered by these pulses in this mode (ALT) and the Ch 3 & 4 Multivibrator does change states at the pulse rate but there is no interference with the Channel 2 display because the alternate-trace switching occurs during the sweep retrace interval.

The blocking oscillators for the Ch 1 & 2 Multivibrator and the Display Multivibrator are resting in a triggered state. No triggers are applied to Q420 or Q450.

Q420, Q423 and Q504 Circuitry (see Fig. 4-5). This partial schematic diagram shows the circuit connected for Channel 2 only operation. However, the Ch 1 & 2 MODE switch can be placed to CHANNEL 1 or ADD and the circuits are still connected the same way as shown for CHANNEL 2. Thus, a description for the CHANNEL 2 position will also apply for the CHANNEL 1 and ADD positions. A short description of the ALT position is also included to fully explain the use of R427 in the circuitry.

Referring to R427, the 1R wafer of the Ch 1 & 2 MODE switch connects the base of Q423 to R427. The divider, consisting of R426 and R427, forward biases Q423 into saturation. In the collector circuit of Q423 a divider is formed that consists of R425 connected to +12 V (at Q423 collector) and R423 connected to -150 V.

With +12 V applied to the top of divider at the collector of Q423, the voltage at the junction of R425, R423 and the emitter of Q420, is slightly above ground or about +1.2 V. The base of Q420 is connected to ground through T420 winding and R420. Thus, the voltage at the base is zero. Under the given conditions, the base-emitter junction of Q420 is reverse biased and the transistor is held at cutoff. Positive-going triggers through C424 are required to trigger the blocking oscillator. However, since there are no triggers applied to Q420 in Channel 2, Channel 1 or Add mode of operation, the blocking oscillator is not triggered. No triggers are applied to the Ch 1 & 2 Multivibrator and no triggers are applied to Q504 to produce blanking pulses.

Ch 1 & 2 Multivibrator, Q405 and Q415 (see Fig. 4-6). For Channel 2 only operation the multivibrator is set to the following stable state by means of the Ch 1 & 2 MODE switch: Q405 is on and Q415 is off. This is accom-

plished by connecting one end of R402 to ground so a divider, consisting of R401 and R402, is formed to forward bias the base-emitter junction of Q405.

Q405 goes into saturation and the rise in collector voltage is applied to the Q415 base divider consisting of R413 and R411. The voltage increase, coupled to the base of Q415, reverse biases the base-emitter junction of the transistor. Hence, Q415 goes into cutoff. The multivibrator is locked into this stable state (Q405 on, Q415 off) during Channel 2 only operation.

With Q405 biased into saturation, the voltage at the junction of R405 and R406 is +9.4 V. This voltage is applied to the junction of the Ch 1 shunt diodes, D307 and D308. The voltage forward biases the shunt diodes and reverse biases the Ch 1 series diodes, D306 and D309. Thus, the Ch 1 diode switch is turned off and the Ch 1 input signal is stopped.

Q415, being biased into cutoff, reduces the voltage at the junction of R415 and R416 to a quiescent level of +5.2 V. This voltage reverse biases the Ch 2 shunt diodes, D317 and D318. This action allows the Ch 2 series diodes, D316 and D319, to become forward biased and permits the Ch 2 input signal to pass through the series diodes to the Ch 1 & 2 diode Switch. As pointed out in the block diagram of Fig. 4-3, Q445 in the Display Multivibrator is off, so +7.9 V is applied from the collector circuit of Q445 to the Ch 1 & 2 shunt diodes, D342 and D343. This voltage reverse biases the shunt diodes and forward biases the series diodes, D341 and D344. Now the Ch 2 signal passes through the Ch 1 & 2 diode switch to the Output Amplifier.

The DC Interconnection shown going from the collector of Q415 through R414 (see Fig. 4-6) to other multivibrators is not used in Channel 2 only operation. (This same DC Interconnection is, however, used as a drive signal to Q450 in some ALT and CHOP modes.) The Ch 1 & 2 MODE switch provides the means for disconnecting this interconnection for Channel 2, Channel 1 and Add modes of operation. Refer to the Channel Switching Logic diagram at the rear of the manual to follow the routing of this circuit.

Alternate Trace Sync Pulse Amplifier Q493 and Q494 (see Fig. 4-7). In all positions except ALT of the MODE and DISPLAY switches the emitter of Q493 is not grounded. Therefore, in all positions except ALT, R493 and R494 form a divider circuit that raises the emitter level sufficiently above ground to reverse bias the base-emitter junction of Q493 into an inactive state so the alternate trace sync pulses cannot drive Q493 into conduction. As a result, Q493 does not apply alternate trace sync pulses to Q494 for inversion, shaping and amplification. No pulses appear at the collector of Q494 for distribution to the blocking oscillators.

C493 in the emitter circuit of Q493 bypasses any signal to ground. R490 and R491 is a divider network for the cathode circuit of the Sync Amplifier in the oscilloscope via pin 8 of the interconnecting plug. Resistor R504 in the Q504 circuitry is connected to +100 V to provide plate voltage to the Sync Amplifier via pin 16 of the interconnecting plug. Thus, with the cathode and plate circuits completed in this manner, the oscilloscope Sync Amplifier functions as a cathode follower for the alternate trace sync pulses. The oscilloscope Sync Amplifier stage always operates in this mode when the Type 1A4 is used with the oscilloscope.

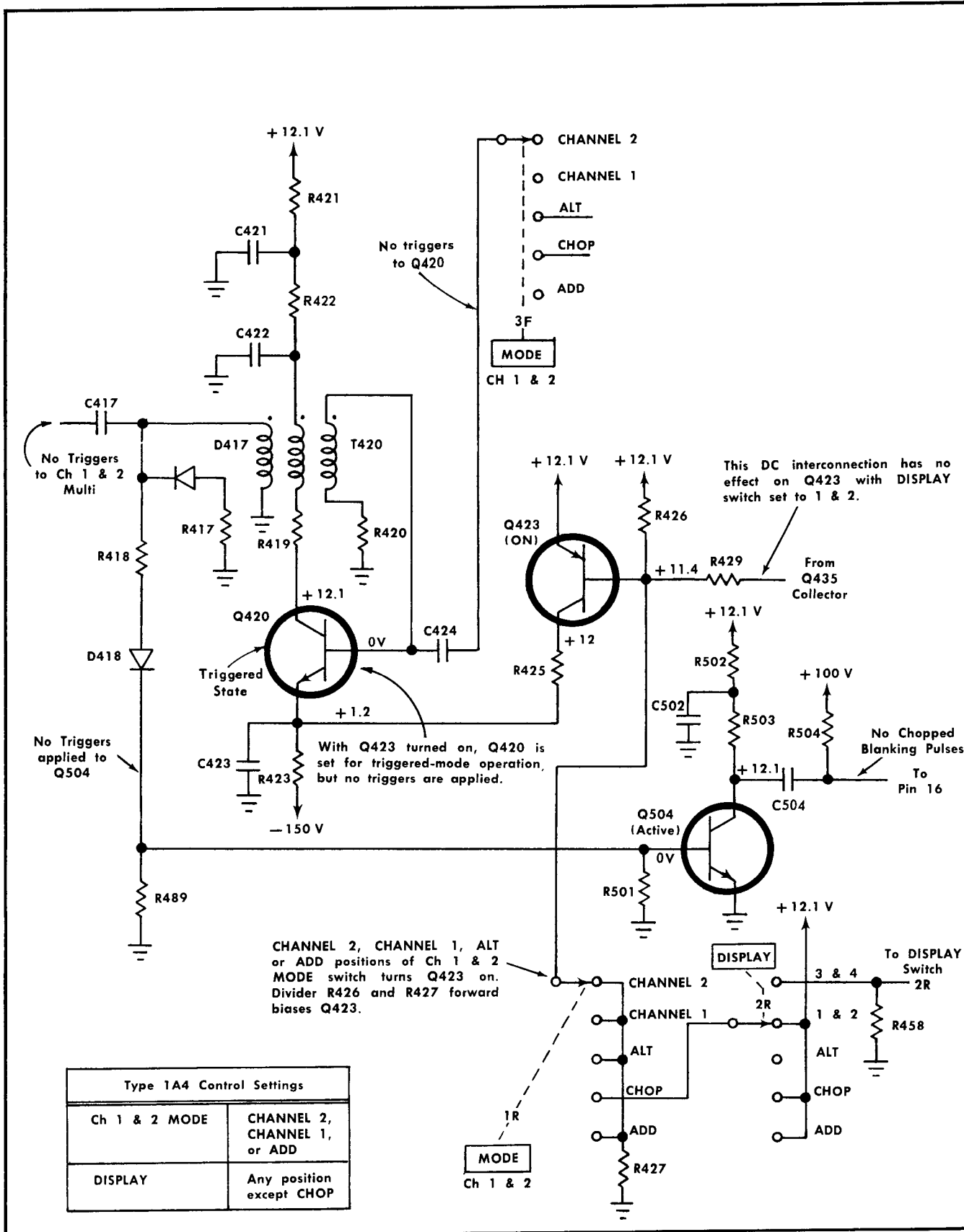


Fig. 4-5. Schematic diagram showing Q420, Q423 and Q504 circuitry with quiescent voltages that apply for the switch settings given in the table.

Circuit Description—Type 1A4

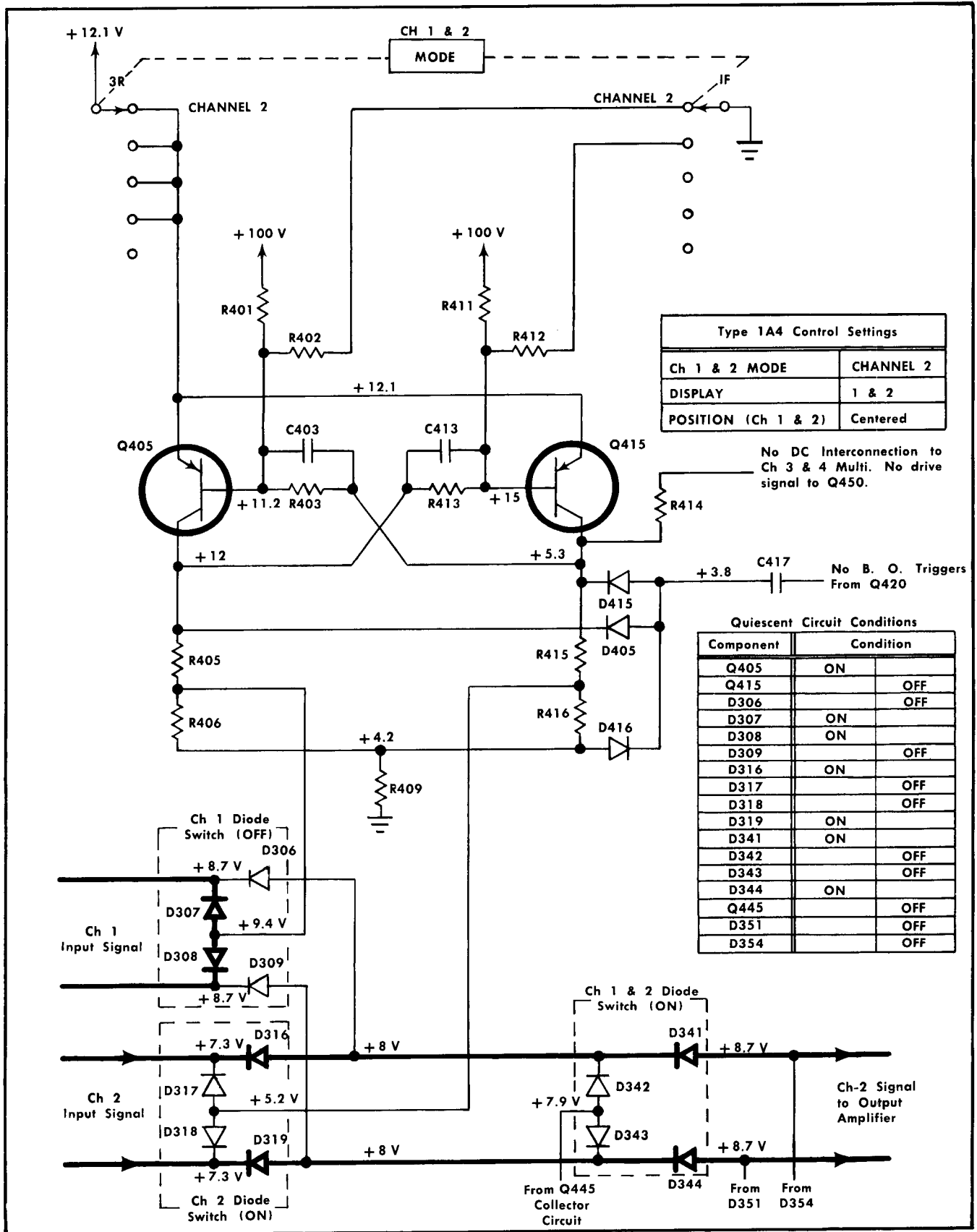


Fig. 4-6. Schematic diagram of the Ch 1 & 2 Multivibrator shown with the Ch 1 & 2 MODE switch set to CHANNEL 2. ON or OFF condition of the Ch 1, Ch 2 and Ch 1 & 2 diode switches are shown. Heavy lines show signal paths.

Channel 1 Only Operation

Block Diagram (Fig. 4-8) and Diode Switches (Fig. 4-9). In Channel 1 only operation the Ch 1 & 2 Multivibrator operates in this stable state: Q405 is off and Q415 is on. Q405 applies +5.2 V to Ch 1 shunt diodes, D307 and D308. This voltage reverse biases the shunt diodes and permits the series diodes, D306 and D309, to be forward biased. The Ch 1 series diodes allow the signal to go to Ch 1 & 2 diode switch.

Q415 applies +9.4 V to the Ch 2 shunt diodes, D317 and D318. This voltage forward biases the shunt diodes and reverse biases the series diodes, D316 and D319. Thus, the Channel 2 signal is prevented from going to the Ch 1 & 2 diode switch.

With the DISPLAY switch set to 1 & 2, the Display Multivibrator is set to operate in this stable state: Q435 is on

and Q445 is off. This is the same state as described previously for Channel 2 only operation. As a result, the Ch 1 & 2 diode switch is turned on to allow the Channel 1 signal to be applied to the Output Amplifier.

The Channel 2 only block diagram description given for the Ch 3 & 4 Multivibrator with associated circuits also applies for Channel 1 only operation.

Q420, Q423, Q504, Q493 and Q494 Circuitry. For a description of these transistors with associated circuitry, refer to the Channel 2 only description given earlier. Use Figs. 4-5 and 4-7 as a guide to see the circuit comments and quiescent voltage conditions.

Ch 1 & 2 Multivibrator, Q405 and Q415 (see Fig. 4-10). For Channel 1 only operation the multivibrator is

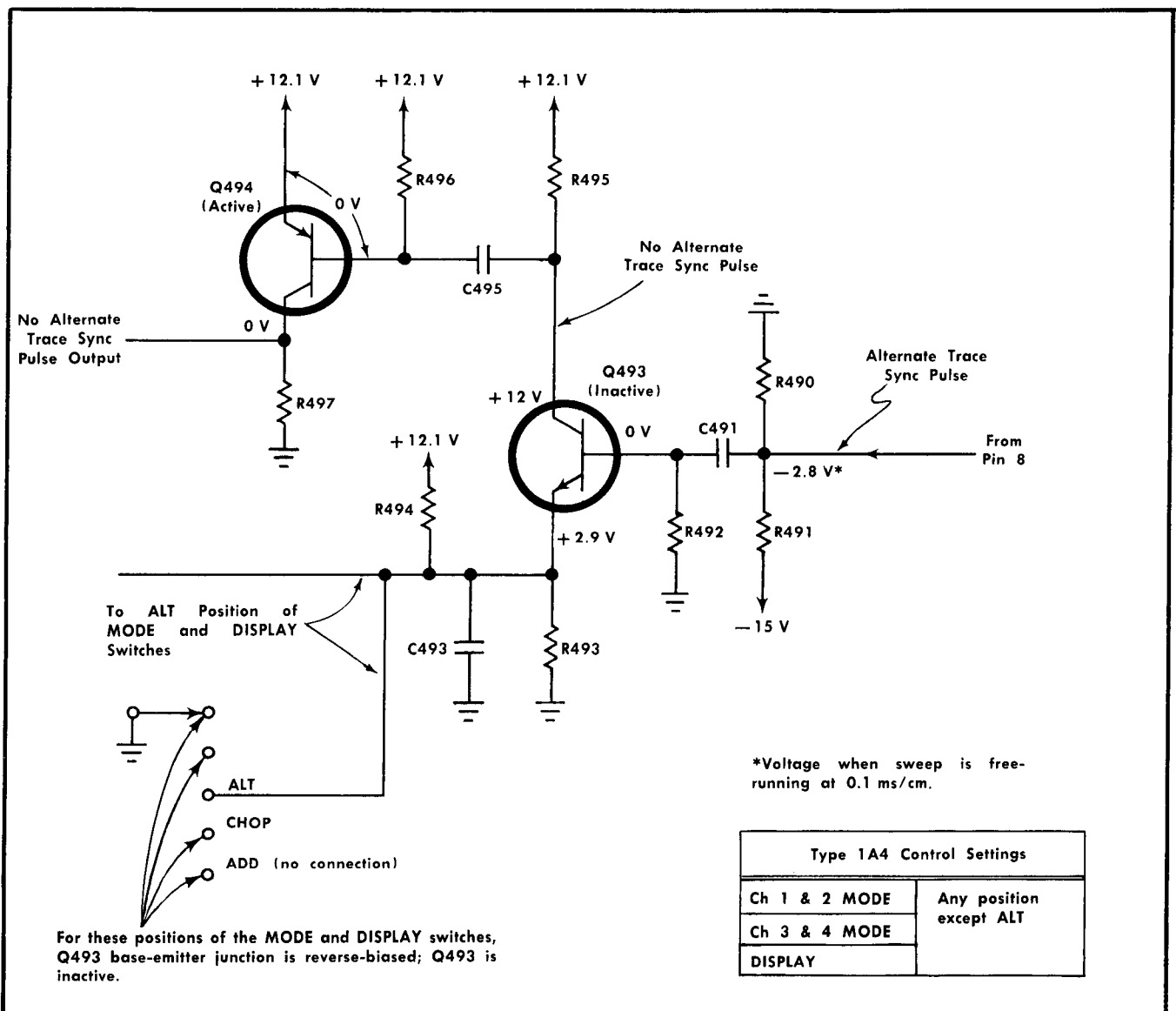


Fig. 4-7. Schematic diagram of the Alternate Trace Sync Pulse Amplifier shown with Q493 in its inactive state.

Circuit Description—Type 1A4

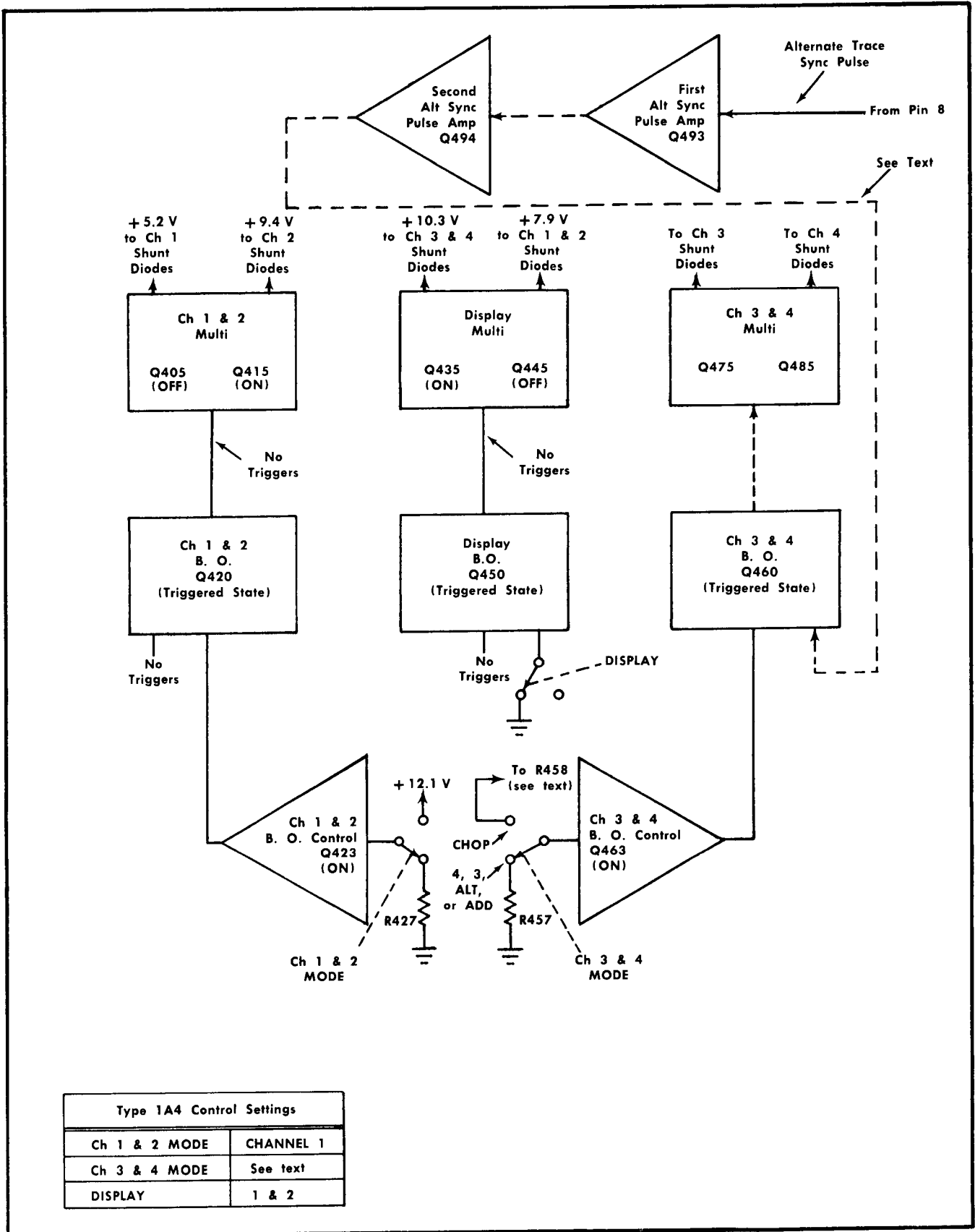


Fig. 4-8. Simplified block diagram of the Logic circuit set for Channel 1 only operation.

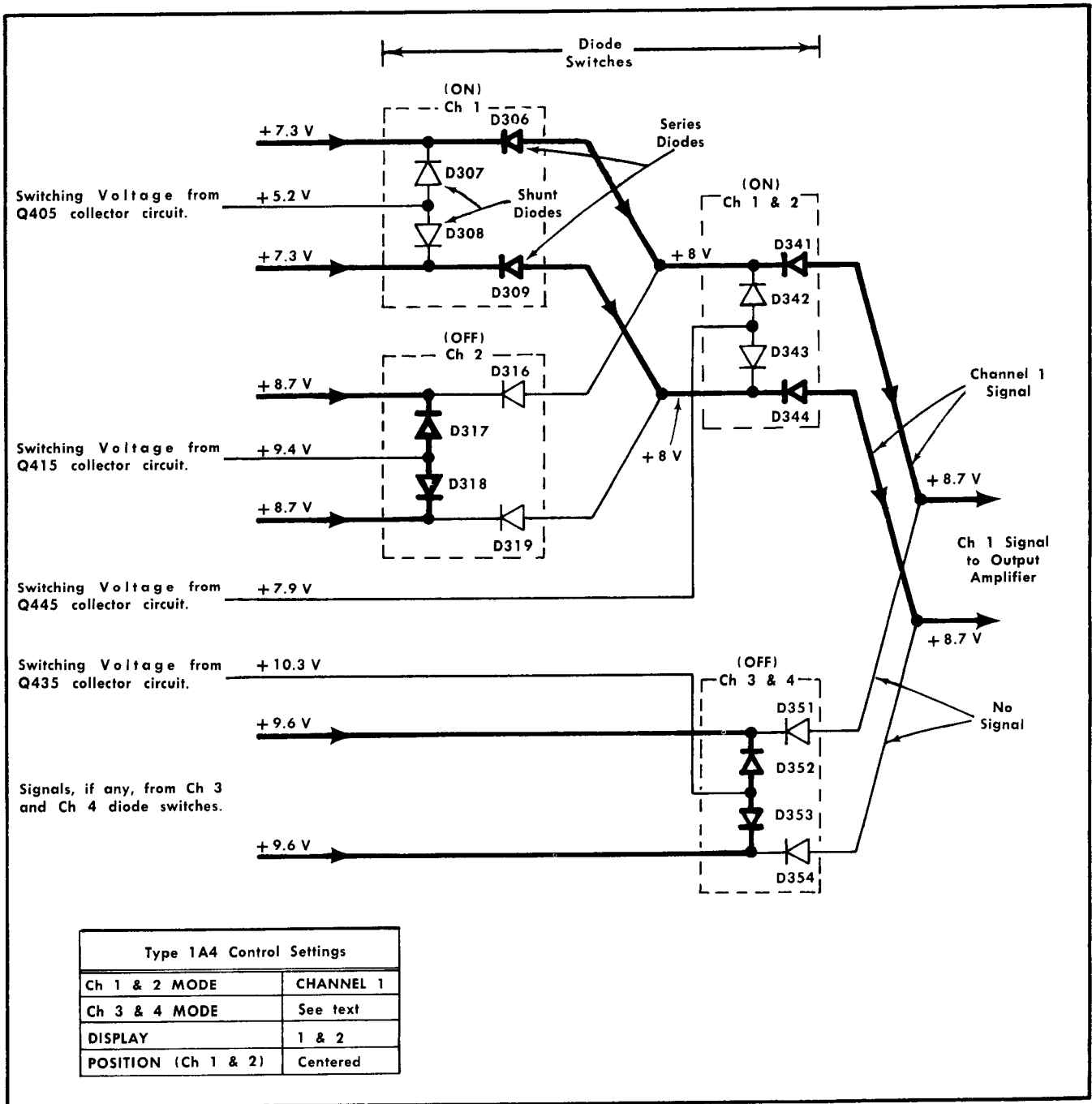


Fig. 4-9. Simplified diagram of the applicable diode switches that show Channel 1 only operation. Channel 1 signal passes through the Ch 1 and Ch 1 & 2 diode switches to the Output Amplifier.

set to this stable state by means of the Ch 1 & 2 MODE switch: Q405 is off and Q415 is on. The switch connects R412 to ground to form a divider consisting of R411 and R412. The +11.2V at the junction of the two resistors is connected to the base of Q415 and this voltage forward biases the base-emitter junction of Q415.

Q415 goes into saturation and the rise in collector voltage is applied to one end of the divider consisting of R403 and R401. The increased voltage at the junction of the divider is applied to the base of Q405. The voltage reverse biases

the base-emitter junction of Q405 so the transistor is driven into cutoff. Thus, the multivibrator is locked into a stable state (Q405 off, Q415 on) for Channel 1 only operation.

With Q405 held at cutoff, the voltage at the junction of R405 and R406 is +5.2V. This voltage is connected to the junction of the Ch 1 shunt diodes, D307 and D308. The voltage reverse biases the shunt diodes and allows the series diodes, D306 and D309, to become forward biased. The series diodes permit the Channel 1 signal to continue on and be applied to the Ch 1 & 2 diode switch.

Circuit Description—Type 1A4

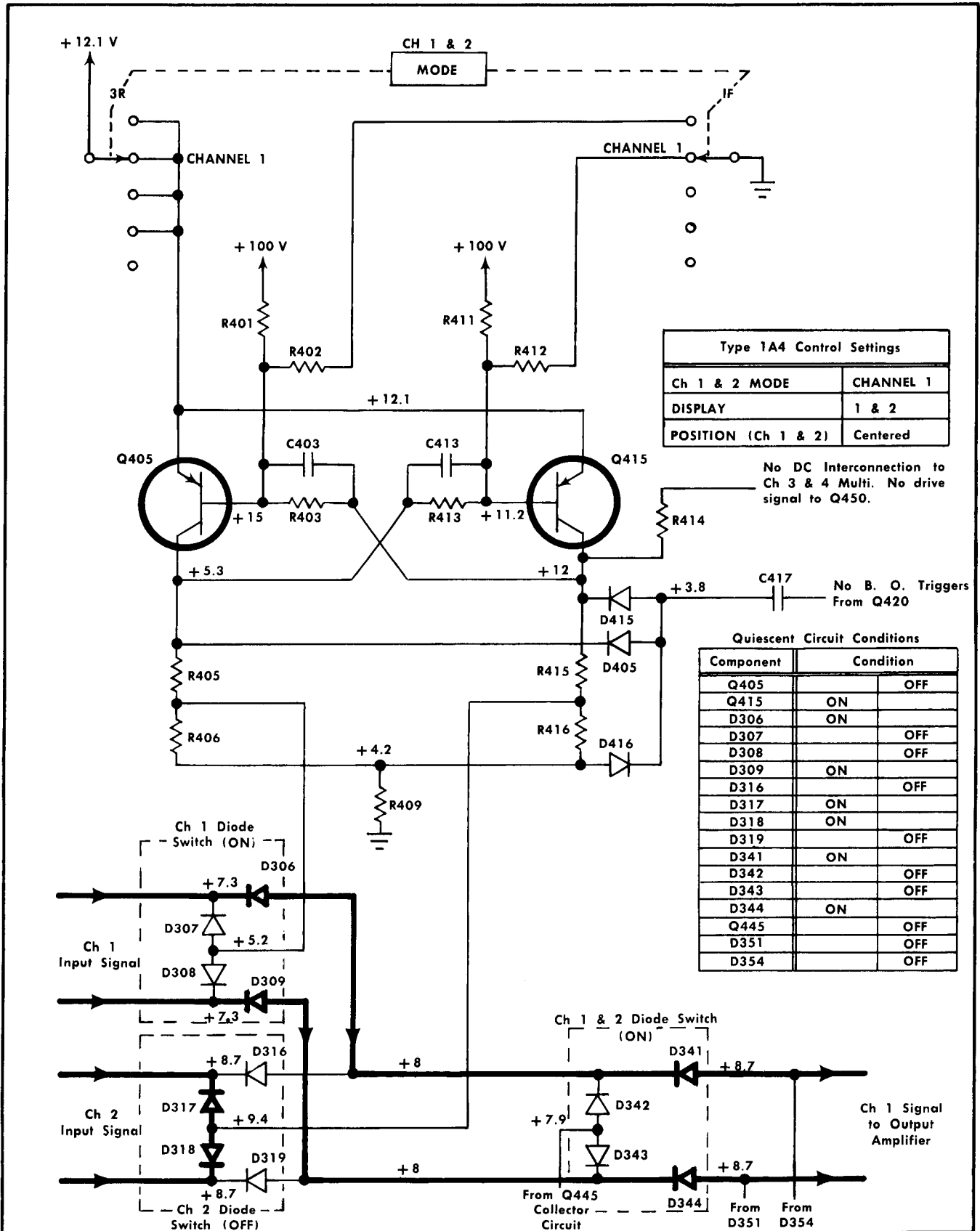


Fig. 4-10. Schematic diagram of the Ch 1 & 2 Multivibrator shown with the Ch 1 & 2 MODE switch set to CHANNEL 1. ON or OFF condition of the Ch 1, Ch 2 and Ch 1 & 2 diode switches are shown. Heavy lines show signal paths.

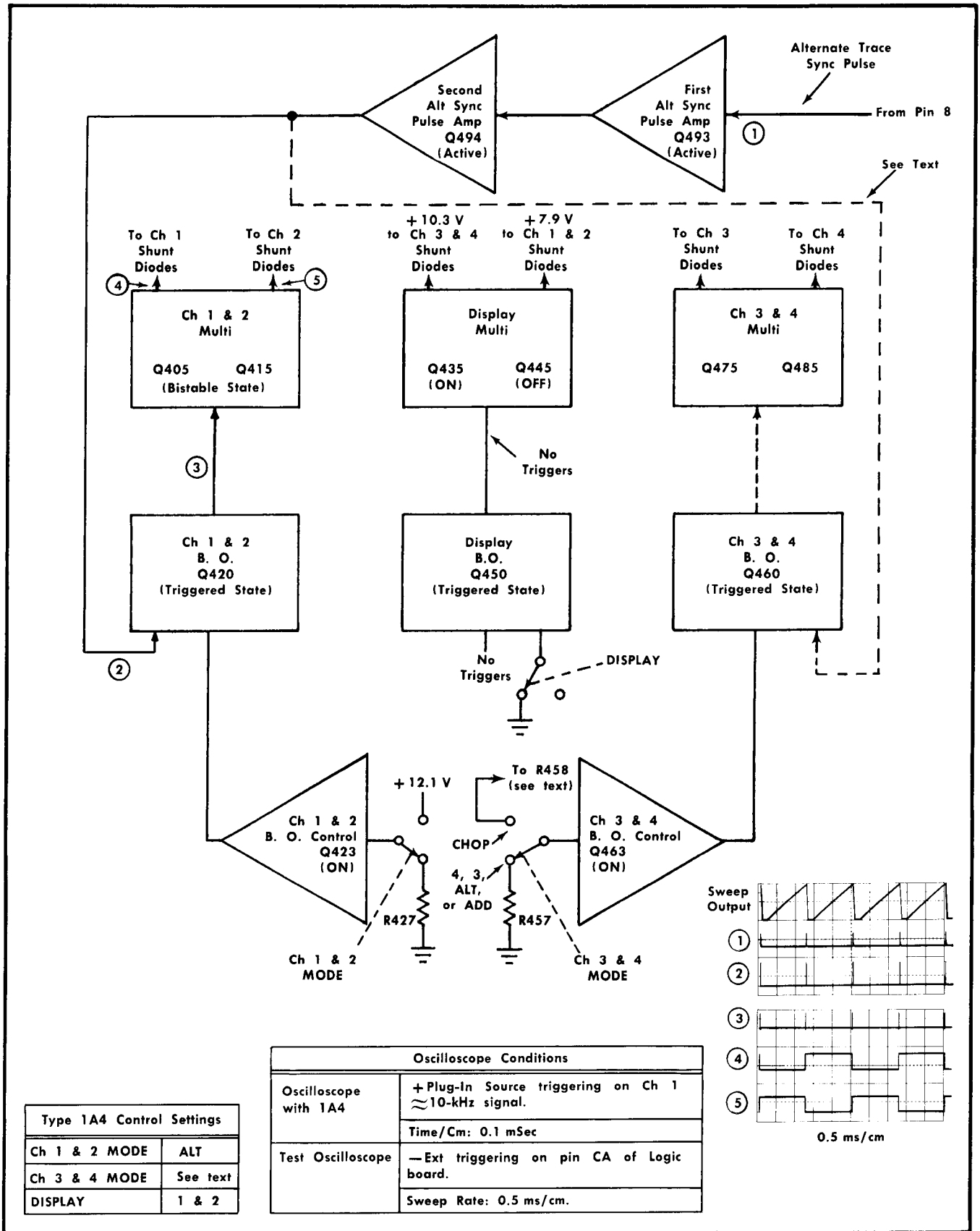


Fig. 4-11. Simplified block diagram of the Logic circuit set for Channel 1 and 2 alternate mode of operation.

Circuit Description—Type 1A4

Q415, being biased into saturation, increases the voltages at the junction of R415 and R416 to a quiescent level of +9.4V. This voltage is applied to the junction of the Ch 2 shunt diodes, D317 and D318. As a result, the shunt diodes are forward biased and series diodes, D316 and D319, are reverse biased. The reverse-biased series diodes prevent the Ch 2 signal from being applied to the Ch 1 & 2 diode switch.

Referring to the block diagram shown in Fig. 4-8, the Display Multivibrator is resting in a stable state that is the same

as for Channel 2 operation; that is, Q435 is on and Q445 is off. Thus, Q435 holds the Ch 3 & 4 diode switch in an off condition to prevent the Channel 3 or 4 signals from going to the Output Amplifier. Q445 holds the Ch 1 & 2 diode switch in an on condition to allow the Channel 1 signal to pass through the Ch 1 & 2 series diodes, D341 and D344, to the Output Amplifier.

No triggers are applied to Q420; therefore, no triggers are generated by Q420 in Channel 1 only operation. There

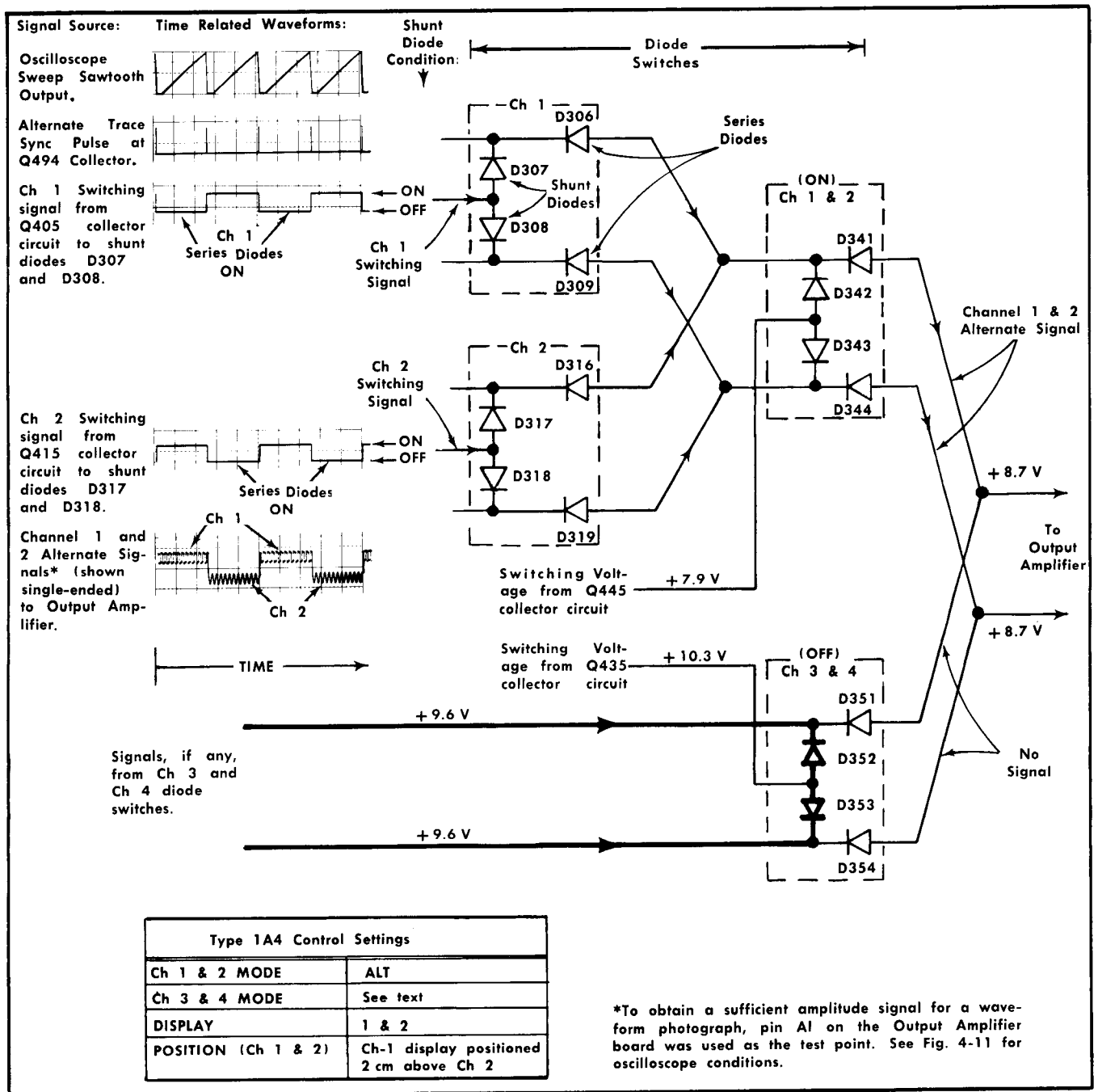


Fig. 4-12. Time-related waveforms show how the Ch 1 and Ch 2 diode switches are alternately turned on and off by the switching signals during alternate mode of operation.

is no DC interconnection from the collector of Q415 through R414 to the other multivibrators. There is no drive signal and no connection to Q450. These are the same conditions as existed for Channel 2 only operation.

Channel 1 and 2 Alternate Mode Operation

Block Diagram (Fig. 4-11) and Diode Switches (Fig. 4-12). Table 4-2 summarizes the circuit configurations for this mode of operation.

TABLE 4-2

Channel 1 & 2 Alternate Mode of Operation
(See Figs. 4-11 and 4-12)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	Ch 1 & 2 MODE switch connects Q493 emitter to ground and places Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to R427. Q423 turns on.
Ch 1 & 2 B. O., Q420.	With Q423 turned on, Q420 is placed in a triggered state. Q494 provides the trigger drive to Q420.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places the multivibrator into a bistable state. Triggers from Q420 drive the multivibrator at the alternate trace sync pulse rate. Switching occurs during the sweep retrace interval.
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off alternately. Channel 1 and 2 alternate signals are applied to the Ch 1 & 2 diode switch.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state but no triggers are applied. Thus, there is no output from Q450.
Display Multi, Q435 and Q445	DISPLAY switch places the multivibrator in this stable state: Q435 is ON and Q445 is OFF.
Ch 1 & 2 diode Switch.	Q445 turns on the Ch 1 & 2 diode switch so the Channel 1 and 2 alternate signals go to the Output Amplifier.

Ch 3 & 4 Diode Switch.	Q435 turns off the Ch 3 & 4 diode switch. Hence, the Channel 3 & 4 signals cannot go to the Output Amplifier.
System associated with Ch 3 and 4 diode switches.	Since the Ch 3 & 4 diode switch is turned off, the operation of this system has no effect on the display as explained earlier in the Channel 2 only block diagram description.

Alternate Sync Pulse Amplifier, Q493 and Q494 (see Fig. 4-13). In the ALT position of the MODE or DISPLAY switch, the emitter of Q493 is connected to ground. Thus, Q493 is placed in the active state; that is, the transistor is at cutoff but it can be pulsed into conduction during the positive-going portion of the alternate trace sync pulse that is applied to Q493 base.

The alternate trace sync pulses, arriving at pin 8 of the interconnecting plug during the sweep retrace interval, are coupled through C491 and applied to the base of Q493. The positive-going portion of the sync pulses drive Q493 from cutoff into saturation and 12-V negative-going (+12 V to about 0 V) pulses are developed at Q493 collector. These pulses are coupled through C495 to the base of Q494.

Transistor Q494 is always in an active state and is biased at cutoff. The transistor functions as a pulse amplifier and shaper. Each negative-going pulse from Q493 drives Q494 from cutoff into saturation and a 12-V positive-going trigger pulse is produced at Q494 collector. This reshaped positive-going alternate sync pulse is now available for distribution to the blocking oscillators as needed. For example, with the Ch 1 & 2 MODE switch set to ALT and the DISPLAY switch set to 1 & 2, the pulse from Q494 collector is connected via these switches and C424 to the Ch 1 & 2 Blocking Oscillator, Q420.

The trigger produced by Q420 is then applied to the Ch 1 & 2 Multivibrator, Q405 and Q415. The multivibrator, operating in the bistable state, changes states every time a trigger from Q420 is applied. Thus, the multivibrator turns the Ch 1 and Ch 2 diode switches on and off alternately at the alternate trace sync pulse rate.

Q420, Q423 and Q504 Circuitry (see Fig. 4-14). The schematic diagram of Fig. 4-14 shows the circuit connected for alternate mode of operation. The base of Q423 is connected to R427 via the Ch 1 & 2 MODE switch. Divider resistors R426 and R427 forward bias the base-emitter junction and Q423 turns on.

With Q423 turned on, divider resistors R425 and R423 in the collector circuit of Q423 cause Q420 to be placed in a triggered state. The 12-V positive-going alternate trace sync pulses from the collector of Q494 are coupled through C424 and applied to the base of Q420. The positive-going pulse drives Q420 into conduction.

The collector winding of T420 supplies regenerative feedback to the base winding and this causes Q420 to go into saturation. The dots above the windings indicate similar polarities. Resistor R420 limits the base-emitter junction

Circuit Description—Type 1A4

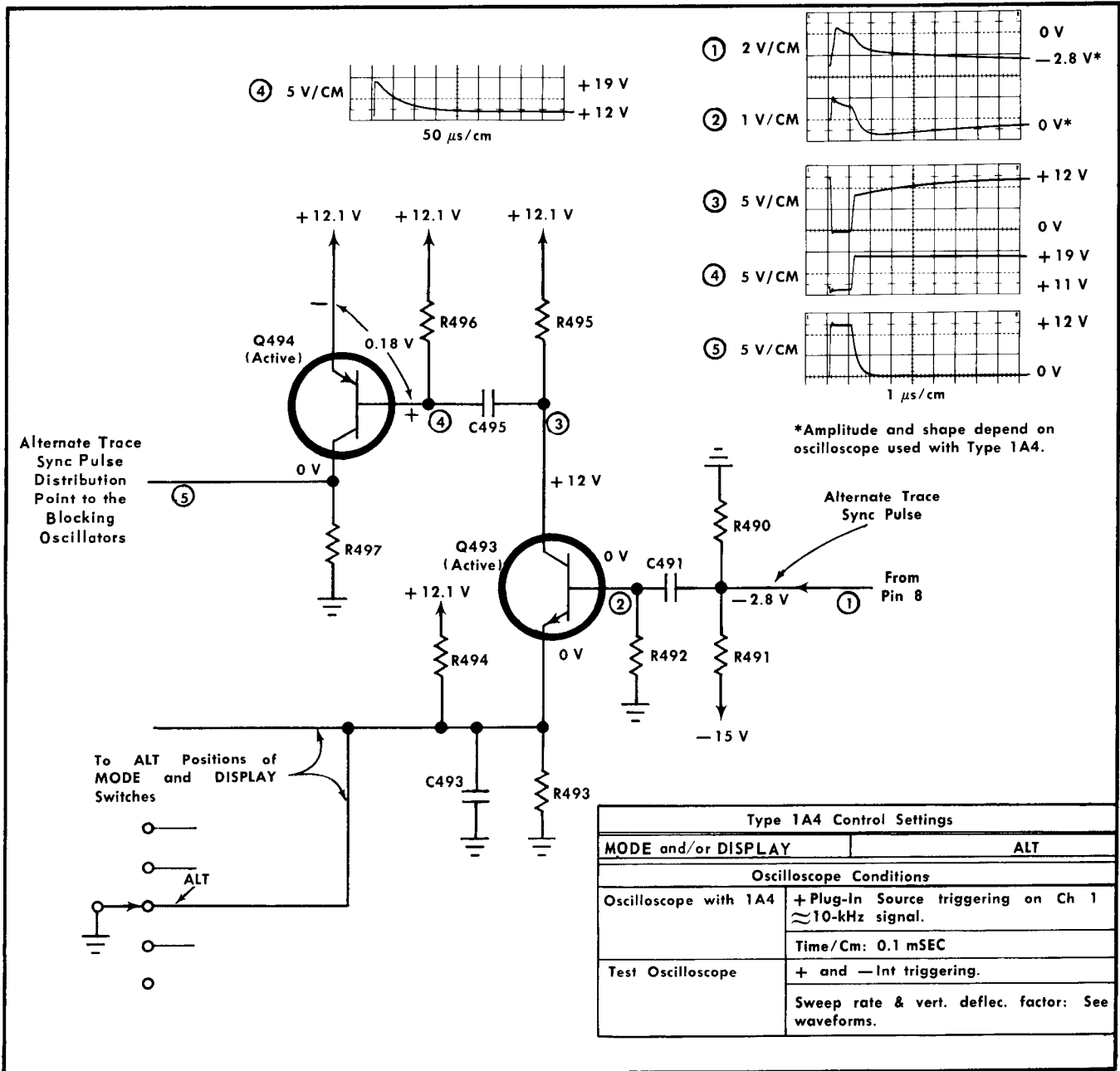


Fig. 4-13. Schematic diagram of the Alternate Sync Pulse Amplifier shown in its active state. Voltages and waveforms are included.

current during the peak feedback interval. As Q420 goes into saturation, the collector current ceases to increase. Induced feedback voltage decreases, Q420 becomes reverse biased and the collapsing field produces a backswing voltage.³

The polarity and approximate pulse amplitude induced in the output winding of T420 is a positive-going 20-V pulse. This is reduced somewhat by the loading of the circuit components. The backswing portion of the pulse in this wind-

ing and the collector winding is limited by D417. This diode conducts during the backswing interval. The output pulse is applied through D418 to the base of Q504 and is also coupled through C417 to the Ch 1 & 2 Multivibrator steering diodes, D405 and D415.

Q504 and associated circuitry form the Chopped Blanking Amplifier. It always remains in the active state. Positive-going pulses from the output winding of T420 are applied to Q504 whenever the Type 1A4 operates in the alternate or chopped mode of operation. However, only the pulses during chopped mode of operation are useful as blanking pulses to blank (turn off) the beam during the time

³Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms", McGraw-Hill, New York, 1965, pp. 597-621.

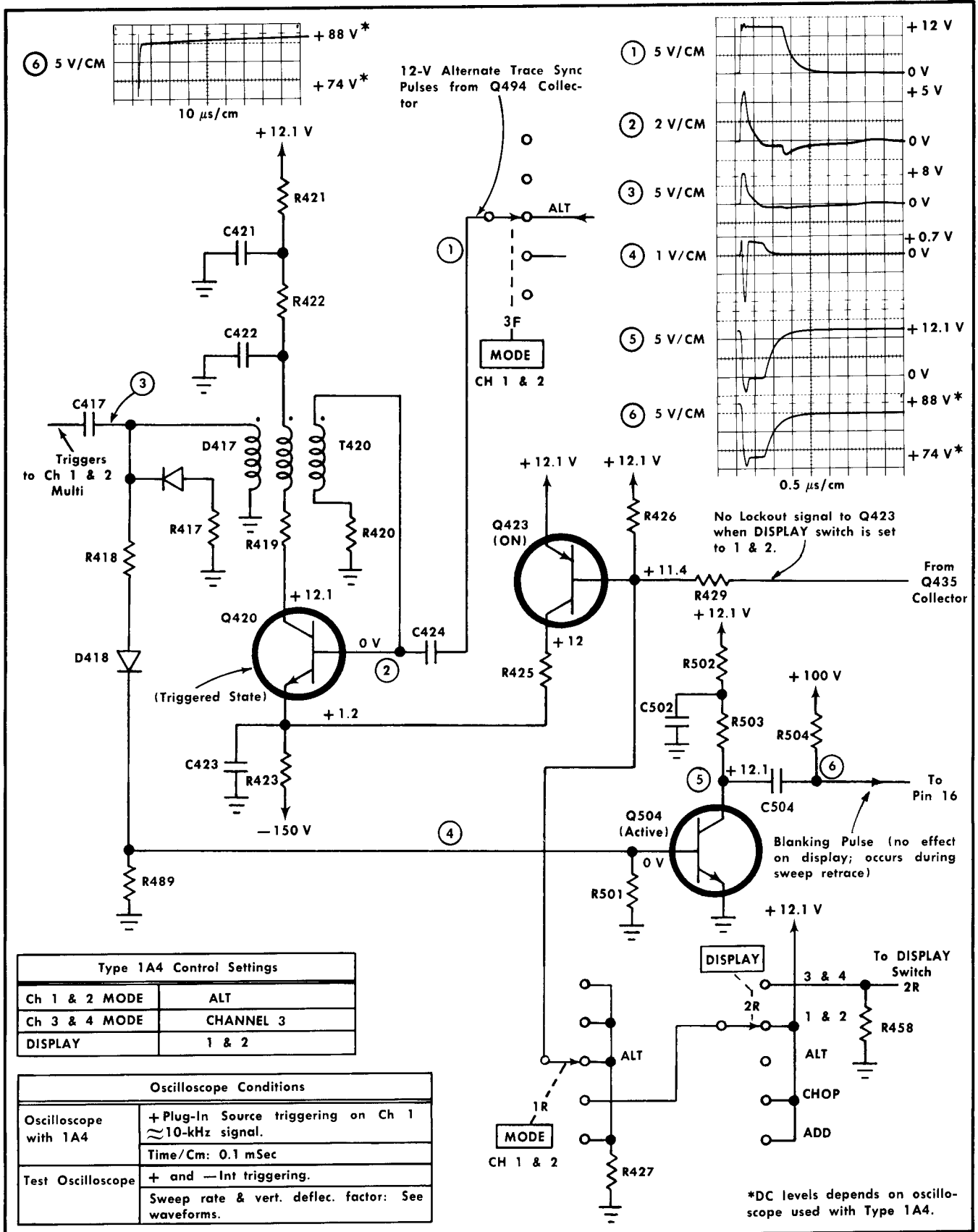


Fig. 4-14. Schematic diagram of Q420, Q423 and Q504 with associated circuitry. Voltages, waveforms and comments apply for control settings given in the tables.

Circuit Description—Type 1A4

that the multivibrator switches the channels. During alternate mode operation, the pulses occur during the sweep retrace interval, and therefore have no effect on the display.

Transistor Q504 base-emitter junction is at cutoff and the positive-going pulse from the output winding of T420 easily drives Q504 from cutoff into saturation. As a result, a 12-V negative-going pulse (+12.1 V to about 0 V) is produced at the collector.

The 12-V pulse is coupled through C504 to pin 16 of the interconnecting plug. From pin 16 the pulse is applied through a coupling capacitor in the oscilloscope to the Chopped Blanking Amplifier. From the amplifier the output pulse is positive-going and is applied via the oscilloscope CRT Cathode Selector switch to the CRT. However, since the mode being described is the alternate mode, the oscilloscope CRT Cathode Selector switch would normally be set to the External CRT Cathode position. Therefore, the pulse would never reach the CRT. However, if the switch is set to the Chopped Blanking position for various reasons, the pulse reaches the CRT, but the pulse will not affect the display because it occurs during the retrace interval when the beam is already blanked.

Diode D418 and the other diodes having the same purpose (D448 and D468; see The Channel Switching Logic diagram at rear of manual), aid in isolating the blocking oscillators from each other while enabling the pulses to be applied to the base of Q504.

Referring to the connection going from the collector of Q435 through R429 to the base of Q423, this connection has no effect on Q423 in Channel 1 and 2 only alternate mode of operation. This connection does have a purpose during chopped mode of operation, which is explained later.

Ch 1 & 2 Multivibrator, Q405 and Q415 (see Fig. 4-15). For Channel 1 and 2 only alternate mode of operation, this multivibrator is placed in the bistable state by disconnecting R402 and R412 from ground and leaving the emitters connected to +12.1 V. Initially, the multivibrator seeks its own initial stable state⁴.

When triggered by a positive-going pulse applied via C417 to the junction of diodes D405 and D415, the circuit switches to its other stable state. The multivibrator will remain in this state until triggered once again.

Diodes D405 and D415 are steering diodes that direct the pulse to the proper transistor. In their quiescent state these diodes are not conducting; but one of the diodes is easily driven into conduction while the other is not affected. For example, assume Q405 is on and Q415 is off. The collector voltage of Q415 is down sufficiently to enable diode D415 to conduct when triggered.

During the positive-going pulse interval, D415 conducts and the pulse is coupled through C403 to the base of Q405. The pulse drives Q405 toward cutoff and the multivibrator action continues this cycle until Q405 is fully cut off and Q415 is saturated.

With Q415 turned on, the associated Ch 2 diode switch is turned off and the Channel 2 signal is prevented from reaching the Ch 1 & 2 diode switch. However, Q405 is turned off and its associated Ch 1 diode switch is turned

on. Thus, the Channel 1 signal passes through the Ch 1 diode switch and is applied to the Ch 1 & 2 diode switch. Since the mode being described is Channel 1 and 2 only alternate mode of operation, the Ch 1 & 2 diode switch is on and the Channel 1 signal will then pass through this switch to the Output Amplifier. When the next trigger is applied to diodes D415 and D405, the opposite situation occurs. D405 conducts, the multivibrator switches states, and the Channel 2 signal passes through the Ch 2 diode switch. The signal then passes from the Ch 2 diode switch through the Ch 1 & 2 diode switch to the Output Amplifier.

Diode D416 is a recharge diode for C417. The diode is normally conducting to maintain the charge on C417. This is the quiescent DC level. When a pulse is coupled through C417, D416 reverse biases and C417 discharges an amount equal to the pulse amplitude. To quickly recharge C417 to its former level before the next pulse is applied, D416 conducts and recharges C417. Thus, the quiescent DC level is quickly re-established.

The DC Interconnection from the collector of Q415 through R414 to the MODE and DISPLAY switches is disconnected by these switches and not used for this mode of operation. In four-trace alternate mode of operation, however, this DC Interconnection provides the means for locking the Ch 1 & 2 Multivibrator to the Ch 3 & 4 Multivibrator. In addition, this connection provides a drive signal to the Display Blocking Oscillator so the Display Multivibrator can be triggered at the proper time. More details about four-trace alternate mode of operation are given later in this section.

Channel 1 and 2 Chopped Mode Operation

Block Diagram (Fig. 4-16) and Diode Switches (Fig. 4-17). Table 4-3 summarizes the circuit configurations for this mode of operation.

TABLE 4-3
Channel 1 & 2 Chopped Mode of Operation
(See Figs. 4-16 and 4-17)

Circuit	Configuration
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	DISPLAY switch connects Q423 base to +12.1 V via the Ch 1 & 2 MODE switch. Q423 turns off.
Ch 1 & 2 B. O., Q420.	With Q423 turned off, Q420 is placed in a free-running state. Q420 provides the trigger drive to the Ch 1 & 2 Multi. The triggers are also used as pulses for application to Q504.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable state. Triggers from Q420 drive the multivibrator at the Q420 free-running rate.
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off so the Channel 1 and 2 chopped signals are applied to the Ch 1 & 2 diode switch.

⁴Jacob Millman and Herbert Taub, "Pulse, Digital and Switching Waveforms", McGraw-Hill, New York, 1965, pp. 362-389.

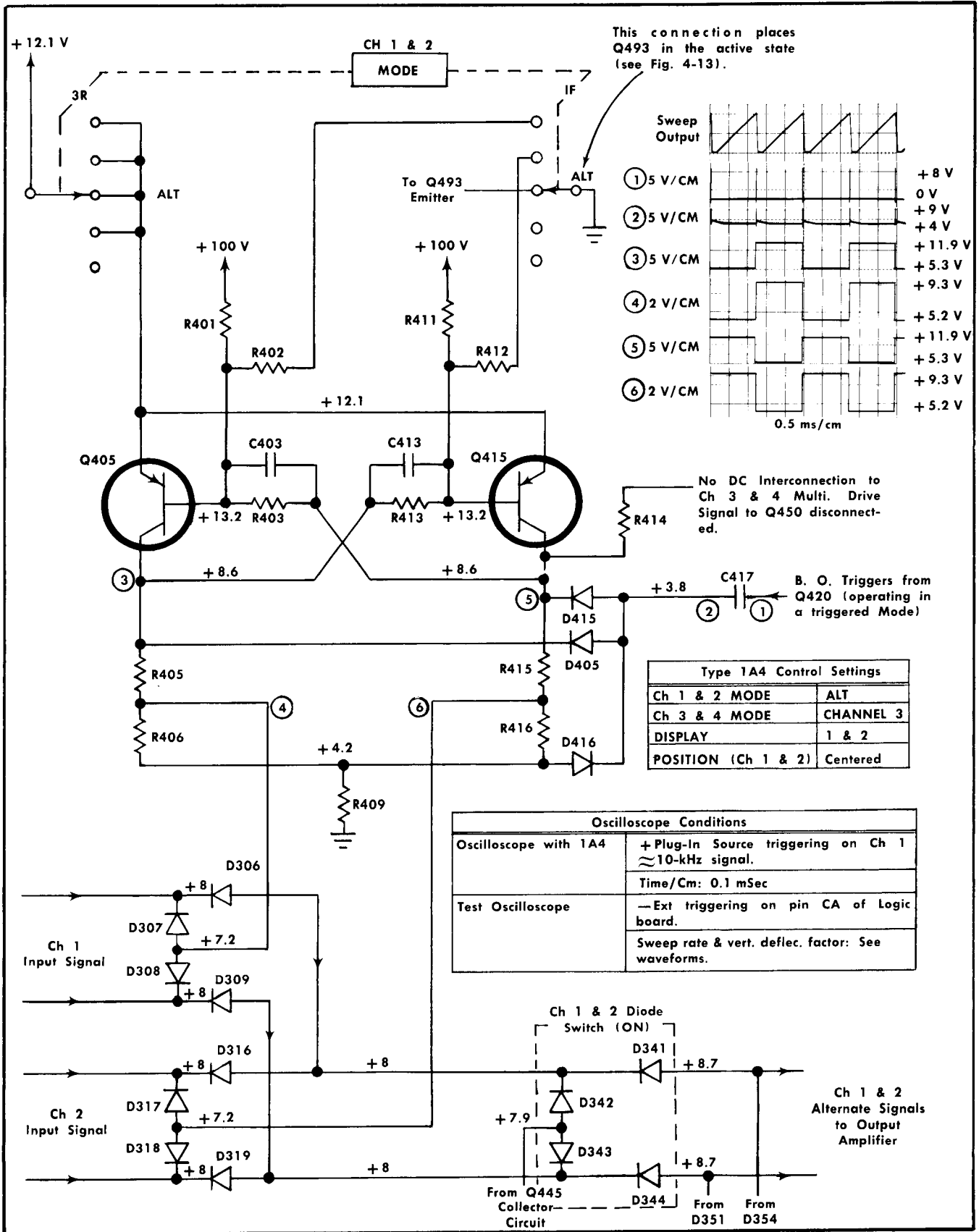


Fig. 4-15. Schematic diagram of the Ch 1 & 2 Multivibrator operating as a base-triggered bistable circuit. The Ch 1 & 2 MODE switch is set to ALT.

Circuit Description—Type 1A4

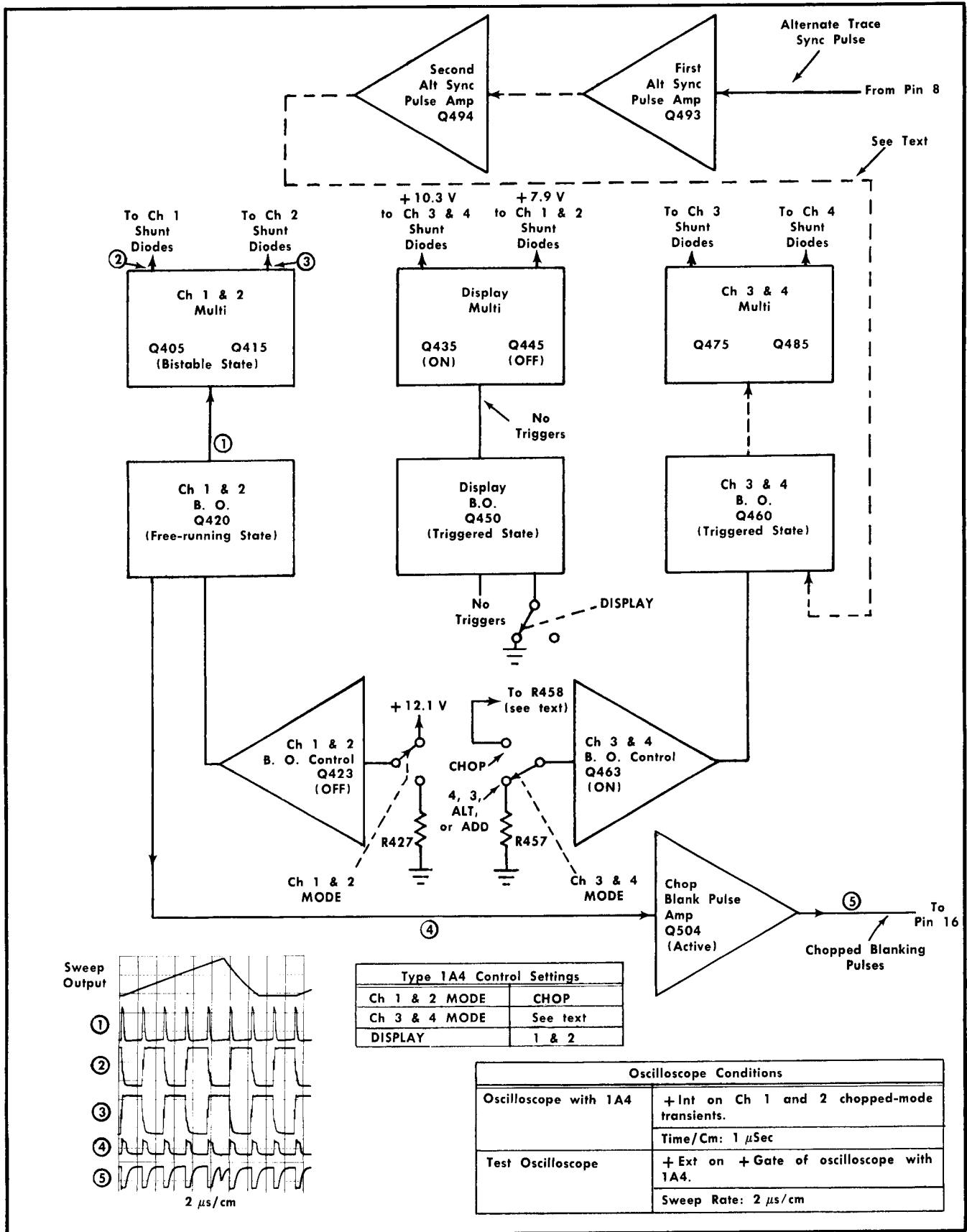


Fig. 4-16. Simplified block diagram of the Logic circuit set for Channel 1 and 2 chopped mode of operation. Waveforms were obtained with Ch 3 & 4 MODE switch set to CHANNEL 3.

TABLE 4-3 (cont)

System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state but no triggers are applied. Thus, there is no output from Q450.
Display Multi, Q435 and Q445.	DISPLAY switch places the multivibrator in this stable state: Q435 is ON and Q445 is OFF.
Ch 1 & 2 Diode Switch.	Q445 turns on the Ch 1 & 2 diode switch so the Channel 1 and 2 chopped signals go to the Output Amplifier.
Ch 3 & 4 Diode Switch.	Q435 turns off the Ch 3 & 4 diode switch. Hence, the Channel 3 & 4 signals are not applied to the Output Amplifier.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active state, amplifies the positive-going pulses from Q420. The negative going output pulses at pin 16 are used to blank the beam during the switching interval between channels.
System associated with Ch 3 and Ch 4 diode switches.	Since the Ch 3 & 4 diode switch is turned off, the operation of this system has no effect on the display as explained earlier in the Channel 2 only block diagram description.

Q420, Q423 and Q504 Circuitry (see Fig. 4-18). The schematic diagram of Fig. 4-18 shows the circuit connected for chopped mode of operation. The base of Q423 is connected to +12.1 V via the Ch 1 & 2 MODE switch and the DISPLAY switch. Now the base and emitter potentials are equal and Q423 is cut off or in the off state. With Q423 in its off state, Q423 enables Q420 to be forward biased and Q420 free runs. The free-running rate is about 400 kHz determined mainly by the RC time constant of C423 and R423. Note that the value of R423 is slightly smaller than R466 in Q460 (Ch 3 & 4 B. O.) emitter circuit. This allows Q420 to run at a faster rate than Q460. Thus, Q420 is used to synchronize Q460 when both MODE switches are set to CHOP and the DISPLAY switch is set to CHOP or ADD.

The operation of the blocking oscillator is similar to the description given for alternate mode of operation except the forward-biased base-emitter junction causes Q420 to conduct without being triggered. Capacitor C423 charges and the regenerative feedback voltage induced in the base winding of T420 drives Q420 into saturation. At saturation the current is constant, T420 field collapses, and the reverse direction of the field drives Q420 into cutoff. C423 discharges through R423 toward -150 V. When C423 discharges to the point where the emitter voltage is about -1 V, Q420 conducts and the cycle is repeated. Thus, the decay time, which occurs as C423 discharges through R423, determines the time interval that Q420 remains cutoff. This time interval is the resting or blocking time between pulses.

The pulse in the output winding of T420 is applied through R418 and D418 to the base of Q504. In addition, the pulse is coupled through C417 to the steering diodes, D405 and D415, in the Ch 1 & 2 Multivibrator. The steering diodes direct the pulses to the proper transistors in the Ch 1 & 2 Multivibrator so the multivibrator switches states at the chopping rate (free-running rate of the B. O.). Since the multivibrator turns the diode switches on and off, Channels 1 and 2 are switched at the same rate.

Q504, operating in the active state, amplifies the pulses for use in turning off the CRT beam at the same time that channel switching occurs. The negative-going pulse width at the collector of Q504 is about 0.6 μ s at the 50% amplitude level as observed when only two channels are operated in the chopped mode.

As mentioned earlier in the Channel 1 and 2 alternate mode operation, the routing of the pulse from the collector of Q504 is through pin 16 of the interconnecting plug to the oscilloscope Chopped Blanking Amplifier. Then, the pulse is applied via the Chopped Blanking position of the oscilloscope External CRT Cathode Selector switch to the CRT circuit. The CRT beam is blanked (turned off) during the switching time between Channels 1 and 2 so the undesirable portion of the switching transients do not appear as part of the display.

Note that in Fig. 4-18 the DISPLAY switch can be set to the CHOP and ADD positions to achieve the same circuit configurations as previously described. These positions allow Q420 to operate in the free-running state while Ch 1 & 2 MODE switch is set to CHOP. R489 and R501 in the base circuit of Q504 are identical in value but are physically located at each end of the wire that goes between the boards. This arrangement minimizes the effect of radiated signals.

No lockout signal is applied from Q435 through R429 to the base of Q423 in Channel 1 and 2 only chopped mode operation for two reasons: (1) The Display Multivibrator is in a stable state, and (2) transistor Q423 is off. However, if the DISPLAY switch is set to ALT and the Ch 3 & 4 MODE switch is set to CHOP (see Fig. 4-19), Q423 is placed in an active state. The DISPLAY switch disconnects the base from +12.1 V; Q423 base-emitter junction bias is now controlled by Q435. (The next two paragraphs assume both MODE switches are set to CHOP and the DISPLAY switch is set to ALT.)

When Q435 is on, the collector rests at about +12 V and this voltage level turns off Q423. Transistor Q420 is placed in a free-running state. Channel 1 and 2 chopped signals are displayed. When Q435 is off, Channel 3 and 4 chopped signals are displayed. The collector of Q435 rests at about +8 V and this level turns on Q423. Thus, Q420 is placed in a triggered state so it cannot free run while the Channel 3 and 4 signals are being displayed. No pulses are applied from Q420 to Q504. Hence, no blanking pulses are produced that will interfere with the Channel 3 and 4 display.

While Channel 3 and 4 chopped signals are being displayed, pulses from Q460 through T460 are applied through D468 to Q504 for use as blanking pulses. In addition, Q460 applies a sync signal through C424 to Q420 but this signal is too low in amplitude (about 3 V as compared to the 12-V alternate trace sync pulse amplitude) to trigger Q420.

These 3-V sync pulses are used mainly during four-channel chopped mode of operation and when two chopping pairs of channels are being added. During these modes of operation, the pulses synchronize the two blocking oscillators, Q420 and

Circuit Description—Type 1A4

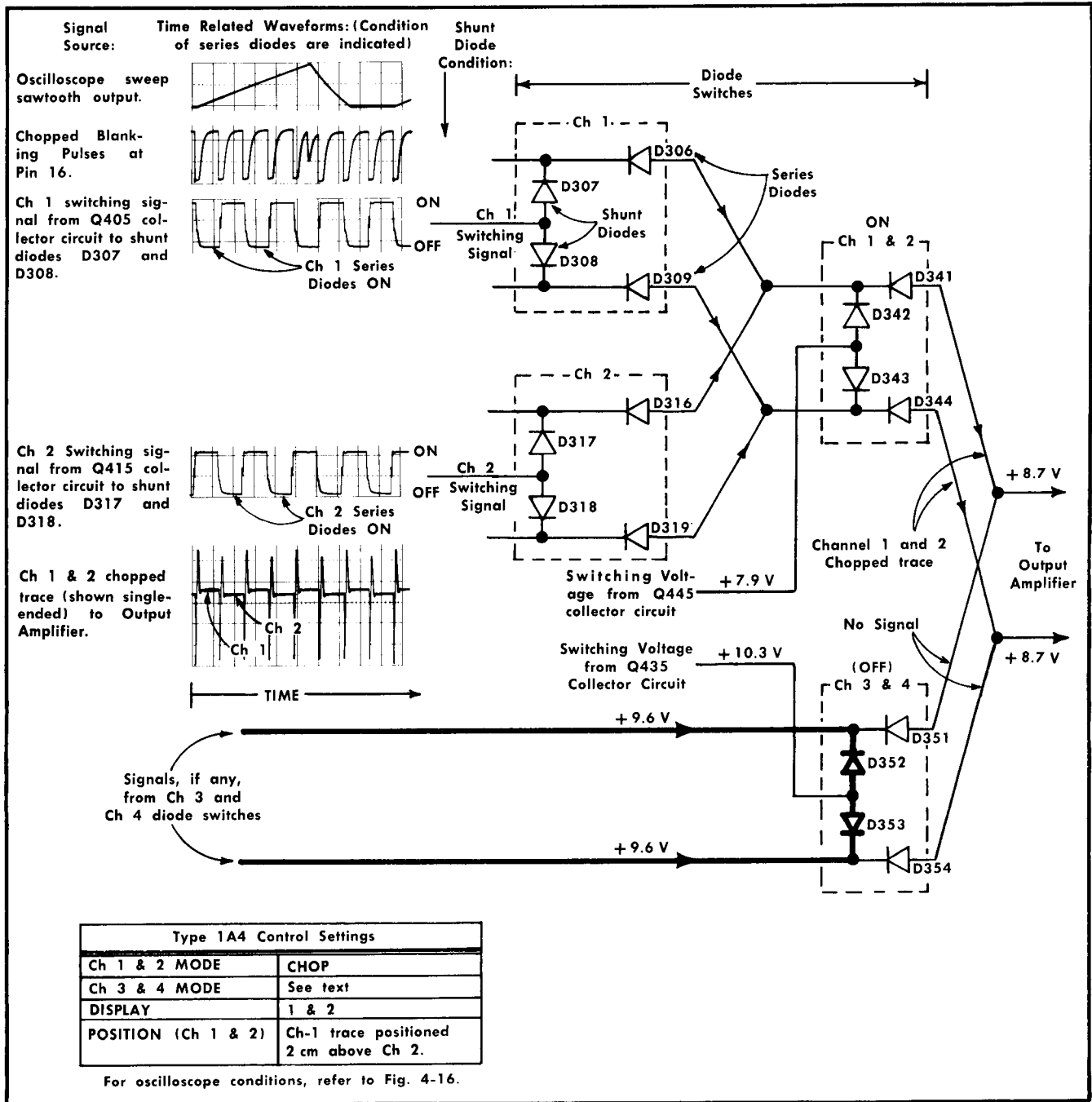


Fig. 4-17. Time-related waveforms show how the Ch 1 and Ch 2 diode switches are alternately turned on and off by the switching signals during chopped mode of operation.

Q460. Block diagrams, included later in this section, show the interconnections between the blocks for these modes. Although it is stated that the sync pulse amplitude is about 3 V, these pulses do range in amplitude from about 2.3 V to 4 V, depending on the mode of operation. For example, during four-channel chopped mode of operation the pulse amplitude is about 4-V.

Ch 1 & 2 Multivibrator, Q405 and Q415 (see Fig. 4-20). In channel 1 and 2 only chopped mode of operation,

the multivibrator is placed in the bistable state and is base-triggered by Q420. The multivibrator action in this mode is the same as described for alternate mode of operation.

Channel 1 and 2 Add Mode Operation

Block Diagram (Fig. 4-21) and Diode Switches (Fig. 4-22). Table 4-4 summarizes the circuit configurations for Channel 1 and 2 add mode of operation.

Circuit Description—Type 1A4

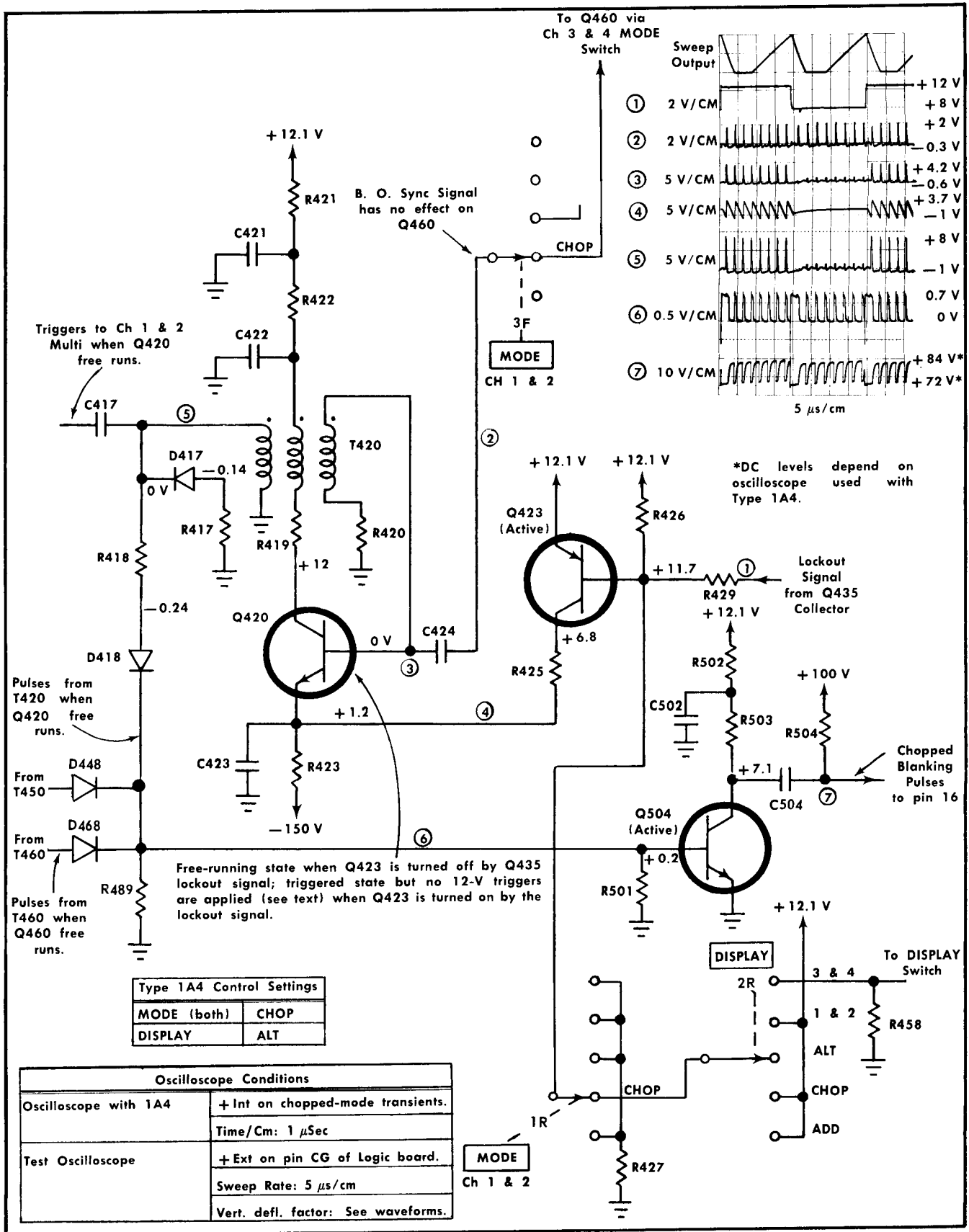


Fig. 4-19. Schematic diagram of Q420, Q423 and Q504 with associated circuitry. Voltages, waveforms and comments apply for the control settings given in the tables.

TABLE 4-4
Channel 1 and 2 Add Mode of Operation
(See Figs. 4-21 and 4-22)

Circuit	Configuration
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to R427. Q423 turns on.
Ch 1 & 2 B. O., Q420.	With Q423 turned on, Q420 is placed in a triggered state but no triggers are applied.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places the multivibrator into this stable state: Q405 and Q415 are both OFF.
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns both of these diode switches on. Channel 1 and 2 signals add. The added signal is applied to the Ch 1 & 2 diode switch.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds, Q450 emitter. Q450 is placed in a triggered state but no triggers are applied. There is no output from Q450.
Display Multi, Q435 and Q445.	DISPLAY switch places the multivibrator in this stable state: Q435 is ON and Q445 is OFF.
Ch 1 & 2 Diode Switch.	Q445 turns on the Ch 1 & 2 diode switch so the Channel 1 and 2 added signals go to the Output Amplifier.
Ch 3 & 4 Diode Switch.	Q435 turns off the Ch 3 & 4 diode switch. The Channel 3 and 4 signals are not applied to the Output Amplifier.
System associated with Ch 3 and Ch 4 diode switches.	Since the Ch 3 & 4 diode switch is turned off, the operation of this system has no effect on the display as explained earlier in the Channel 2 only block diagram description.

Q420, Q423 and Q504 Circuitry (see Fig. 4-5). Refer to the Channel 2 only description and Fig. 4-5 for an explanation of this circuit.

Ch 1 & 2 Multivibrator, Q405 and Q415 (see Fig. 4-23). For Channel 1 and 2 add mode of operation, the multivibrator is placed in this stable state: Both Q405 and Q415 are off (inoperative). This is accomplished by using the Ch 1 and 2 MODE switch ADD position to disconnect the emitters of Q405 and Q415 from the +12.1 V supply. Also, the Ch 1 & 2 MODE switch disconnects the base circuit divider networks to assure that both transistors remain in an inoperative state.

With Q405 and Q415 transistors inoperative, the voltage level at the junction of R405 and R406 is +1.4 V. This voltage level is the same at the junction of R415 and R416. Thus, +1.4 V is applied to the shunt diodes in the Ch 1 and

Ch 2 diode switches. The shunt diodes in both channels are reverse biased and the series diodes are forward biased. As a result, the Ch 1 and Ch 2 diode switches are turned on and the signals in both channels add algebraically.

The Channel 1 and 2 added signals are then applied to the Ch 1 & 2 diode switch. This switch is turned on and the Ch 3 & 4 diode switch is turned off by the Display Multivibrator, Q435 and Q445. Referring to the block diagram of Fig. 4-21, the Display Multivibrator is resting in the same stable state as that described for Channel 2 only operation and the other modes already described; that is, in those modes where the DISPLAY switch is set to 1 & 2.

The Channel 1 and 2 added signal passes through the Ch 1 & 2 diode switch to the Output Amplifier. Since the Ch 3 & 4 diode switch is turned off, the Channel 3 & 4 signals are prevented from going to the Output Amplifier.

The Channel 1 & 2 Blocking Oscillator, Q420, is operating in the triggered state and no triggers are applied to Q420. Thus, no triggers are applied to the Ch 1 & 2 Multivibrator while the Type 1A4 is operating in the Channel 1 and 2 mode. Also, there is no DC Interconnection between Q415 collector and the collector of Q485. There is no drive signal from Q415 to the Display Blocking Oscillator, Q450. In addition, the connection between Q415 and Q450 is open due to the positions of the Ch 1 & 2 MODE switch and the DISPLAY switch.

Q420, Q423, Q504, Q493 and Q494 Circuitry. For a description of these transistors with associated circuitry, refer to the Channel 2 only description given earlier. Use Figs. 4-5 and 4-7 as a guide to see the circuit comments and quiescent voltage conditions.

Four-Channel Alternate Mode Operation

Block diagram (Fig. 4-24) and the time-related waveforms illustrated in Fig. 4-25 show the operation of the logic circuits during four-channel alternate mode of operation. Figs. 4-26 and 4-27 show the time-related waveforms obtained when the Type 1A4 is used with a Type 547 Oscilloscope.

To obtain Fig. 4-26 waveforms the Type 547 Horizontal Display switch is set to A/Alt/B and the 547 TRACE SLAVING switch is set to LOCK to show how the slave pulse keeps the Display Multivibrator, Q435 and Q445, in step with the Sweep Switching Multivibrator in the oscilloscope. Thus, Channel 1 and 2 signals are always displayed during the A sweep time; Channel 3 and 4 signals are displayed during the B sweep time. If the 547 TRACE SLAVING switch is set to unlock, the pairs of channels will not stay locked to the proper time bases.

Fig. 4-27 shows the waveforms obtained when the Type 547 Horizontal Display switch is set to B-Intens-By-'A'/Alt/A-Dly'd. The 547 TRACE SLAVING switch is not involved in this mode of operation because no alternate sweep slave pulse is applied to pin 7 from the Type 547. For this reason the slave pulse waveform is not included in this set of waveforms. The time relationship of the waveforms illustrates the switching sequence that occurs when the Type 547 is presenting an eight-trace display.

Table 4-5 summarizes the circuit configurations shown in the block diagram of Fig. 4-24. Appropriate comments are included to explain the purpose of the interconnections between blocks.

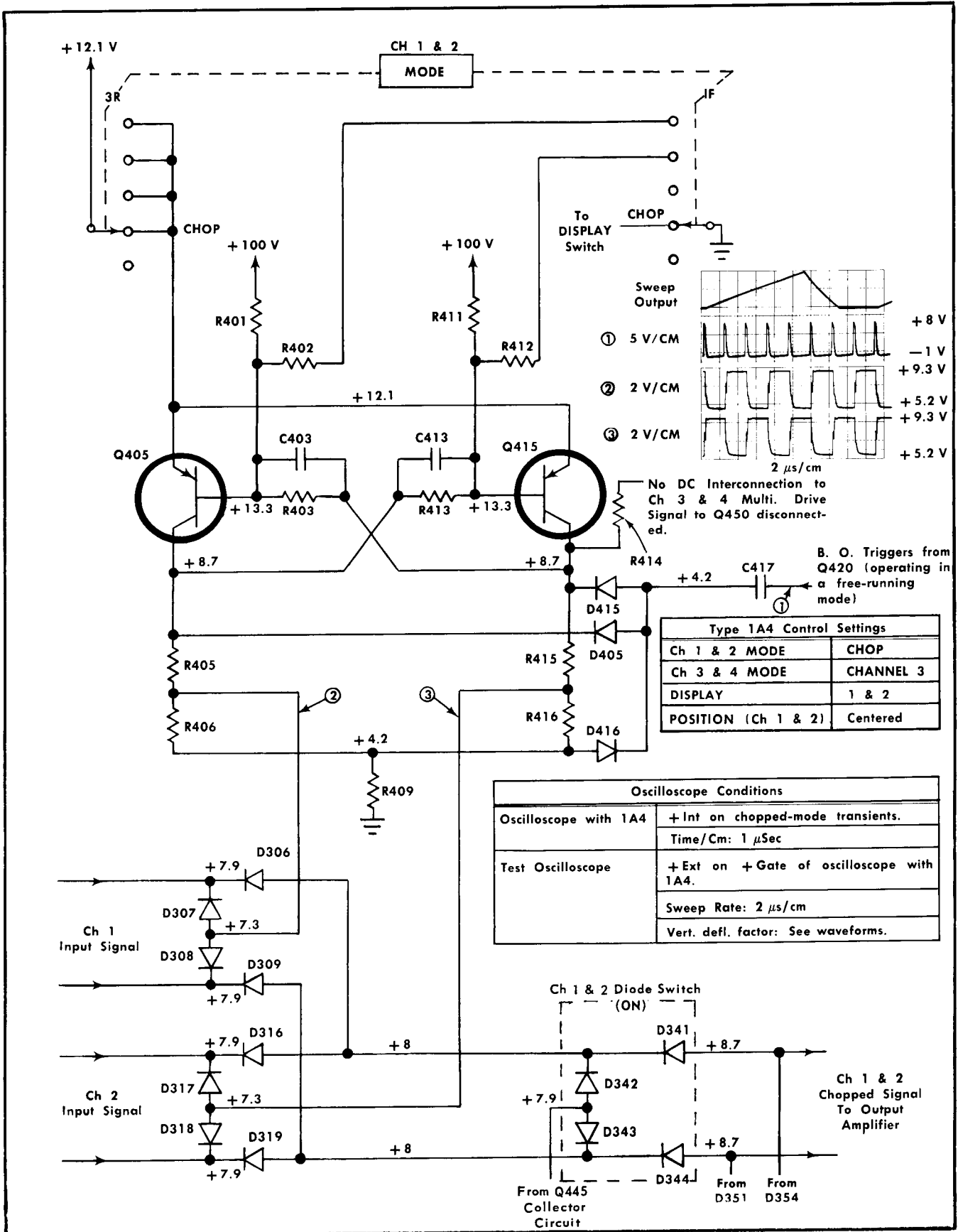


Fig. 4-20. Schematic diagram of the Ch 1 & 2 Multivibrator operating as a base-triggered bistable circuit. The Ch 1 & 2 MODE switch is set to CHOP.

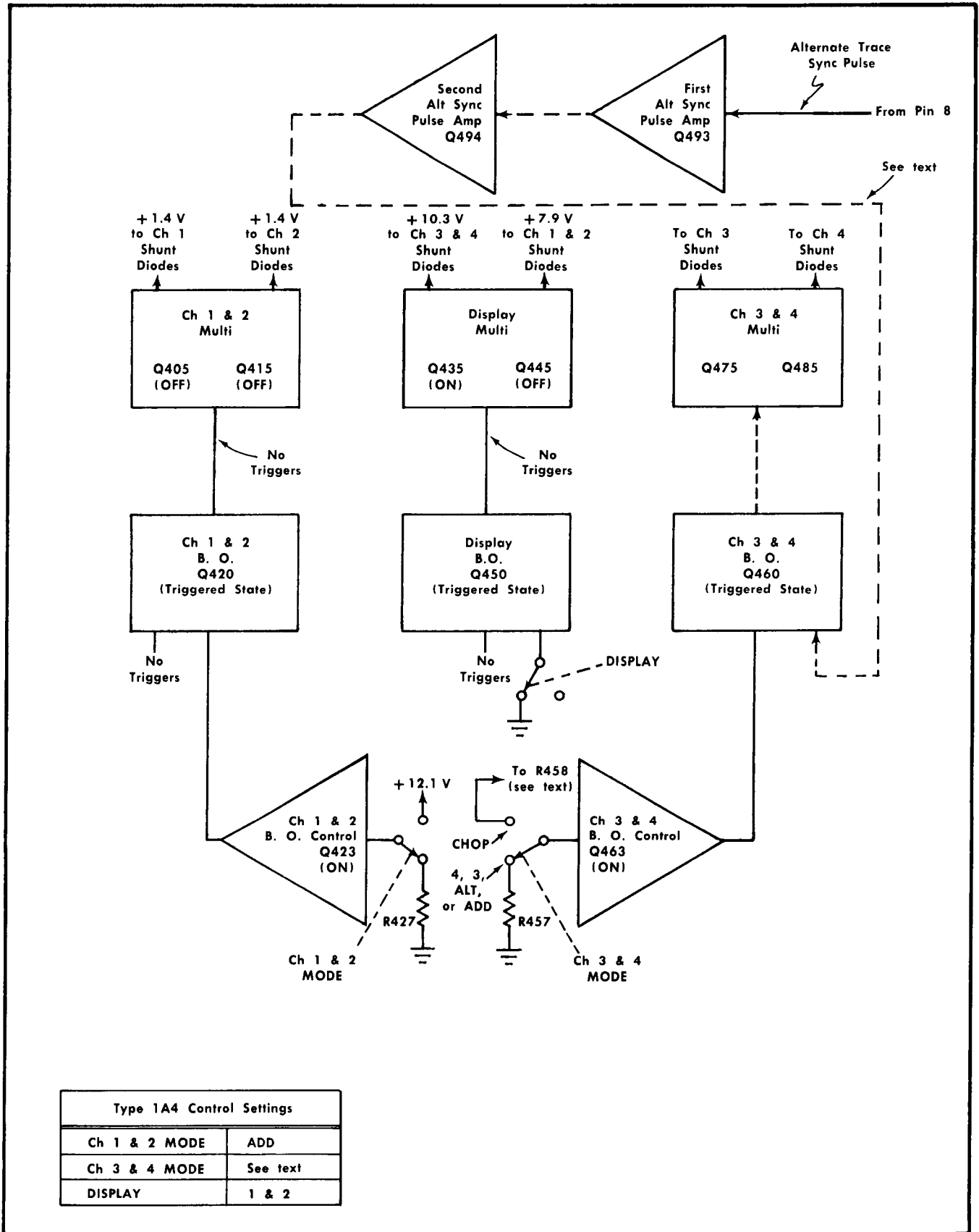


Fig. 4-21. Simplified block diagram of the Logic circuit set for Channel 1 and 2 add mode of operation.

Circuit Description—Type 1A4

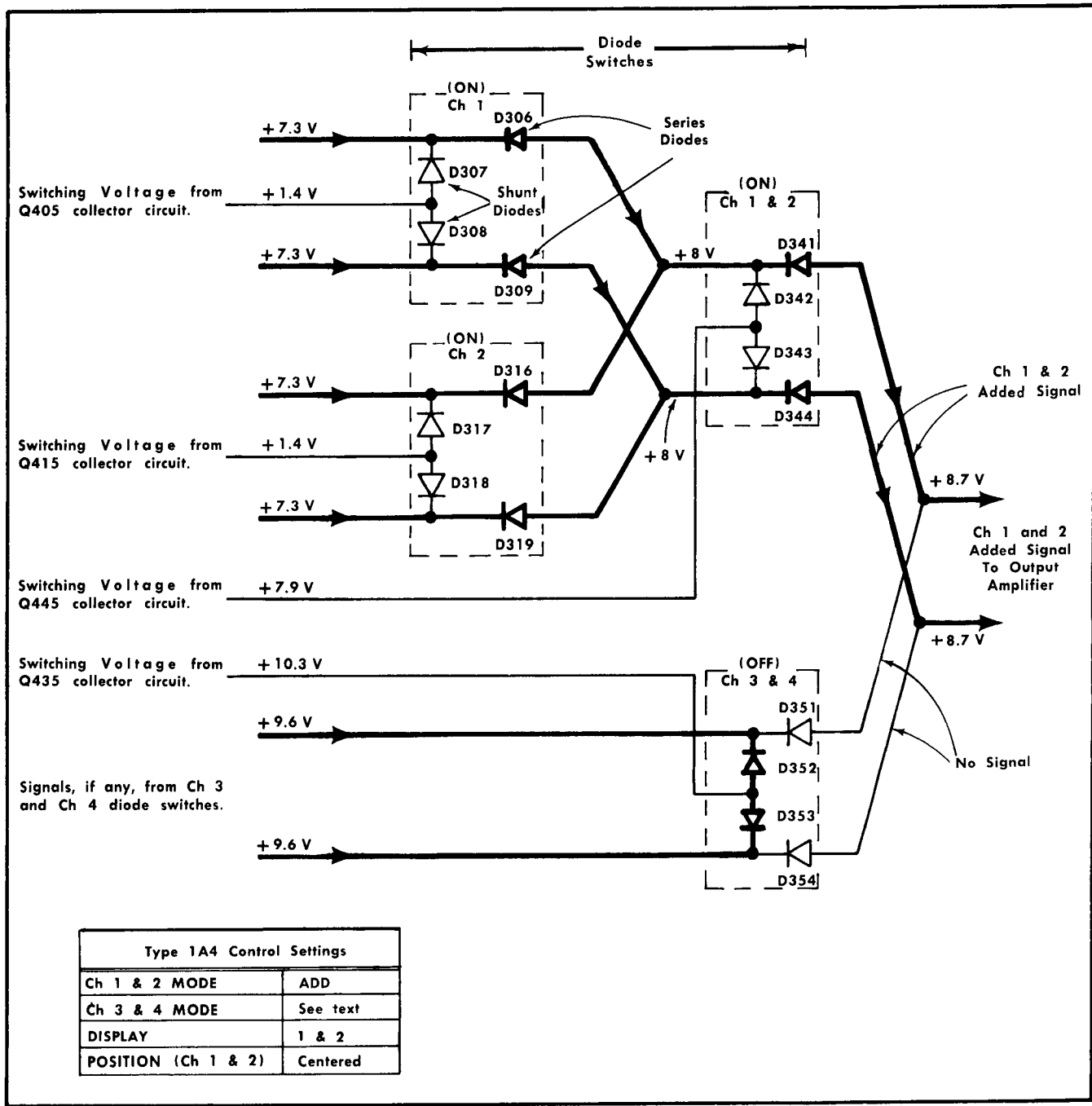


Fig. 4-22. Simplified diagram of the diode switches to show Channel 1 and 2 add mode of operation. Channels 1 and 2 pass through their respective diode switches and add algebraically. The added signal passes through the Ch 1 & 2 diode switch to the Output Amplifier.

TABLE 4-5

Four-Channel Alternate Mode of Operation
(See Figs. 4-24 through 4-27)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	The DISPLAY and MODE switches connect Q493 emitter to ground and place Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.

System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to R427. Q423 turns on.
Ch 1 & 2 B. O., Q420.	With Q423 turned on, Q423 places Q420 in a triggered state. Q494 provides the trigger drive to Q420.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable

TABLE 4-5 (cont)

Circuit	Configuration
	state. Triggers from Q420 drive the multivibrator at the alternate sync pulse rate. Switching occurs during the sweep retrace interval. Also, see DC Interconnection footnote. ⁵
Ch 1 & 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off alternately. Channel 1 and 2 signals are applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & Ch 4 diode switches.	This system operates the same as described for the system associated with the Ch 1 and Ch 2 diode switches.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B.O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state. Q415 and Q485 collectors (locked together) provide the drive signal through D454 and C454 to the base of Q450. Triggers from Q450 are applied to the Display Multi.
Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator in a bistable state. Triggers from Q450 drive the multivibrator at one-half the rate of the alternate trace sync pulses.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to permit the Channel 1 and 2 alternate signals to be applied to the Output Amplifier. Q435 turns off the Ch 3 & 4 diode switch at this time.
Ch 3 & 4 diode switch.	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. Channel 3 and 4 alternate signals go to the Output Amplifiers; simultaneously, the Channel 1 and 2 signals are stopped.
547 TRACE SLAVING switch (set to the LOCK position).	If the Type 547 Horizontal Display switch is set to A/Alt/B, a negative-going (+32 V to 0 V alternate sweep slave pulse is DC-coupled via pin 7 to Q445 base circuit. This pulse forces Q445 to turn on during the B sweep time. Thus, Q445 turns off the Ch 1 & 2 diode switch and Q435 turns on the Ch 3 & 4 diode switch to permit Channel 3 or 4 to be applied to the Output Amplifier. When the B sweep ends, the pulse

⁵The DC Interconnection, connected from the collector of Q415 through R414 and R484 to the collector of Q485, locks the Ch 1 & 2 Multi and the Ch 3 & 4 Multi together. To provide a count of 4, the DC Interconnection is also applied through D454 for use as a drive signal that will trigger the display B. O., Q450.

	returns to the +32-V level and Q445 turns off to permit Channel 1 or 2 signal to be applied to the Output Amplifier during the A sweep.
--	---

Four-Channel Chopped Mode Operation

Table 4-6 provides a concise description of the switching circuit configurations indicated in Fig. 4-28.

TABLE 4-6
Four-Channel Chopped Mode Operation
(See Fig. 4-28)

Circuit	Configuration
System associated with Ch 1 and Ch 2 diode switches:	
Ch 1 & 2 B. O. Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to +12.1 V. Q423 turns off.
Ch 1 & 2 B. O., Q420.	With Q423 turned off, Q420 is placed in a free-running state. Q420 provides the trigger drive to Ch 1 & 2 Multi. The triggers are also used as pulses for application to Q504. In addition, Q420 applies sync pulses to Q460 so the two blocking oscillators are synchronized. ⁶
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable state. Triggers from Q420 drive the multivibrator at the B.O. free-running rate. Also, see DC Interconnection footnote. ⁷
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns these diode switches on and off to let the Channel 1 & 2 signals pass through the switches and be applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & Ch 4 diode switches.	This system operates similar to the system associated with the Ch 1 and Ch 2 diode switches, except Q460 is synchronized by the sync signal from Q420.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B.O., Q450.	Q450 is placed in a triggered state by grounding Q450 emitter via the

⁶Q420 synchronizes Q460 by means of sync pulses applied from Q420 through C424, the MODE switches, and C465 to the base of Q460. To ensure synchronization, R423 in Q420 emitter circuit is a smaller value than R466 located in the Q460 emitter circuit. Hence, Q420 runs slightly faster than Q460's free-running rate and forces Q460 to synchronize. NOTE: If Q420 and Q460 run at the same rate or if Q460 runs faster than Q420 due to the characteristics of the transistors, interchange the transistors.

⁷The DC Interconnection, connected from the collector of Q415 through R414 and R484 to the collector of Q485, locks the Ch 1 & 2 Multi and the Ch 3 & 4 Multi together. To provide a count of 4, the DC Interconnection is also applied through D454 for use as a drive signal that will trigger the Display B. O., Q450.

Circuit Description—Type 1A4

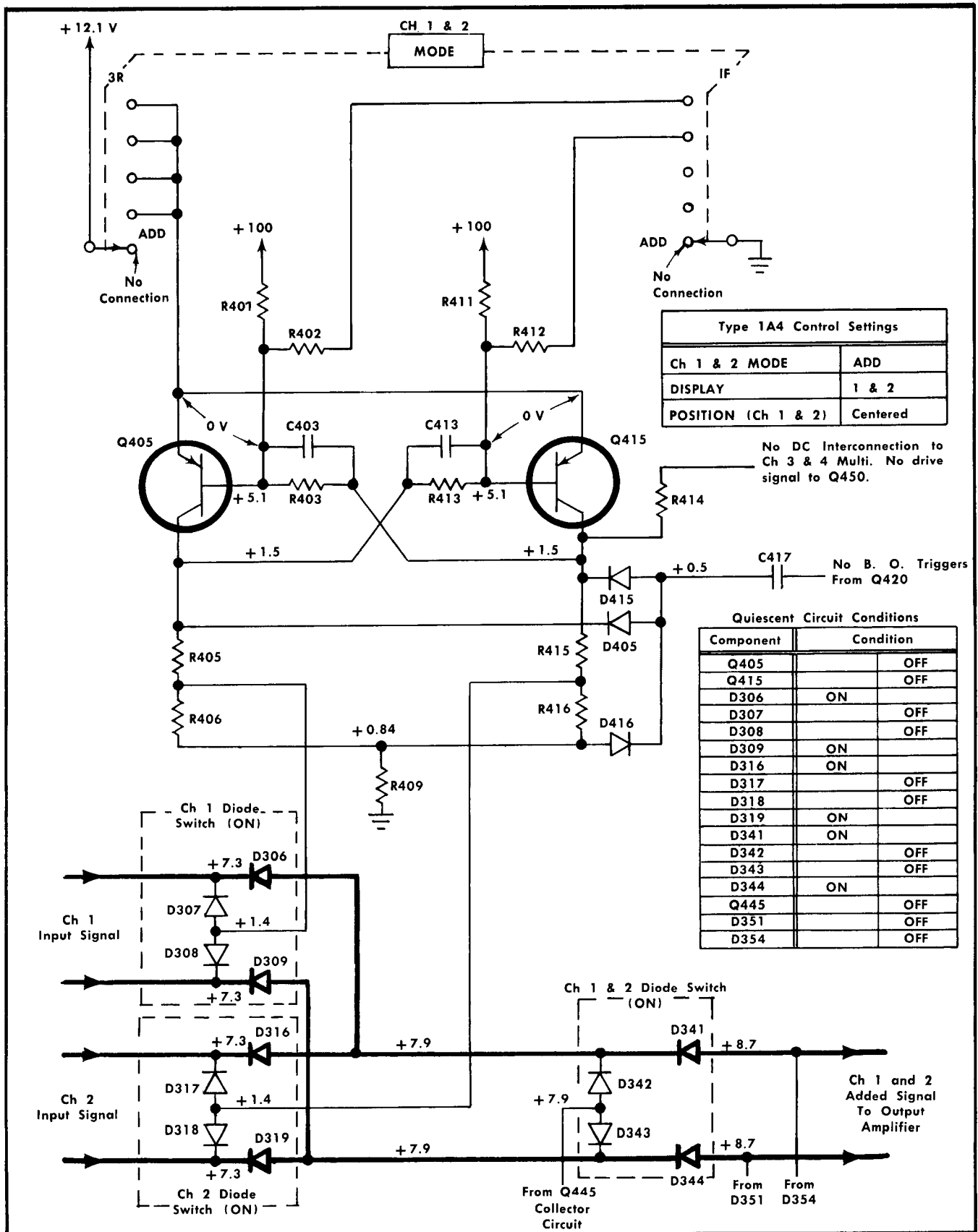


Fig. 4-23. Schematic diagram of the Ch 1 & 2 Multivibrator shown with the Ch 1 & 2 MODE switch set to ADD. All the diode switches shown are on and heavy lines indicate the signal paths.

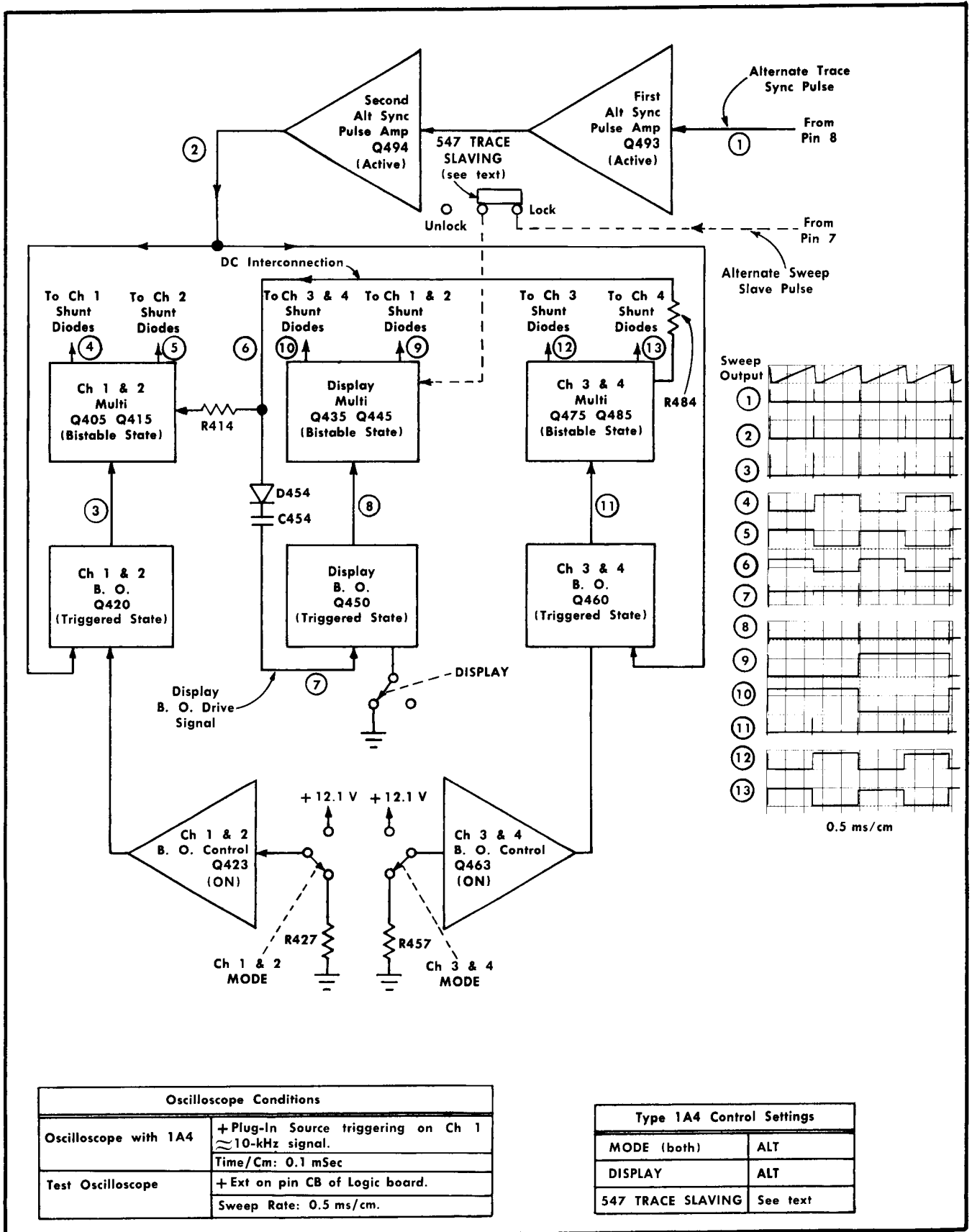


Fig. 4-24. Simplified block diagram of the Logic circuit when four-channel alternate mode of operation is selected.

Circuit Description—Type 1A4

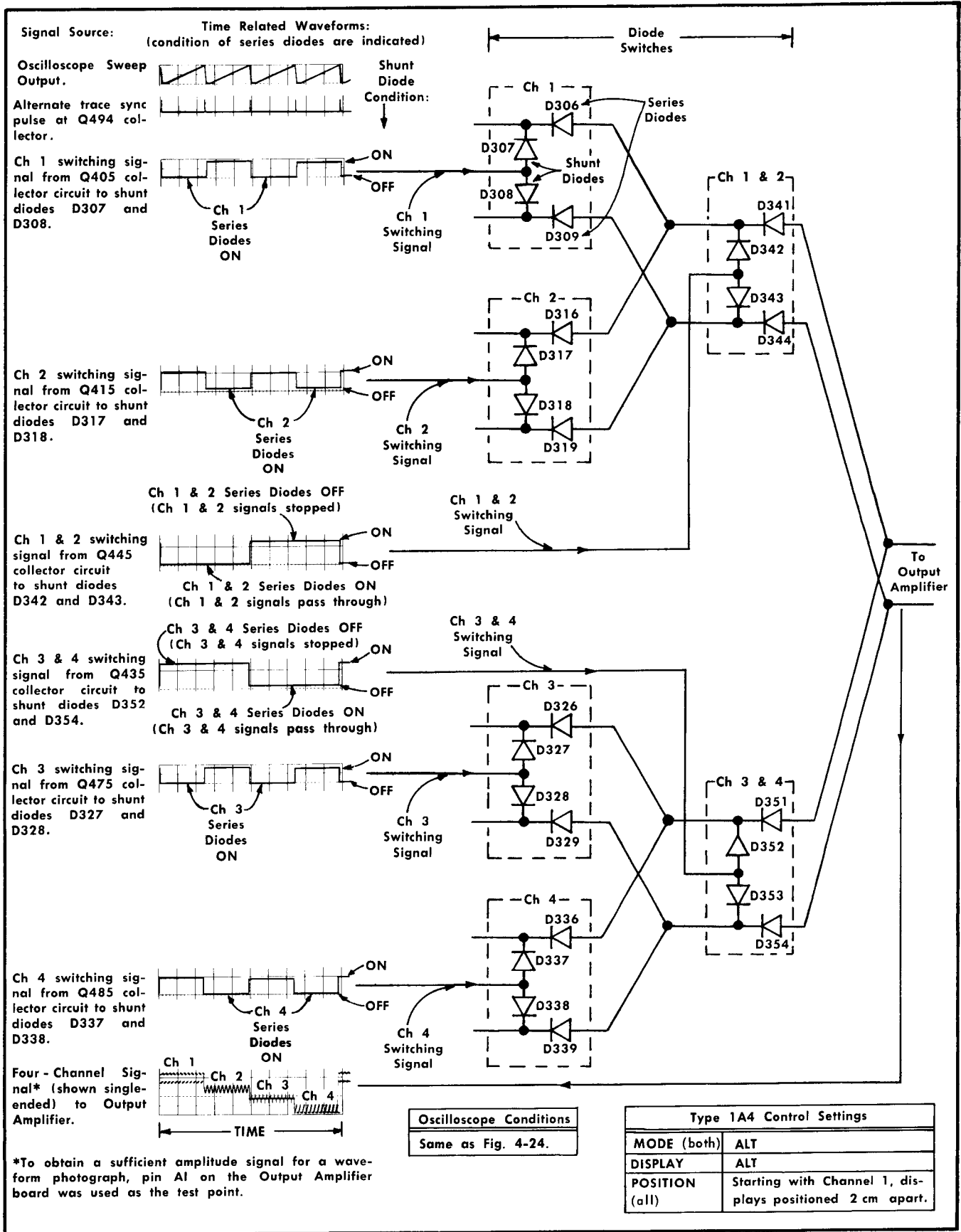


Fig. 4-25. These time-related waveforms show how the diode switches are turned on and off during four-channel alternate mode operation.

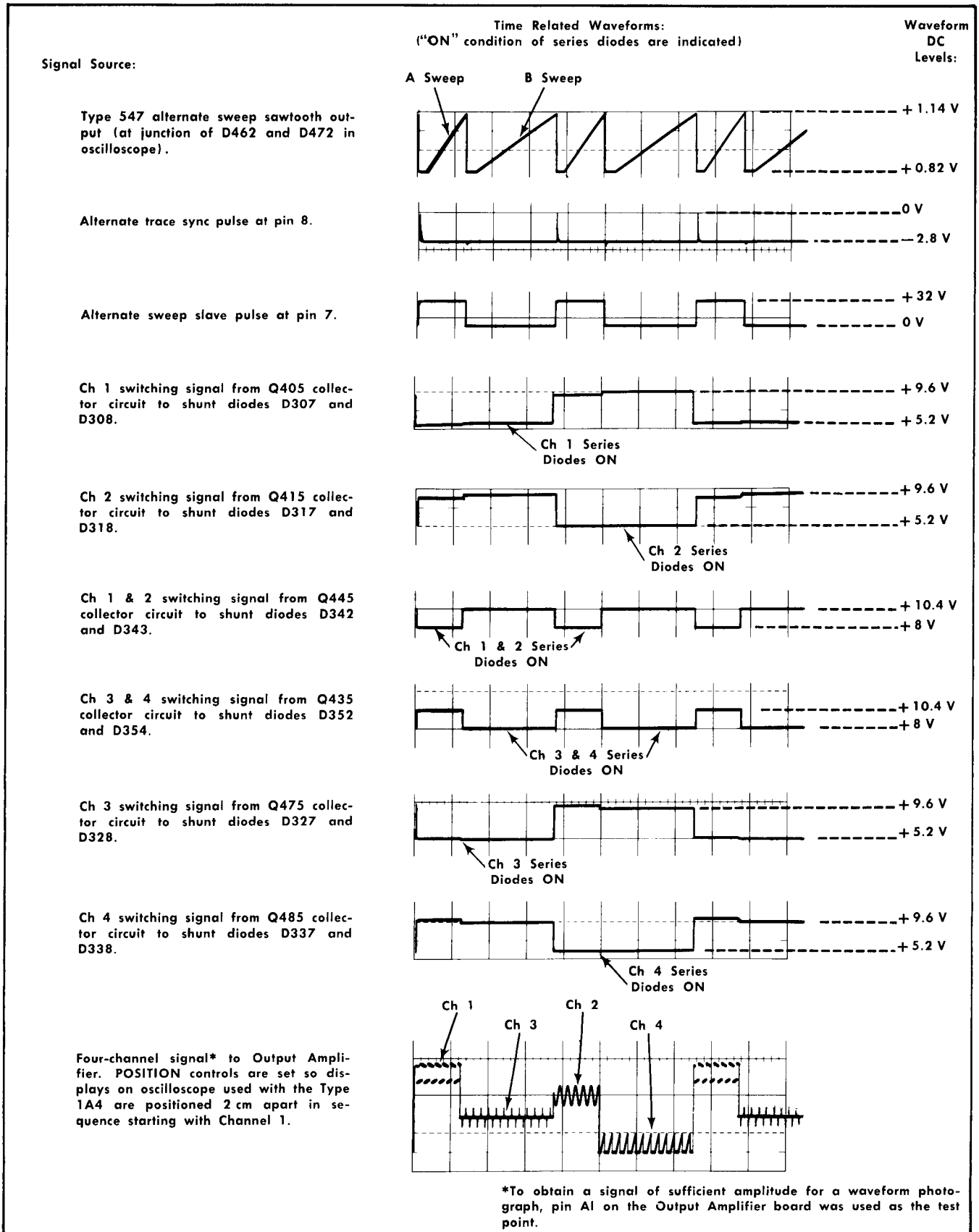


Fig. 4-26. Time-related waveforms showing the sequence for turning the diode switches on and off during four-channel alternate mode of operation when the Type 547 Horizontal Display switch is set to A/Alt/B. 547 TRACE SLAVING switch is set to LOCK. Sweep rates: A sweep at 50 μ s/cm; B sweep at 0.1 ms/cm.

Circuit Description—Type 1A4

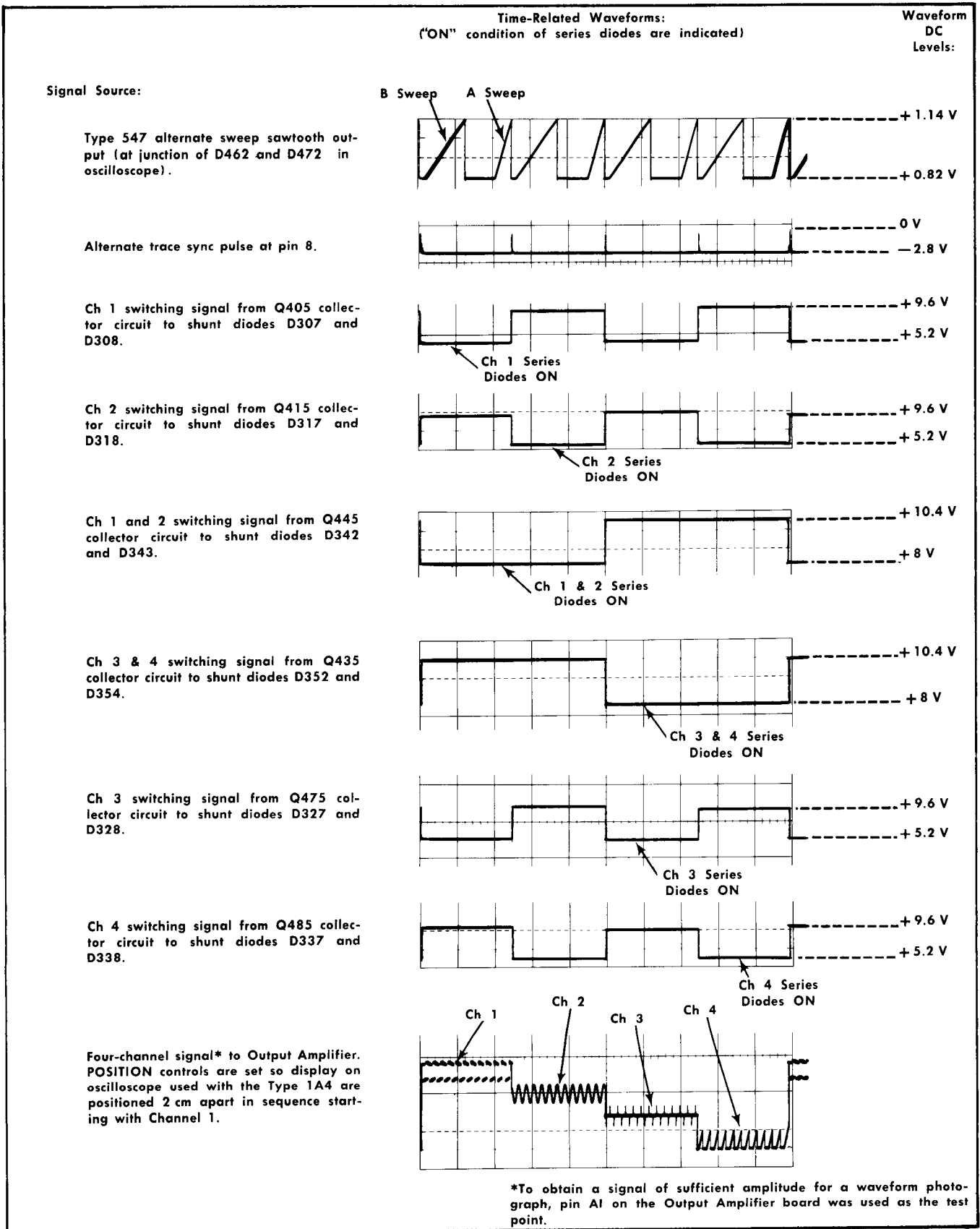


Fig. 4-27. Time-related waveforms showing the sequence for turning the diode switches on and off during four-channel alternate mode of operation when the Type 547 Horizontal Display switch is set to B-Intens-By-'A'/Alt/A-Dly'd. All four channels are displayed by each time base; thus, an eight-trace display is obtained. Delay-Time Multiplier dial is set to 6.60. Sweep rates: A sweep at 10 μ s/cm; B sweep at 20 μ s/cm.

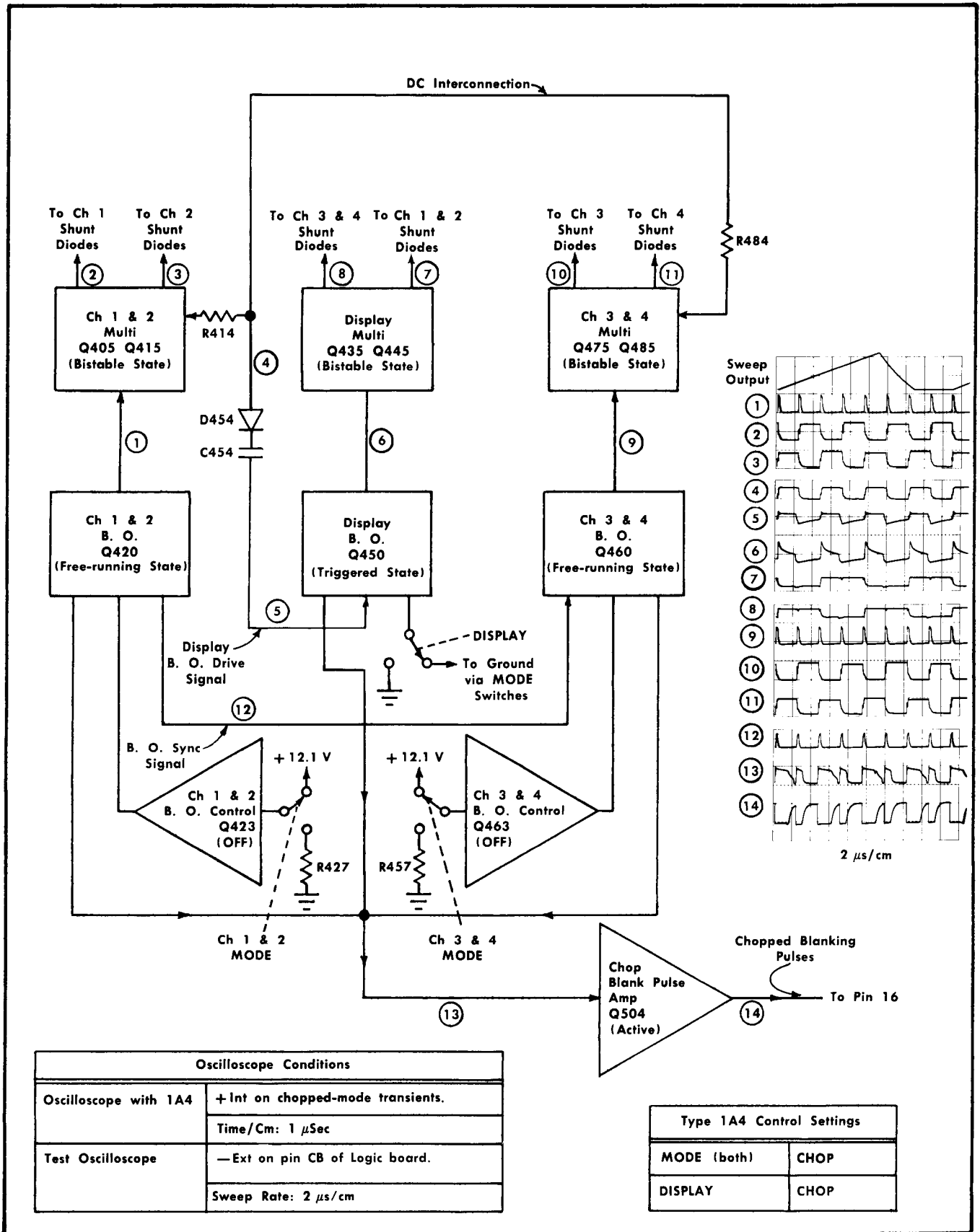


Fig. 4-28. Block diagram of the Logic circuit when four-channel chopped mode of operation is used.

Oscilloscope Conditions	
Oscilloscope with 1A4	+ Int on chopped-mode transients.
	Time/Cm: 1 μSec
Test Oscilloscope	— Ext on pin CB of Logic board.
	Sweep Rate: 2 μs/cm

Type 1A4 Control Settings	
MODE (both)	CHOP
DISPLAY	CHOP

TABLE 4-6 (cont)

Circuit	Configuration
	DISPLAY and MODE switches. Q415 and Q485 collectors (locked together) provide the drive signal through D454 and C454 to the base of Q450. Triggers from Q450 drive the Display Multi and are also used as pulses for application through D448 to the base of Q504.
Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator in a bistable state. Triggers from Q450 drive the multivibrator at one-half Q420/Q450 free-running rate.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to permit the Channel 1 and 2 chopped signals to be applied to the Output Amplifier. Q435 turns off the Ch 3 & 4 diode switch during the time Ch 1 & 2 diode switch is on.
Ch 3 & 4 diode switch.	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. Channel 3 and 4 chopped signals go to the Output Amplifier; simultaneously, the Channel 1 and 2 signals are stopped.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active state, amplifies the positive-going synchronized pulses from Q420, Q450 and Q460. The negative-going pulses at Q504 collector are applied to pin 16 for use as blanking pulses that blank (turn off) the beam during the switching interval between channels.

Chopping Between Two Alternating Pairs of Channels

Table 4-7 provides a brief description of the various configurations used when performing the logic illustrated in Fig. 4-29.

TABLE 4-7
Chopping Between Two Alternating Pairs of Channels
(See Fig. 4-29)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	The MODE switches connect Q493 emitter to ground and place Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.
System associated with Ch 1 and Ch 2 diode switches:	

Ch 1 & 2 B. O., Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to R427. Q423 turns on.
Ch 1 & 2 B. O., Q420.	With Q423 turned on, Q423 places Q420 in an triggered state. Q494 provides the trigger drive to Q420.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places the multivibrator into a bistable state. Triggers from Q420 drive the multivibrator at the alternate sync pulse rate. Switching occurs during the sweep retrace interval.
Ch 1 & Ch 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off alternately. Channel 1 and 2 signals are applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & Ch 4 diode switches.	This system operates the same as described for the system associated with the Ch 1 and Ch 2 diode switches.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B.O., Q450.	Q450 emitter circuit, via the DISPLAY switch, is disconnected from ground at the MODE switches. This allows Q450 base-emitter junction to be forward biased and Q450 free runs. Q450 provides the trigger drive to the Display Multi. The triggers are also used as pulses for application through D448 to the base of Q504.
Display Multi, Q435 and Q445.	DISPLAY switch places the multivibrator in a bistable state. Triggers from Q450 drive the multivibrator at Q450's free-running rate.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to permit the Channel 1 and 2 signals to be applied alternately to the Output Amplifier. Q435 turns off the Ch 3 & 4 diode switch during the interval that Ch 1 & 2 diode switch is on.
Ch 3 & 4 diode switch.	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. Channel 3 and 4 signals are applied alternately to the Output Amplifier.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active, state, amplifies the positive-going pulses from Q450. The negative-going pulses at Q504 collector are applied to pin 16 for use as blanking pulses that turn off the beam during the switching interval between channels.

Alternating Between Two Chopping Pairs of Channels

Table 4-8 lists and describes the configurations used when performing the logic shown in Fig. 4-30.

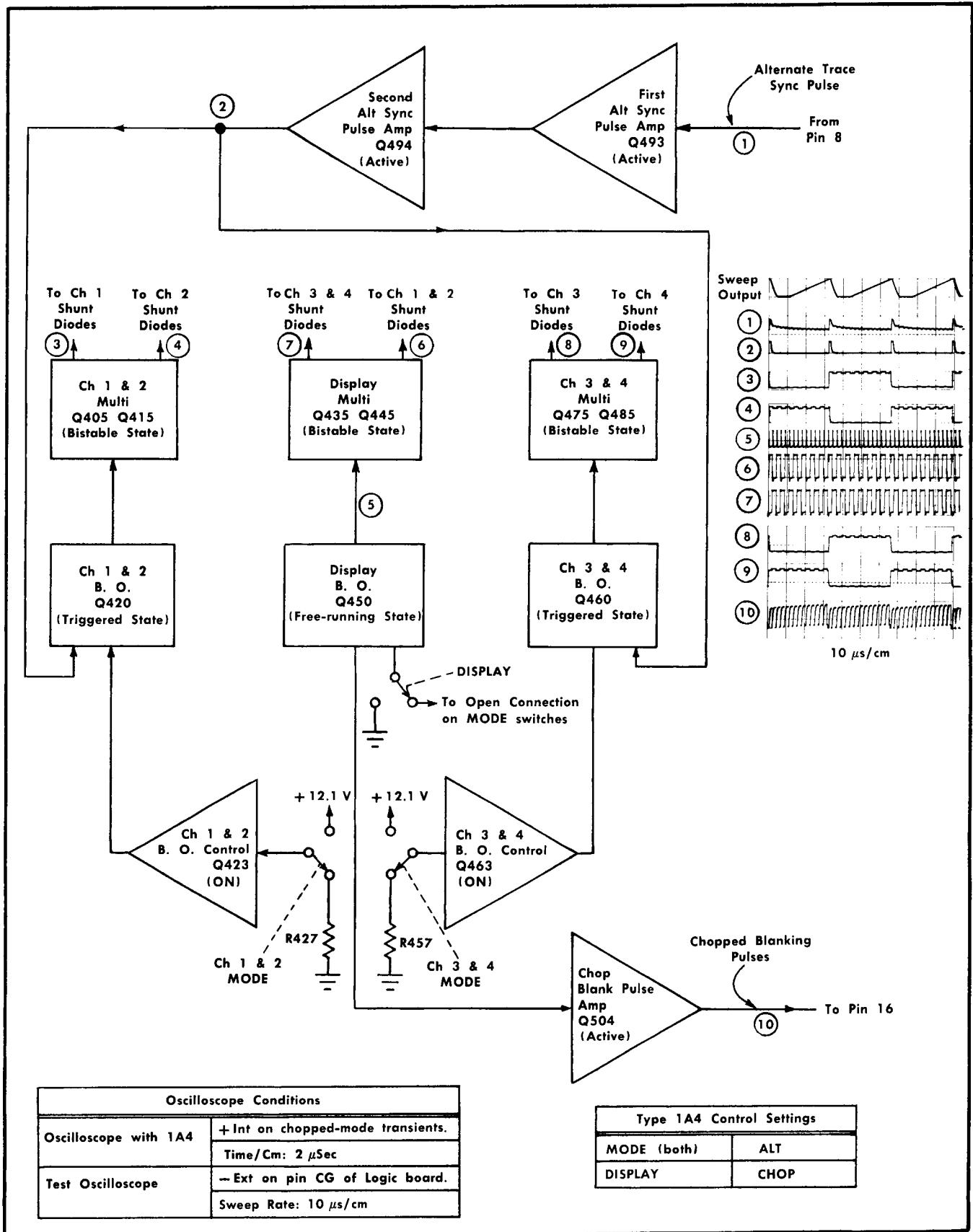


Fig. 4-29. Logic block diagram when the Type 1A4 is chopping between two alternating pairs of channels.

Circuit Description—Type 1A4

TABLE 4-8
Alternating Between Two Chopping
Pairs of Channels
(See Fig. 4-30)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	The DISPLAY switch connects Q493 emitter to ground and this places Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	Q423 base circuit, via the Ch 1 & 2 MODE switch, goes to an open connection on the DISPLAY switch. Q423 is now turned on and off by the lockout signal from Q435 collector circuit. Thus, Q423 operates in the active state.
Ch 1 & 2 B. O., Q420.	When Q435 is on, Q423 is turned off and Q420 is allowed to free-run. Q420 triggers the Ch 1 & 2 Multi. Also, the triggers from Q420 are used as pulses for application through D418 to the base of Q504. For further information, see footnote ^a .
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable state. When Q420 is free running, triggers from Q420 cause the multivibrator to switch states at Q420 free-running rate.
Ch 1 and 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off so the Channel 1 & 2 chopped signals are applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & 4 diode switches.	This system operates similar to the system associated with the Ch 1 and Ch 2 diode switches.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state. Q494 output pulses, connected via the Ch 1 & 2 MODE and DISPLAY switches, is coupled through D454 and C454 to the base of Q450. These pulses trigger Q450 at the alternate sync pulse rate. Triggers from Q450 are applied to the Display Multi.

^aWhile Q420 is free running, Q420 is producing a B. O. Sync Signal that is applied via C424 and the MODE switches through C466 to the base of Q460. However, since the lockout signal from Q445 collector prevents Q460 from free running during the time that Q420 free runs, the sync signal is ineffective. When Q435 is off, Q423 is turned on and Q420 is placed in the triggered state. At this time, Q460 is free running and the B. O. Sync Signal from Q460 has no effect on Q420. Thus, since Q420 is in a triggered state and not being triggered, Q420 produces no triggers to drive the Ch 1 & 2 Multi or Q504.

Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator in a bistable state. Triggers from Q450 drive the multivibrator at the alternate sync pulse rate.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to allow the Channel 1 and 2 chopped signals to be applied to the Output Amplifier. Q435 turns off the Ch 3 & 4 diode switch at this time.
Ch 3 & 4 diode switch.	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. During this time, Channel 3 and 4 chopped signals are applied to the Output Amplifier; simultaneously, the Channel 1 and 2 signals are stopped.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active state, amplifies the positive-going pulses arriving from Q420 and Q460 when they free-run. The negative-going pulses at Q504 collector are applied to pin 16 for use as blanking pulses that will turn off the beam during the switching interval between pairs of channels.
547 TRACE SLAVING switch (set to the LOCK position).	If the Type 547 Horizontal Display switch is set to A/Alt/B, the alternate sweep slave pulse is DC-coupled to Q445 base circuit. The pulse forces Q445 to turn on during the B sweep time and turn off during the A sweep time. Thus, during the B sweep, Channels 3 and 4 are displayed; during the A sweep, Channels 1 and 2 are displayed.

Alternating Between Ch 1 & 2 Chopping and Ch 3 & 4 Alternating

Table 4-9 describes the configurations that are employed to obtain the switching circuit logic shown in Fig. 4-31.

TABLE 4-9
Alternating Between Ch 1 & 2 Chopping
and Ch 3 & 4 Alternating
(See Fig. 4-31)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	The DISPLAY and Ch 3 & 4 MODE switches connect Q493 emitter to ground and this places Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.
System associated with Ch 1 and Ch 2 diode switches:	

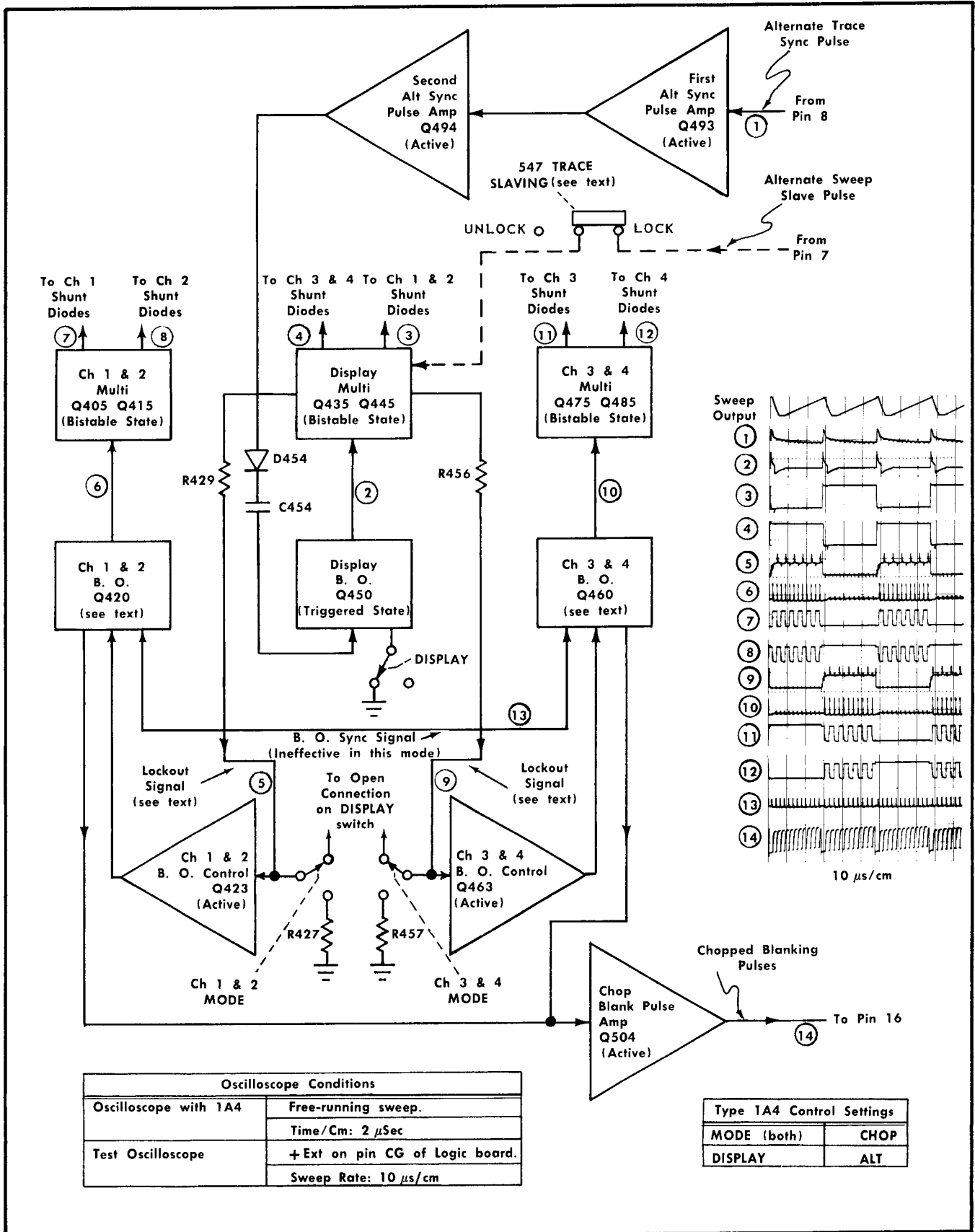
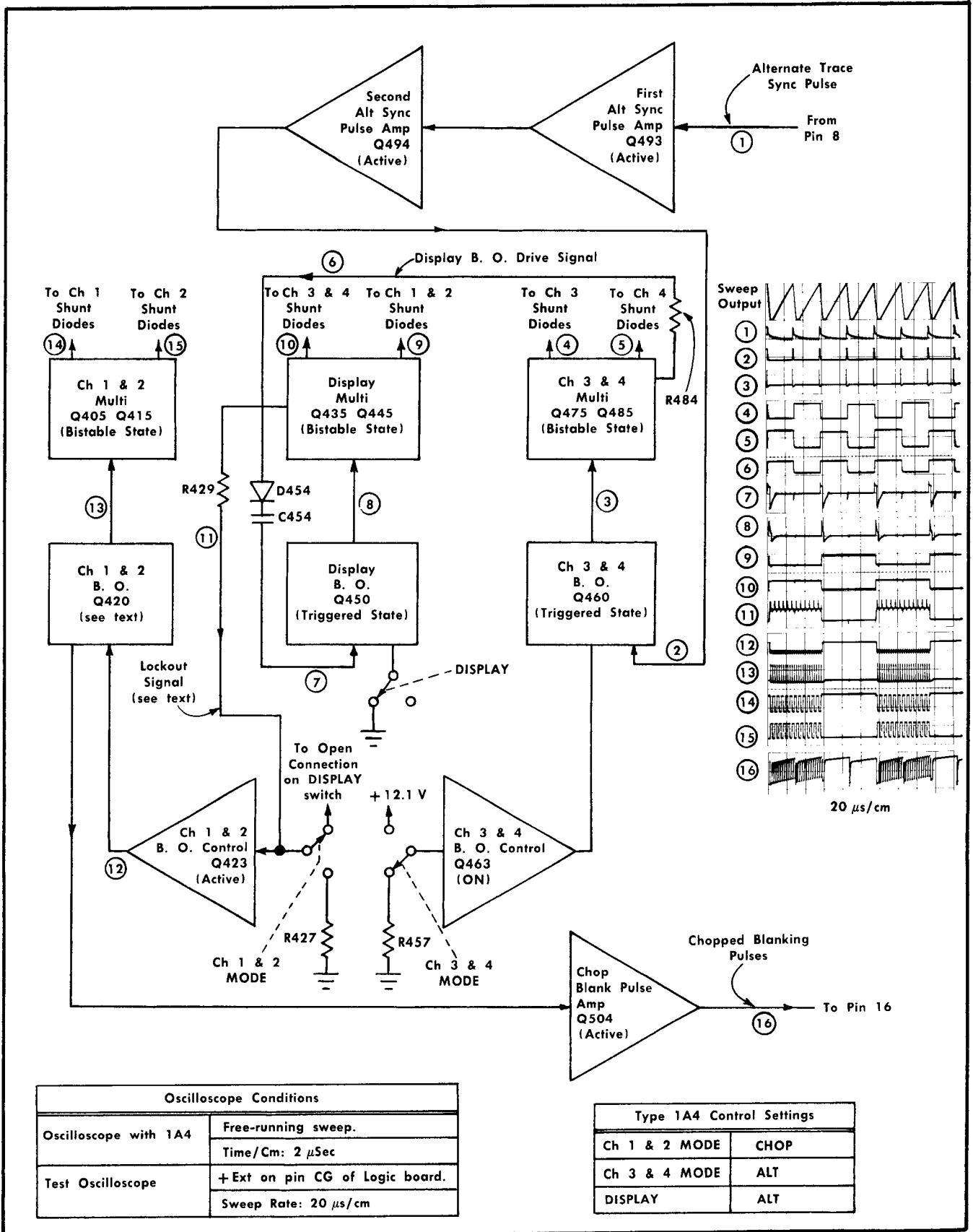


Fig. 4-30. Block diagram of the Logic circuit when the Type 1A4 is alternating between two chopping pairs of channels.



Oscilloscope Conditions	
Oscilloscope with 1A4	Free-running sweep.
	Time/Cm: 2 μSec
Test Oscilloscope	+Ext on pin CG of Logic board.
	Sweep Rate: 20 μs/cm

Type 1A4 Control Settings	
Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	ALT
DISPLAY	ALT

Fig. 4-31. Block diagram of the Logic circuit when the Type 1A4 is alternating between Channel 1 & 2 chopping and Channel 3 & 4 alternating.

TABLE 4-9 (cont)

Circuit	Configuration
Ch 1 & 2 B. O. Control, Q423.	Q423 base circuit, via the Ch 1 & 2 MODE switch, goes to an open connection on the DISPLAY switch. Q423 is now turned on and off by the lockout signal from Q435 collector circuit. Thus, Q423 operates in an active state.
Ch 1 & 2 B. O., Q420.	When Q435 is on, Q423 is turned off and Q420 is allowed to free run. Q420 triggers the Ch 1 & 2 Multi. Also, the triggers from Q420 are used as pulses for application through D418 to the base of Q504. When Q435 is off, Q423 is turned on and Q420 is placed in the triggered state but not triggered. Hence, Ch 1 & 2 Multi is not triggered during the time that Channel 3 and 4 signals are displayed.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable state. When Q420 is free running, triggers from Q420 cause the multivibrator to switch states at Q420 free-running rate.
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns the diode switches on and off so the Channel 1 and 2 chopped signals are applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & 4 diode switches: Ch 3 & 4 B. O. Control, Q463.	Ch 3 & 4 MODE switch connects Q463 base to R457. Q463 is turned on.
Ch 3 & 4 B. O., Q460.	With Q463 turned on, Q463 places Q460 in a triggered state. Q494 provides the trigger drive to Q460.
Ch 3 & 4 Multi, Q475 and Q485.	Ch 3 & 4 MODE switch places this multivibrator into a bistable state. Triggers from Q460 drive the multivibrator at the alternate sync pulse rate. Switching occurs during the sweep retrace interval.
Ch 3 & 4 diode switches.	Ch 3 & 4 Multi turns the diode switches on and off alternately. Channel 3 and 4 signals are applied to the Ch 3 & 4 diode switch.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state. Q485 collector circuit, via R484, Ch 1 & 2 MODE

	switch and DISPLAY switch, provides the drive signal to Q450. This signal triggers Q450 at one-half the alternate trace sync pulse rate.
Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator in a bistable state. Triggers from Q450 drive the multivibrator.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to allow the Channel 1 and 2 chopped signals to be applied to the Output Amplifier. Simultaneously, Q435 turns off the Ch 3 & 4 diode switch at this time.
Ch 3 & 4 diode switch	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. During this time, Channel 3 and 4 alternate signals are applied to the Output Amplifier; simultaneously, the Channel 1 and 2 signals are stopped. Sequence: Channels 1 and 2 chopped signals run twice, Channel 3 signal runs once, Channel 4 signal runs once, etc.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active state, amplifies the positive-going pulses arriving from Q420 when Q420 free runs. The negative-going pulses at Q504 collector are applied to pin 16 for use as blanking pulses that will turn off the beam during the switching interval between Channels 1 and 2.

Alternating Between Two Added Pairs of Channels

Table 4-10 describes the configurations that are employed to obtain the logic shown in Fig. 4-32.

TABLE 4-10

Alternating Between Two Added Pairs of Channels (See Fig. 4-32)

Circuit	Configuration
Alt Sync Pulse Amp, Q493 and Q494.	The DISPLAY switch connects Q493 emitter to ground and this places Q493 in the active state. Q493 and Q494 reshape and amplify the alternate trace sync pulses.
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to R427. Q423 turns on.

TABLE 4-10 (cont)

Circuit	Configuration
Ch 1 & 2 B. O., Q420.	With Q423 turned on, Q423 places Q420 in a triggered state but no triggers are applied.
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places the multivibrator into this stable state: Q405 and Q415 are both OFF.
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns both of these diode switches on. Channel 1 and 2 signals add. The added signal is applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 and Ch 4 diode switches.	This system operates the same as described for the system associated with the Ch 1 and Ch 2 diode switches.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	DISPLAY switch grounds Q450 emitter. Q450 is placed in a triggered state. Q494 output pulses, connected via the Ch 1 & 2 MODE and DISPLAY switches, are coupled through D454 and C454 to the base of Q450. These pulses trigger Q450 at the alternate sync pulse rate. Triggers from Q450 are applied to the Display Multi.
Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator in a bistable state. Triggers from Q450 drive the multivibrator at the alternate trace sync pulse rate.
Ch 1 & 2 diode switch.	Q445 turns on the Ch 1 & 2 diode switch to allow the Channel 1 and 2 added signal to be applied to the Output Amplifier. During this time, Q435 turns off the Ch 3 & 4 diode switch so the Channel 3 and 4 added signal is stopped.
Ch 3 & 4 diode switch.	Q435 turns on the Ch 3 & 4 diode switch while Q445 turns off the Ch 1 & 2 diode switch. Thus, Channel 3 and 4 added signal is applied to the Output Amplifier and the Channel 1 and 2 added signal is stopped.

Adding Two Chopped Pairs of Channels

Table 4-11 describes the configurations that are employed to obtain the logic shown in Fig. 4-33.

TABLE 4-11

Adding Two Chopping Pairs of Channels
(See Fig. 4-33)

Circuit	Configuration
System associated with Ch 1 and Ch 2 diode switches: Ch 1 & 2 B. O. Control, Q423.	Ch 1 & 2 MODE switch connects Q423 base to +12.1 V. Q423 turns off.
Ch 1 & 2 B. O., Q420.	With Q423 turned off, Q420 is placed in a free-running state. Q420 provides the trigger drive to Ch 1 & 2 Multi. The triggers are also used as pulses for application to Q504. In addition, Q420 applies sync pulses to Q460 so the two blocking oscillators are synchronized. ⁹
Ch 1 & 2 Multi, Q405 and Q415.	Ch 1 & 2 MODE switch places this multivibrator into a bistable state. Triggers from Q420 drive the multivibrator at the B. O. free-running rate. Also, see DC Interconnection footnote. ¹⁰
Ch 1 and Ch 2 diode switches.	Ch 1 & 2 Multi turns these diode switches on and off to let the Channel 1 and 2 chopped signals pass through the switches and be applied to the Ch 1 & 2 diode switch.
System associated with Ch 3 & Ch 4 diode switches.	This system operates similar to the system associated with the Ch 1 and Ch 2 diode switches except Q460 is synchronized by the sync signal from Q420.
System associated with Ch 1 & 2 and Ch 3 & 4 diode switches: Display B. O., Q450.	Q450 is placed in a triggered state by grounding Q450 emitter via the DISPLAY switch. No triggers are applied to Q450 and, hence, there will be no output from Q450.
Display Multi, Q435 and Q445.	DISPLAY switch places this multivibrator into this stable state: Q435 and Q445 are both OFF. No triggers from Q450 are applied.

⁹Q420 synchronizes Q460 by means of sync pulses applied from Q420 through C424, the MODE switches, and C465 to the base of Q460. To ensure synchronization, R423 in Q420 emitter circuit is a smaller value than R466 located in the Q460 emitter circuit. Hence, Q420 runs slightly faster than Q460's free-running rate and forces Q460 to synchronize.

¹⁰The DC Interconnection, connected from Q415 collector through R414 and R484 to the collector of Q485, locks the Ch 1 & 2 Multi and the Ch 3 & 4 Multi together so they are in step with each other.

TABLE 4-11 (cont)

Circuit	Configuration
Ch 1 & 2 and Ch 3 & 4 diode switches.	Display Multi turns both of these diodes switches on simultaneously. The chopped signals from Channel 1 algebraically add to Channel 3 and Channel 2 chopped signals algebraically add to Channel 4.
Chopped Blanking Pulse Amplifier, Q504.	Q504, operating in the active state, amplifies the positive-going synchronized pulses arriving from Q420 and Q460. The negative-going pulses at Q504 collector are applied to pin 16 for use as blanking pulses that turn off the beam during the switching interval between channels.

POWER SUPPLY

Introduction

Two electronically regulated DC supplies, -15 V and $+12.1\text{ V}$ as shown on the Power Supply schematic diagram provide power to most of the circuits in the Type 1A4. The -15 V supply provides power to the four Input Amplifiers, Trigger Amplifier and to a portion of the oscilloscope sync amplifier cathode circuit via pin 8 of the interconnecting plug on the Channel Switching Logic diagram. The $+12.1\text{ V}$ supply provides power to the Input Amplifier for all four channels, to the Trigger Amplifier, to all stages in the Channel Switching Logic circuit and to the Output Amplifier.

Power for the regulator circuits is obtained from a 6.3-V AC winding on the oscilloscope power transformer and applied via pins 13 and 14 of the interconnecting plug to the primary winding of T601 (terminals 1 and 2). T601 has two secondary windings for use in developing the required voltages.

Both of the regulated circuits operate in a similar manner. An error sensing circuit compares a sample of the output voltage against a fixed reference voltage. Any difference between the output voltage and the reference produces an error signal which is amplified and applied to the series regulator transistor, causing the regulator to correct for the error and return the output to the proper value. Fig. 4-34 is a block diagram of the Type 1A4 Power Supply circuit.

-15-V Supply

The -15-V supply in the Type 1A4 is the reference voltage for the $+12.1\text{-V}$ supply and therefore must be stable. The -15-V supply includes a high-gain regulating circuit designed to provide good regulation within the power-line operating range of the oscilloscope. The regulator circuit contains a Zener diode for use as a reference source, a Comparator stage and a Series Regulator.

In operation, the input power to the -15-V supply is supplied by the associated secondary winding connected to terminals 5 and 6 of T601. The AC output of the secondary winding is rectified by a full-wave silicon-diode rectifier bridge D602 and filtered by capacitor C602. In series with

the positive side of the supply and ground is a series regulator transistor Q617. The output of -15-V supply is taken from the negative side.

Error sensing in the regulator circuit is accomplished by the Comparator stage (Q604 and Q614). Current through transistors Q604 and Q614 is established by divider resistors R610, R611 and R612. The -15 VOLTS adjustment R610 is adjusted so the output of the supply is exactly -15 V . Zener reference diode D603 maintains a fixed voltage drop of 9.1 V , $\pm 5\%$ between ground and its anode. Thus, even if the diode bridge output voltage changes, the voltage between the base of Q604 and ground remains at the voltage fixed by the reference diode.

The Comparator circuit senses any deviations between ground and the rated output voltage of -15 V . To follow the operation of the regulator circuit, assume the diode-bridge output voltage increases slightly and this has a tendency to drive the -15-V supply toward an output of -16 V .

As the diode-bridge output voltage increases, current through the sensing resistors R610, R611 and R612 increases. The divider action of the sensing resistors causes about 62% of the voltage increase to be applied between the base of Q614 and ground. This negative-going voltage change decreases the current through Q614 and R615. Decreased current through R615 results in an increase in current through Q604 to restore the original Q604 base-emitter junction bias. The increased current through Q604 causes the collector voltage to decrease.

The decreased Q604 collector voltage is applied to the base of the series-regulating transistor Q617. As a result, the forward bias on the base-emitter junction of Q617 is decreased, current through Q617 decreases and the voltage drop across Q617 increases. This action effectively offsets the original voltage increase that occurred at the diode-bridge output.

The voltage necessary to provide the increased drop across the series regulator, Q617, can only be obtained by subtracting the voltage drop of the positive side of the supply from that of the negative side, so the original undesired increase in negative voltage is absorbed in the series regulator. If the output of the -15-V supply had decreased rather than increased, the error voltage applied to the base of the series regulator would have been positive going. The positive-going error voltage would decrease the drop across Q617, leaving more voltage for the negative side of the supply. Since the output voltage of the -15-V supply depends upon the relationship of the voltage applied to the base of Q614 and the reference voltage from D603 applied to the base of Q604, accurate adjustment of the output voltage can be obtained by adjusting the -15 VOLTS control R610.

Filter capacitor C602 does not remove all the ripple from the output of the bridge rectifier. However, the action of the series regulator aids in greatly reducing the remaining output ripple voltage. Any ripple between the -15-V bus and ground reaches the base of Q614. The Comparator amplifies these fluctuations and applies them to the series regulator. The series regulator acts to oppose the original ripple voltage.

Important components that insure proper operation of the -15-V supply under adverse conditions are as follows.

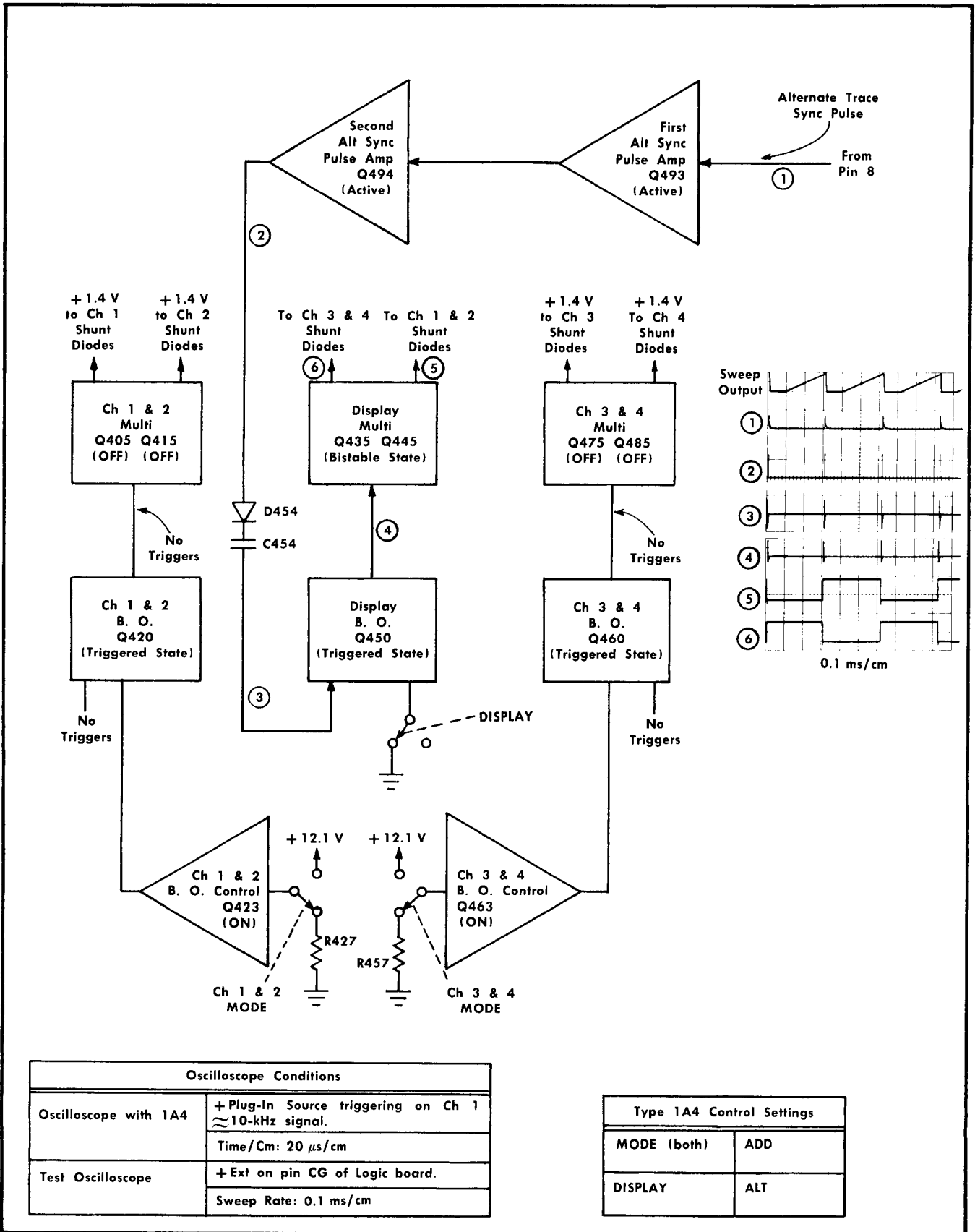


Fig. 4-32. Simplified block diagram of the Logic circuit showing dual-trace differential mode of operation. DISPLAY switch is set for alternate mode of operation between the two pairs of added channels.

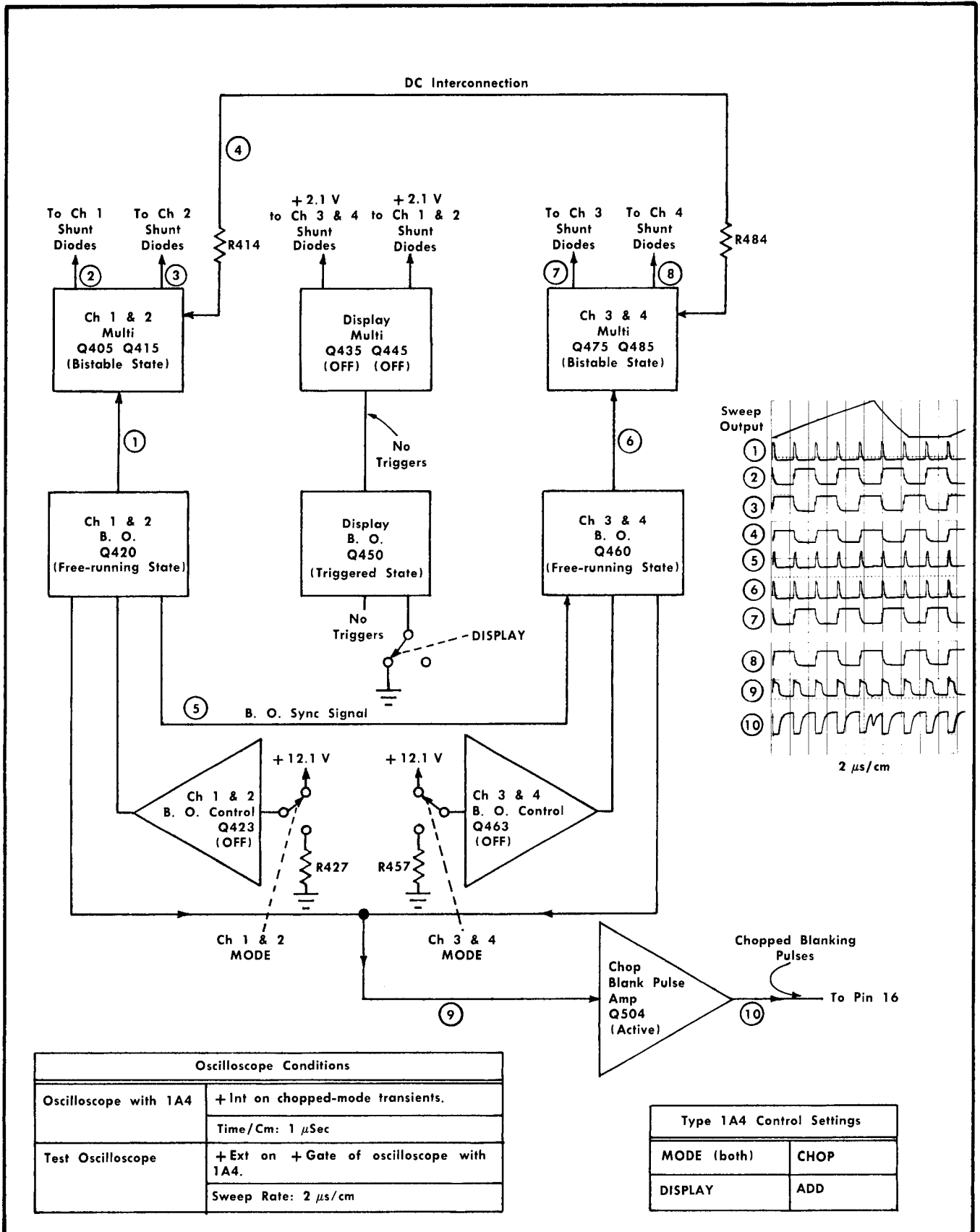


Fig. 4-33. Simplified block diagram of the Logic circuit showing the Type 1A4 adding two pairs of chopping channels. Channel 1 algebraically adds to Channel 3 and Channel 2 algebraically adds to Channel 4.

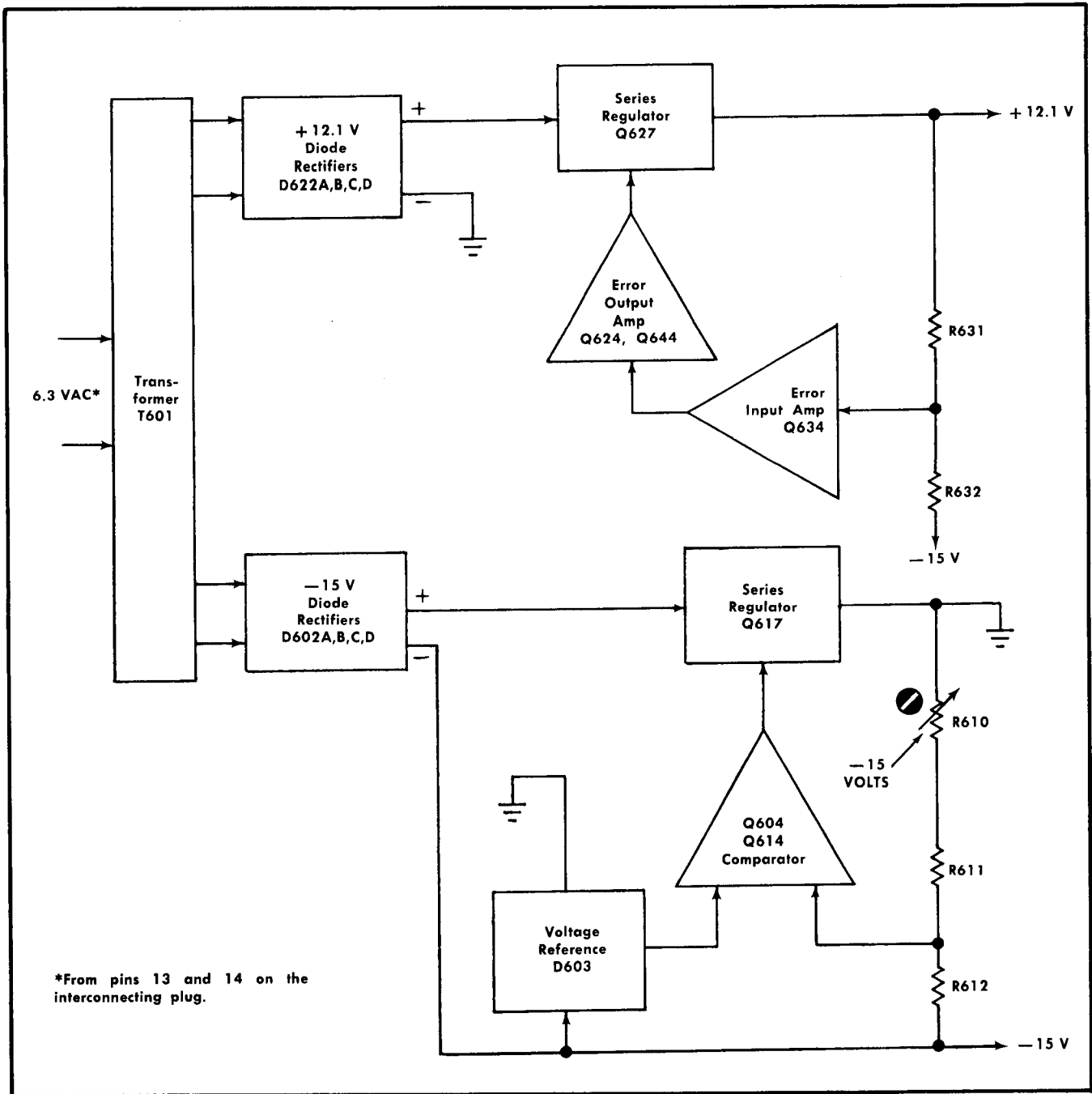


Fig. 4-34. Block diagram of the Type 1A4 regulated Power Supply circuit.

Filter capacitor C612 suppresses sudden load changes to minimize the work done by the regulator circuit. C610 is a bypass capacitor for fast signal transients that may occur in the base circuit of Q614. C604 is a bypass capacitor for the base of Q604. R617, D606 and D607 provide current limiting for Q617 in the event that the -15-V supply is shorted to ground. The diodes limit Q617 base current and R617 limits the emitter-to-collector current within the dissipation rating of the transistor.

+12.1-Volt Supply

The input to the +12.1-V supply is the AC output of the secondary winding connected to terminals 3 and 4 on the power transformer T601. To convert the AC output to DC, the AC voltage is rectified by the full-wave silicon-diode rectifier bridge D622 and filtered by C622. Reference voltage source for this supply is the regulated output of the -15-V supply. Q634 is the Error Input Amplifier; Q624 and Q644

are the Error Output Amplifier transistors. Q627 is the Series Regulator.

The error feedback circuit starts from the junction of the error sensing resistors, R631 and R632. The top end of R631 is connected to the output of the +12.1-V supply; the lower end of R632 is connected to the regulated -15-V supply used as the reference. With normal line voltages and loads, the voltage at the junction of R631 and R632 is at about ground. This is the voltage level applied to the base of Q634.

If the load current, output voltage, or input voltage (from T601) starts to change (including a change due to ripple), the output of the regulated +12.1-V supply tends to change also. As a result, any change that appears across the sensing resistors is applied to the base of Q634 as a change in operating bias. Assuming that the output of the +12.1-V regulated supply tries to increase, the increased voltage at the top end of R631 causes about 55% of the change to be applied to the base of Q634. Thus, the forward bias on the base-emitter junction of Q634 is increased and current through the transistor is increased.

An increase in current through Q634 causes the collector voltage to decrease and this change is applied to the base of Q644. Current through Q644 increases and its collector goes less negative, resulting in a positive-going signal at the collector. The positive-going signal is applied to the base of Q624 and current through Q624 increases. The increased drop across R624 results in a negative-going signal applied to the base of the series regulator, Q627. Collector current through Q627 decreases, the internal resistance increases, and the output voltage decreases; thus compensating for the increase in output voltage which initiated the regulating action.

Filter capacitor C632 suppresses sudden load changes on the +12.1-V supply so the effect on the regulating circuit is

minimized. C634 is a small value negative feedback capacitor. C624 is a decoupling capacitor for the +75-V supply. D635 is a temperature compensating diode for Q634. D624 is a protection diode for Q624. This diode limits the reverse bias in the event that Q644 is pulled out of its socket while the system is operating. R627, D626 and D627 provide current limiting for Q627 if the +12.1-V supply happens to be shorted to ground. The diodes limit Q627 base current and R627 limits the collector current within the dissipation rating of the transistor.

Distribution Circuits

The Power Supply diagram shows the Output board power distribution and interconnecting plug (P11) details. Pins 1, 3, 5, 7, 8 and 16 on P11 are used for signals; pins 9, 10, 11, 13, 14 and 15 are power connections; pins 2 and 4 are ground return connections; pins 6 and 12 are not used by the Type 1A4.

Tapped divider resistor, R392, is connected between the +75-V and +12.1-V sources to provide +15 V for use in the POSITION and IDENTIFY control circuitry. These controls are located on the Output Amplifier diagram.

C398 and R398 form a decoupling network. This network provides filtering of undesirable signals to prevent interaction between circuits. (Other decoupling networks that have the same purpose are shown on the Ch 1 Input Amplifier diagram. Some examples are: C93 and L92; C153 and R153.)

R399 is a current-shunting resistor that shunts some of the current from the +225-V supply to the +100-V supply. Thus, the +100-V supply will have sufficient current for powering its own circuits.

SECTION 5

MAINTENANCE

Introduction

This section contains maintenance instructions for the Type 1A4. The main topics are preventive maintenance, corrective maintenance and troubleshooting information.

PREVENTIVE MAINTENANCE

General

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

Cleaning

The Type 1A4 should be cleaned as often as operating conditions require. The oscilloscope side panels and air filter provide some protection against dust accumulating in the interior of the unit, but a small amount of dust is still brought in by the circulating air. Dust on the circuit components reduces heat dissipation and may cause component overheating. Clean the unit by loosening the accumulated dust with a dry, soft paint brush. Remove the loosened dust by vacuum and/or dry, low-pressure compressed air (high-velocity air can damage some components). Hardened dirt and grease may be removed with a cotton-tipped swab or a soft cloth dampened with water and mild detergent solution (such as Kelite or Spray White). Abrasive cleaners should not be used.

CAUTION

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

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

Lubrication

The life of rotary switches is lengthened if they are properly lubricated. Use a cleaning type lubricant (such as Cramoline) on shaft bushings, plug-in connector contacts, and

switch contacts. Lubricate the switch detents with a heavier grease (Beacon grease No. 325 or equivalent). The necessary materials and instructions for proper lubrication of Tektronix instruments are contained in component lubrication kit which may be ordered from Tektronix. Order Tektronix Part No. 003-0342-00.

Visual Inspection

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

Tube and Transistor Checks

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

Recalibration

To ensure accurate measurements, the calibration of the Type 1A4 should be checked after each 500 hours of operation or every six months if the unit is used intermittently. The performance check or calibration procedure is helpful in isolating major troubles in the unit. More over, minor troubles not apparent during regular operation are frequently revealed and can be corrected during recalibration. Complete performance check and calibration instructions are contained in Sections 6 and 7 respectively.

CORRECTIVE MAINTENANCE

General

Corrective maintenance consists of component replacement and plug-in unit repairs. Special techniques or procedures required to replace certain components in the unit are described here.

	SOCKETS (Top View)	COMPONENT (Bottom View)	INSTALLED (Top View)
Dual Diode	None		Not shown
Dual FET, Transistor Pair	<p>Letters in parenthesis pertain to dual FET's.</p>	<p>Dual FET</p>	<p>Dual FET Q53</p> <p>May be installed either way.</p>
		<p>Single Transistor</p>	<p>Q73 and Q83; Q74 and Q84.</p> <p>Plastic thermal cover is not shown.</p>
Transistors			<p>All remaining plastic transistors.</p>
	<p>NOTE Emitter and case terminals are connected together on board.</p>		<p>Q384 Q394</p> <p>Locating tab and dimple aligned.</p>
			<p>Q624</p>
			<p>Q627</p>

Fig. 5-1. Transistor and dual-diode installation.

Obtaining Replacement Parts

Standard Parts. All electrical and mechanical part replacements for the Type 1A4 can be obtained through your local Tektronix Field Office or representative. However, many of the standard electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, consult the Electrical Parts List for value, tolerance and rating.

NOTE

When selecting replacement parts, it is important to remember that the physical size and shape of a component may affect its performance at high frequencies. All replacement parts should be direct replacements unless it is known that a different component will not adversely affect the Type 1A4 performance.

Special Parts. In addition to the standard electronic components, some special parts are used in the Type 1A4. 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 Tektronix Field Office or representative.

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

1. Type 1A4 plug-in unit and serial number of the unit.
2. A description of the part (if electrical, include circuit number).
3. Tektronix Part Number.

Soldering Techniques

Replacing Components on the Circuit Boards.¹ Use ordinary electronic grade 60/40 solder and a 35- to 40-watt pencil soldering iron with a 1/8-inch wide chisel tip. The tip of the iron should be clean and properly tinned for best heat transfer in short time to a soldered connection. A higher wattage soldering iron, if used and applied for too long a time may ruin the bond between the etched wiring and base material by charring the glass epoxy laminate. Component replacement technique is as follows:

1. To remove a defective component, cut the leads near the body. This frees the leads for individual unsoldering.
2. Grip the lead with needle-nose pliers. Apply the tinned tip of the soldering iron to the lead between the pliers and the solder joint; then pull gently.

¹Includes Trigger card. A card is essentially a circuit board that can be plugged into a socket; the socket is used to make circuit connections to the card. A circuit board, on the other hand, is fastened with screws to a permanent mount; connections to a circuit board are made by pin connections and/or soldered leads to the board. In the Type 1A4 all connections to the boards are made using quick-disconnect pin connections.

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

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

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

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

7. Clean all flux from the joint, thus assuring good environmental characteristics and appearance.

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

Observe the following precautions when soldering to metal terminals:

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

Replacing Tantalum Capacitors

Tantalum capacitors are used in some of the Type 1A4 circuits. Since they are electrolytic-type capacitors, polarity must be observed. Install replacement capacitors with the polarity markings located in the same direction as the part that was removed.

Removing Q373 or Q374

Procedure for removing Q373 or Q374 is as follows:

1. Unclip the transistor leads and straighten them.
2. Unscrew the threaded plastic ring that fits around the transistor.
3. Remove the transistor from the heat sink.

4. Note that there is an insulator between the bottom of the transistor and the heat sink. Remove the insulator and coat both sides with silicone grease. Install the insulator on the replacement transistor. (If the insulator is broken, use silicone grease to stick the pieces to the replacement transistor until a new part can be obtained.)

WARNING

Handle silicone grease with care. Wash hands thoroughly after use. Avoid getting silicone grease in the eyes.

Subassembly Removal

V/CM Attenuator (any channel)

Removal requires a soldering iron, a pair of needle-nose pliers, 1/16-inch and 0.050-inch hex wrenches, a ground-down 1/2-inch open end wrench, a 3/16-inch wrench and a 7/16-inch nut driver. Remove the attenuator assembly as follows:

1. Disconnect the nine interconnecting leads from the attenuator. (For channels 2 and 3 V/CM attenuators, remove V374 to obtain access to some of the leads.)
2. Unsolder the strap that connects to the BNC (INPUT) connector center conductor.
3. Loosen two hex setscrews that hold the VARIABLE control shaft in place. One screw is located directly in front of the VARIABLE potentiometer and the other setscrew is located in the front end of the shaft coupler.
4. Remove the VARIABLE knob and shaft as one assembly.
5. Remove the V/CM knob from its shaft.
6. Remove the front-panel 7/16-inch nut and flat washer from the V/CM switch bushing.
7. Set the Input Coupling switch to the GND position and pull off the knob from the switch lever.
8. Using the ground-down 1/2-inch wrench, remove the nut that holds the BNC (INPUT) connector to the front panel.
9. Remove the lockwasher and BNC connector.
10. Loosen the hex screw that holds the rear end of the attenuator to the bracket.
11. Tilt the rear end of the attenuator at an angle that permits removal of the complete attenuator subassembly with mounting lockwasher.

To replace the attenuator, reverse the order of the previous procedure. Be sure the lockwasher is on the attenuator bushing when inserting the control shift through the front panel.

IMPORTANT

Under no conditions should the lockwasher be left out or one of a different thickness substituted.

POSITION Control and IDENTIFY Switch (channel 2 or 3)

To clear the way for removing the POSITION control with IDENTIFY switch as an assembly, the V/CM attenuator directly below the control must be removed first. Follow the procedure given previously for removal of the attenuator assembly. Then, proceed as follows:

1. Unsolder all accessible interconnecting leads that go to the POSITION control and IDENTIFY switch assembly.
2. Using 0.035-inch and 0.050-inch hex wrenches, remove the IDENTIFY and POSITION knobs.

3. Using a 5/16-inch nut driver, remove the mounting nut.
4. Turn the assembly so any remaining interconnecting leads can be unsoldered.
5. Remove the POSITION control and IDENTIFY switch assembly.

To replace the subassemblies, reverse the order of the previous procedures.

VAR BAL Control (channel 2 or 3)

For access to this control, the channel 1 or 4 V/CM attenuator nearest the control must be removed first. Use the procedure given earlier that describes removal of the attenuator subassembly. Then, proceed as follows:

1. Using the 1/16-inch hex wrench, loosen the setscrew that holds the control to the bushing.
2. Turn the component so the interconnecting leads are accessible and unsolder the leads.
3. Remove the control.

To replace the control and the attenuator subassembly, reverse the order of the previous procedures.

Circuit Board Replacement

If a circuit board is damaged and cannot be repaired, a circuit board without components may be obtained, or, if desired, a board completely wired with components mounted may be obtained by using the normal ordering procedure.

All electrical connections to the circuit boards are made with push-on pin connectors, that are easily removed. The boards can be replaced using the procedures given here and by referring to the illustrations provided later in this section.

Procedure for removal of the circuit boards is as follows:

Output Amplifier Board

1. Disconnect all pin connectors from the board.
2. Remove tube V374.
3. Loosen the setscrew in the rear end of each shaft coupler that holds the INVERT switch pins.
4. Slide out and remove the INVERT switch pins.
5. Remove the two front-mounting screws for the board.
6. Remove the two screws that go through the back panel into the metal mounting blocks for the board.
7. Remove the two screws that go through the back panel bottom corners into the frame rods.
8. Loosen the remaining screws that hold the back panel in place to make room for removing the Output Amplifier board. Exception: Remove the two screws going into the lower frame rods so the back panel can be tilted outward at the bottom.
9. Remove the Output Amplifier board.

To replace the board, reverse the order of removal.

Logic Board

1. Disconnect all pin connectors from the board.

2. Remove seven mounting screws.
3. Slide the board out through the right side of the plug-in unit.

To replace the board, reverse the order of removal.

Trigger Card

1. Disconnect the four coaxial connectors from the card.
2. Remove the two screws that hold the card plugged in.
3. Unplug the card and remove it from the left side of the plug-in unit.

To replace the card, reverse the order of removal.

TROUBLESHOOTING

Introduction

The following information is provided to facilitate troubleshooting the Type 1A4. Information contained in other sections of this manual should be used in conjunction with the following information to aid in locating the defective component or other cause of trouble.

Troubleshooting Aids

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

Switch Wafer Identification. Wafers for the DISPLAY, SIGNAL & TRIGGER SOURCE, MODE and V/CM switches are coded on the schematic diagrams to indicate the physical location of the wafer on the actual switches. The number portion of the code refers to the wafer number on the switch assembly. Wafers are numbered from the first wafer located behind the detent section of the switch to the last wafer. The letters F and R indicate whether the front or rear of the wafer is used to perform the particular switching function. For example, 2R of the DISPLAY switch indicates that this is the rear side of the second wafer when counting back from the detent section.

TABLE 5-1

Supply	Color Code
+225 V	Red-Red-Brown on White
+100 V	Brown-Black-Brown on White
+75 V	Purple-Green-Black on White
+15 V	Brown-Green-Black on White
+12 V	Brown-Red-Black on White
-15 V	Blue-Black-Black on Tan
-150 V	Brown-Green-Brown on Tan
6.3 VAC	Blue-Yellow on White
	Blue-Orange on White

Wiring Color Code. All insulated wires in the Type 1A4 are colored coded to facilitate circuit tracing. In the case of power supply leads the color code indicates the voltage

carried, with the widest stripe denoting the first significant figure. Table 5-1 lists the color combinations and the voltages indicated by the colors.

The color code of leads that connect to the circuit boards and the Input Amplifier are shown in the illustrations later on in this section.

Resistor Coding. The Type 1A4 uses a number of very stable metal film resistors usually identified by their gray or light blue background color and color coding.

If a metal-film resistor has three significant figures with a multiplier, the resistor will be EIA color coded according to the sequence illustrated in Fig. 5-2. If the resistor has four significant figures with a multiplier, the value will be printed on the resistor. For example, a 333 k Ω resistor will be color coded, but a 333.5 k Ω resistor will have its value printed on the resistor body.

Subassembly and Circuit Board Illustrations. Figs. 5-6 through 5-16 show illustrations of circuit areas, Input Amplifier subassembly and the individual circuit boards, with the circuit numbers for each component identified on the assembly or board. In addition, the wiring color code to each pin connector is given. On the diagram the circuit board areas are outlined in blue as an aid to locating components that are associated with a board.

Test Equipment. When preparing to troubleshoot the circuits of the Type 1A4, you may find useful some of the minimum equipment described here.

1. Transistor Curve Display Instrument

Description: Tektronix Type 575 Transistor-Curve Tracer.

Purpose: Test semiconductors used in the Type 1A4.

2. VOM

Description: 20,000 Ω /VDC. Be sure the test prods are suitable for use in tight places to prevent accidental shorting.

Purpose: For detailed circuit troubleshooting.

3. Low-Bandwidth Test Oscilloscope (with a 10 \times probe)

Description. Bandwidth, DC to 300 kHz or better. Calibrated vertical deflection factors down to 50 mV/div with the 10 \times probe. An external trigger input connector on the test oscilloscope is desirable to check waveform polarity with respect to the signal source.

Purpose: For low-frequency signal tracing the amplifier stages. Can be used to signal trace the Logic circuit if bandwidth limitation is considered.

4. Wide-bandwidth Test Oscilloscope (with two 10 \times attenuator probes)

Description: Bandwidth, DC to 10 MHz or better. Calibrated vertical deflection factor down to 50 mV/div with a 10 \times probe. Has an external trigger input connector.

Purpose: For signal tracing the Logic circuit. Can be used in place of item 3 when signal tracing the amplifier circuits. The second probe is useful for applying a reference trigger to the external trigger input connector for quick signal tracing and checking time relationship of signals. The cable end of the probe connects to the External Trigger input

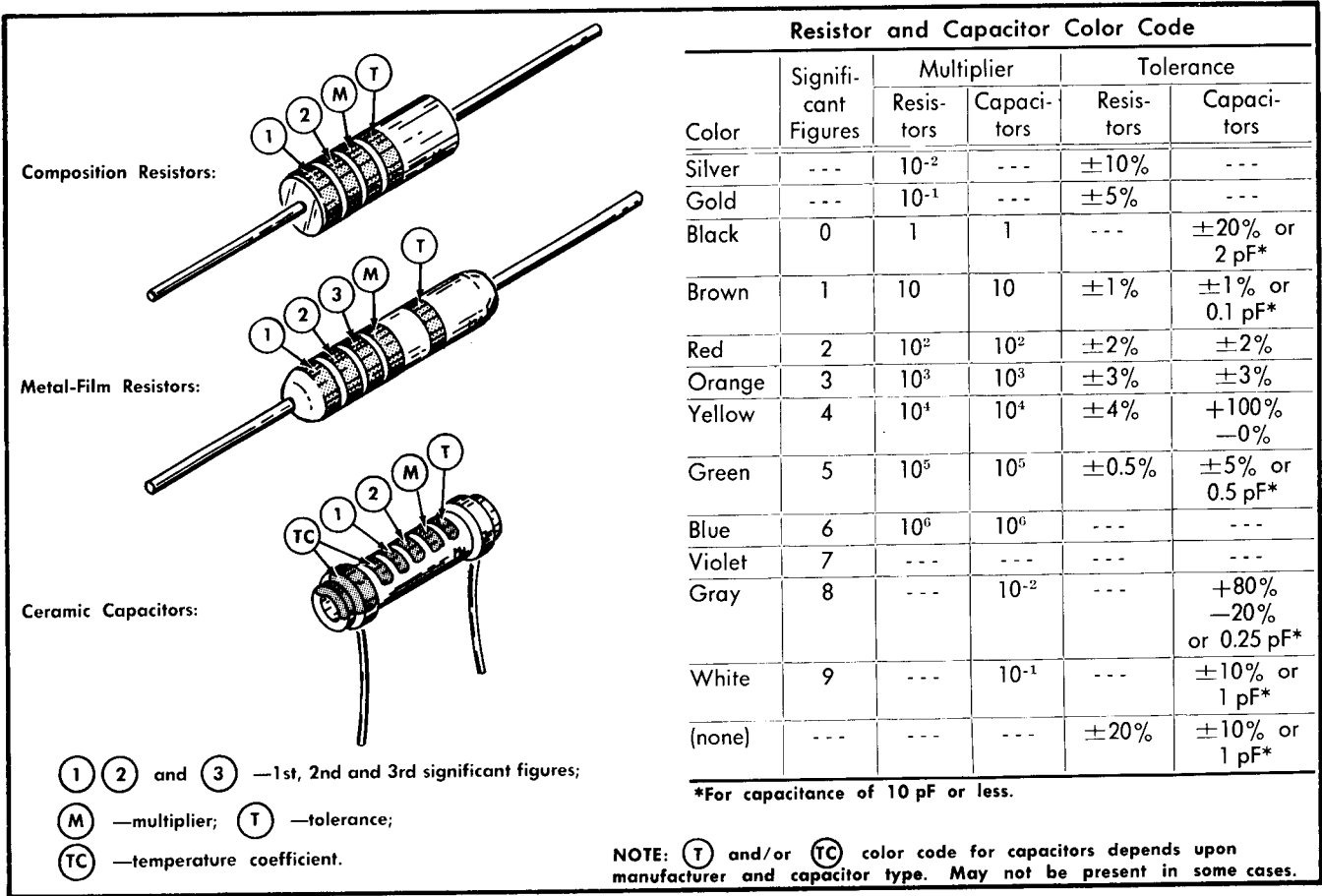


Fig. 5-2. Color-code for resistors and ceramic capacitors.

connected on the test oscilloscope and the probe tip is connected to the reference signal.

5. Circuit Extender Card

Description: Rigid extension connector card for the Trigger card. Complete with four signal extension leads. Tektronix Part No. 018-0009-00.

Purpose: Permits operating the Trigger card sufficiently extended out of the unit for troubleshooting.

6. Plug-In Extension

Either of two types can be used:

a. Plug-in extension. Description: Rigid type, 6½ inches long, Tektronix Part No. 013-0055-00.

b. Flexible extension cable. Description: 30 inches long, Tektronix Part No. 012-0038-00.

Purpose: Permits operating the Type 1A4 out of the oscilloscope plug-in compartment for better accessibility when troubleshooting.

CAUTION

If the Type 1A4 is used with a Type 544, 546 or 547 Oscilloscope and a plug-in extension is used, be sure to pull the oscilloscope plug-in sensing

switch to its outward position before turning on the oscilloscope power. The switch connects the +75 V supply to pin 15 of the 16-pin interconnecting plug.

7. BNC Coaxial Cables (two required)

Description: Impedance, 50 ohms; length, 42 inches; BNC connectors. Tektronix Part No. 012-0057-01.

Purpose: Use in the signal-tracing setup to apply the oscilloscope calibrator signal to the Type 1A4 and to the test oscilloscope external Trigger Input connector.

8. BNC T Connector

Description: Fits one BNC jack and two BNC plugs. Tektronix Part No. 103-0030-00.

Purpose: Use in the signal-tracing setup for connecting the BNC coaxial cables to the oscilloscope Cal Out connector.

9. Miscellaneous: Replacement tubes, FET's, transistors and diodes.

Troubleshooting Techniques

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceed-

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

Check Front-Panel Control Settings

Incorrect control settings can indicate a trouble that does not exist. For example, an incorrect settings of the VARIABLE control for one channel appears as incorrect gain. If there is any question about the correct function or operation of any control, see the Operating Instructions section for the Type 1A4 or the associated oscilloscope.

Isolate Trouble to Type 1A4 or Oscilloscope

When following a troubleshooting procedure, it is assumed that the oscilloscope used with the Type 1A4 is operating

normally. Since this is not always the case, check the operation of the oscilloscope before attempting to troubleshoot the Type 1A4.

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

NOTE

Be sure proper line voltage that does not exceed harmonic distortion limits of the input power waveform is applied to the oscilloscope used with the Type 1A4. This assures that the oscilloscope low-voltage power supplies will regulate properly.

TABLE 5-2
Approximate Resistance Between the 16-pin Interconnecting Plug Pins and Ground

No. Pin	Type of Meter: VOM ²		Ohms Range Used	Type of Meter: _____ Manufactured By: _____ Model No. _____ Type 1A4 Serial No. _____		
	Resistance + Gnd	Readings ³ - Gnd		Resistance + Gnd	Readings - Gnd	Ohms Range Used
1	6.9 kΩ	5.2 kΩ	RX1k			
2	0 (Gnd)	0 (Gnd)	RX1			
3	6.9 kΩ	5.2 kΩ	RX1k			
4	0 (Gnd)	0 (Gnd)	RX1			
5	1.7 kΩ	1.7 kΩ	RX1k			
6	No Connection	No Connection	- - -			
7 ⁴	14.5 kΩ	14.5 kΩ	RX1k			
8	3.2 kΩ	3.2 kΩ	RX1k			
9	6.3 kΩ	14.5 kΩ	RX1k			
10	6.3 kΩ	4.1 kΩ	RX1k			
11	16 kΩ	14 kΩ	RX1k			
12	No Connection	No Connection	- - -			
13 ⁵	Infinity	Infinity	RX10k			
14 ⁵	Infinity	Infinity	RX10k			
15	730 Ω	730 Ω	RX100			
16	50 kΩ	50 kΩ	RX10k			

²VOM used to obtain these measurements was a 20,000 Ω/V DC meter with a mid-scale reading of 4.5 kΩ on the RX1k range. For this range the mid-scale deflection current is 160 μA; full scale current is 320 μA.

³Ohmmeter leads are first connected one way and then the other way to get the two readings.

⁴DISPLAY switch set to ALT and 547 TRACE SLAVING switch set to LOCK.

⁵0.34 Ω on RX1 Range when measured between pins 13 and 14.

Check Calibration

Check the calibration of the Type 1A4, or the affected circuit if the trouble exists in one circuit. The indicated trouble may only be a result of misadjustment and could be corrected by calibration. Complete instructions are given in the Calibration section of this manual. Individual steps can be performed out of sequence. However, if the circuit affects the calibration of other circuits in the unit, a more complete calibration will be necessary. General information in the Calibration section describes how calibration steps which interact are noted.

Check Interconnecting Plug Resistances

Table 5-2 lists the approximate resistances measured between the interconnecting-plug pins and ground of the 16-pin plug located on the rear panel of the Type 1A4. These measurements were taken with the unit disconnected from the oscilloscope. Resistance readings are particularly useful as an aid to locating a possible short or open circuit in this area.

The measurements are not absolute and may vary considerably when different types of ohmmeters are used to measure resistance in circuits that contain semiconductors. Significant differences between ohmmeter types are:

1. The amount of internal voltages they use.
2. The current required to obtain full-scale deflection for each range.
3. The meter scale readings.

If all ohmmeters were identical, the resistance measurements would be typical.

To allow for differences between ohmmeter types, blank columns are provided in the table for logging your own measurements. Space at the top of the columns is provided to record the type of meter used, model number and the Type 1A4 serial number.

Visual Check

When checking the interconnecting plug resistances, some troubles can be found by visually checking the Type 1A4. Check for unsoldered connections, broken or disconnected wires, damaged circuit boards, damaged components, etc.

NOTE

Check that all connectors to the pins are in place and that each connector fits snugly on the pin.

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, no signal at the SIGNAL OUTPUT connector when the desired channel is selected by the SIGNAL & TRIGGER SOURCE switch, but proper triggering when the oscilloscope Triggering Source switch is set to the Plug-In position, indicates that the circuit between R149 and the SIGNAL OUTPUT connector for that channel is probably at fault.

When trouble symptoms appear in more than one circuit, check all affected circuits by using the signal-tracing method and by taking voltage readings. Another method is to use Table 5-3 as a guide for isolating trouble. This table lists some symptoms that aid in isolating a trouble to a certain area in the Type 1A4.

NOTE

Voltages and waveforms given on the diagrams may vary slightly between units. To obtain operating conditions similar to those used for the diagrams, see the IMPORTANT note on the inside portion of the Plug-In Block Diagram pull-out page (see Section 10).

TABLE 5-3

Circuit Isolation Troubleshooting Guide

Symptoms	Some Possible Causes
1. No trace or waveform display from any channel. Trace is deflected off the CRT.	Defective tube or transistor in Output Amplifier (Q363, Q373, Q374, Q344, Q354, V374, Q384 or Q394). Check these supply voltages in the Type 1A4: -150 V, -15 V, +12.1 V, +75 V, +100 V and 6.3 VAC. If any of these voltages are incorrect, they may be the source of trouble. If these voltages are correct, check the Output Regulator circuit (Q363, Q373 and Q374).
2. Single trace that cannot be positioned. No waveform display from any channel.	Defective components in the Output Level Regulator circuit (Q363, Q373 and Q374). Check this circuit.
3. No trace or waveform from one of the channels.	DC imbalance in the Input Amplifier for the channel affected. Check for faulty INVERT switch (could be caused by mechanical linkage that prevents switch from reaching the full-contact positions).
4. No signal at the SIGNAL OUTPUT connector. Improper or unstable triggering on one channel when using the Plug-In position of the Triggering source switch.	Defective transistor in the Trigger Amplifier. Check this circuit.
5. Low bandwidth in the Trigger Amplifier for all positions of the MODE and DISPLAY switches.	Gray-on-white Trigger Amplifier bandwidth control lead is connected to pin N on the Logic board. Move the lead to pin M. This is the normal position for the lead (see Operating Instructions section of this manual).
6. No chopped mode of operation when either MODE switch or the DISPLAY switch is set to CHOP.	Check blocking oscillator and multivibrator for the pair of channels affected.

TABLE 5-3 (cont)

Symptoms	Some Possible Causes
7. No alternate mode of operation when either MODE switch or DISPLAY switch is set to ALT.	Check Alternate-Trace Sync Pulse Amplifier (Q493 and Q494). Check blocking oscillator or multivibrator for the pair of channels affected.
8. No chopped blanking pulses during chopped mode of operation.	Defective transistor and components associated with Q504.
9. Improper slaving-operation when the Type 1A4 is used with a Type 547 Oscilloscope.	Faulty 547 TRACE SLAVING switch and associated wiring.

Isolating DC Imbalance

A quick method for isolating DC imbalance to either the Output Amplifier or one of the Input Amplifier channels is to turn one channel on one at a time to see if its trace can be positioned in a normal manner onto the screen. If the trace for the channel cannot be positioned onto the screen, then the DC imbalance originates in that channel. If none of the traces appear on the screen, the trouble is probably in the Output Amplifier which includes the Output Level Regulator circuit.

The Output Voltage Regulator can be assumed to be working properly if the average voltage is 67.5 V (± 2 V) as measured between ground and pins 1 and 3 (or pins A1 and AH on the Output Amplifier board). For example: Assume that the voltage between ground and pin A1 is +67 V; the voltage between ground and pin AH is +68 V. Then the average voltage would be +67.5 V. This indicates the regulator circuit is functioning normally and the DC imbalance is caused by a trouble in the signal-amplifier stages of the Input or Output Amplifiers. To isolate DC imbalance in the signal-amplifier stages, two methods are provided using Channel 1 as an example. Method 1 applies a short circuit between opposite points in the push-pull circuit. Method 2 uses the voltmeter to measure the difference voltage between the opposite points. Before using either method, set the controls as follows:

Type 1A4

All Channels	
AC-GND-DC	GND
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Midrange
Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	4

Oscilloscope with Type 1A4

Triggering and Time/Cm

0.1-ms/cm free-running sweep

Method 1:

1. Short pins A and B together. This is the Channel 1 output circuit and the pins are located on the Output Amplifier board; see Fig. 5-3.

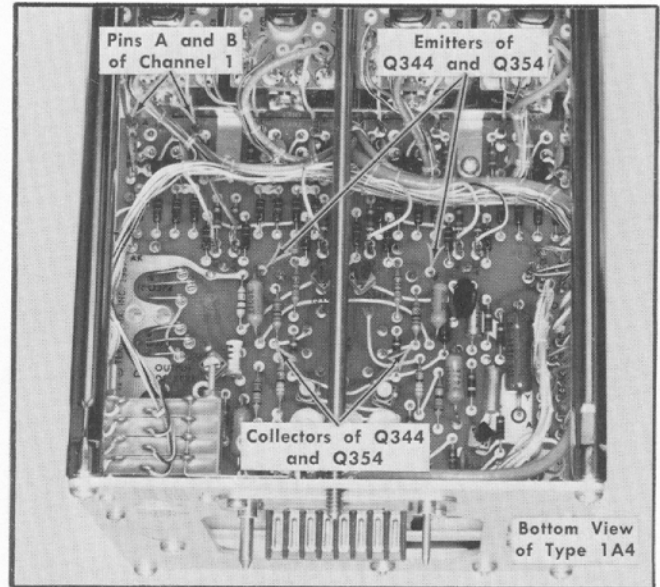


Fig. 5-3. Test point locations when isolating DC imbalance. Channel 1 is used as an example.

2. Trace is on the screen. Use the Channel 1 POSITION control to center the trace on the screen. This indicates the Ch 1 and Ch 1 & 2 diode switches are good. In addition, the Output Amplifier is functioning properly.

If the trace remains off the screen, the trouble could be in the Ch 1 and Ch 1 & 2 diode switches or the Output Amplifier. Proceed to step 3.

3. Short the emitters of Q344 and Q354 together. This can be accomplished at R345 and R355 as shown on Fig. 5-3.

4. Trace is on the screen. Check the Ch 1 and Ch 1 & 2 diode switches.

If the trace is off the screen, check the Output Amplifier (Q344, Q354, V374, Q384 and Q394).

Method 2:

To make the trace appear at or near the center of the CRT, the DC output voltage at pins 1 and 3 of the interconnecting plug must be essentially equal. To make the trace appear within the usable viewing area of the CRT, the DC voltage measured between pins 1 and 3 (or pins A1 and AH on the Output Amplifier board; see Fig. 5-4) must be within ± 0.25 V, assuming the Type 1A4 is used with an oscilloscope having a 6-cm high viewing area and the

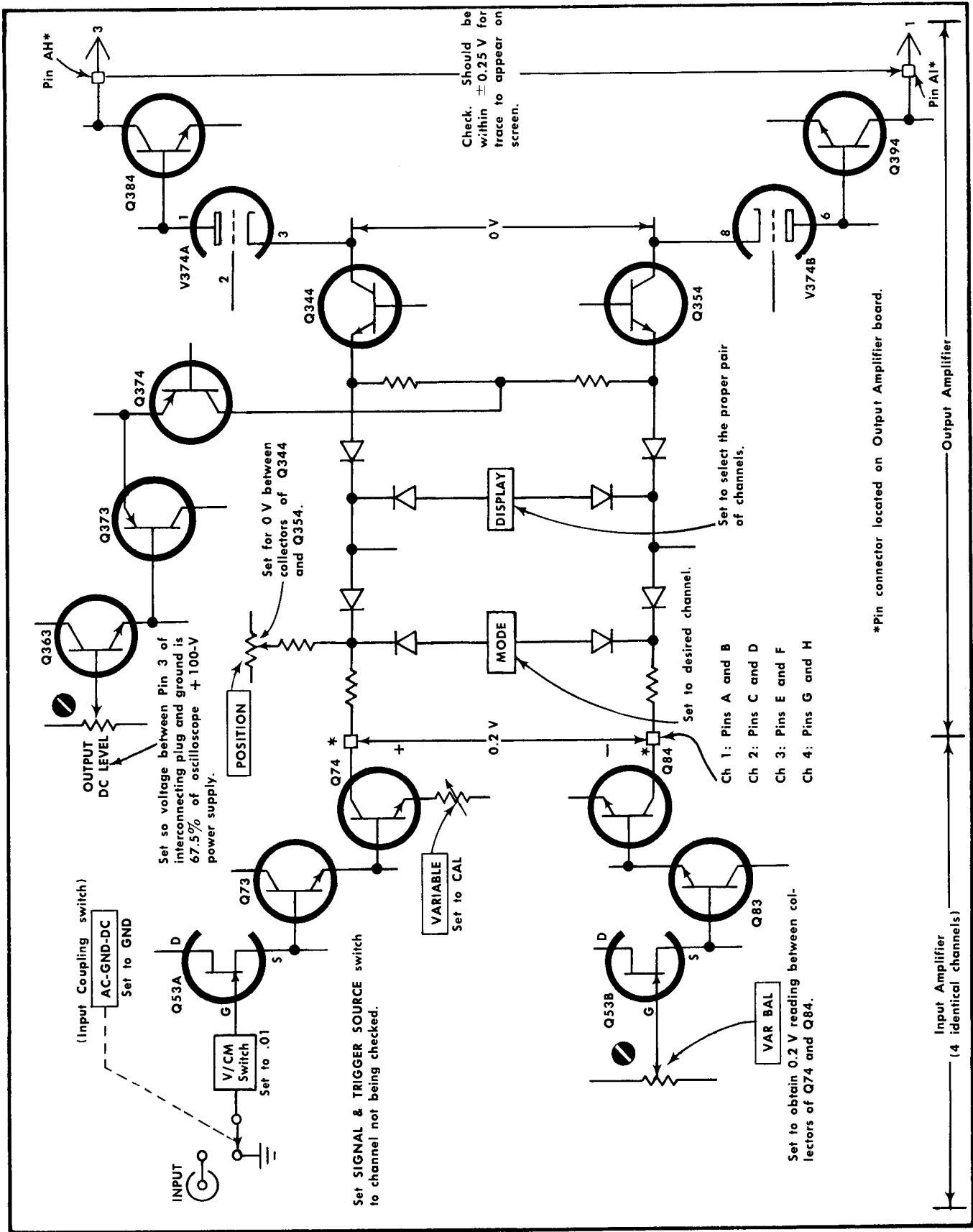


Fig. 5-4. Voltmeter method for isolating DC imbalance.

oscilloscope vertical amplifier DC balance is within ± 0.5 cm of graticule center.

The DC voltages at pins AI and AH of the interconnecting plug depend on the DC balance of each stage. Since all the signal-amplifier stages are DC coupled, any excessive imbalance condition existing anywhere between input and output of the Type 1A4 Output Amplifier or a channel Input Amplifier can unbalance the output and cause the trace to be deflected out of the viewing area. Fig. 5-4 illustrates how imbalance can be isolated by using a voltmeter to monitor the difference voltage between symmetrically opposite points in the push-pull circuit. To use the illustration, start from the input and work towards the output to find the area of imbalance. Refer to Fig. 5-3 to find Q344 and Q354 collector test point locations.

Signal Tracing

Signal Amplifier Stages. A method is described here for checking waveform amplitude and polarity at the test points shown on the Input Amplifier and Output Amplifier schematic diagrams. The technique is based on using a plug-in extension to operate the Type 1A4 outside the oscilloscope plug-in compartment. The plug-in extension permits access to the circuits in the Type 1A4 for detailed signal tracing and troubleshooting.

After the faulty stage is located and the trouble found and corrected, then it is easy to remove the extension, insert the plug-in in the oscilloscope and go directly to the Performance Check procedure in Section 6 to check frequency response and other performance requirements. If preferred, the Calibration Procedure in Section 7 can be used. The advantage of using the Calibration Procedure is that the control setups provide convenient starting places when steps are performed out of sequence.

To signal trace the Type 1A4 amplifier stages, proceed as follows:

1. Connect an extender card between the Trigger card and socket. Connect the interconnecting leads to complete the circuit interconnections.
2. Connect a plug-in extension between the Type 1A4 and the associated oscilloscope.

CAUTION

If the Type 1A4 is used with a Type 544, 546 or 547 Oscilloscope, be sure to pull the oscilloscope sensing switch to its outward position before turning on the oscilloscope power.

3. Set the front-panel controls of the Type 1A4 to the same positions as listed in the IMPORTANT note located on the inside portion of the Block Diagram pull-out page. Exception: If some channel other than Channel 1 needs to be checked, set the MODE and DISPLAY switches to select the desired channel.

4. Apply a 2V peak to peak calibrator signal through a T connector and coaxial cables to the Type 1A4 Input connector of the selected channel and to the test oscilloscope (item 3 or 4 in Test Equipment list) external Trigger Input connector.

5. Set the test oscilloscope Input Coupling switch to AC, the V/cm switch to 0.5, the Time/cm switch to 0.2 ms, and the triggering controls for +Ext triggering on the 2V calibrator signal.

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

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

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

9. Locate the same test point in the Type 1A4 that corresponds to the one on the diagram and connect the probe tip to this test point. Check the displayed waveform amplitude and polarity. Disconnect the probe.

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

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

1. Use a 10-MHz or higher bandwidth test oscilloscope.
2. Use AC input coupling to check the waveform amplitude.
3. Use DC input coupling and a suitable vertical deflection factor to check DC levels.
4. Use appropriate + and — Triggering Slope and Source switch positions for the waveform being checked.
5. If time relationships of waveforms are being checked, use appropriate external triggering of the test oscilloscope as described in the IMPORTANT note to the left of the Block Diagram in the schematics section of the manual and as indicated above the waveforms.

Check Individual Components

The following procedures describe methods of checking the individual components in the Type 1A4. Components which are soldered in place can be checked most easily by disconnecting one end. This eliminates incorrect measurements due to the effects of surrounding circuitry.

1. Tube. The best check of tube operation is actual performance under operating conditions. If the tube is sus-

Maintenance—Type 1A4

pected of being defective, it can best be checked by substituting a new tube or one which has been previously checked. Turn off the oscilloscope power when substituting the tube to safeguard the life expectancy.

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

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

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

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

NOTE

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

When the ohmmeter ranges that will not harm the transistor are known, then those ranges should be used to measure resistances with the ohmmeter connected both ways as given in Table 5-4.

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

CAUTION

Use care when making measurements in an operating unit. The small size and high density of components used in the Type 1A4 result in close spacing. An inadvertent movement of the test prods, or the use of oversized prods may cause a short between circuits.

TABLE 5-4
Transistor Resistance Checks

Ohmmeter Connections ^a	Resistance Readings That Can Be Expected Using the RX1 k Range
Emitter-Collector	High readings both ways (about 200 k Ω or higher).
Emitter-Base	High reading one way (about 200 k Ω or more). Low reading the other way (about 400 Ω to 5 k Ω).
Base-Collector	High reading one way (about 500 k Ω or more). Low reading the other way (about 400 Ω to 5 k Ω).

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

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

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

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

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

Chopped Blanking Pulse Width

When troubleshooting the Chopped Blanking Pulse Amplifier Q504, the blanking pulse at pin 16 of the interconnecting plug (or pin AG on the Output Amplifier board) can be checked for proper width by using the following procedure.

1. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHOP
Ch 3 & 4	CHANNEL 3
DISPLAY	1 & 2

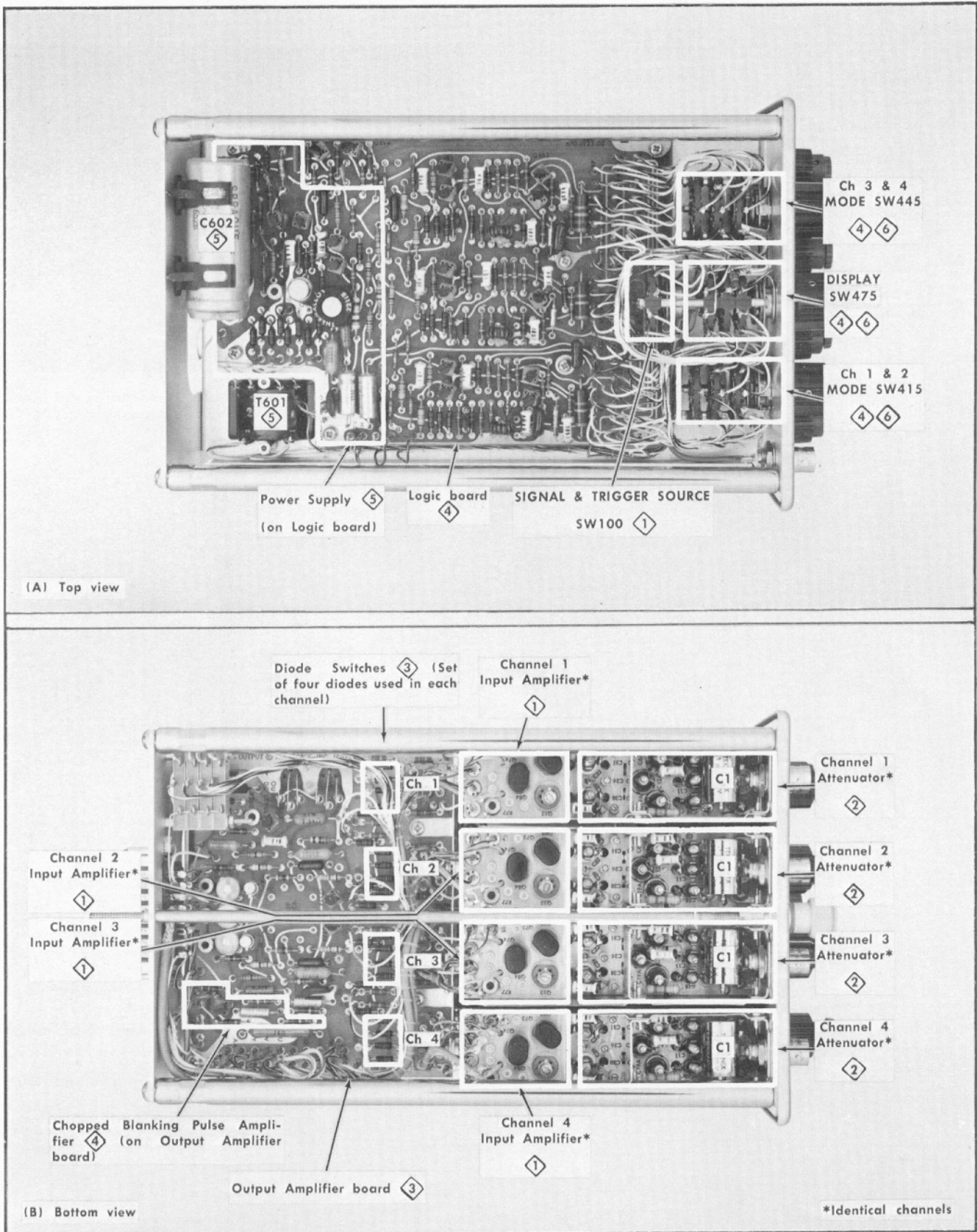


Fig. 5-6. Top and bottom views showing location of electrical parts and major circuits. Numbers in the diamond frames are referenced to the schematic diagrams.

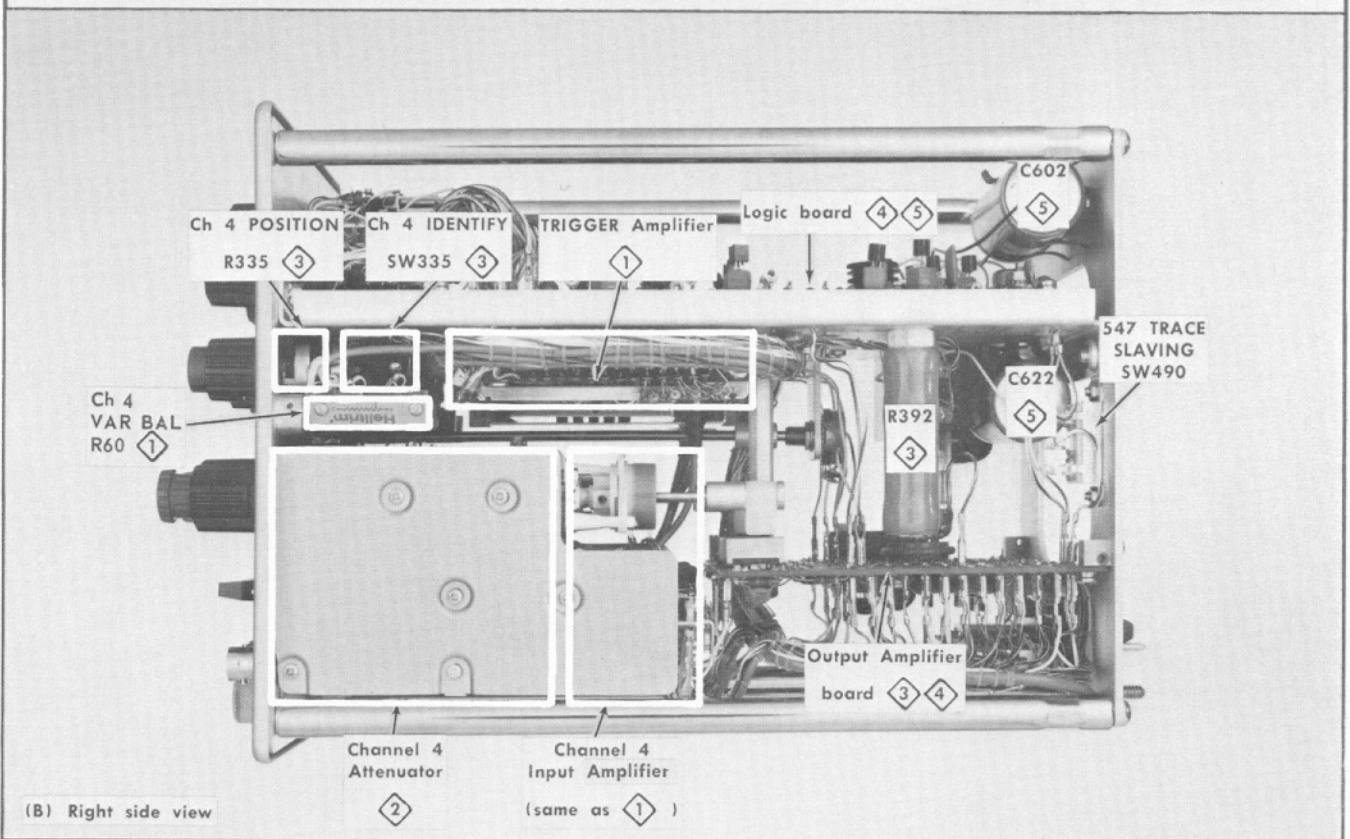
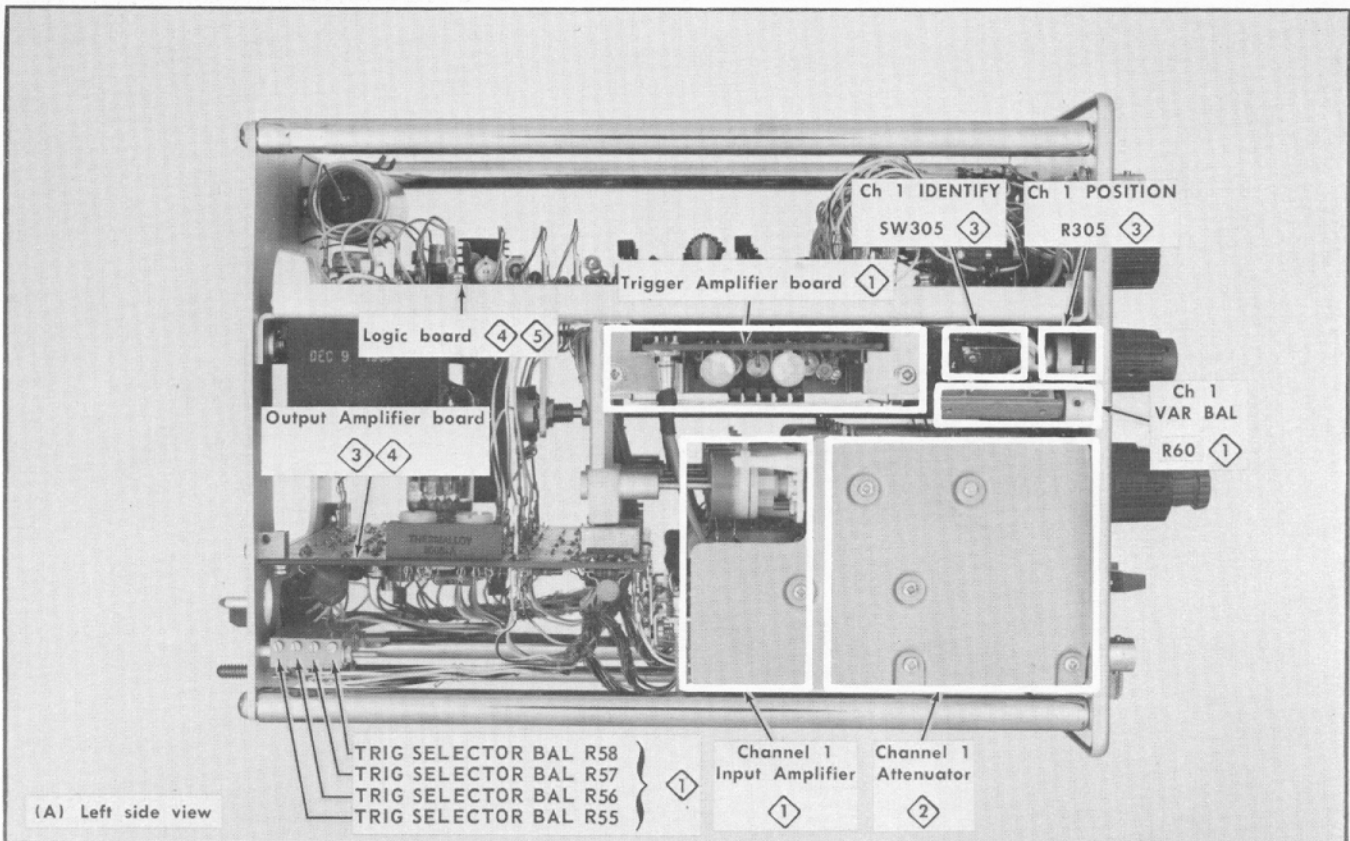


Fig. 5-7. Left and right side views show location of electrical parts and major circuits. Numbers in the diamond frames are referenced to the schematic diagrams.

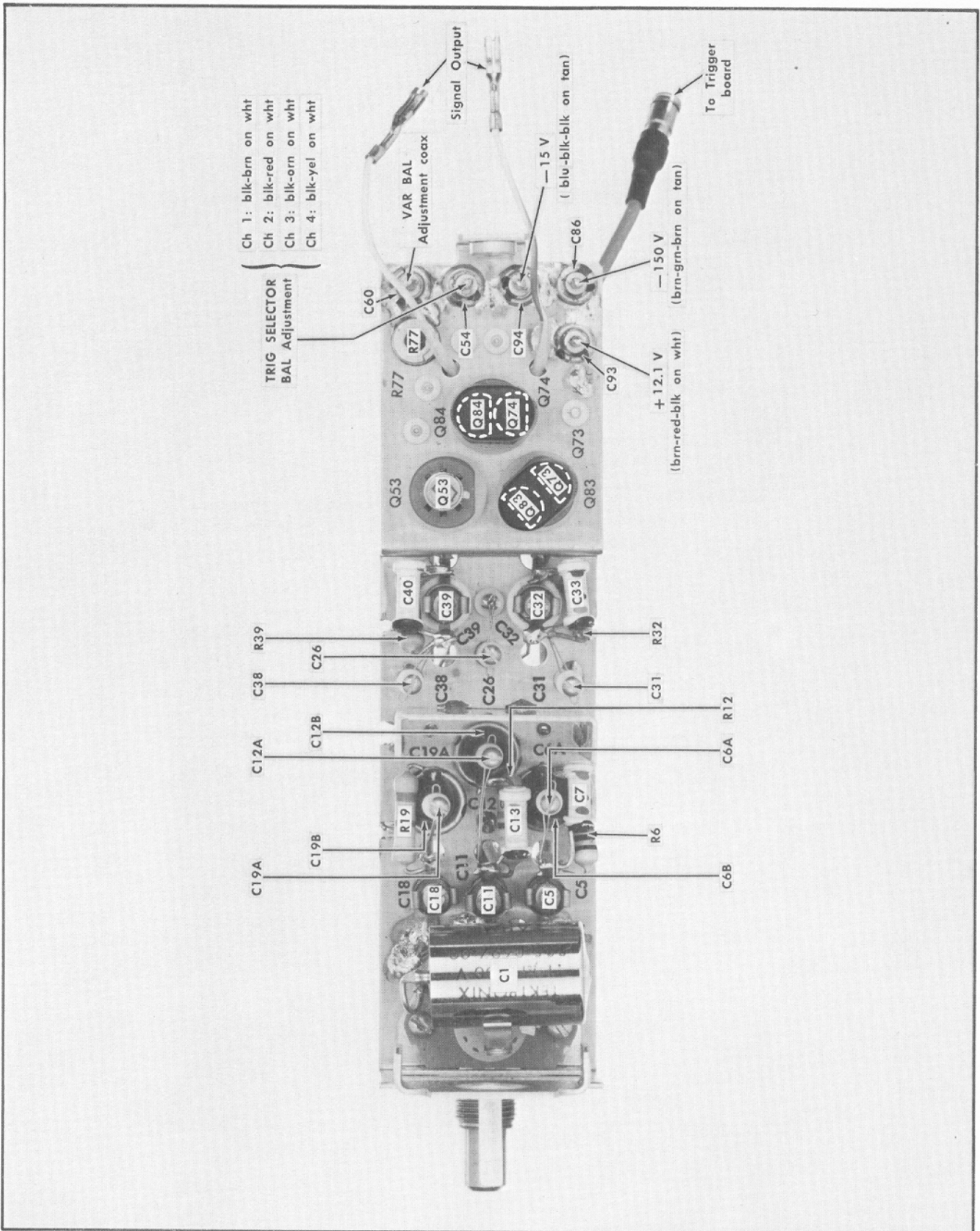


Fig. 5-8. Top view of attenuator and Input Amplifier.

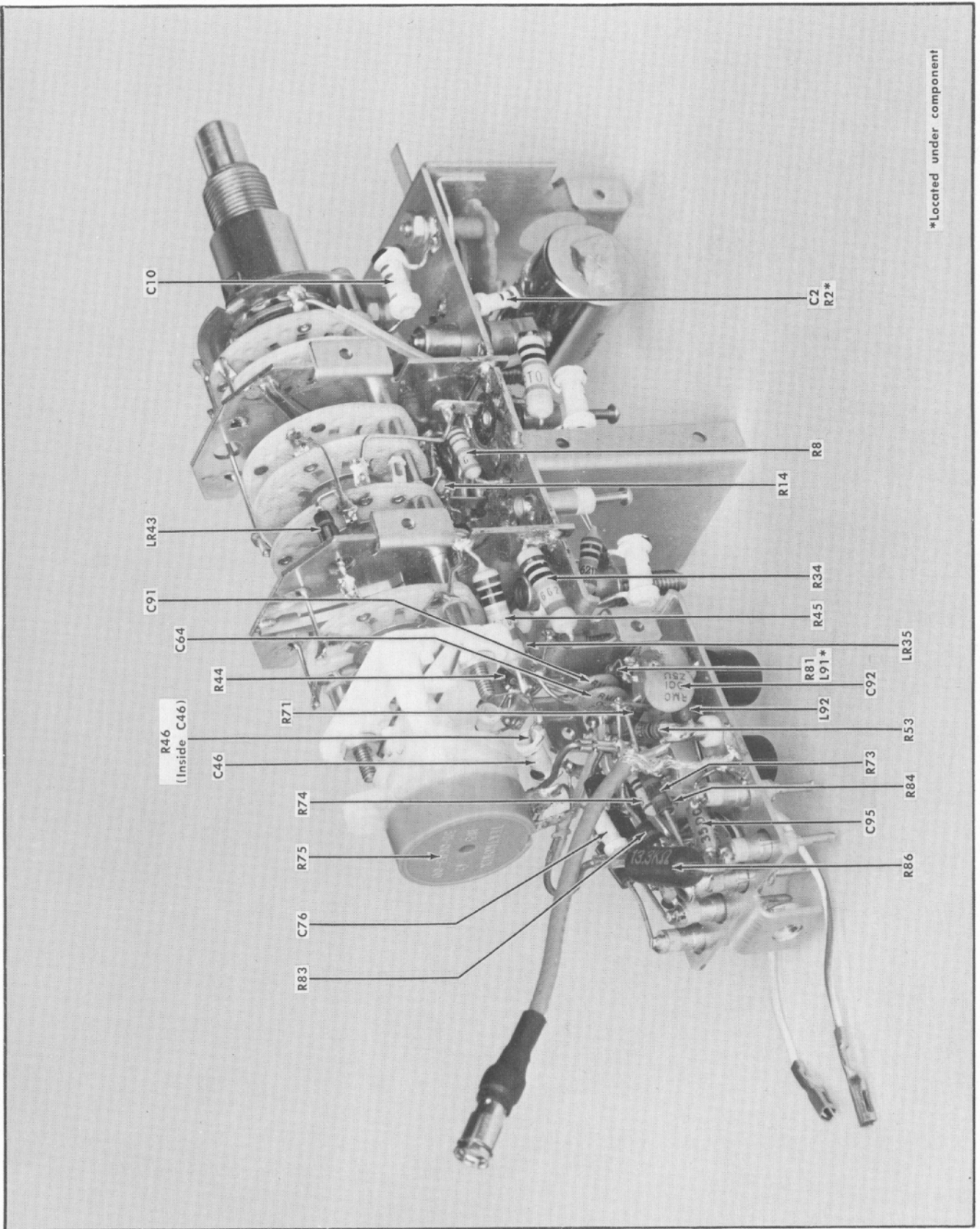


Fig. 5-9. Left side view of attenuator and Input Amplifier.

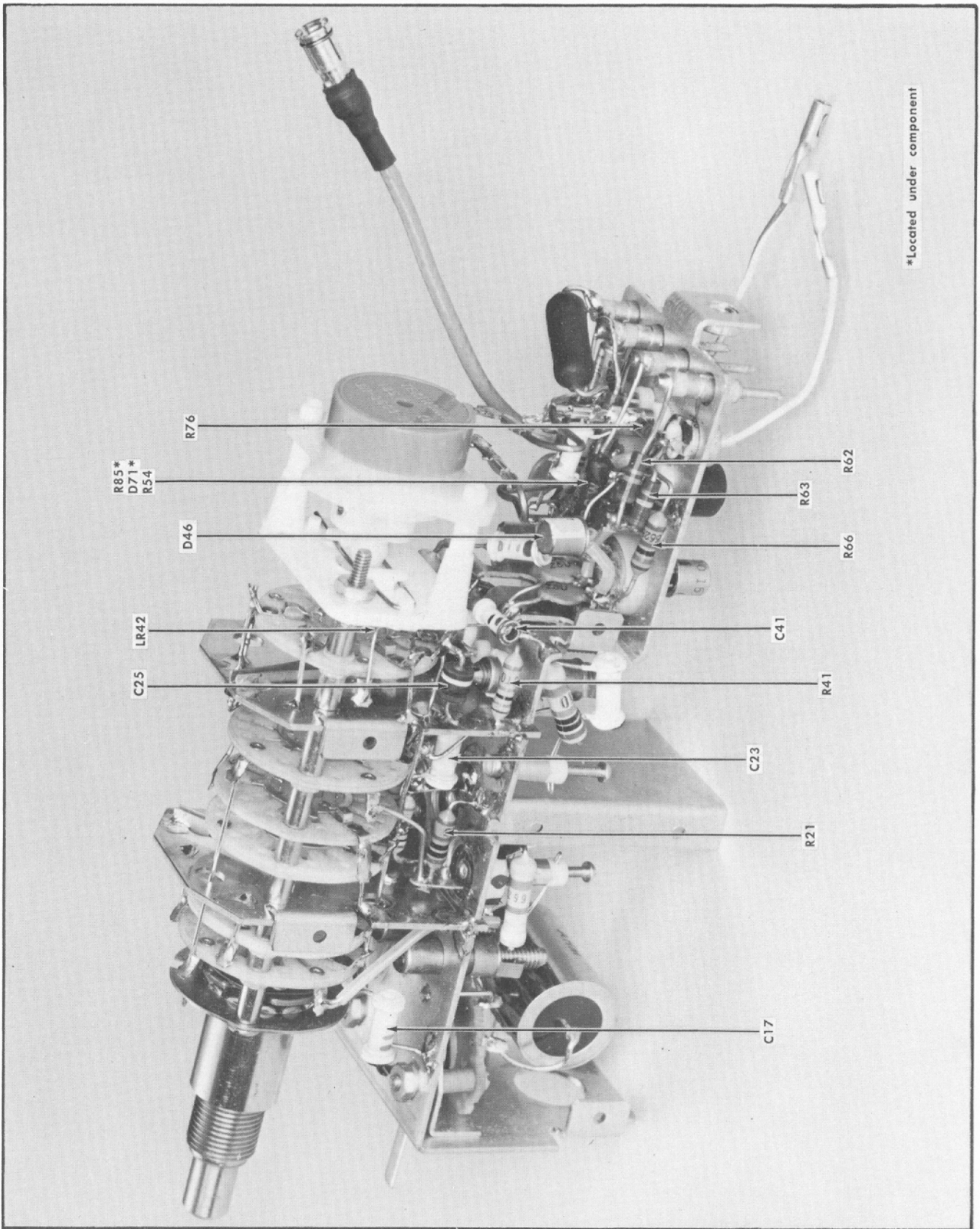


Fig. 5-10. Right side view of attenuator and Input Amplifier.

SECTION 6

PERFORMANCE CHECK

Introduction

This performance check is provided to check the operation of the Type 1A4 without removing the side or bottom covers from the oscilloscope. This procedure may be used for incoming inspection, instrument familiarization, reliability testing, calibration verification, etc.

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

Recommended Equipment and Calibration Fixtures

The following equipment (items 1 through 5) is recommended for a complete performance check. Specifications given are the minimum necessary to perform this procedure. All equipment is assumed to be calibrated and operating within the original specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

For the most accurate performance check, use the calibration fixtures (items 6 through 16) described in this list. The calibration fixtures that have a Tektronix part number are available from Tektronix, Inc. Order by description and part number from your local Tektronix Field Office or representative.

1. Calibrated Type 547 Oscilloscope. For use with the Type 1A4 Plug-In Unit being checked. NOTE: The Type 547 was used when preparing this procedure and is required for checking the 547 TRACE SLAVING switch (steps 10e through 10k). If steps 10e through 10k are omitted, a Type 544 or 546 oscilloscope can be used with the Type 1A4.

2. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude 50 mV to 100 V; output signal, 1-kHz square wave. Tektronix calibration fixture No. 067-0502-00 recommended.

3. Square-wave generator. Frequency, 1 kHz and 100 kHz; risetime, 20 ns or faster from the high-amplitude output; 1 ns or faster from the fast-rise output. High-amplitude output: variable from 0.5 V to 12 V into a 50-ohm load, about 7 V to 120 V unterminated. Fast-rise output: variable from 50 mV to 500 mV into a 50-ohm load. Tektronix Type 106 Square-Wave Generator recommended.

4. Constant amplitude sine-wave generator. Frequency, 50 kHz, 500 kHz, 10 MHz, 20 MHz and 50 MHz; output amplitude, 40 mV to 5 V peak to peak into a 50-ohm load. Amplitude accuracy within $\pm 3\%$ at 500 kHz, 10 MHz, 20 MHz and 50 MHz using the amplitude at 50 kHz for a reference. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

5. Low-frequency sine-wave generator. Output frequencies, 2 Hz, 20 Hz and 50 Hz; output amplitude, 40 mV peak to

peak into a 1-Megohm load. Equipped with a BNC output connector or adapter.

6. Dual-input connector. Connectors, BNC female input and two BNC male outputs. For applying a signal to two channels simultaneously. Tektronix Part No. 067-0525-00.

7. Input capacitance normalizer. Time constant, 1 megohm \times 20 pF; attenuation 2 \times ; connectors, BNC. Tektronix Part No. 067-0538-00.

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

9. 2 \times attenuator. Impedance, 50 ohms; accuracy within $\pm 3\%$; connectors, GR-Type. Tektronix Part No. 017-0080-00.

10. 10 \times attenuators. Impedance, 50 ohms; accuracy within $\pm 3\%$; connectors, GR-Type. Tektronix Part No. 017-0078-00.

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

12. Adapter, probe-to-male BNC connector. Tektronix Part No. 013-0056-00. For use with the 10 \times probe (item 16).

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

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

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

16. 10 \times passive probe with BNC connector. Tektronix P6008 Probe recommended. Probe risetime is about 2 ns. Tektronix Part Number for the probe package is 010-0129-00.

17. Screwdriver, 2-inch shaft, 3/32-inch wide bit. Xcelite No. R-3322 or equivalent.

PERFORMANCE CHECK PROCEDURE

General

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

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

Performance Check—Type 1A4

Preliminary Procedure

1. Check that the gray-on-white lead for controlling the Type 1A4 trigger amplifier bandwidth is connected to pin "M" on the Logic board (see Fig. 6-1A).
2. Set the 547 TRACE SLAVING switch, located at the rear of the Type 1A4 (see Fig. 6-1B), to the LOCK position.

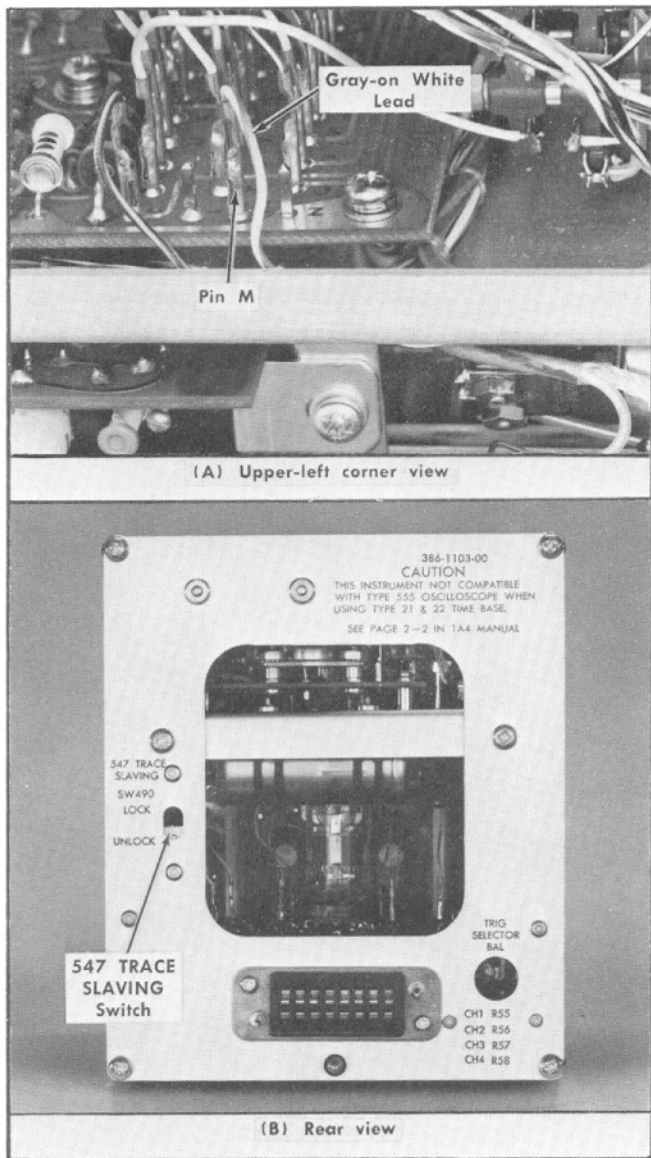


Fig. 6-1. Pin "M" and 547 TRACE SLAVING switch locations.

3. Connect the oscilloscope power cord to a suitable power source.

4. Turn on the oscilloscope power and allow 20 minutes warm up at an ambient temperature of 25° C, $\pm 5^\circ$ C. While the oscilloscope is warming up, preset the controls to the positions given in the list that follows.

Control Settings

Type 1A4

All Channels	
AC-GND-DC	GND
V/CM	.01
VARIABLE (V/CM)	CAL
INVERT	Pushed in
POSITION	Midrange
Other controls	
Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING	Set to LOCK in step 2 of Preliminary Procedure

Type 547 Oscilloscope

A Triggering controls	
Triggering Level	Fully CW and pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int
Time Base A controls	
Time/CM	.1 mSec
Variable (Time/CM)	Calibrated
Other controls	
Horizontal Display	A
Sweep Magnifier	$\times 1$ Off
Single Sweep switch	Normal
Horizontal Position	Midrange
Vernier (Horiz. Pos.)	Midrange
Delay-Time Multiplier	1.00
Amplitude Calibrator	Off
Ext CRT Cathode to Gnd connector strap	Installed
CRT Cathode Selector (rear panel)	External CRT Cathode
Intensity	Fully CCW
Focus and Astigmatism	Midrange
Trace Separation	0
Power	On

NOTE

Time-Base A triggering and sweep controls are used throughout this procedure except in steps 10e through 10k where both time bases are used.

1. Check Variable Balance Front-Panel Adjustments

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

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

NOTE

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

c. CHECK—Rotate the Channel 1 VARIABLE control throughout its range and check for trace shift.

d. If there is trace shift or the trace is not on the screen, adjust the Channel 1 VAR BAL control to meet the desired requirement.

NOTE

The VAR BAL control for each channel is a 20-turn variable resistor that has no mechanical stops (uses a slip-clutch arrangement to prevent over-travel damage) for the adjusting screw. Clockwise rotation moves the trace upward and counterclockwise rotation moves the trace downward with the appropriate INVERT knob pushed in.

e. Set Ch 1 & 2 MODE switch to CHANNEL 2.

f. Using Table 6-1 and steps 1c and 1d as a guide, check the other channels for no trace shift.

TABLE 6-1

Ch 3 & 4 MODE Switch	DISPLAY Switch	Adjustment
CHANNEL 3	1 & 2	Ch 2 VAR BAL
CHANNEL 3	3 & 4	Ch 3 VAR BAL
CHANNEL 4	3 & 4	Ch 4 VAR BAL

2. Check Front-Panel Gain Adjustment

a. Requirement—Vertical deflection within $\pm 3\%$ of V/CM switch indication.

b. Set the controls as follows:

Type 1A4

AC-GND-DC	DC
Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2

Type 547 Oscilloscope

Triggering Level	Near 0 and knob pushed in
Time/Cm	.5 mSec

Standard Amplitude Calibrator

Amplitude	50 mVolts
Mode	Square Wave
Mixed	Up
$\times 100$ Amplifier	Not Applicable
Power	On

c. Connect the 50-mV signal from the Standard Amplitude Calibrator output connector through a 42-inch 50-ohm cable and dual-input connector (item 6) to the Type 1A4 Channel 1 and 2 Input connectors.

NOTE

The dual-input connector is installed at this time in preparation for the step 3 procedure.

d. Use the Channel 1 POSITION control to center the display and, if required, adjust the oscilloscope Triggering Level control to obtain a stable display.

e. CHECK—CRT display for exactly 5 cm of vertical deflection (see Fig. 6-2).

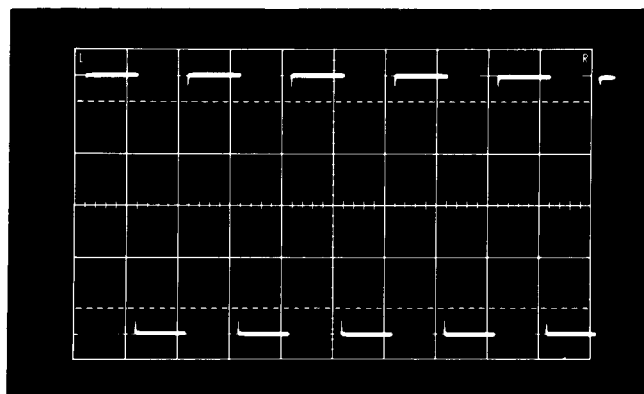


Fig. 6-2. Typical CRT display showing correct vertical gain at 10 mV/cm. Sweep rate: 0.5 ms/cm.

f. If necessary, adjust the front-panel GAIN adjustment for exactly 5 cm of deflection.

3. Check Preamplifier Gain and Added Accuracy

a. Requirement—Null display (superimposed traces) when 100-mV common-mode signals in any two channels are added algebraically. Vertical deflection should not exceed 1 mV (or $\pm 1\%$).

b. Set the controls as follows:

Type 1A4

INVERT (Ch 1)	Pulled outward
Ch 1 & 2 MODE	ADD

TABLE 6-2

Apply 0.1 V Signal to:	INVERT Knobs	Ch 1 & 2 MODE Switch	Ch 3 & 4 MODE Switch	DISPLAY Switch	Check
Inputs 1 & 3	Ch 1 Out, Ch 3 In	CHANNEL 1	CHANNEL 3	ADD	Repeat steps 3c and 3d
Inputs 1 & 4	Ch 1 Out, Ch 4 In	CHANNEL 1	CHANNEL 4	ADD	Repeat steps 3c and 3d
Inputs 3 & 4	Ch 3 In, Ch 4 Out	CHANNEL 1	ADD	3 & 4	Repeat steps 3c and 3d
Inputs 2 & 4	Ch 2 In, Ch 4 Out	CHANNEL 2	CHANNEL 4	ADD	Repeat steps 3c and 3d
Inputs 2 & 3	Ch 2 In, Ch 3 Out	CHANNEL 2	CHANNEL 3	ADD	Repeat steps 3c and 3d

Type 547 Oscilloscope

Triggering Level Fully CW and knob pulled outward
 Time/Cm .1 mSec

Standard Amplitude Calibrator

Amplitude .1 Volt

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

d. CHECK—CRT free-running display for a null indication within a maximum deflection of 1 mm (see Fig. 6-3). This amplitude is equivalent to 1 mV or $\pm 1\%$ of the 100 mV applied signal.

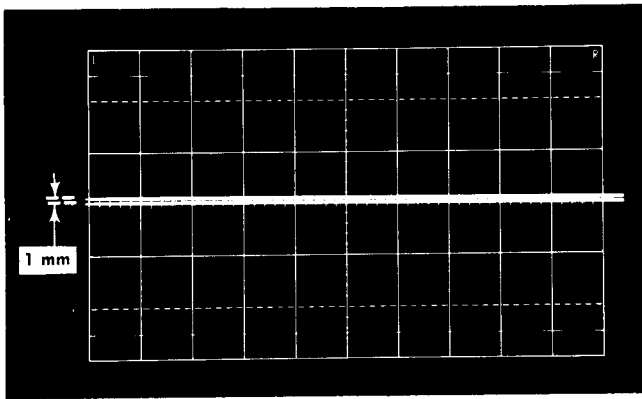


Fig. 6-3. CRT display showing maximum allowable amplitude when checking added accuracy in step 3. Sweep rate: 0.1 ms/cm free running.

e. Using Table 6-2 and steps 3c through 3d as a guide, check the other channels for a null indication.

NOTE

When repeating a procedure to check the channels listed in a table, use controls that apply for the channel(s) being checked. For example, when repeating step 3c for Channels 2 and 3 in Table 6-2, use Channel 2 or 3 POSITION control to center the display.

4. Check AC Coupling

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

b. Set the Amplitude switch on the Standard Amplitude Calibrator to 20 mV.

c. Remove the dual-input connector and apply the 20 mV signal to the Channel 1 Input connector.

d. Set the controls as follows:

Type 1A4

INVERT (Ch 1, 3 & 4) Pushed in
 Ch 1 & 2 MODE CHANNEL 1
 DISPLAY 1 & 2

Type 547 Oscilloscope

Triggering Level Near 0 and knob pushed in
 Time/Cm .5 mSec

e. Use the Channel 1 POSITION control to position the bottom of the waveform to graticule center. If necessary, adjust the oscilloscope Triggering Level control to obtain a stable display.

f. Set Channel 1 AC-GND-DC switch to AC.

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

h. Set Ch 1 & 2 MODE switch to CHANNEL 2.

i. Using Table 6-3 and steps 4e through 4g as a guide, check the AC input coupling circuit for the remaining channels.

TABLE 6-3

Apply 20 mV Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Procedure
Input 2	CHANNEL 3	1 & 2	Steps 4e through 4g
Input 3	CHANNEL 3	3 & 4	Steps 4e through 4g
Input 4	CHANNEL 4	3 & 4	Steps 4c through 4g

j. Return all the AC-GND-DC switches to the DC position.

5. Check Variable Volts/Cm Range

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

b. Set the Amplitude switch on the Standard Amplitude Calibrator to 50 mVolts.

c. Use the Channel 4 POSITION control to center the display. Check that the Channel 4 VARIABLE control is set to CAL and the display is 5 cm in amplitude.

d. Rotate the Channel 4 VARIABLE control a few degrees clockwise so the control is out of the CAL detent position and the display amplitude is minimum.

e. CHECK—The display amplitude should be reduced to 2 cm or less (see Fig. 6-4).

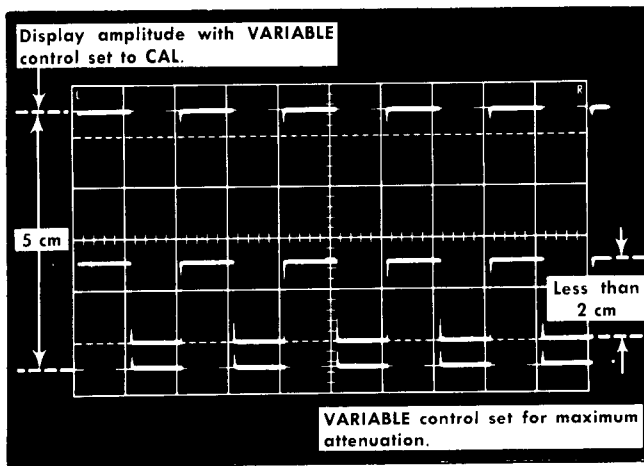


Fig. 6-4. Typical CRT display showing VARIABLE (V/CM) control range (double exposure photograph). Sweep rate is 0.5 ms/cm.

f. Return the Channel 4 VARIABLE control to the CAL detent position.

g. Set Ch 3 & 4 MODE switch to CHANNEL 3.

h. Using Table 6-4 and steps 5c through 5f as a guide, check the VARIABLE (V/CM) controls for the other channels.

TABLE 6-4

Apply 50 mV Signal to:	Ch 1 & 2 MODE Switch	DISPLAY Switch	Check VARIABLE Control for:
Input 3	CHANNEL 2	3 & 4	Channel 3
Input 2	CHANNEL 2	1 & 2	Channel 2
Input 1	CHANNEL 1	1 & 2	Channel 1

6. Check Volts/Cm Deflection Accuracy

a. Requirement—Vertical deflection within $\pm 3\%$ of V/CM switch indication.

b. Check that all the VARIABLE controls are set to CAL.

c. CHECK—Using Table 6-5 as a guide, check vertical deflection within $\pm 3\%$ in each position of the Channel 1 V/CM switch.

TABLE 6-5

V/CM Switch Setting	Standard Amplitude Calibrator Output	Vertical Deflection	Maximum Error for $\pm 3\%$ Accuracy
.01	50 mVolts	5 cm	Set exactly in Step 2.
.02	.1 Volt	5 cm	± 1.5 mm
.05	.2 Volt	4 cm	± 1.2 mm
.1	.5 Volt	5 cm	± 1.5 mm
.2	1 Volt	5 cm	± 1.5 mm
.5	2 Volts	4 cm	± 1.2 mm
1	5 Volts	5 cm	± 1.5 mm
2	10 Volts	5 cm	± 1.5 mm
5	20 Volts	4 cm	± 1.2 mm
10	50 Volts	5 cm	± 1.5 mm
20	100 Volts	5 cm	± 1.5 mm

d. After completing step 6c, set the Standard Amplitude Calibrator for an output of 50 mV and disconnect the signal. Set the Type 1A4 V/CM switch for the checked channel to .01.

e. Set Ch 1 & 2 MODE switch to CHANNEL 2.

f. Using Table 6-6 and steps 6c through 6d as a guide, check the vertical deflection accuracy in each position of the V/CM switch for the other channels.

TABLE 6-6

Apply Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Check V/CM Switch for:
Input 2	CHANNEL 3	1 & 2	Channel 2
Input 3	CHANNEL 3	3 & 4	Channel 3
Input 4	CHANNEL 4	3 & 4	Channel 4

g. Check that the Standard Amplitude Calibrator is disconnected and the Type 1A4 V/CM switches for all channels are set to .01. Turn off the Standard Amplitude Calibrator.

7. Check Normal-Invert DC Balance

a. Requirement—Trace shift should be less than 1 cm with VAR BAL adjustment properly adjusted.

b. Set the oscilloscope Triggering Level control fully clockwise and pull the knob to its outward position. Set the Time/Cm switch to .1 mSec.

c. Using the Channel 4 POSITION control, position the trace to graticule center.

Performance Check—Type 1A4

d. Rotate the Channel 4 VARIABLE (V/CM) control through-out its range and check for trace shift. If there is trace shift, adjust the Channel 4 VAR BAL control until the trace is stationary.

e. Recheck that the trace is positioned to graticule center. This is the reference location for the trace.

f. Pull the front-panel Channel 4 INVERT knob to its outward position.

g. CHECK—Trace should be located within 1 cm or less with respect to graticule center.

h. Push the Channel 4 INVERT knob to its inward position.

i. Set Ch 3 & 4 MODE switch to CHANNEL 3.

j. Using Table 6-7 and steps 7c through 7h as a guide, check the INVERT switch for the remaining channels.

TABLE 6-7

Ch 1 & 2 MODE Switch	DISPLAY Switch	Procedure
CHANNEL 2	3 & 4	Repeat steps 7c through 7h to check Ch 3 INVERT switch.
CHANNEL 2	1 & 2	Repeat steps 7c through 7h to check Ch 2 INVERT switch.
CHANNEL 1	1 & 2	Repeat steps 7c through 7h to check Ch 1 INVERT switch.

8. Check Trigger Selector DC Balance

a. Requirement—Trace shift when selecting the trigger source is equal to or less than 2 mm.

b. Set the Type 1A4 controls as follows:

Ch 1 & 2	ALT
Ch 3 & 4	ALT
DISPLAY	ALT
SIGNAL & TRIGGER SOURCE	2

c. Using the POSITION controls, position the traces one cm apart according to channel alternation sequence; i.e., Channel 1 trace positioned 2 cm above graticule center, Channel 2 trace 1 cm above graticule center, Channel 3 trace coincides with graticule center and Channel 4 trace 1 cm below graticule center. Check that all traces coincide with their respective graticule lines for reference purposes.

d. Set the SIGNAL & TRIGGER SOURCE switch to 1.

e. CHECK—Trace shift with respect to the graticule reference line for Channel 1 is equal to or less than 2 mm.

f. Using Table 6-8 and step 8e as a guide, check the trigger selector DC balance for the remaining channels.

g. Set the SIGNAL & TRIGGER SOURCE switch to 1.

9. Check Identify Switches

a. Requirement—Trace shifts upward with respect to the graticule line that is used as a reference. Typical shift is 2 mm to 5 mm.

TABLE 6-8

SIGNAL & TRIGGER SOURCE Switch Positions and Procedure	Check
Set to 1; position Ch 2 trace to reference; set to 2.	Repeat step 8e to check Ch-2 trace shift.
Set to 2; position Ch 3 trace to reference; set to 3.	Repeat step 8e to check Ch-3 trace shift.
Set to 3; position Ch 4 trace to reference; set to 4.	Repeat step 8e to check Ch-4 trace shift.

b. Check that the traces are positioned as described in step 8c.

c. Depress the front-panel Channel 1 IDENTIFY button and hold in this position.

d. CHECK—Trace for channel shifts upward about 2 mm to 5 mm with respect to the reference graticule line.

e. Release the button.

f. Using steps 9c through 9e as a guide, check the IDENTIFY buttons for the remaining channels.

10. Check Alternate Mode Operation

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

b. Check that the traces are positioned near the locations described in step 8c.

c. Set the oscilloscope A Time/Cm switch to .5 Sec.

d. CHECK—Sequence of alternation; i.e., 1, 2, 3, 4, 1, etc. Check that 4 traces are obtained in each of these A Time/Cm switch positions: 50 mSec, 0.5 mSec, 50 μ Sec, 5 μ Sec, and 0.5 μ Sec.

e. Set the Type 547 Oscilloscope controls as follows:

B Triggering controls

Triggering Level	Fully CW and knob pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm

Time Base controls

A Time/Cm	50 μ Sec
B Time/Cm	.5 mSec
Variable (B Time/Cm)	Calibrated

Other controls

Horizontal Display	A/Alt/B
Brightness	Fully CW
Trace Separation	0

f. CHECK—Channel 1 and 2 traces should be displayed by the A sweep; channel 3 and 4 traces should be displayed by the B sweep.

NOTE

The channels can be identified by pressing the IDENTIFY buttons. The sweeps can be identified as follows: The A sweep produces dim traces and the B sweep produces bright traces (see Fig. 6-5).

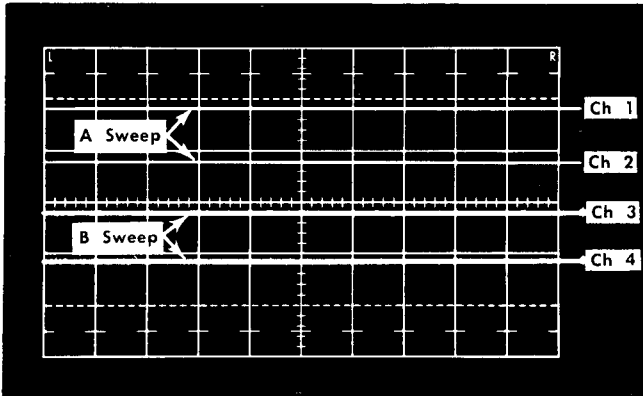


Fig. 6-5. Checking for proper slaving of channels to the A and B sweeps when the 547 TRACE SLAVING switch is set to LOCK. A sweep rate: 50 μ s/cm; B sweep rate: 0.5 ms/cm.

g. Unplug the Type 1A4 from the oscilloscope, set the 547 TRACE SLAVING switch to UNLOCK and return the Type 1A4 to the oscilloscope plug-in compartment.

h. Set the oscilloscope controls as follows:

- A Time/Cm .1 mSec
- B Time/Cm .1 mSec

i. CHECK—Eight traces should be displayed. Use the oscilloscope Trace Separation control to position the traces as desired.

j. Set the oscilloscope Horizontal Display switch to B Intens by 'A'/Alt/A Dly'd.

k. CHECK—Eight traces should be displayed.

11. Check Chopped Mode Blanking

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

b. Set controls as follows:

- | | |
|------------------------------|---------------------------|
| Type 1A4 | |
| Ch 1 & 2 MODE | CHOP |
| Ch 3 & 4 MODE | CHOP |
| DISPLAY | CHOP |
| Type 547 Oscilloscope | |
| Triggering Level | Near 0 and knob pushed in |
| Coupling | AC LF Rej |
| Time/Cm | 2 μ Sec |
| Horizontal Display | A |

c. Using the Type 1A4 POSITION controls, position Channel 1 segmented trace about 1.5 cm above graticule center. Position the traces for the other channels in succession about one cm apart below Channel 1 (see Fig. 6-6A). Use the oscilloscope Triggering Level control to obtain Fig. 6-6A display or, if desired, trigger on any channel.

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

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

f. Return the oscilloscope CRT Cathode Selector switch to the External CRT Cathode position.

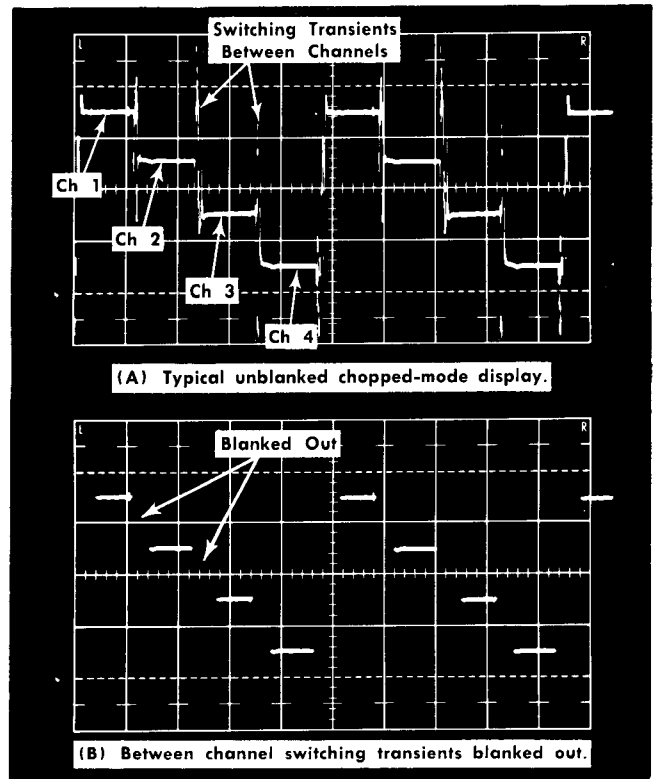


Fig. 6-6. Checking for proper chopped-mode blanking at normal intensity. Sweep rate is 2 μ s/cm.

12. Check Chopped Mode Repetition Rate

a. Requirement—Chopped mode repetition rate, 400 kHz, \pm 20%.

b. Set the controls as follows:

- | | |
|------------------------------|-------------|
| Type 1A4 | |
| Ch 3 & 4 MODE | CHANNEL 3 |
| DISPLAY | 1 & 2 |
| Type 547 Oscilloscope | |
| Coupling | AC |
| Time/Cm | 1 μ Sec |

Performance Check—Type 1A4

NOTE

For this procedure use the oscilloscope Triggering Level and Horizontal Position controls for desired triggering and positioning of the display. Use Fig. 6-7 as a guide. In addition, use the Type 1A4 POSITION controls for proper vertical positioning.

c. With the Ch 1 & 2 MODE switch set to CHOP, position the Channel 1 and 2 chopped display so the horizontal center-line can be conveniently used for measuring the horizontal distance of two successive segments.

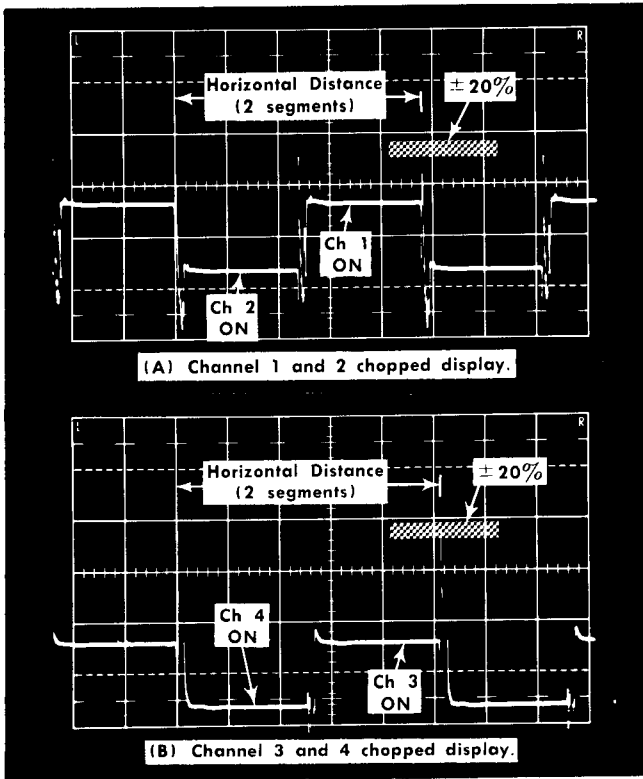


Fig. 6-7. Typical waveforms obtained when checking chopping rate. Both waveforms are within requirements. Sweep rate is 1 μ s/cm.

d. CHECK—Horizontal distance for two successive segments should be 4.16 cm to 6.24 cm (see Fig. 6-7A). This is equivalent to a time duration of 4.16 μ s to 6.24 μ s. Actual distance, _____ cm. To determine chopping rate, use this formula:

$$\text{Chopping Rate} = \frac{2}{\text{Time duration in } \mu\text{s for two segments}}$$

Using Fig. 6-7A as an example:

$$\text{Chopping Rate} = \frac{2}{4.8 \mu\text{s}} = \frac{2}{4.8 \times 10^{-6}} = 417 \text{ kHz}$$

e. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	ADD
Ch 3 & 4 MODE	CHOP
DISPLAY	3 & 4

f. CHECK—Using steps 12c through 12d and Fig. 6-7B as a guide, check the Channel 3 and 4 chopped waveform horizontal distance for two successive segments. The distance should be between 4.16 cm and 6.24 cm. Actual distance, _____ cm.

g. Set the Type 1A4 controls as follows:

Ch 3 & 4 MODE	ADD
DISPLAY	CHOP

h. CHECK—Using steps 12c through 12d as a guide, check the chopped-mode display horizontal distance for two successive segments. The distance should be between 4.16 cm and 6.24 cm. Actual distance, _____ cm.

13. Check Input Capacitance and Attenuator Compensation

a. Requirement—Optimum square-wave response with roll-off, overshoot or tilt within 1% peak to peak.

b. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2

Type 547 Oscilloscope

Time/Cm	.5 mSec
---------	---------

Type 106 Square-Wave Generator

Repetition Rate Range	1 kHz
Multiplier	Less than 1
Symmetry	Midrange
Amplitude	Fully ccw
Hi Amplitude Fast Rise switch	Hi Amplitude
Fast Rise controls	Not Applicable
Power	On

c. Apply the 1-kHz signal from the Type 106 high amplitude output connector through a 10 \times attenuator (item 10), 5-ns 50-ohm cable (item 15), 50-ohm in-line termination (item 8) and a 20 pF input-capacitance normalizer (item 7) to the Channel 1 Input connector in the order given.

d. Set the Type 106 Amplitude control to produce a display 4 cm in amplitude.

e. Set the oscilloscope Triggering Level control, if necessary, to obtain a stable display and use the Type 1A4 channel 1 POSITION control to center the display.

f. Set the Type 106 Symmetry control for 50% duty factor waveform and, if necessary, adjust the Multiplier control to obtain the 1-kHz output repetition rate.

g. CHECK—Using Table 6-9 as a guide, check top front corner on the square wave for optimum square-wave response (see Fig. 6-8A). Front-corner aberrations should not exceed 1% peak to peak (or 0.4 mm peak to peak on a 4-cm waveform).

When using Table 6-9, maintain 4 cm of deflection for each V/CM switch position. In the 2 V/CM position, replace the 50-ohm termination with a GR-to-BNC Adapter (item 11). In the 20 V/CM position, maximum generator output produces about 3 cm of deflection. Waveforms shown in Fig. 6-8B and 6-8C are examples of incorrect waveforms.

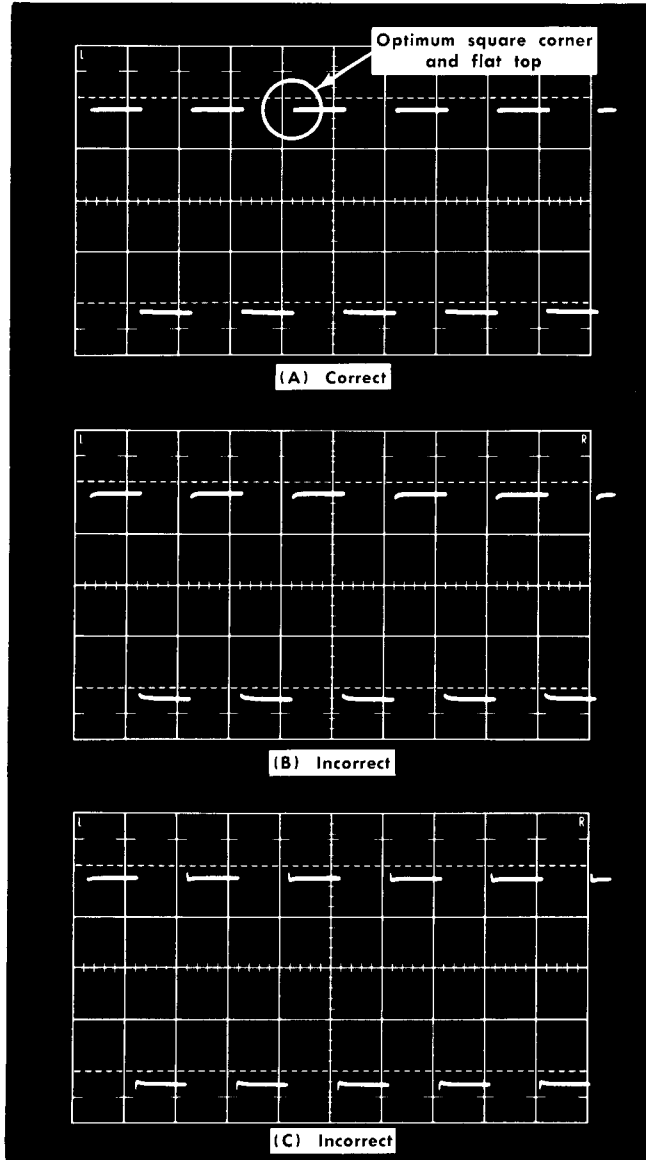


Fig. 6-8. (A) Typical CRT display showing correct input compensation. (B) Shows an example of incorrect input-capacitance compensation and (C) shows effect on display when the attenuator adjustments are incorrect such as C31 and C32 in the .02 V/CM position. Sweep rate is 0.5 ms/cm.

- h. After completing the check for Channel 1, set the Type 106 for minimum output amplitude and disconnect the signal.
- i. Set the Ch 1 & 2 MODE switch to CHANNEL 2.
- j. Using Table 6-10 and step 13g as a guide, check the input capacitance and attenuator adjustments for the remaining channels.

TABLE 6-9

V/CM Switch	Use 10X Attenuator	Use 50-ohm Termination	Use GR-to-BNC Adapter	Use RC Normalizer
.01	X	X		X
.02	X	X		X
.05	X	X		X
.1	X	X		X
.2		X		X
.5		X		X
1		X		X
2			X	X
5			X	X
10			X	X
20			X	X

TABLE 6-10

Apply Type 106 Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Repeat Step 13g for:
Input 2	CHANNEL 3	1 & 2	Channel 2
Input 3	CHANNEL 3	3 & 4	Channel 3
Input 4	CHANNEL 4	3 & 4	Channel 4

14. Check Output Amplifier High-Frequency Compensation

a. Requirement—Optimum high-frequency response to a 100-kHz fast-rise square-wave signal. Ringing, rounding, overshoot and tilt should be less than 4% peak to peak on a 4 cm positive-going signal.

b. Set the controls as follows:

Type 1A4

V/CM (all channels) .01

Type 547 Oscilloscope

Time/Cm 5 μSec

Type 106 Square-Wave Generator

Repetition Rate Range 100 kHz

Hi Amplitude Fast Rise Fast Rise switch

+Transition Amplitude Fully CCW

c. Apply the 100-kHz fast-rise signal from the +Output connector on the Type 106 through a 2X attenuator (item 9), a 5-nsec cable, and a 50-ohm in-line termination to the Type 1A4 Channel 4 Input connector. Connect all calibration fixtures in the order given.

d. Set the Type 106 +Termination Amplitude control to obtain a 4-cm amplitude display. Set the Symmetry control to obtain a symmetrical (50% duty factor) waveform and, if necessary, adjust the Multiplier control to obtain the 100-

Performance Check—Type 1A4

kHz output repetition rate. Use the Type 1A4 Channel 4 POSITION control to center the display.

e. Set the oscilloscope Time/Cm switch to $.1 \mu\text{Sec}$.

f. Use the oscilloscope Horizontal Position control to position the rising portion of the waveform about 2.5 cm to the right of the 0-cm graticule line. Use the Type 1A4 Channel 4 POSITION control to position the top leading corner of the waveform about 1.5 cm above the graticule horizontal centerline (see Fig. 6-9).

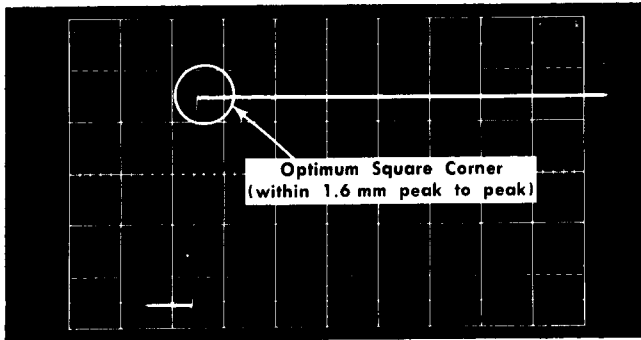


Fig. 6-9. Typical CRT display showing correct output-amplifier high-frequency compensation. Sweep rate: $0.1 \mu\text{s/cm}$.

g. CHECK—CRT display for optimum square corner (see Fig. 6-9). Ringing, rounding, overshoot and tilt should be less than 1.6 mm (or 4%) peak to peak when a 4 cm positive-going square wave is displayed.

h. Set the Ch 3 & 4 MODE switch to CHANNEL 3.

i. Using Table 6-11 and step 14g as a guide, check the output amplifier high-frequency compensation when the other channels are switched into the circuit. Use the appropriate channel POSITION control when positioning the display.

TABLE 6-11

Apply Fast-Rise Signal to:	Ch 1 & 2 MODE Switch	DISPLAY Switch	Check High-Frequency Response to a Square Wave Using:
Input 3	CHANNEL 2	3 & 4	Channel 3
Input 2	CHANNEL 2	1 & 2	Channel 2
Input 1	CHANNEL 1	1 & 2	Channel 1

j. Leave the Type 106 signal connected to the Type 1A4 Channel 1 Input connector.

15. Check Signal Output Gain

a. Requirement—Equal to or greater than 0.5 V/cm of displayed signal; SIGNAL OUTPUT connector is unterminated at 1 kHz.

b. Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 1 & 2) AC
V/CM (Ch 2) .5
Ch 1 & 2 MODE ALT

Type 547 Oscilloscope

Triggering Level Fully CW and knob pulled outward
Time/Cm $10 \mu\text{Sec}$

Type 106 Square-Wave Generator

Repetition Rate Range 1 kHz

c. At this point in the procedure, the setup and connections should be the same as described in step 14c with these exceptions: The generator is set for 1-kHz repetition rate and the fast-rise signal is applied to Channel 1.

d. Connect an 18-inch 50-ohm cable from the Type 1A4 SIGNAL OUTPUT connector to the Channel 2 Input connector.

e. Check that the Type 106 +Transition Amplitude control is set to obtain a 4-cm amplitude display for Channel 1 (see Fig. 6-10).

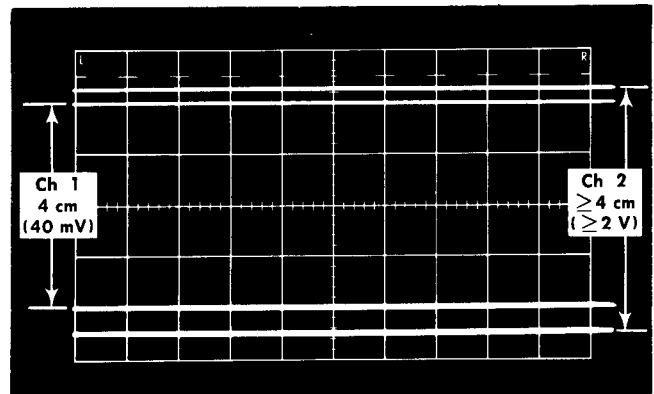


Fig. 6-10. Typical CRT display showing adequate trigger-amplifier voltage gain (double-exposure photograph). Sweep rate: $10 \mu\text{s/cm}$ free running.

f. Use the oscilloscope and Type 1A4 POSITION controls, as necessary, to position the dual-channel free-running displays similar to the locations shown in Fig. 6-10.

g. CHECK—Channel 2 display amplitude at a vertical deflection factor of 0.5 V/cm should be equal to or greater than the 4 cm Channel 1 display amplitude at 10 mV/cm . Actual Channel 2 display amplitude, _____ cm.

h. Leave the Type 106 signal connected to the Type 1A4 Channel 1 Input connector.

16. Check Trigger Amplifier High-Frequency Compensation

a. Requirement—Optimum high-frequency response to a 100-kHz fast-rise square-wave signal. SIGNAL OUTPUT connector is unterminated.

b. Substitute a compensated Type P6008 10× Probe for the 50-ohm cable as follows: Disconnect the 18-inch 50-ohm cable from the SIGNAL OUTPUT and Channel 2 Input connectors. Connect the cable end of the compensated 10× probe to the Channel 2 Input connector. Attach a probe-to-male BNC connector adapter (item 12) to the tip of the 10× probe. Connect the probe tip with adapter to the SIGNAL OUTPUT connector.

c. Set the front-panel controls as follows:

Type 1A4

V/CM (Ch 2)	.05
Ch 1 & 2 MODE	CHANNEL 2

Type 547 Oscilloscope

Triggering Level	Near 0 and knob pushed in
Time/Cm	5 μSec

Type 106 Square-Wave Generator

Repetition Rate Range	100 kHz
-----------------------	---------

d. With the Type 106 signal applied to the Channel 1 Input connector, adjust the Type 106 +Transition Amplitude control to obtain a Channel 2 display which is 4 cm in amplitude. If necessary, adjust the oscilloscope Triggering Level control to obtain a stable display.

e. Set the oscilloscope Time/Cm switch to 0.5 μSec.

f. Using the Type 1A4 Channel 2 POSITION and oscilloscope Horizontal Position controls, position the display to a location similar to the one shown in Fig. 6-11.

g. CHECK—CRT display for optimum top front corner on the rising portion of the waveform (see Fig. 6-11). Minor aberrations can be expected but they should not be of the ringing type.

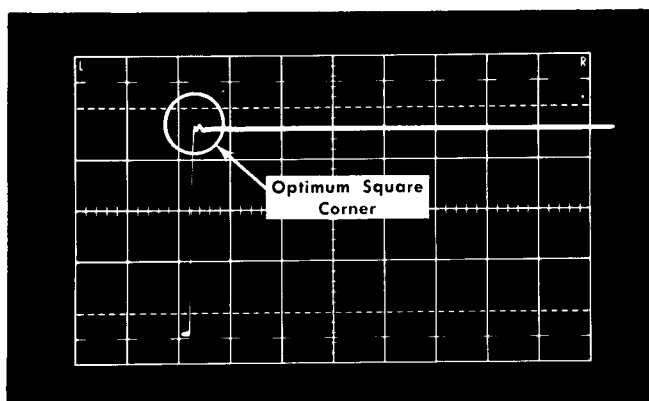


Fig. 6-11. Typical CRT display showing correct trigger-amplifier high-frequency compensation. Sweep rate: 0.5 μs/cm.

h. Disconnect the Type 106 signal from the Type 1A4 Channel 1 Input connector but leave the 10× probe connected as is. Turn off the Type 106.

17. Check Trigger Amplifier High-Frequency Response

a. Requirement—With gray-on-white trigger amplifier bandwidth-control lead connected to pin "M" on the logic board, upper-limit frequency response at -3 dB is as follows:

- Any mode except CHOP: ≥10 MHz; SIGNAL OUTPUT connector is unterminated.
- CHOP modes only: 500 kHz, ±20%.

b. Set the controls as follows:

Type 547 Oscilloscope

Triggering Level	Fully CW and knob pulled outward
Time/Cm	.5 mSec
Horizontal Position	Set so trace starts at left edge of graticule

Type 191 Constant Amplitude Signal Generator

Frequency dial	8 MHz
Frequency Range	50 kHz Only
Amplitude	30
Variable	CAL
Amplitude Range	5-50 mV
Power	On

c. Apply the 50-kHz reference signal from the Type 191 Output connector through a 5-ns cable and a 50-ohm in-line termination to the Type 1A4 Channel 1 Input connector. Check that the compensated 10× probe is connected from the Channel 2 Input connector to the SIGNAL OUTPUT connector.

d. Adjust the Type 191 Variable control and, if necessary, the Amplitude switch, to obtain a 4-cm amplitude Channel 2 display. This is the reference amplitude at 50 kHz (see Fig. 6-12A).

e. Set the Type 191 Frequency Range switch to 8-18.

f. Without changing the Type 191 output amplitude, increase the output frequency until the deflection is reduced to 2.8 cm (see Fig. 6-12B). This is the 30% down voltage point (equivalent to -3 dB). Use the Channel 2 POSITION control to position the display for convenient viewing.

g. CHECK—Output frequency should be 10 MHz or higher. Actual response, _____ MHz.

h. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	ALT
DISPLAY	ALT

Type 547 Oscilloscope

CRT Cathode Selector	Chopped Blanking
----------------------	------------------

i. Position Channel 1, 3 and 4 traces off the screen so they will not appear with the Channel 2 display.

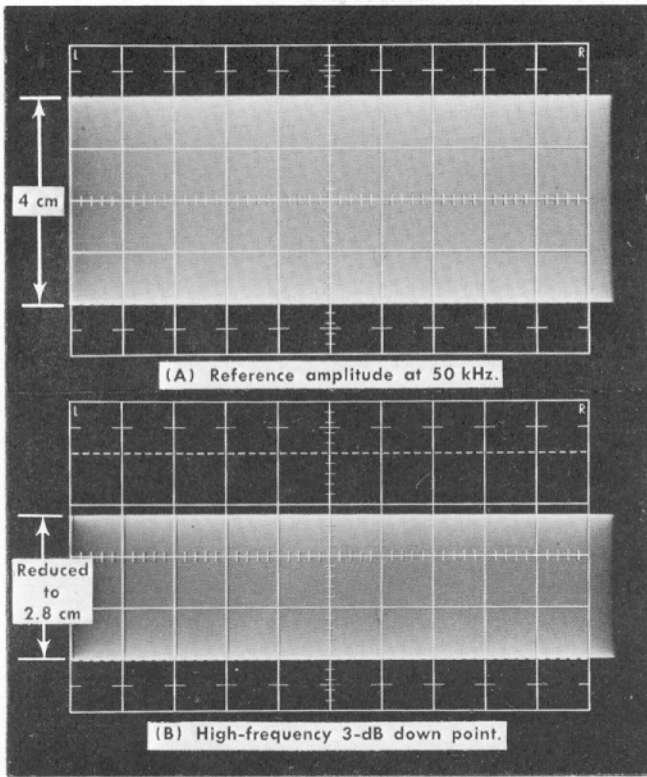


Fig. 6-12. Typical CRT displays obtained when checking high-frequency response. Sweep rate: 0.5 ms/cm free running.

j. Set the Type 191 Frequency Range switch to 50 kHz Only. Adjust the Type 191 Variable control and, if necessary the Amplitude switch so the reference amplitude is exactly 4 cm on the CRT.

k. Set the Type 191 Frequency Range switch to .35-75.

l. Without changing the Type 191 output amplitude, set the Frequency dial to a point where the Channel 2 display is exactly 2.8 cm in amplitude. Use the Channel 2 POSITION control to position the display for desired viewing.

m. CHECK—Output frequency should be between 400 kHz and 600 kHz. This frequency range meets the 500 kHz, $\pm 20\%$, requirement. Actual response, _____ kHz.

n. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE ALT
 DISPLAY CHOP

o. CHECK—Channel 2 display amplitude should be 2.8 cm. This indicates the trigger amplifier upper-frequency limit is the same as described in step 17m.

p. Set the Type 1A4 controls as follows:

Ch 3 & 4 MODE CHOP
 DISPLAY ALT

q. CHECK—Channel 2 display amplitude should be 2.8 cm. This indicates the trigger amplifier upper-frequency limit is the same as described in step 17m.

r. Disconnect the 10X probe from the Type 1A4, but leave the Type 191 signal applied to Channel 1.

18. Check Output Amplifier High-Frequency Response

- a. Requirement—Not more than 30% down at 50 MHz.
- b. Set the controls as follows:

Type 1A4

V/CM (Ch 2) .01
 POSITION (Ch 1, 3 & 4) Midrange
 Ch 1 & 2 MODE CHANNEL 1
 Ch 3 & 4 MODE CHANNEL 3
 DISPLAY 1 & 2

Type 547 Oscilloscope

Time/CM 50 μ Sec
 CRT Cathode Selector External CRT Cathode

Type 191 Constant Amplitude Signal Generator

Frequency dial 45 MHz
 Frequency Range 50 kHz Only
 Amplitude 40

c. Check that the Type 191 signal is applied to the Channel 1 Input connector.

d. Adjust the Type 191 Variable control so the display is exactly 4 cm in amplitude. This is the reference amplitude (similar to the display shown in Fig. 6-12A).

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

f. Without changing the Type 191 output amplitude, increase the output frequency until the deflection is reduced to 2.8 cm (similar to the display shown in Fig. 6-12B). This is the 30% down voltage point (equivalent to -3 dB).

g. CHECK—Output frequency should be 50 MHz or higher. Actual response when using Channel 1, _____ MHz.

h. Set the Ch 1 & 2 MODE switch to CHANNEL 2.

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

j. Using Table 6-12 and steps 18d through 18g and step 18i as a guide, check the high-frequency response when the signal is applied to the other channels. (Repeat step 18i first and then steps 18d through 18g.)

TABLE 6-12

Apply Type 191 Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Check High-Frequency Response of:
Input 2	CHANNEL 3	1 & 2	Ch 2; actual response is _____ MHz.
Input 3	CHANNEL 3	3 & 4	Ch 3; actual response is _____ MHz.
Input 4	CHANNEL 4	3 & 4	Ch 4; actual response is _____ MHz.

k. Disconnect the Type 191 signal from the Channel 4 Input connector and, instead, apply the signal to the Channel 1 Input connector.

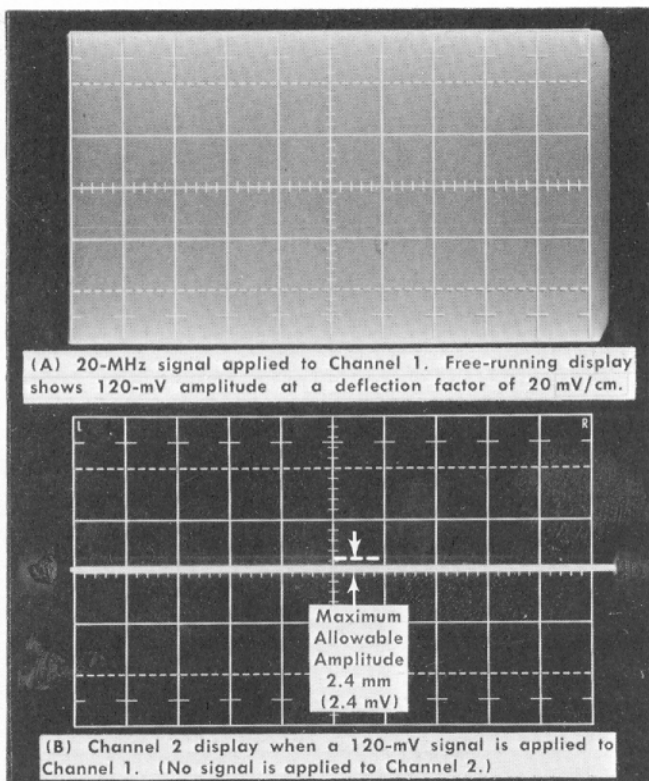


Fig. 6-13. Typical CRT displays obtained when checking amplifier isolation between Channels 1 and 2. Sweep rate: 0.5 ms/cm free running.

19. Check Amplifier Inter-Channel Isolation

- Requirement—Equal to or greater than 50:1 at 20 MHz.
- Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 2, 3 & 4)	GND
V/CM (Ch 1)	.02
Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2

Type 547 Oscilloscope

Time/Cm	.5 mSec
---------	---------

Type 191 Constant Amplitude Signal Generator

Frequency dial	20 MHz
Frequency Range	18-42
Amplitude	10
Amplitude Range	50-500 mV

- Check that the signal is applied to the Channel 1 Input connector. Adjust the Type 191 Variable control to obtain 6-cm display (see Fig. 6-13A).
- Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	CHANNEL 2
V/CM (Ch 1)	.01
- CHECK—Channel 2 display amplitude (see Fig. 6-13B) should not exceed 2.4 mm. ($120 \text{ mV} \div 2.4 \text{ mV} = 50$.)
- Using Table 6-13 and step 19e as a guide, check the amplifier isolation between the remaining channels.
- Leave the Type 191 signal connected to the Channel 3 Input connector.

20. Check Attenuator Inter-Channel Isolation

- Requirement—Equal to or greater than 5000:1 at 20 MHz.
- Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 4)	DC
V/CM (Ch 3)	2
Ch 3 & 4 MODE	CHANNEL 3

Type 191 Constant Amplitude Signal Generator

Amplitude	50
Amplitude Range	.5-5 V

- Replace the 50-ohm in-line termination with a GR-to-BNC male adapter (item 11) to obtain more signal drive from the signal generator.
- Adjust the Type 191 Variable control so the Channel 3 display is 5 cm in amplitude.
- Set the Ch 3 & 4 MODE switch to CHANNEL 4.
- CHECK—Channel 4 display amplitude should not exceed 2 mm. ($10 \text{ V} \div 0.002 \text{ V} = 5000$.)
- Using Table 6-14 and step 20f as a guide, check attenuator isolation between the remaining adjacent channels.

TABLE 6-13

Apply Type 191 Signal to:	Preliminary Procedure		Final Procedure
Input 2	AC-GND-DC (Ch 2):	DC	DISPLAY: 3 & 4
	V/CM (Ch 2):	.02	V/CM (Ch 2): .01
	Adjust Type 191 Variable control for 6-cm display.		Perform step 19e but check Ch 3 amplitude.
Input 3	AC-GND-DC (Ch 3):	DC	Ch 3 & 4 MODE: CHANNEL 4
	V/CM (Ch 3):	.02	V/CM (Ch 3): .01
	Adjust Type 191 Variable control for 6-cm display.		Perform step 19e but check Ch 3 amplitude.

Performance Check—Type 1A4

TABLE 6-14

Preliminary Procedure	Final Procedure
V/CM (Ch 2): 2 DISPLAY: 1 & 2 Apply Type 191 signal to Channel 2 Input connector. Adjust Type 191 Variable control for 5-cm display.	DISPLAY: 3 & 4 V/CM (Ch 3): .01 Perform step 20f but check Channel 3 amplitude.
V/CM (Ch 1): 2 DISPLAY: 1 & 2 Apply Type 191 signal to Channel 1 Input connector. Adjust Type 191 Variable control for 5-cm display.	Ch 1 & 2 MODE: CHANNEL 2 V/CM (Ch 2): .01 Perform step 20f but check Channel 2 amplitude.

h. Disconnect the Type 191 signal but do not turn off the generator.

21. Check Common-Mode Rejection Ratio

- a. Requirement—At least 20:1 at 10 MHz.
- b. Set the controls as follows:

Type 1A4

V/CM (all channels)	.02
Ch 1 & 2 MODE	ALT
Ch 3 & 4 MODE	CHANNEL 3

Type 191 Constant Amplitude Signal Generator

Frequency dial	10 MHz
Frequency Range	8-18
Amplitude	5
Amplitude Range	50-500 mV

c. Apply the 10-MHz signal from the Type 191 Output connector through a 5-ns cable, a 50-ohm in-line termination and a dual-input connector (item 6) to the Type 1A4 Channel 1 and 2 Input connectors in the order given.

d. Adjust the Type 191 Variable control so both waveforms (superimposed using the Channel 1 and 2 POSITION controls) are exactly 5 cm in amplitude.

e. Set the Type 1A4 controls as follows:

INVERT (Ch 1)	Knob pulled outward
Ch 1 & 2 MODE	ADD
V/CM (Ch 1 & Ch 2)	.01

f. CHECK—CRT display amplitude should be 5 mm or less. ($100\text{ mV} \div 5\text{ mV} = 20$.) This is equivalent to a common-mode rejection ratio of 20:1 or greater at 10 MHz.

g. Using Table 6-15 and step 21f as a guide, check common-mode rejection ratio for the remaining pairs of channels.

h. Disconnect the signal and turn off the Type 191 Constant Amplitude Signal Generator.

22. Check Amplifier Low-Frequency Response (AC Coupled)

- a. Requirement—Not more than 30% down at 2 Hz, AC coupled.
- b. Set the controls as follows:

Type 1A4

INVERT (Ch 1, 2 & 3)	Knob pushed in
Ch 3 & 4 MODE	CHANNEL 4

Type 547 Oscilloscope

Triggering Level	Near 0 and knob pushed in
Triggering Mode	Trig
Triggering Coupling	DC
Time/Cm	.5 Sec

Low-Frequency Sine-Wave Generator

Frequency controls	2 Hz
Output Level	Fully CCW
Power	On

c. Apply the 2-Hz signal from the low-frequency generator through a 42-inch 50-ohm coaxial cable to the Type 1A4 Channel 4 Input connector.

d. Adjust the generator Output Level control to obtain a display exactly 4 cm in amplitude (see Fig. 6-14A). Carefully adjust the oscilloscope Triggering Level control to obtain a stable display.

TABLE 6-15

Apply Type 191 Signal to:	Preliminary Procedure	Final Procedure
Channel 2 & 3 Input connectors	V/CM (Ch 2): .02 Ch 1 & 2 MODE: CHANNEL 2 DISPLAY: ALT Adjust Type 191 Variable control for a 5-cm display.	INVERT (Ch 2): Pulled outward DISPLAY: ADD V/CM (Ch 2 & 3): .01 Perform step 21f.
Channel 3 & 4 Input connectors	V/CM (Ch 3): .02 Ch 3 & 4 MODE: ALT DISPLAY: 3 & 4 Adjust Type 191 Variable control for a 5-cm display.	INVERT (Ch 3): Pulled outward Ch 3 & 4 MODE: ADD V/CM (Ch 3 & 4): .01 Perform step 21f.

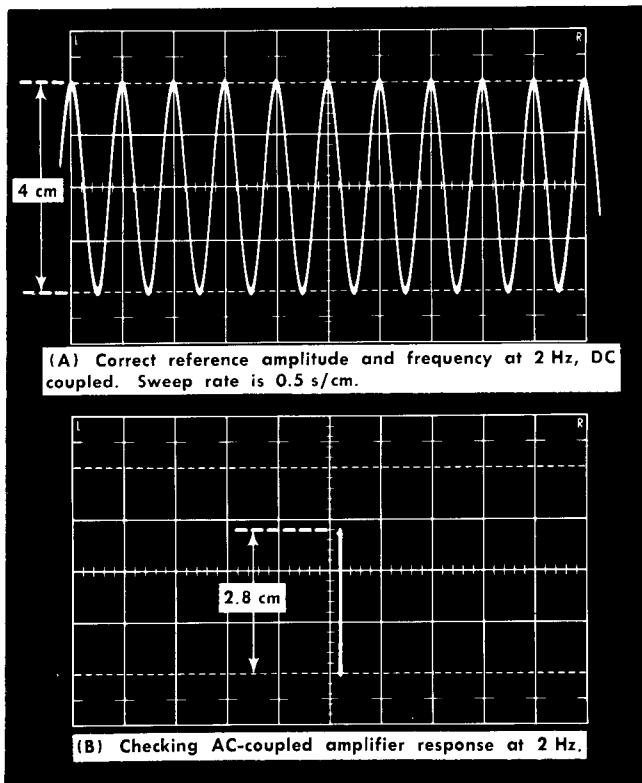


Fig. 6-14. Typical CRT displays obtained when checking the Type 1A4 AC-coupled low-frequency response.

e. Check that one cycle per cm is displayed. If not, adjust the generator Frequency control to obtain the correct output frequency (2 Hz).

f. Set the controls as follows:

Type 1A4
 AC-GND-DC (Ch 4) AC

Type 547 Oscilloscope
 Horizontal Display ×10 Ext

g. Use the Type 1A4 POSITION and oscilloscope Horizontal Position controls to move the display to a location such as shown in Fig. 6-14B.

h. CHECK—Display amplitude should be 2.8 cm (see Fig. 6-14B) or more at 2 Hz. Actual Channel 4 amplitude, _____ cm.

i. Set the Ch 3 & 4 MODE switch to CHANNEL 3.

j. Using Table 6-16, step 22d and step 22h as a guide, check the AC-coupled low-frequency response of the remaining channels.

k. Leave the Low-Frequency Sine-Wave Generator connected to the Type 1A4 Channel 1 Input connector.

23. Check Trigger Amplifier Low-Frequency Response

a. Requirement—Not more than 30% down at 20 Hz, untruncated.

b. Set the controls as follows:

Type 1A4
 AC-GND-DC (Ch 1, 3 & 4) DC
 AC-GND-DC (Ch 2) AC
 V/CM (Ch 2) .5
 Ch 1 & 2 MODE CHANNEL 2
 SIGNAL & TRIGGER SOURCE 1

Type 547 Oscilloscope
 Triggering Coupling AC
 Time/CM 20 μSec
 Horizontal Display A

TABLE 6-16

Apply 2 Hz Signal to:	Ch 1 & 2 MODE Switch	DISPLAY Switch	Procedure
Input 3	CHANNEL 2	3 & 4	Adjust generator output amplitude for 4-cm display. Set Ch 3 AC-GND-DC switch to AC. Perform step 22h. Actual Ch 3 amplitude, _____ cm.
Input 2	CHANNEL 2	1 & 2	Adjust generator output amplitude for 4-cm display. Set Ch 2 AC-GND-DC switch to AC. Perform step 22h. Actual Ch 2 amplitude, _____ cm.
Input 1	CHANNEL 1	1 & 2	Adjust generator output amplitude for 4-cm display. Set Ch 1 AC-GND-DC switch to AC. Perform step 22h. Actual Ch 1 amplitude, _____ cm.

Performance Check—Type 1A4

Low-Frequency Sine-Wave Generator

Frequency controls 50 kHz

c. Connect an 18-inch 50-ohm coaxial cable to the Type 1A4 SIGNAL OUTPUT and Channel 2 Input connectors.

d. Set the generator Output Level control to obtain a 4 cm Channel 2 CRT display. Use the oscilloscope Triggering Level control to obtain a stable display.

e. If necessary, adjust the generator output frequency so one cycle per cm (50 kHz waveform) is displayed.

f. Set the Ch 1 & 2 MODE switch to CHANNEL 1.

g. Note the amplitude of the waveform. This amplitude will be used for reference purposes to monitor the generator output amplitude.

h. Set the controls as follows:

Type 547 Oscilloscope

Time/Cm 50 mSec

Low-Frequency Sine-Wave Generator

Frequency controls 20 Hz

i. Check that one cycle per cm is displayed to indicate the generator is set for 20 Hz output frequency.

j. Set the oscilloscope Horizontal Display switch to $\times 10$ Ext.

k. Use the Type 1A4 POSITION and oscilloscope Horizontal Position controls to move the display similar to the location shown in Fig. 6-14B.

l. If necessary, adjust the generator output amplitude so the Channel 1 display is the same amplitude as was noted in step 24g.

m. Set the Ch 1 & 2 MODE switch to CHANNEL 2.

n. CHECK—Channel 2 display amplitude should be 2.8 cm or more. Actual amplitude at 20 Hz, _____ cm.

o. Set the oscilloscope controls as follows:

Triggering Level	Fully CW
Triggering Mode	Auto Stability
Time/Cm	.1 mSec
Horizontal Display	A

This completes the performance check procedure for the Type 1A4. Disconnect and turn off the Low-Frequency Sine-Wave Generator. Disconnect the 18-inch 50-ohm cable. If the Type 1A4 has met all performance requirements given in this procedure, it is correctly calibrated and within the specified tolerances.

SECTION 7

CALIBRATION

Introduction

Complete calibration information for the Type 1A4 is given in this section. This procedure calibrates the unit to the performance requirements listed in the Characteristics section. The Type 1A4 can be returned to original performance standards by completion of each step in this procedure. If it is desired to merely touch up the calibration, perform only those steps entitled "Adjust . . .". A short-form calibration procedure is also provided in this section for the convenience of the experienced calibrator.

The Type 1A4 should be checked, and recalibrated if necessary, after each 500 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 1A4 and determine if recalibration is required.

TEST EQUIPMENT AND CALIBRATION FIXTURES

General

The following test equipment (items 1 through 7; see Fig. 7-1), or its equivalent, is required for complete calibration of the Type 1A4. Specifications given are the minimum necessary for accurate calibration of this unit. All test equipment is assumed to be correctly calibrated and operating within the given specifications. If equipment is substituted, it must meet or exceed the specifications of the recommended equipment.

Fig. 7-2 shows the calibration fixtures (items 8 through 21) that are used in this procedure. All fixtures except item 19 have a Tektronix part number and can be ordered through your local Tektronix Field Office or representative. Item 19 is a standard item that can be purchased locally.

Test Equipment (Fig. 7-1)

1. Calibrated Type 547 Oscilloscope. For use with the Type 1A4 Plug-In Unit being calibrated. NOTE: The Type 547 was used when performing this procedure and is required for checking the 547 TRACE SLAVING switch (steps 4f through 4k). If steps 4f through 4k are omitted, a Type 544 or 546 oscilloscope can be used with Type 1A4.

2. Test oscilloscope. Bandwidth, 2 Hz to 300 kHz or higher (if a wide-bandwidth oscilloscope is used, ignore any "noise" not synchronized with the line frequency); minimum deflection factor, 5 mV/div. Tektronix Type 531A Oscilloscope with a Type B High-Gain Plug-In Unit is used in this procedure for checking power-supply ripple.

3. Variable autotransformer with an AC monitoring voltmeter. Meter accuracy, within $\pm 3\%$ of full scale. Autotransformer must be capable of supplying at least 600 volts

amperes over a range of 103.5 V to 126.5 V (207 V to 253 V for 230 V nominal line), 50 to 60 Hz. For example, General Radio W10MT3W Metered Variac Autotransformer designed for 120 V input is used in this procedure. If the oscilloscope (item 1) is wired for use on a 230 V nominal line, then an autotransformer designed for 230 V will have to be used.

4. Precision DC voltmeter. Accuracy, with $\pm 0.02\%$; meter resolution, 50 μ V. Voltages to be measured: -15 V, $+12.1$ V, $+67.5$ V and $+100$ V. For example, Fluke Model 825A.

5. Standard amplitude calibrator. Amplitude accuracy, within 0.25%; signal amplitude 50 mV to 100 V; output signal, 1-kHz square wave. Tektronix calibration fixture No. 067-0502-00 recommended.

6. Square-wave generator. Frequency, 1 kHz and 100 kHz; rise time, 20 ns or faster from high-amplitude output; 1 ns or faster from fast-rise output. High-amplitude output: variable from 0.5 V to 12 V into a 50-ohm load, about 7 V to 120 V untermi-nated. Fast-rise output: variable from 50 mV to 500 mV into a 50-ohm load. Tektronix Type 106 Square-Wave Generator recommended.

7. Constant amplitude sine-wave generator. Frequency 50 kHz, 500 kHz, 10 MHz, 20 MHz and 50 MHz; output amplitude, 40 mV to 5 V into a 50-ohm load. Amplitude accuracy, within $\pm 3\%$ at 500 kHz, 10 MHz, 20 MHz and 50 MHz using the amplitude at 50 kHz for a reference. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

Calibration Fixtures (Fig. 7-2)

8. Dual-input connector. Connectors, BNC female input and two BNC male outputs. For applying a signal to two channels simultaneously. Tektronix Part No. 067-0525-00.

9. Input capacitance normalizer. Time constant, 1 megohm \times 20 pF; attenuator 2 \times ; connectors, BNC. Tektronix Part No. 067-0538-00.

10. In-line termination. Impedance, 50 ohm; accuracy, within $\pm 3\%$; connectors, GR input with BNC male output. Tektronix Part No. 017-0083-00. (Supplied with items 6 and 7.)

11. 2 \times attenuator. Impedance, 50 ohms; accuracy, within $\pm 3\%$; connectors, GR-Type. Tektronix Part No. 017-0080-00.

12. 10 \times attenuator. Impedance, 50 ohms; accuracy, within $\pm 3\%$; connectors, GR-Type. Tektronix Part No. 017-0078-00.

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

14. Adapter, probe-to-male BNC connector. Tektronix Part No. 013-0056-00. For use with the 10 \times probe (item 21) when performing steps 28 and 29 in the calibration procedure.

15. Plug-in extension (optional). Rigid type, 6 $\frac{1}{2}$ inches long. Tektronix Part No. 013-0055-00. Permits easy access to the Channel 1 and 4 attenuator adjustments performed in step 21. Adjustments can be reached without using this extension.

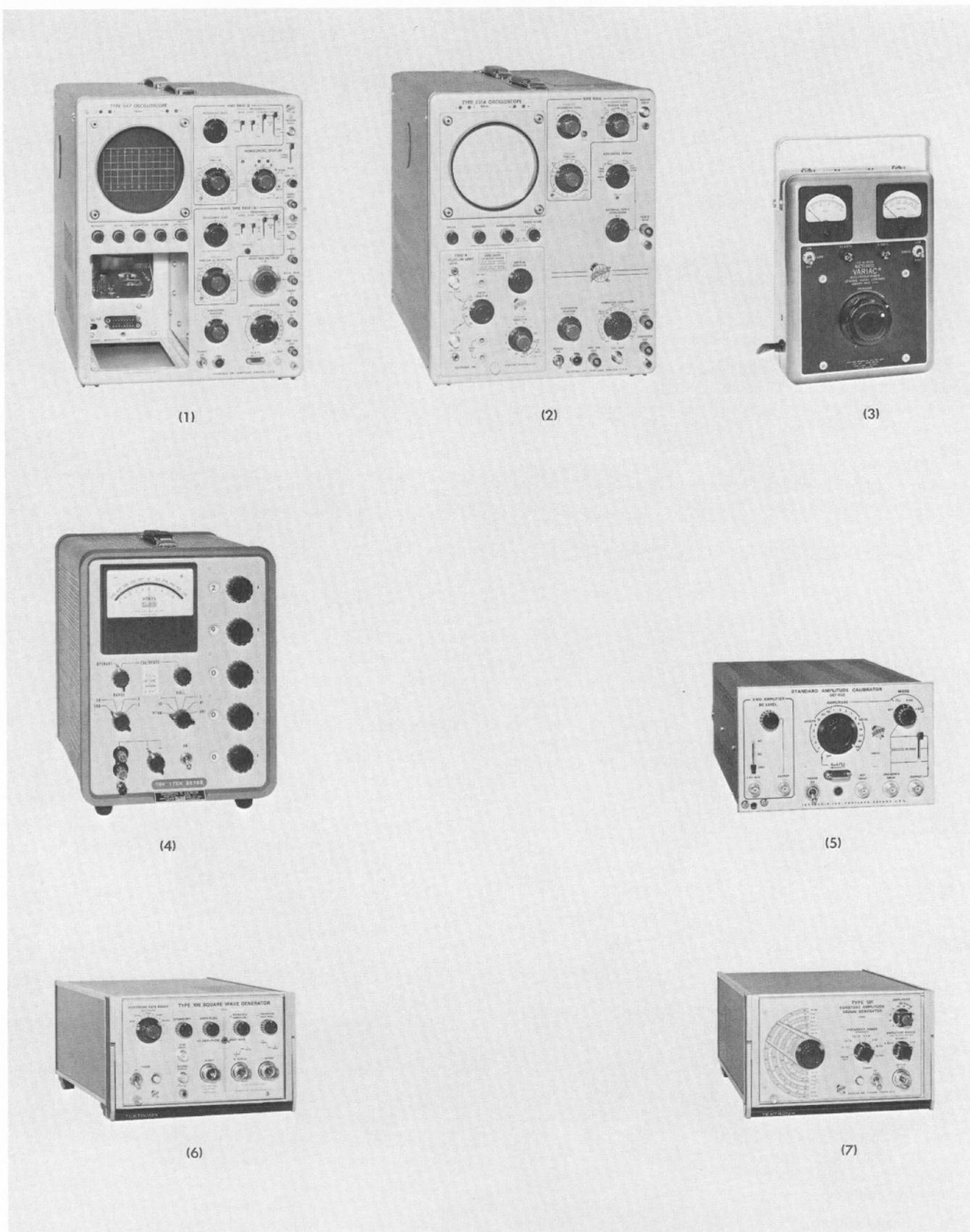


Fig. 7-1. Equipment required for the calibration of the Type 1A4.

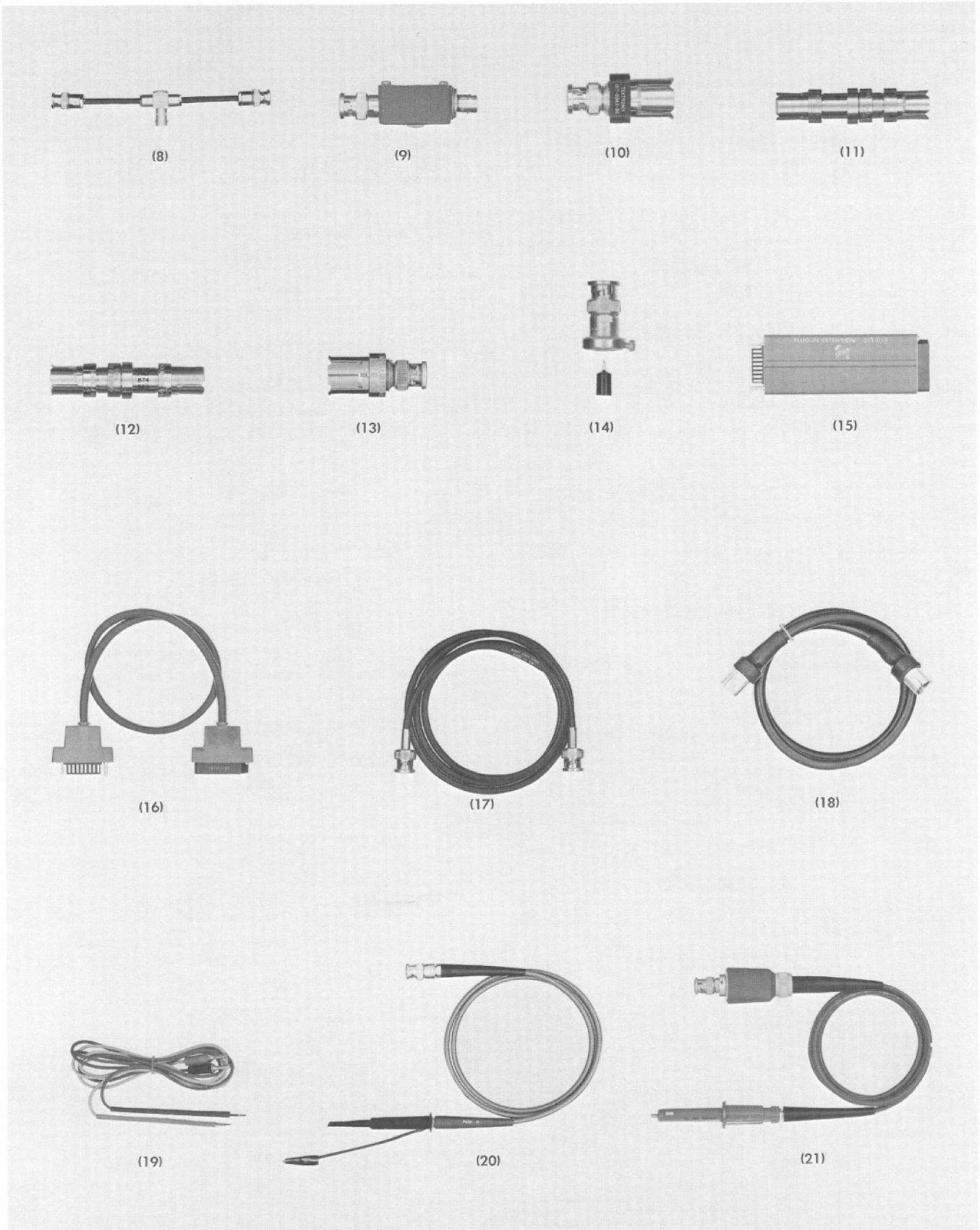


Fig. 7-2. Equipment required for the calibration of the Type 1A4.

Calibration—Type 1A4

16. Flexible extension cable. Permits plug-in unit operation outside the oscilloscope plug-in compartment. Tektronix Part No. 012-0038-00.

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

18. Coaxial cable. Impedance, 50 ohms; Type RG8/213; length, five nanoseconds; connectors, GR874. Tektronix Part No. 017-0502-00. Supplied with items 6 and 7.

19. Two test leads, about 4 feet long. To fit the precision DC voltmeter being used.

20. $1\times$ passive probe with BNC connector. Tektronix P6011 Probe recommended. Tektronix Part Number for the probe package is 010-0190-00. For use with the test oscilloscope (item 2) when checking power-supply ripple.

21. $10\times$ passive probe with BNC connector. Tektronix P6008 Probe recommended. Probe risetime is about 2 ns. Tektronix Part Number for the probe package is 010-0129-00. For use with Type 1A4 when checking trigger amplifier response and bandwidth.

Adjustment Tools (Fig. 7-3)

22. Screwdriver, 2-inch shaft, $\frac{3}{32}$ -inch wide bit. Xcelite No. R3322 or equal.

23. Low capacitance alignment tool consisting of:

Description	Tektronix Part No.
Handle	003-0307-00
Nylon insert with recessed wire pin	003-0308-00
Nylon insert with recessed metal screwdriver tip	003-0334-00

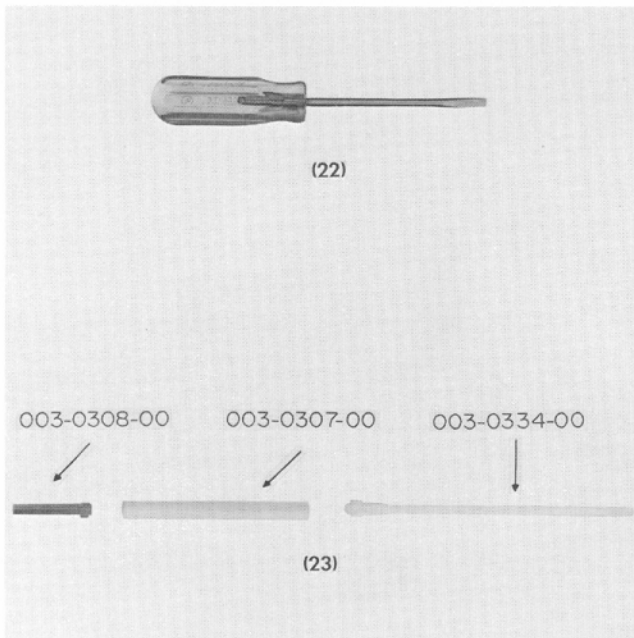


Fig. 7-3. Adjustment tools.

CALIBRATION RECORD AND INDEX

This short-form calibration procedure is provided to aid in checking the operation of the Type 1A4. It may be used as a calibration guide by the experienced calibrator, or it may be used as a record of calibration. Since the step numbers and titles used here correspond to those used in the complete procedure, this procedure also serves as an index to locate a step in the complete Calibration Procedure. Performance requirements correspond to those given in the Characteristics section.

Type 1A4, Serial No. _____

Calibration Date _____

Calibration Technician _____

1. Adjust -15 -V Power Supply Page 7-8

-15 volts, ± 0.15 volt (or $\pm 0.1\%$).

INTERACTION: Steps 2, 3, 7, 15, 16 and 17 should also be checked if the -15 VOLTS control is adjusted.

2. Check $+12.1$ -V Power Supply Page 7-9

$+12.1$ volts, ± 0.24 volts (or $\pm 2\%$).

3. Preadjust Variable Balance (R60) Page 7-10

Adjust VAR BAL control for no trace shift as the appropriate VARIABLE (V/CM) control is rotated throughout its range. Check all channels.

4. Check Alternate Mode Operation Page 7-11

Proper sequence of alternation for the Type 1A4. Proper trace slaving to the Type 547 time bases operating in the A/Alt/B mode.

5. Check Chopped Mode Operation Page 7-12

Proper chopped-mode display.

6. Check Add Mode of Operation Page 7-12

When the MODE and DISPLAY switches are set to ADD, there is a trace shift as the IDENTIFY buttons are pressed. This is an indication of proper add mode operation. Check all channels.

7. Adjust Output DC Level R360 Page 7-13

67.5% of the oscilloscope non-decoupled $+100$ -V power supply. Accuracy is within $\pm 2\%$ of the 67.5% voltage calculation.

8. Check Regulation and Ripple Page 7-16

Power Supply	Regulation	Maximum Ripple (peak-to-peak)
-15 V	± 0.3 V (or $\pm 2\%$)	2 mV
$+12.1$ V	± 0.24 V (or $\pm 2\%$)	2 mV

9. Adjust GAIN R379 Page 7-17

Set to electrical center or, if preferred, midrange position.

INTERACTION: Perform step 10. If step 10 is not going to be performed refer to Operating Instructions, Section 2, Gain Adjustment procedure.

- 10. Adjust Preamplifier Gain R77 Page 7-18
Correct Channel 1 display amplitude at a deflection factor of 10 mV/cm. Correct null indication at 10 mV/cm when matching Channel 2, 3 and 4 pre-amplifier gain to Channel 1.
INTERACTION: Perform step 9 first.
- 11. Check Added Accuracy Page 7-19
Correct algebraic addition for each pair of channels checked.
- 12. Check Variable Volts/Cm Range Page 7-20
VARIABLE (V/CM) control range of at least 2.5:1. Check all channels.
- 13. Check AC Input Coupling Page 7-20
A DC-coupled positive-going (from ground) displayed-waveform shifts downward to its average AC level when the AC-GND-DC switch is set from DC to AC. Check all channels.
- 14. Check Volts/Cm Deflection Accuracy Page 7-20
Vertical deflection within $\pm 3\%$ of V/CM switch indication with the VARIABLE control set to CAL. Check all channels.
- 15. Adjust Variable Balance (R60 Final Adjustment) Page 7-22
Adjust VAR BAL control for no trace shift as the appropriate VARIABLE (V/CM) control is rotated throughout its range. Check all channels.
- 16. Adjust Trigger Selector DC Balance Page 7-23
Adjust R55, R56, R57 and R58 for no trace shift when switching the SIGNAL & TRIGGER SOURCE switch from a non-displayed channel to a displayed channel.
INTERACTION: Perform step 15 first.
- 17. Check Normal-Invert DC Balance Page 7-23
 ≤ 1 cm trace shift as the appropriate INVERT knob is pulled to its outward position. Check all channels.
INTERACTION: Perform step 15 first.
- 18. Check Identify Switches Page 7-24
With the INVERT knobs pushed in check for an upward trace shift as each IDENTIFY button is depressed. Typical shift is 2 mm to 5 mm. Check all channels.
- 19. Adjust Output Amplifier High-Frequency Compensation Page 7-26
Adjust C395, R395, C396, R396, C397 and R397 for optimum high-frequency response to a square wave.
- 20. Check Output Amplifier High-Frequency Response Page 7-28
 ≥ 50 MHz at -3 dB. Check all channels.
- 21. Adjust Input Capacitance and Attenuator Compensation Page 7-31
Optimum 1-kHz square-wave response in all V/CM switch positions.

- 22. Check Common-Mode Rejection Ratio Page 7-34
 $\geq 20:1$ when checked with a 10-MHz common-mode sine-wave signal that produces 10 cm of vertical deflection. Check each pair of channels.
- 23. Check Amplifier Inter-Channel Isolation Page 7-34
 $\geq 50:1$ isolation when using a 20-MHz sine-wave signal. Check between pairs of channels.
- 24. Check Attenuator Inter-Channel Isolation Page 7-35
 $\geq 5000:1$ isolation when using a 20-MHz sine-wave signal. Check between pairs of channels.
- 25. Check Chopped Mode Repetition Rate Page 7-36
400 kHz, $\pm 20\%$. Check the rate of each blocking oscillator by checking trace segment time duration. Ch 3 and 4 chop rate should be at least 5% slower than Ch 1 and 2 chop rate.
- 26. Check Chopped Mode Blanking Page 7-37
Switching transients between channels should blank out when oscilloscope CRT Cathode Selector switch is set to the Chopped Blanking position and normal trace intensity is used.
- 27. Check Signal Output Gain Page 7-40
 ≥ 0.5 V/cm of displayed signal when SIGNAL OUTPUT connector is unterminated. Equivalent to a voltage gain of ≥ 50 .
- 28. Adjust Trigger Amplifier High-Frequency Compensation Page 7-41
Adjust C117, C137 and C147 for optimum high-frequency response to a square wave.
- 29. Check Trigger Amplifier High-Frequency Response Page 7-43

Trigger Amplifier Bandwidth Control Lead Connected to:	Mode of Operation for Check	Upper-Limit Frequency Response (-3 dB)
Pin M	ALT	≥ 10 MHz, unterminated
	CHOP	500 kHz, $\pm 20\%$
Pin N	ALT	500 kHz, $\pm 20\%$
Pin L	CHOP	≥ 10 MHz, unterminated

- 30. Check Plug-In Triggering Page 7-44
Stable 2-cm sine-wave display at 10 MHz.

CALIBRATION PROCEDURE

General

The following procedure is arranged in a sequence which allows the Type 1A4 to be calibrated with the least interaction of adjustments if the complete procedure is followed. However, if steps out of sequence are performed, some adjustments will affect the calibration of other circuits within the unit. In this case, it will be necessary to check the operation of those circuits that are affected. When a step interacts with others, the steps which need to be checked are noted under "INTERACTION...".

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

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

In the following procedure, a test equipment setup picture is shown for each major group of adjustments and checks. Following each setup picture is a complete list of front-panel control settings for the Type 1A4 and a guide list for setting pertinent controls on the oscilloscope, particularly Time Base and Triggering Controls.

To aid in locating individual controls which have been changed during complete calibration, these control names are printed in bold type. If only a partial calibration is performed, start with the nearest setup preceding the desired portion. Type 1A4 front-panel and internal control titles referred to in this procedure are capitalized to match the lettering used in the unit. Any additional clarifying information for the title is usually given in initial capitals; e.g., Ch 1 & 2 MODE.

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

NOTE

All waveforms shown in this procedure are actual waveform photographs taken with a Tektronix Oscilloscope Camera system. Projected graticules (for Type 547 and 531A Oscilloscopes) were used. Each major division on the graticule illustrations represents one cm.

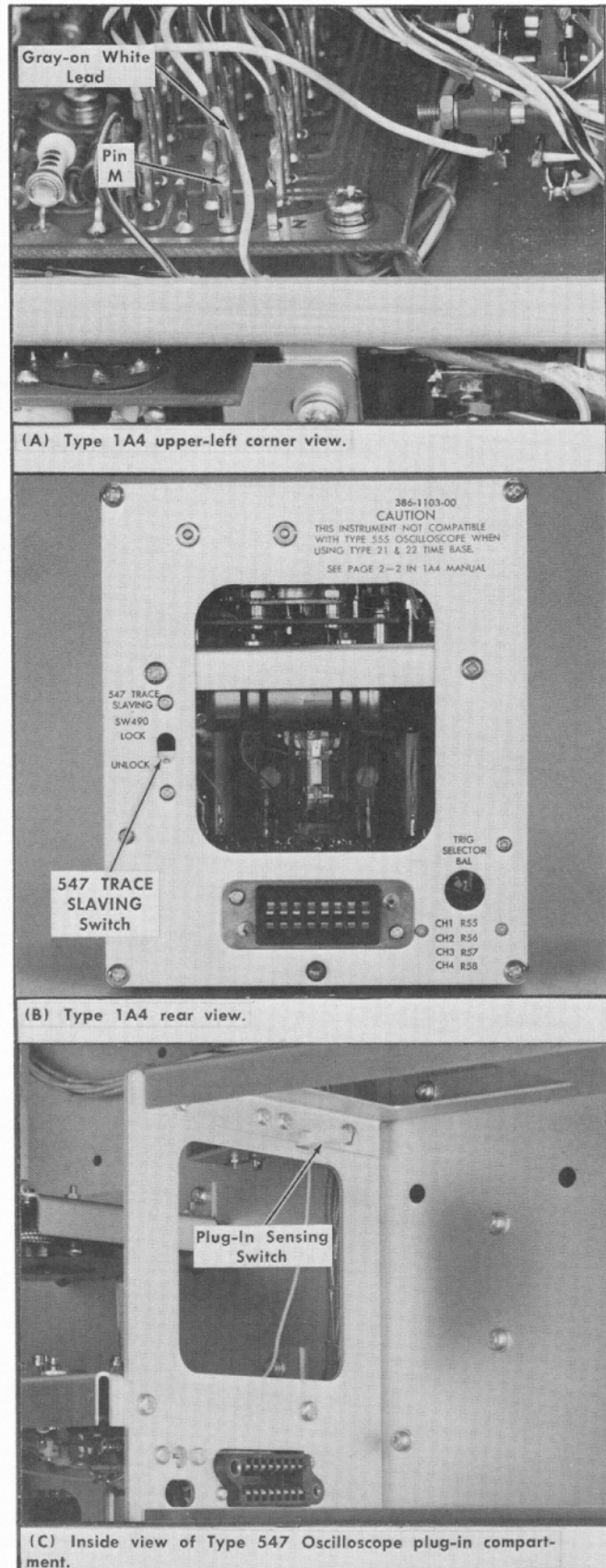


Fig. 7-4. (A) Shows the gray-on-white lead connected to pin "M" on the Logic board, (B) shows the 547 TRACE SLAVING switch set to LOCK, and (C) shows the location of the plug-in sensing switch.

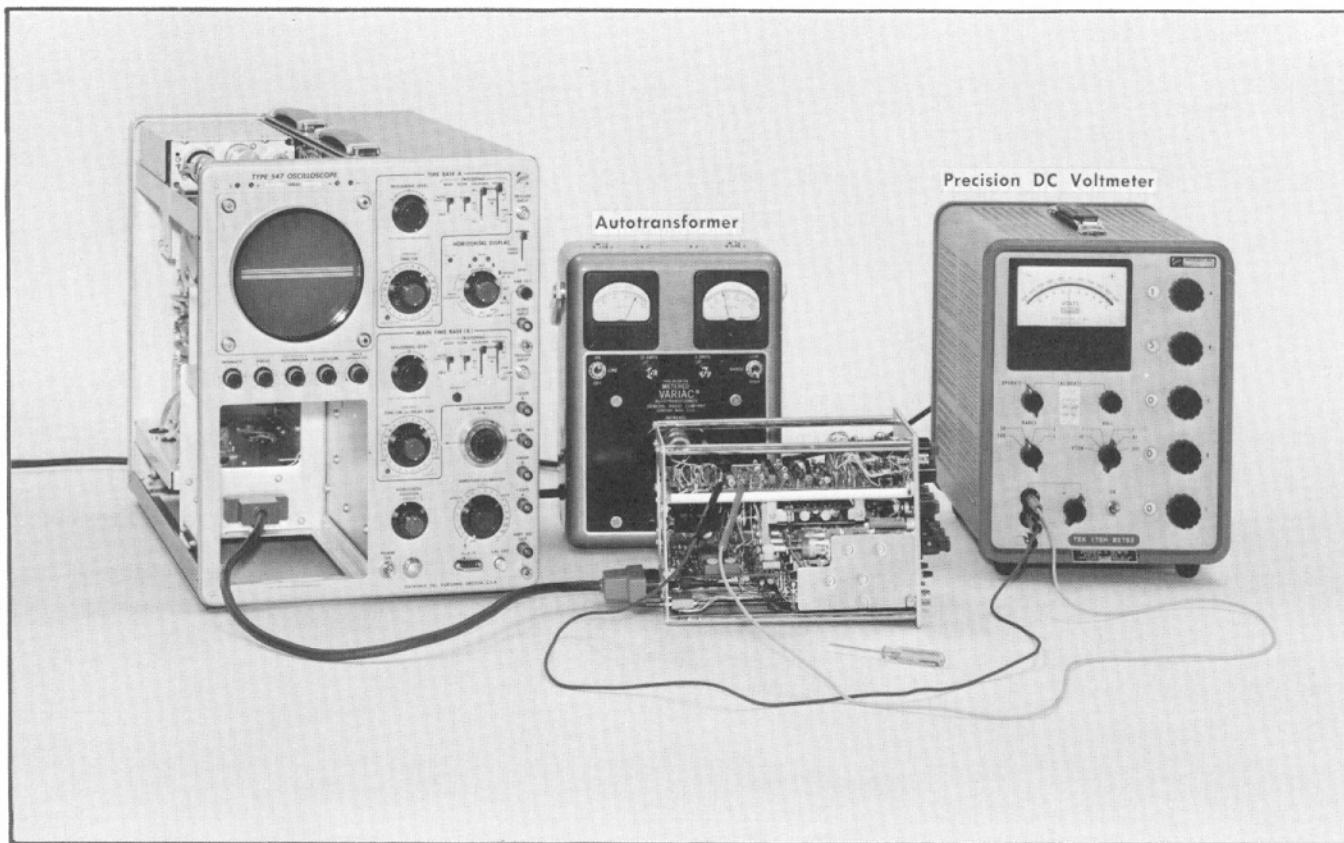


Fig. 7-5. Test equipment setup for steps 1 and 2.

Control Settings

Type 1A4

All Channels	
AC-GND-DC	GND
V/CM	.01
VARIABLE (V/CM)	CAL
INVERT	Pushed in
POSITION	Midrange
Other controls	
Ch 1 & 2 MODE	ALT
Ch 3 & 4 MODE	ALT
DISPLAY	ALT
SIGNAL & TRIGGER SOURCE	1
547 TRAVE SLAVING	Set to LOCK in step 5 of Preliminary Procedure

Type 547 Oscilloscope

A Triggering controls	
Triggering Level	Fully CW and pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int

Time Base A controls

Time/Cm	.1 mSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position	Midrange
Vernier (Horiz. Pos.)	Midrange
Delay-Time Multiplier ¹	1.00
Amplitude Calibrator ¹	Off
Ext CRT Cathode to Gnd Strap ¹	Installed
CRT Cathode Selector (rear panel)	External CRT Cathode
Intensity ¹	Fully CCW
Focus and Astigmatism ¹	Midrange
Power	On

1. Adjust —15-V Power Supply



a. Test equipment setup, with connections made at completion of step 1b in this procedure, is shown in Fig. 7-5.

¹Not included in subsequent lists of front-panel control settings.

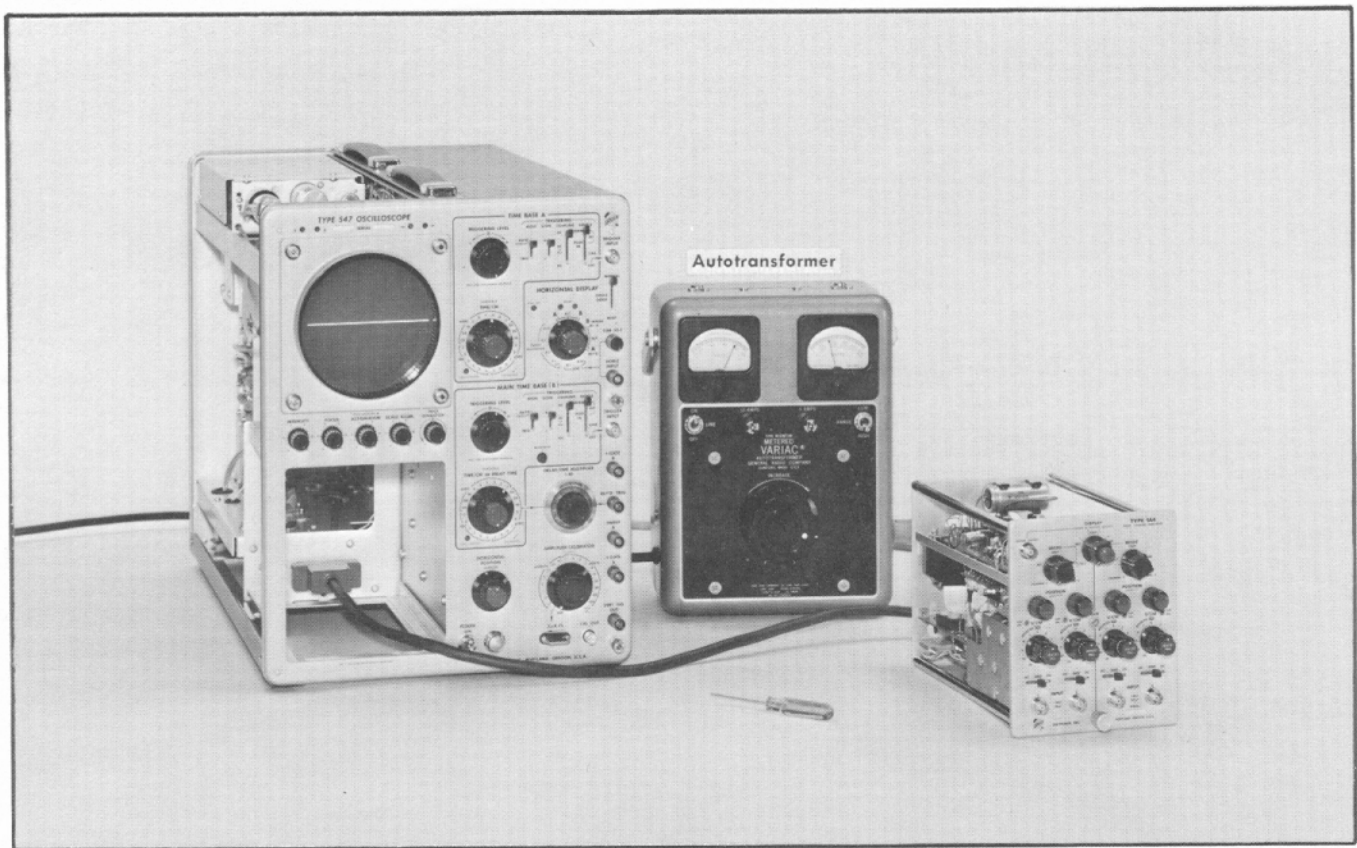


Fig. 7-7. Test equipment setup for steps 3 through 6.

Control Settings

	Type 1A4	
All Channels		
AC-GND-DC	GND	
V/CM	.01	
VARIABLE (V/CM)	CAL	
INVERT	Pushed in	
POSITION	Midrange	
Other controls		
Ch 1 & 2 MODE	CHANNEL 1	
Ch 3 & 4 MODE	ALT	
DISPLAY	1 & 2	
SIGNAL & TRIGGER	1	
SOURCE		
547 TRACE SLAVING	LOCK	
(rear panel)		
	Type 547 Oscilloscope	
A Triggering controls		
Triggering Level	Fully CW and pulled out-ward	
Mode	Auto Stability	
Slope	+	
Coupling	AC	
Source	Norm Int	

Time Base A controls

Time/Cm	.1 mSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position	Midrange
Vernier (Horiz. Pos.)	Midrange
CRT Cathode Selector	External CRT Cathode
Power	On

3. Preadjust Variable Balance (R60)

- a. Test equipment is shown in Fig. 7-7.
- b. Set the oscilloscope Intensity control for normal trace brightness.

NOTE

If the trace is located off the screen, preadjust the Channel 1 VAR BAL control (see Fig. 7-8) to position the trace near the graticule center. The VAR BAL control is a 20-turn variable resistor that has no mechanical stops (uses a slip-clutch arrangement to prevent over-travel damage) for the adjusting screw. Clockwise rotation moves the trace upward

and counterclockwise rotation moves the trace downward with the INVERT knob pushed inward.

From this point on in the Calibration Procedure, use the Intensity, Focus and Astigmatism controls (as desired) for obtaining sharply-focused normal intensity displays.

c. CHECK—Rotate the Channel 1 VARIABLE control through its range. Trace should not move vertically.

d. ADJUST—Channel 1 VAR BAL control (see Fig. 7-8) for no trace shift as the Channel 1 VARIABLE control is rotated back and forth through its range. Return the VARIABLE control to the CAL position.

e. Set Ch 1 & 2 MODE switch to CHANNEL 2.

f. Use Table 7-1 and steps 3c through 3d as a guide for checking and adjusting the VAR BAL controls for the remaining channels. After completing the procedure for each channel, be sure to return the VARIABLE control for the channel to its CAL position.

TABLE 7-1

Ch 3 and 4 MODE Switch	DISPLAY Switch	Adjustment (see Fig. 7-8)
ALT	1 & 2	Ch 2 VAR BAL
CHANNEL 3	3 & 4	Ch 2 VAR BAL
CHANNEL 4	3 & 4	Ch 4 VAR BAL

NOTE

Final adjustment of the VAR BAL control for each channel is made in step 15.

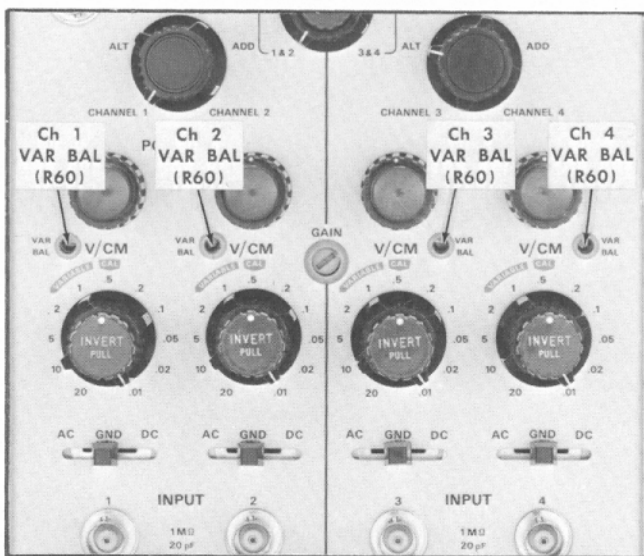


Fig. 7-8. Location of the VAR BAL adjustments.

4. Check Alternate Mode Operation

NOTE

Steps 4 through 6 check for proper alternate, chop and add mode of operation.

a. Test equipment setup is the same as shown in Fig. 7-7.

b. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	ALT
Ch 3 & 4 MODE	ALT
DISPLAY	ALT

The remaining unchanged controls should correspond to those given in the list that precedes step 3. Set the oscilloscope Horizontal Position control so the traces start at the left side of the graticule.

c. Using the Type 1A4 POSITION controls, position the four traces one cm apart as follows: Position Channel 1 trace about 2 cm above graticule center; position the other traces in sequence below the Channel 1 trace.

d. Set the oscilloscope A Time/Cm switch to .5Sec.

e. CHECK—Sequence of alternation; i.e., 1, 2, 3, 4, 1, etc. Check that 4 traces are obtained for each of these A Time/Cm switch positions: 50 mSec, 0.5 mSec, 50 μSec, 5 μSec, and 0.5 μSec.

f. Set the oscilloscope controls as follows:

B Triggering controls

Triggering Level	Fully CW and pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm

Time Base controls

A Time/Cm	50 μSec
B Time/Cm	.5 mSec
Variable (B Time/Cm)	Calibrated

Other controls

Horizontal Display	A/Alt/B
Brightness	Fully CW
Trace Separation	0

g. CHECK—Channel 1 and 2 traces should be displayed by the A sweep; channel 3 and 4 traces should be displayed by the B sweep. The channels can be identified by pressing the IDENTIFY buttons. The sweeps can be identified as follows: The A sweep produces dim traces and the B sweep produces bright traces (see Fig. 7-9).

h. Set the controls as follows:

Type 1A4

547 TRACE SLAVING	UNLOCK
-------------------	--------

Type 547 Oscilloscope

A Time/Cm	.1 mSec
B Time/Cm	.1 mSec

i. CHECK—Eight traces should be displayed. Use the oscilloscope Trace Separation control to separate the traces as desired.

Calibration—Type 1A4

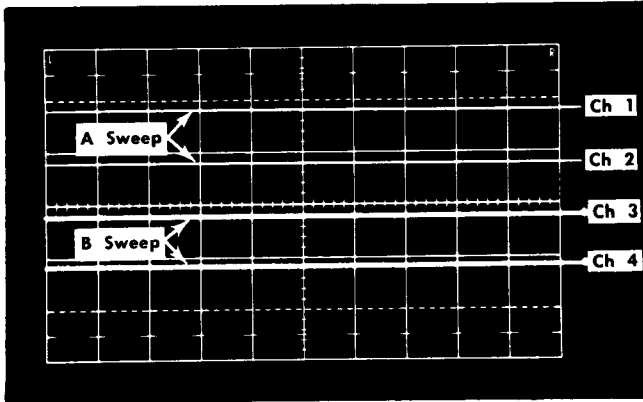


Fig. 7-9. Checking for proper slaving of channels to the A and B sweeps when the 547 TRACE SLAVING switch is set to LOCK. A sweep rate: 50 $\mu\text{s}/\text{cm}$; B sweep rate: 0.5 ms/cm.

- j. Set the oscilloscope Horizontal Display switch to B Intens by 'A'/Alt/A Dly'd.
- k. CHECK—Eight traces should be displayed.
- l. Return the 547 TRACE SLAVING switch to the LOCK position.

5. Check Chopped Mode Operation

- a. Test equipment setup is the same as shown in Fig. 7-7.
- b. Set the front-panel controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	CHOP
DISPLAY	CHOP

Type 547 Oscilloscope

A Time/Cm	2 μSec
Horizontal Display	A

If the positions of the remaining Type 1A4 and oscilloscope controls need to be checked, refer to the list that precedes step 3.

NOTE

For the remaining portion of this Calibration procedure the oscilloscope Horizontal Display switch remains in the A position; Time-Base B controls are not used.

- c. Push the oscilloscope Triggering Level knob inward and adjust the control to obtain a stable display.
- d. Using the Type 1A4 POSITION controls, position the chopped traces so Channel 1 is about 2 cm above the graticule centerline and the traces for the other channels follow in sequence one cm apart below Channel 1. Readjust, if necessary, the oscilloscope Triggering Level control so the Channel 1 trace segment is displayed first (see Fig. 7-10).

- e. CHECK—For a chopped display (see Fig. 7-10). The trace segments for all four channels should be displayed.

NOTE

Disregard the switching transients existing between trace segments. The amplitude of these transients will be high and the trace segments distorted due to operating the Type 1A4 through the long flexible extension cable. Final checks for chopped mode operation are made in steps 25 and 26.

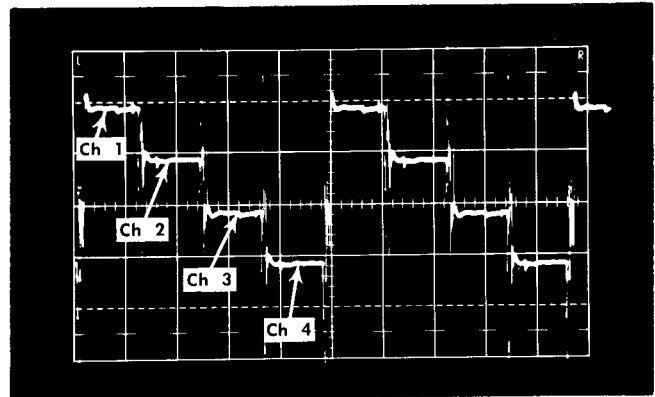


Fig. 7-10. Checking for proper chopped mode of operation. Sweep rate: 2 $\mu\text{s}/\text{cm}$.

6. Check Add Mode Operation

- a. Test equipment setup is the same as shown in Fig. 7-7.
- b. Set the controls as follows:

Type 1A4

POSITION	Midrange
Ch 1 & 2 MODE	ADD
Ch 3 & 4 MODE	ADD
DISPLAY	ADD

Type 547 Oscilloscope

A Triggering Level	Fully CW and pulled outward
A Time/Cm	0.5 mSec

If the positions of the remaining Type 1A4 and oscilloscope controls need to be checked, refer to the list that precedes step 3.

- c. If the trace is not at or near graticule center, slightly readjust the POSITION controls to center the trace.
- d. CHECK—Momentarily push each of the IDENTIFY buttons. Check that the trace shifts upward (about 3 mm) when each button is depressed.

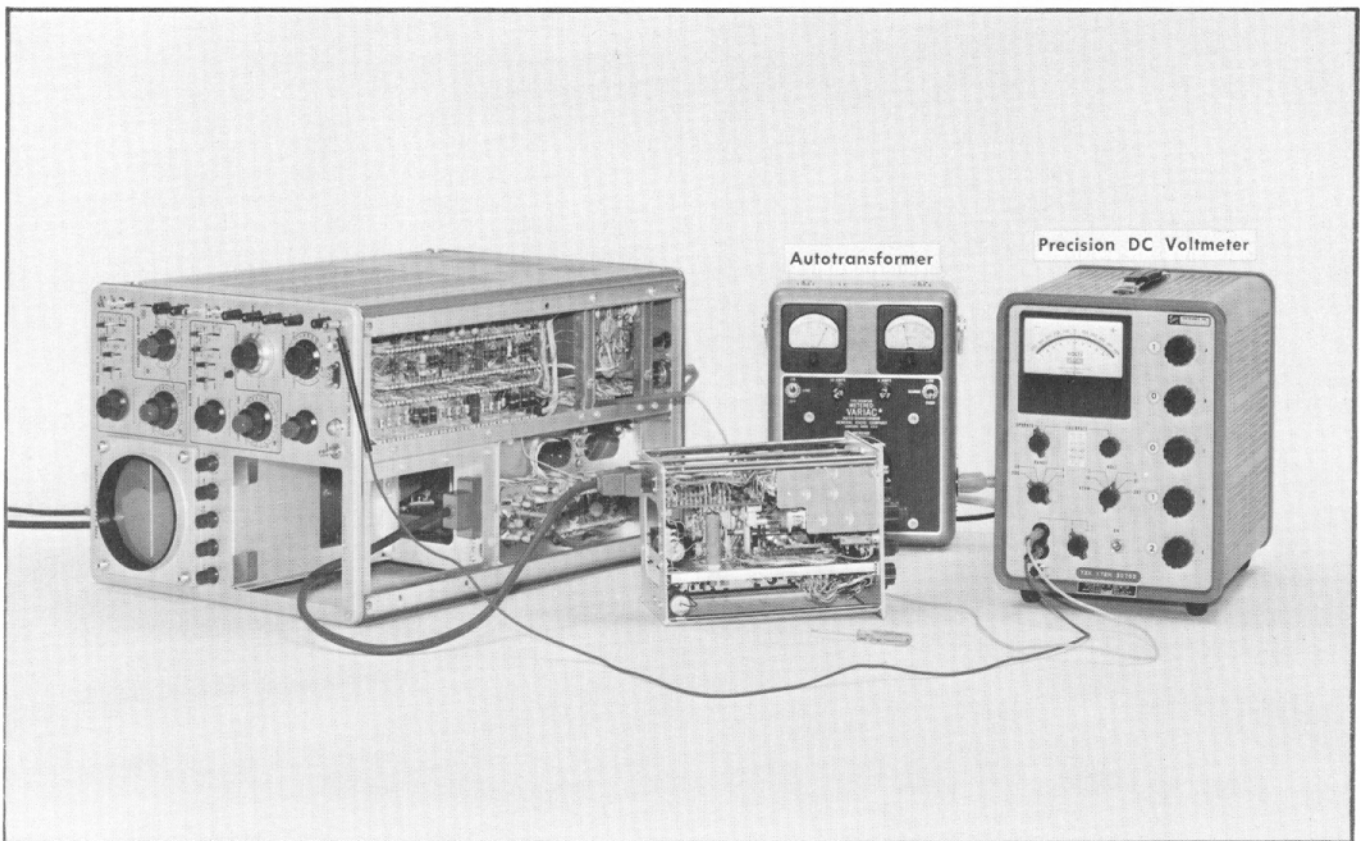


Fig. 7-11. Test equipment setup for step 7.

Control Settings

Type 1A4	
All Channels	
AC-GND-DC	GND
V/CM	.01
VARIABLE (V/CM)	CAL
INVERT	Pushed in
POSITION	Midrange
Other controls	
Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	ADD
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK

Type 547 Oscilloscope

A Triggering controls	
Triggering Level	Fully CW and pulled outward
Mode	Auto Stability
Slope	+

Coupling Source	AC Norm Int
Time Base A controls	
Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated
Other controls	
Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On

7. Adjust Output DC Level R360 ❶

a. Test equipment setup, with connections made at completion of step 7d, is shown in Fig. 7-11.

b. Turn the Type 1A4 upside down.

c. Lay the oscilloscope on its left side for access to the +100-V power supply test point.

d. Measure the non-decoupled +100-V power supply of the oscilloscope with the precision DC voltmeter (see Fig. 7-12A).

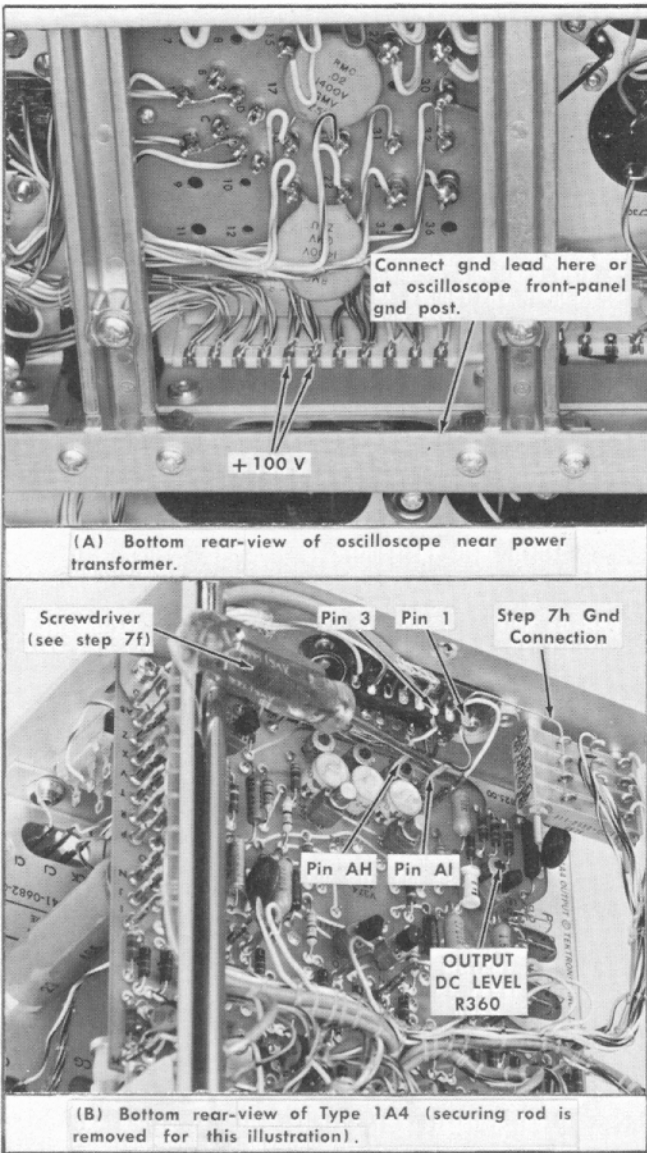


Fig. 7-12. Location of step 7 test points and OUTPUT DC LEVEL adjustment.

NOTE

Do not connect the voltmeter to the +100 V available at pin 10 of the interconnecting plug. This voltage is electrically located at the output side of a decoupling network and will therefore be a few volts less than the non-decoupled +100 V available at the output of the oscilloscope power supply circuit. The non-decoupled +100 V in the oscilloscope can be easily located by the color coded wire (brown-black-brown on white) and by referring to Fig. 7-12A.

- e. Calculate 67.5% of the measured +100 V supply.
- f. Using the small screwdriver, momentarily short pins 1 and 3 of the interconnecting plug. This can be conveniently accomplished by shorting pins AH and AI together on the Output board (see Fig. 7-12B). Note the position of the trace on the oscilloscope CRT. This is the DC electrical center for the oscilloscope vertical amplifier.

CAUTION

Do not short any of these pins to ground.

- g. Using the Channel 1 POSITION control, position the trace to the same location that was noted in step 7f.
- h. Connect the precision DC voltmeter between ground and either pin AH or AI (about 67.5 V) on the Output board (see Fig. 7-12B).
- i. CHECK—Meter reading should be 67.5% of the non-decoupled +100-V supply as calculated in step 7e. Accuracy: Within $\pm 2\%$ of the step 7e calculated voltage.
- j. ADJUST—OUTPUT DC LEVEL control R360 (see Fig. 7-12B) for a meter reading of exactly 67.5% of the measured +100-V supply. (R360 should be adjusted to obtain the same voltage as calculated in step 7e).
- k. Disconnect the voltmeter test leads.
- l. Place the oscilloscope in the upright position.
- m. Disconnect the flexible extension cable and insert the Type 1A4 directly into the oscilloscope plug-in compartment. (The Type 547 Oscilloscope does not have to be turned off when making this change.)

NOTES

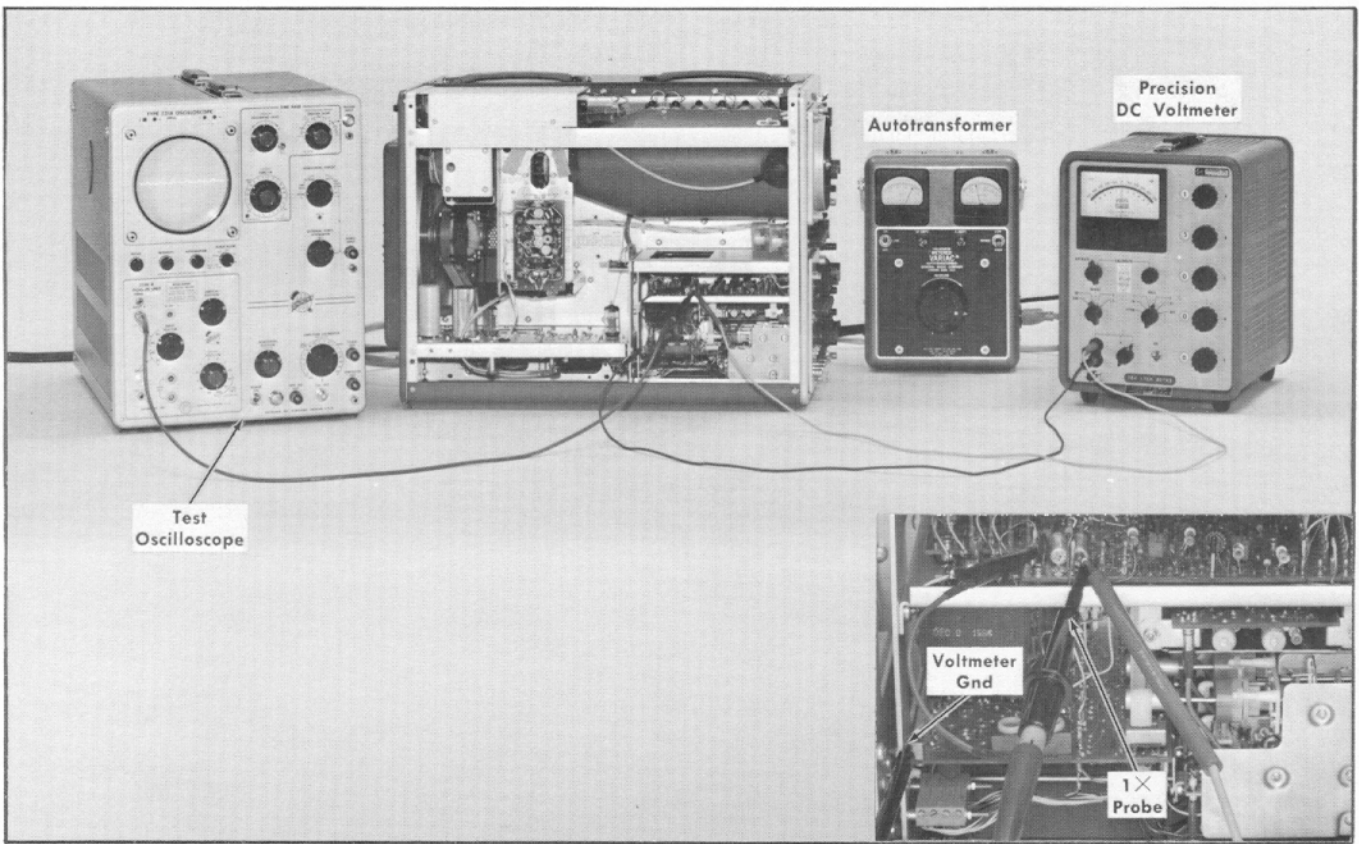


Fig. 7-13. Test equipment setup for step 8.

Control Settings

Type 1A4

All Channels

AC-GND-DC	GND
V/CM	.01
VARIABLE (V/CM)	CAL
INVERT	Pushed in
POSITION	Midrange

Other controls

Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	ADD
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK

Type 547 Oscilloscope

A Triggering controls

Triggering Level	Fully CW and knob pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int

Time Base A controls

Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector (rear panel)	External CRT Cathode
Power	On

Test Oscilloscope

Triggering controls

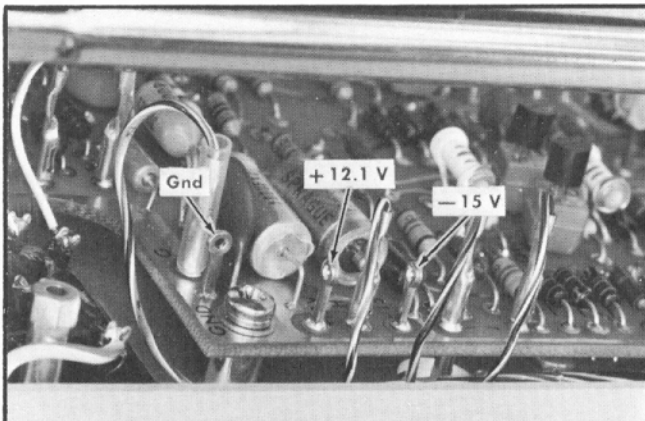
+Line, Auto, Preset Stability

Time Base controls
Horizontal Display
Vertical Amplitude controls
Position controls

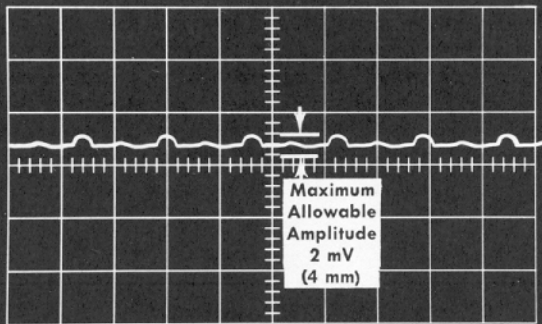
10 mSec, Calibrated Normal (×1)
 AC input coupling, 5 mV/cm
 Trace vertically positioned to graticule center and horizontally positioned to start at left side of graticule.

Power

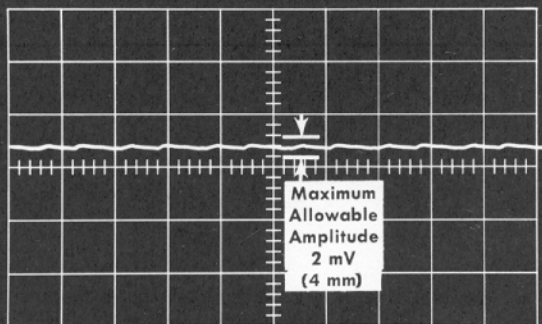
On



(A) Left side rear-portion view of Logic board.



(B) -15-V power-supply ripple at high line.



(C) +12.1-V power-supply ripple at low line.

Fig. 7-14. (A) Shows the power-supply test point locations. (B) and (C) show examples of 120-Hz ripple voltage waveforms obtained at a vertical deflection factor of 5 mV/cm; sweep rate is 10 ms/cm.

8. Check Regulation and Ripple

a. Test equipment setup, with connections made at completion of step 8d, is shown in Fig. 7-13.

b. Connect the precision DC voltmeter between ground and the -15V test point located on the Logic board (see Fig. 7-14A). A convenient ground location is the metal mounting block for the Output Amplifier board (see Fig. 7-13).

c. Connect the cable end of the $\times 1$ probe to the test oscilloscope.

d. Connect the $\times 1$ probe tip to the -15-V test point (see Fig. 7-14A). Connect the probe ground lead to the Gnd terminal on the Logic board (see Fig. 7-14A).

e. CHECK—Using Table 7-2, first check the -15V power supply regulation and ripple, and then repeat the check for +12.1-V power supply. Make the checks for each supply while changing the autotransformer output voltage from 103.5 V AC to 126.5 V AC (207 V to 253 V at 230 nominal line). Location of the +12.1-V test point is shown in Fig. 7-14A.

TABLE 7-2

Power Supply	Regulation	Ripple (peak to peak)
-15 V	± 0.3 V (or $\pm 2\%$)	2 mV (see Fig. 7-14B)
+12.1 V	± 0.24 V (or $\pm 2\%$)	2 mV (see Fig. 7-14C)

NOTE

When checking ripple, be sure none of the Type 1A4 MODE or DISPLAY switches are set to ALT or CHOP.

f. Return autotransformer output voltage to 115 V (230 V). If the line voltage is about 115 V (230 V), the Type 547 Oscilloscope used with the Type 1A4 can be connected directly to the line; otherwise, leave the instrument connected to the autotransformer for the remainder of the procedure.

g. Disconnect the test oscilloscope (includes the $\times 1$ probe) and the precision DC voltmeter. Turn off the test oscilloscope and voltmeter.

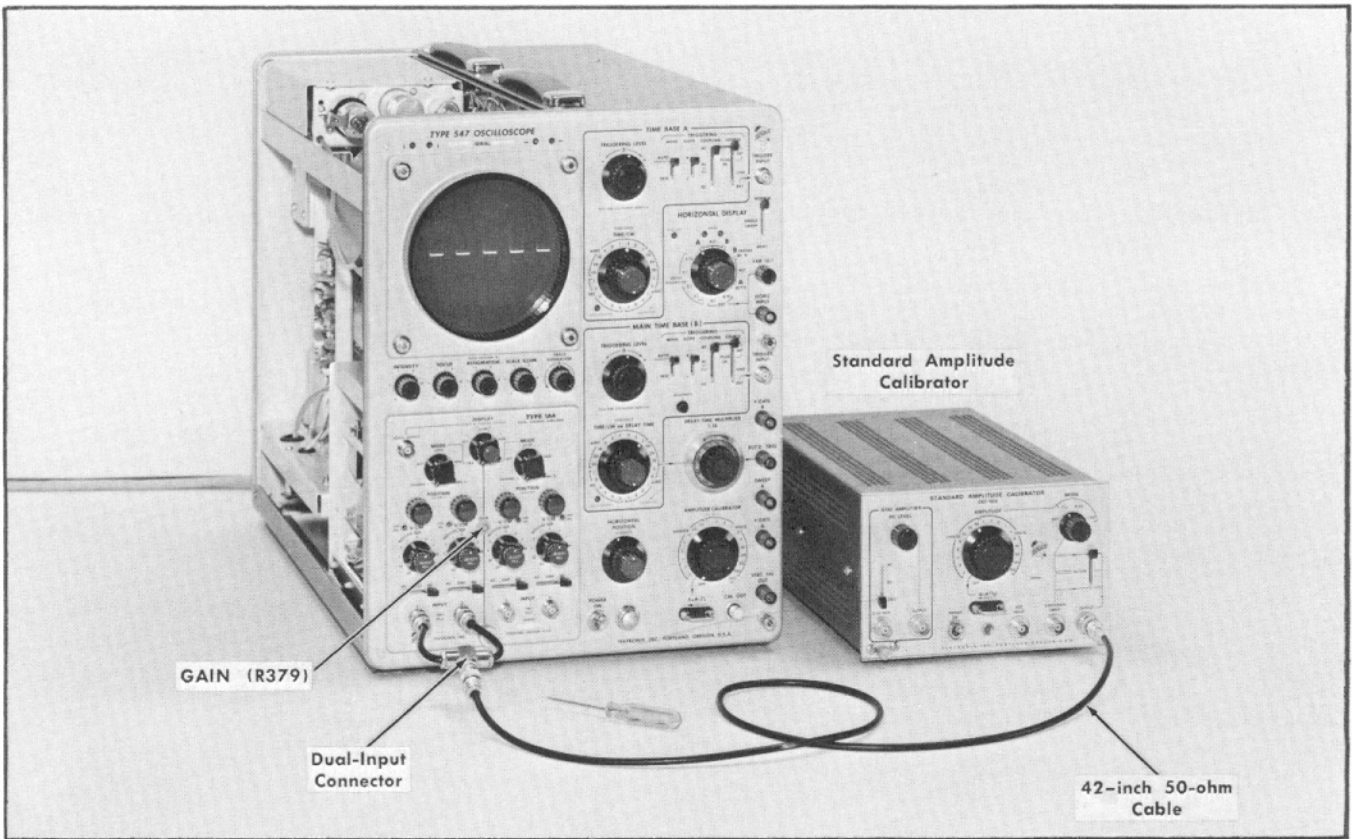


Fig. 7-15. Test equipment setup for steps 9 through 14.

Control Settings

Type 1A4

All Channels

AC-GND-DC DC
 V/CM .01
 VARIABLE (V/CM) CAL
 INVERT Pushed in
 POSITION Midrange

Other controls

Ch 1 & 2 MODE CHANNEL 1
Ch 3 & 4 MODE CHANNEL 3
 DISPLAY 1 & 2
 SIGNAL & TRIGGER SOURCE 1
 547 TRACE SLAVING LOCK
 (rear panel)

Type 547 Oscilloscope

A Triggering controls

Triggering Level Near 0 and knob pushed in
 Mode Auto Stability
 Slope +

Coupling AC
 Source Norm Int

Time Base A controls

Time/Cm .5 mSec
 Variable (Time/Cm) Calibrated

Other controls

Horizontal A
 Sweep Magnifier ×1 Off
 Single Sweep switch Normal
 Horizontal Position and Vernier Set so trace starts near left edge of graticule
 CRT Cathode Selector External CRT Cathode
 Power On

Standard Amplitude Calibrator

Amplitude 50 mV
Mode Square Wave
Mixed Up
 ×100 Amplifier Not applicable
Power On

NOTE

If the Type 1A4 is not being recalibrated but there is need for adjusting the GAIN control, use the procedure provided in the Operating Instructions section of this manual.

9. Adjust GAIN R379 ①

a. Equipment setup and the location of the GAIN adjustment are shown in Fig. 7-15. Connections made at completion of step 9c are also shown.

b. Set the Standard Amplitude Calibrator (item 5) for a 50 mV square-wave output. Front-panel control settings are given in the list that precedes step 9.

c. Connect the Standard Amplitude Calibrator output connector through a 42-inch 50 ohm cable and a dual-input connector (item 8) to the Type 1A4 Channel 1 and 2 Input connectors.

NOTE

Although the dual-input connector is not actually needed for this step, it does prepare the connections for use in step 10. Steps 9 and 10 should be performed together when calibrating the Type 1A4.

d. Using the Channel 1 POSITION control, position the bottom of the waveform to the lower edge of the graticule.

e. Rotate the GAIN control (R379, see Fig. 7-15) fully clockwise and note the amplitude.

f. Rotate the GAIN control fully counterclockwise and note the amplitude.

g. Calculate the electrical center amplitude as follows:

$$\text{Electrical Center Amplitude} = \frac{\text{Larger} - \text{Smaller}}{2} + \text{Smaller}$$

Using Fig. 7-16 as an example:

$$\text{Electrical Center Amplitude} = \frac{5.4 \text{ cm} - 4.6 \text{ cm}}{2} + 4.6 \text{ cm} = 5 \text{ cm}$$

h. ADJUST—GAIN control (R379) so the CRT display amplitude is the same as calculated in step 9g. This is the electrical center of the control. As a guide, Fig. 7-16 shows a triple exposure of the waveform displays similar to those that could be obtained when performing steps 9d, 9e and 9h.

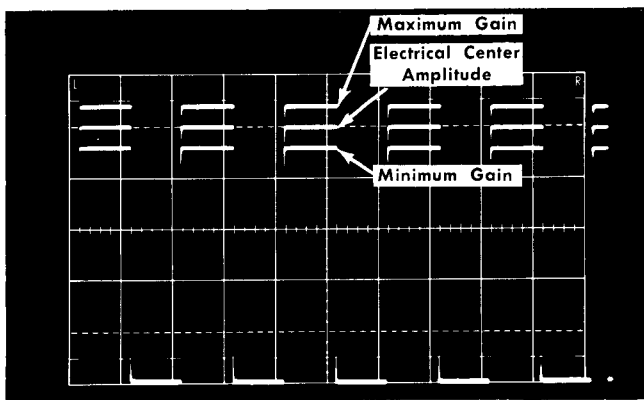


Fig. 7-16. Triple exposure of waveforms showing how to set the GAIN adjustment to electrical center. Sweep rate: 0.5 ms/cm.

NOTE

As a fast but less accurate method, set the GAIN control to midrange.

i. INTERACTION—Perform step 10.

10. Adjust Preamp Gain R77 ①

a. Test equipment setup and connections are the same as shown in Fig. 7-15.

If it is necessary to check the unchanged control settings, refer to the list that precedes step 9.

b. Using the Channel 1 POSITION control, center the display within the graticule area.

c. CHECK—With 50 mV applied to Channel 1 check the CRT display for an amplitude of exactly 5 cm (see Fig. 7-17A).

d. Lay the oscilloscope on its right side.

e. ADJUST—Channel 1 PREAMP GAIN control R77 (see Fig. 7-17B) for exactly 5 cm of deflection.

f. Set the controls as follows:

Type 1A4

INVERT (Ch 1)	Pulled outward
Ch 1 & 2 MODE	ADD

Type 547 Oscilloscope

Triggering Level	Fully CW
Time/Cm	.1 mSec

g. Set the Amplitude switch on the Standard Amplitude Calibrator to 0.1 Volt. Use the Type 1A4 Channel 1 POSITION control to center the display.

h. CHECK—CRT free-running display for a null indication (superimposed traces) within an amplitude of 0.5 mm. See Fig. 7-17C for a typical display. (Accuracy = $\pm 0.5\% \times 100 \text{ mV} = \pm 0.5 \text{ mV}$ or $\pm 0.5 \text{ mm}$.)

NOTE

Accuracy with $\pm 0.5\%$ is used in this procedure to assure that added accuracy within $\pm 1\%$ will be obtained when checking the pairs of channels in step 11.

i. Repeat steps 10h and 10i except adjust Channel 3 PRE-AMP GAIN control R77 (see Fig. 7-17B) to obtain a null indication with respect to the Channel 1 signal.

j. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	ADD

k. Apply the 0.1 V signal through the dual-input connector to Channel 1 and 3 Input connectors.

l. Repeat steps 10h and 10i except adjust Channel 3 PRE-AMP GAIN control R77 (see Fig. 7-17B) to obtain a null indication with respect to the Channel 1 signal.

m. Set the Ch 3 & 4 MODE switch to CHANNEL 4.

n. Apply the 0.1 V signal through the dual-input connector to Channel 1 and 4 Input connectors.

11. Check Added Accuracy

a. Test equipment used in this setup is the same as shown in Fig. 7-15. Set the oscilloscope in the upright position.

b. Apply the 0.1 V signal from the Standard Amplitude Calibrator through the 42-inch 50-ohm cable and dual-input connector to the Channel 3 and 4 Input connectors.

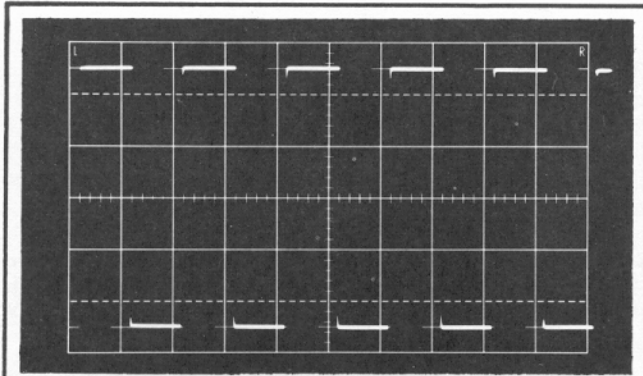
c. Set the Type 1A4 controls as follows:

INVERT (Ch 1)	Pushed in
INVERT (Ch 3)	Pulled outward
Ch 3 & 4 MODE	ADD
DISPLAY	3 & 4

If the settings of the remaining unchanged controls need to be checked for this procedure, refer to the list that precedes step 9 with these exceptions: The oscilloscope Triggering Level control is set fully clockwise to free-run the sweep, the Time/Cm switch is set to .1 mSec and the Amplitude switch on the Standard Amplitude Calibrator is set to 0.1 Volt.

d. Use the Channel 3 or 4 POSITION controls to center the free-running display.

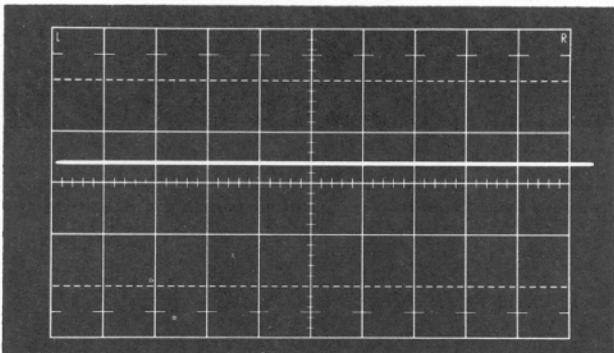
e. CHECK—CRT free-running display for a null indication within an amplitude of 1 mm (see Fig. 7-18). (Accuracy = $\pm 1\% \times 100 \text{ mV} = \pm 1 \text{ mV}$ or $\pm 1 \text{ mm}$.)



(A) Checking Channel 1 preamplifier gain. Sweep rate: 0.5 ms/cm.



(B) Location of the PREAMP GAIN adjustments R77 for each channel. Bottom center-portion view; securing rod removed.



(C) Checking for a null indication. Sweep rate: 0.1 ms/cm free running.

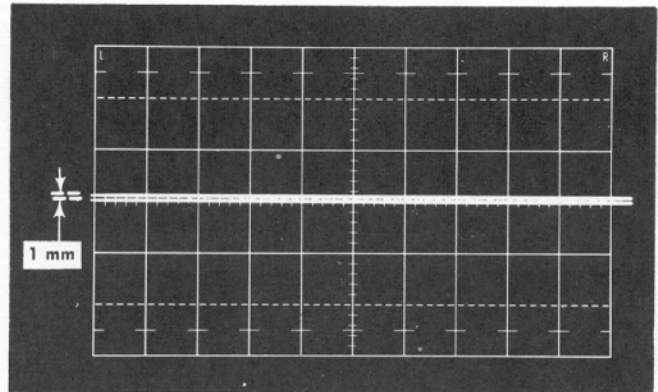


Fig. 7-18. CRT display showing maximum allowable amplitude when checking added accuracy in step 11. Sweep rate: 0.1 ms/cm free running.

f. Set the Type 1A4 controls as follows:

INVERT (Ch 2)	Pulled outward
INVERT (Ch 3)	Pushed in
Ch 1 & 2 MODE	CHANNEL 2
DISPLAY	ADD

g. Using Table 7-3 and steps 11d through 11e as a guide, check added accuracy between the remaining pairs of channels. When using step 11d as a guide, use the applicable POSITION controls to center the display.

TABLE 7-3

Apply 0.1 V Signal to:	Ch 3 & 4 MODE Switch	Check
Inputs 2 & 4	CHANNEL 4	Repeat step 11e
Inputs 2 & 3	CHANNEL 3	Repeat step 11e

Fig. 7-17. Step 10 waveform displays and adjustment locations.

o. Repeat steps 10h and 10i except adjust Channel 4 PREAMP GAIN control R77 (see Fig. 7-17B) to obtain a null indication with respect to the Channel 1 signal.

p. INTERACTION—Step 9 should always be performed first before proceeding with step 10.

12. Check Variable Volts/Cm Range

- a. Test equipment is the same as shown in Fig. 7-15.
- b. Set the Amplitude switch on the Standard Amplitude Calibrator to 50 mV. Remove the dual-input connector and apply the square-wave signal to the Channel 1 Input connector.

c. Set the controls as follows:

Type 1A4	
INVERT (Ch 2)	Pushed in
Ch 1 & 2 MODE	CHANNEL 1
DISPLAY	1 & 2

Type 547 Oscilloscope	
Triggering Level	Near 0
Time/Cm	.5 mSec

If it is necessary to check on the settings of the remaining unchanged controls at this point in the procedure, refer to the list that precedes step 9.

- d. Using the Channel 1 POSITION control, center the display within the graticule area. The display should be 5 cm in amplitude with the Channel 1 VARIABLE (V/CM) control set to CAL.
- e. CHECK—Slowly rotate the Channel 1 VARIABLE control to its fully counterclockwise position but not into the CAL detent position. Check for smooth electrical operation and that the amplitude is reduced to 2 cm or less (see Fig. 7-19). This indicates the ratio is 2.5:1 or more.
- f. Set Channel 1 VARIABLE control into the CAL detent position.
- g. Set Ch 1 & 2 MODE switch to CHANNEL 2.
- h. Using Table 7-4 and steps 12d through 12f as a guide, check the VARIABLE (V/CM) controls for the other channels.

TABLE 7-4

Apply 50 mV Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Check VARIABLE Control for:
Input 2	CHANNEL 3	1 & 2	Channel 2
Input 3	CHANNEL 3	3 & 4	Channel 3
Input 4	CHANNEL 4	3 & 4	Channel 4

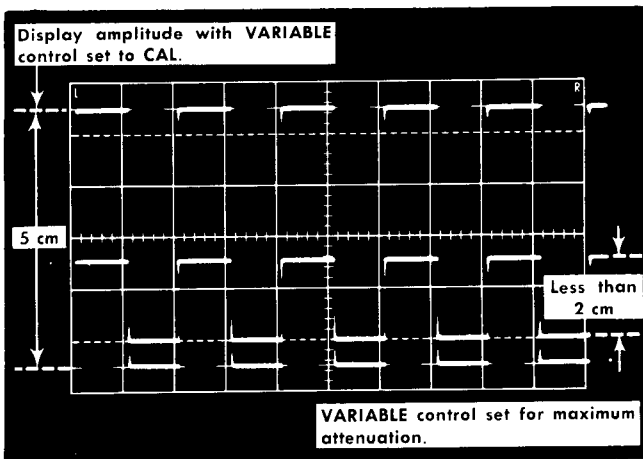


Fig. 7-19. Typical CRT display showing VARIABLE (V/CM) control range (double exposure photograph). Sweep rate is 0.5 ms/cm.

13. Check AC Input Coupling

- a. Test equipment setup is the same as shown in Fig. 7-15.

At this point in the procedure the connections should be as follows: The signal is applied from the Standard Amplitude Calibrator through a coaxial cable to the channel 4 Input connector. (The dual-input connector is not used.) If the Type 1A4 and oscilloscope front-panel control settings need to be checked, the positions are the same as those given in the list that precedes step 9 except as follows: POSITION controls are set slightly counterclockwise from midrange, Ch 1 & 2 MODE switch is set to CHANNEL 2, Ch 3 & 4 MODE switch is set to CHANNEL 4 and the DISPLAY switch is set to 3 & 4.

- b. Set the Standard Amplitude Calibrator for a 20 mV square-wave output signal.
- c. Adjust the oscilloscope Triggering Level control to obtain a stable display.
- d. Using the Channel 4 POSITION control, position the bottom of the waveform display to graticule center.
- e. Set Channel 4 AC-GND-DC switch to AC.
- f. CHECK—The waveform should drift downward about one cm to its average AC level.
- g. Set Ch 3 & 4 MODE switch to CHANNEL 3.
- h. Using Table 7-5 and steps 13d through 13f as a guide, check the AC input coupling circuit for the remaining channels.

NOTE

When repeating a procedure to check the channels listed in a table, use controls that apply for the channel(s) being checked. For example, when repeating step 13d for Channel 3 in Table 7-5, use the Channel 3 POSITION control to position the display.

TABLE 7-5

Apply 20 mV Signal to:	Ch 1 & 2 MODE Switch	DISPLAY Switch	Procedure
Input 3	CHANNEL 2	3 & 4	Steps 13d and 13f
Input 2	CHANNEL 2	1 & 2	Steps 13d and 13f
Input 1	CHANNEL 1	1 & 2	Steps 13d and 13f

- i. Set the AC-GND-DC switches (all channels) to DC.

14. Check Volts/Cm Deflection Accuracy

- a. Test equipment setup is the same as shown in Fig. 7-15. The cable connections should be as follows: The signal from the Standard Amplitude Calibrator is applied through a coaxial cable to the Type 1A4 Channel 1 Input connector. (The dual-input connector is not used.)

If it is necessary to check the Type 1A4 and oscilloscope front-panel control settings, refer to the list that precedes step 9.

- b. CHECK—Using the Channel 1 V/CM switch and Standard Amplitude Calibrator settings given in Table 7-6, check vertical deflection within $\pm 3\%$ in each position of the Channel 1 V/CM switch.

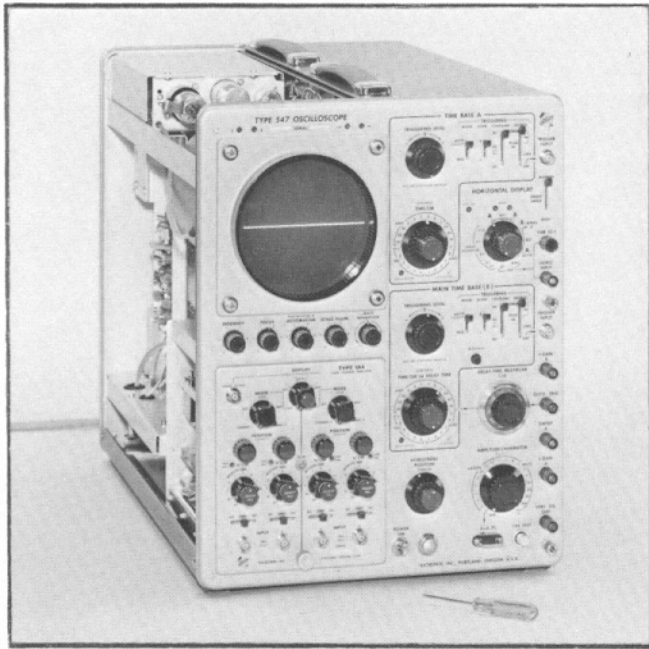


Fig. 7-20. Equipment setup for steps 15 through 18.

Control Settings

Type 1A4

All Channels

AC-GND-DC	GND
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Midrange

Other controls

Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK

Type 547 Oscilloscope

A Triggering controls

Triggering Level	Fully CW and knob pushed in
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int

Time Base A controls

Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On

15. Adjust Variable Balance (R60 Final Adjustment) ①

- a. Equipment setup is shown in Fig. 7-20.
- b. CHECK—Rotate the Channel 1 VARIABLE control through its range. Trace should not move vertically.
- c. ADJUST—Channel 1 VAR BAL (see Fig. 7-21) for no trace shift as the Channel 1 VARIABLE control is rotated back and forth through its range. Return the VARIABLE control to the CAL position.
- d. Set Ch 1 & 2 MODE switch to CHANNEL 2.
- e. Use Table 7-8 and steps 15b through 15c as a guide for checking and adjusting the VAR BAL controls for the remaining channels. After completing the procedure for each channel, return the VARIABLE control for each channel to the CAL position.

TABLE 7-8

Ch 3 & 4 MODE Switch	DISPLAY Switch	Adjustment (see Fig. 7-21)
CHANNEL 3	1 & 2	Ch 2 VAR BAL
CHANNEL 3	3 & 4	Ch 3 VAR BAL
CHANNEL 4	3 & 4	Ch 4 VAR BAL

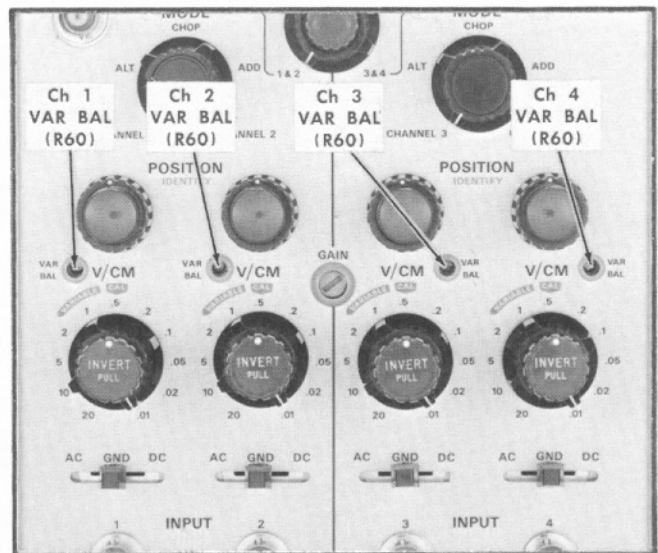


Fig. 7-21. Location of the VAR BAL adjustments.

16. Adjust Trigger Selector DC Balance ①

- a. Equipment setup is the same as shown in Fig. 7-20.
- b. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	2

If it is necessary to check the remaining front-panel control settings, refer to the list that precedes step 15.

- c. Using the Channel 1 POSITION control, position the trace to graticule center for use as a reference.

- d. Set the SIGNAL & TRIGGER SOURCE switch to 1.

- e. CHECK—That the trace shift with respect to graticule center is equal to or less than 2 mm.

f. ADJUST—Ch 1 TRIG SELECTOR BAL control R55 (see Fig. 7-22) to position the trace to graticule center. A check on the adjustment can be made by placing the SIGNAL & TRIGGER SOURCE switch to 2 and then back to 1. The trace should be at the same location for both positions of the switch.

- g. Set the Ch 1 & 2 MODE switch to CHANNEL 2.

h. Use Table 7-9 and steps 16e through 16f as a guide for checking and adjusting the TRIG SELECTOR BAL controls (R56, R57 and R58) for the remaining channels. Locations of the adjustments are shown in Fig. 7-22.

TABLE 7-9

Ch 3 & 4 MODE Switch	DISPLAY Switch	SIGNAL & TRIGGER SOURCE Switch (with a procedure)
CHANNEL 3	1 & 2	Set to 1, position trace to graticule center using Ch 2 POSITION control. Set to 2, repeat steps 16e through 16f except adjustment is R56.
CHANNEL 3	3 & 4	Set to 2, position trace to graticule center using Ch 3 POSITION control. Set to 3, repeat steps 16e through 16f except adjustment is R57.
CHANNEL 4	3 & 4	Set to 3, position trace to graticule center using Ch 4 POSITION control. Set to 4, repeat steps 16e through 16f except adjustment is R58.

- i. INTERACTION: Step 15 should always be performed first.

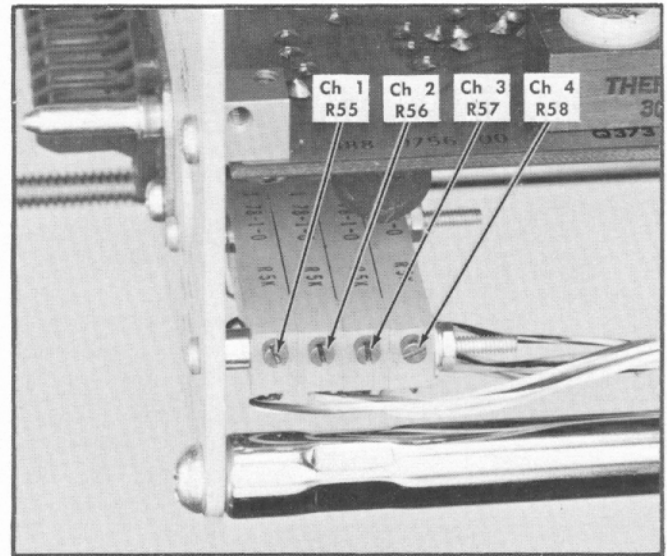


Fig. 7-22. Location of the TRIGGER SELECTOR BAL adjustments for each channel. Left side rear view.

17. Check Normal-Invert DC Balance

- a. Equipment setup is the same as shown in Fig. 7-20.
- b. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	CHANNEL 1
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1

If it is necessary to check the unchanged positions of the remaining front-panel controls, refer to the list that precedes step 15.

- c. Using Channel 1 POSITION control, position the trace to graticule center for use as a reference.

- d. Pull the front-panel Channel 1 INVERT knob to its outward position.

- e. CHECK—Trace should be located one cm or less with respect to graticule center.

f. INTERACTION: This check, including the checks that are made for the remaining channels, are valid only if step 15 is properly performed.

- g. Push the Channel 1 INVERT knob to its inward position.

- h. Set the Ch 1 & 2 MODE switch to CHANNEL 2.

i. Use Table 7-10 and steps 17c through 17g as a guide for checking trace shift when the appropriate front-panel INVERT knob is pulled to its outward position.

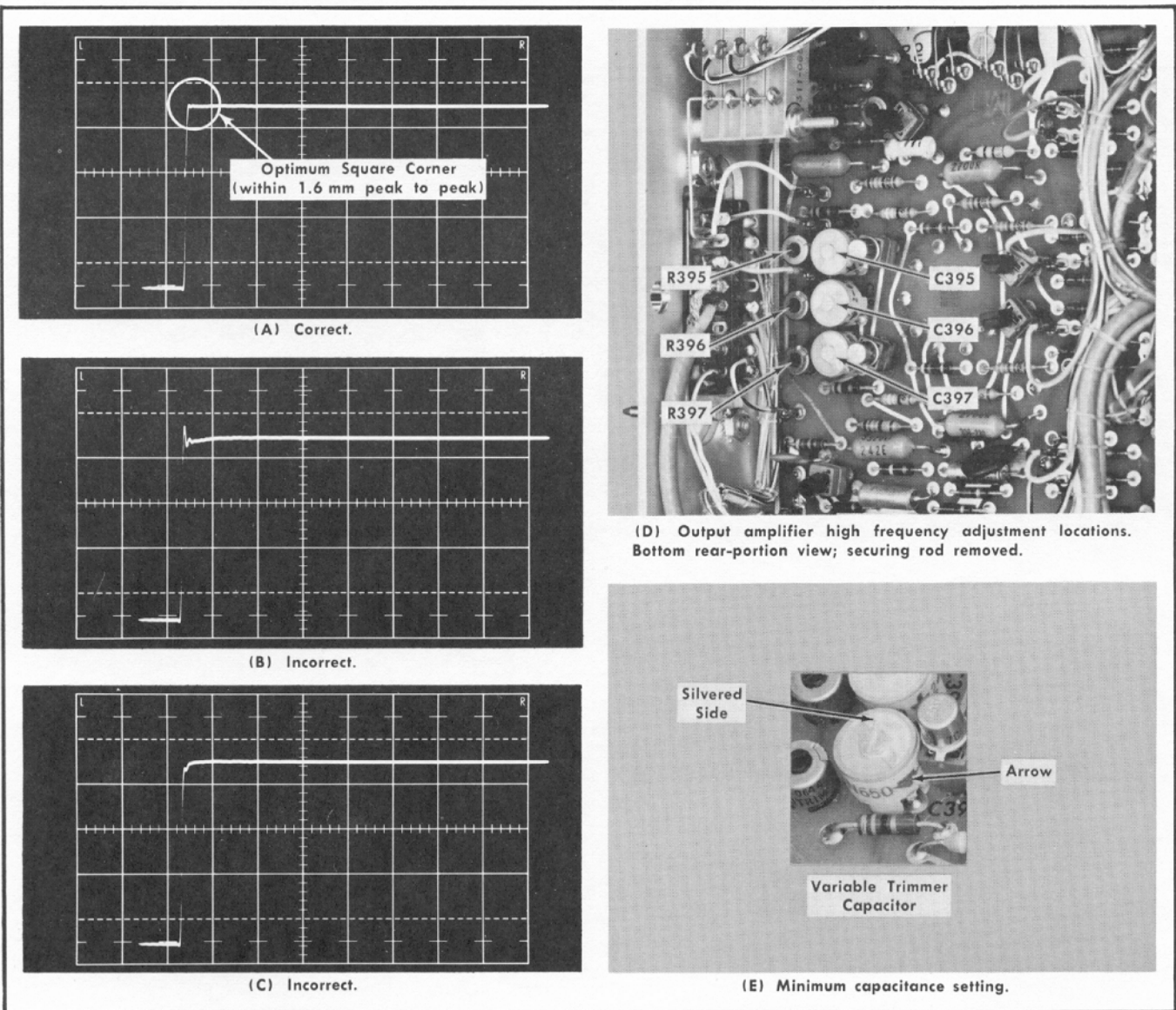


Fig. 7-24. Fast-rise waveforms obtained at a sweep rate of $0.1 \mu\text{s}/\text{cm}$ and adjustment illustrations for step 19.

19. Adjust Output Amplifier High-Frequency Compensation

- a. Test equipment setup, with connections made at completion of step 19d, is shown in Fig. 7-23.
- b. Lay the Type 547 Oscilloscope on its right side.
- c. Turn on the Type 106 Square-Wave Generator and set the controls as given in the list that precedes step 19.
- d. Apply the 100 kHz fast-rise signal from the +Output connector on the Type 106 through a $2\times$ attenuator (item 11), a 5-ns cable (item 18), and a 50-ohm in-line termination to the Type 1A4 Channel 1 Input connector (see Fig. 7-23).
- e. Set the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. Set the Symmetry control to obtain a symmetrical (50% duty factor) waveform and, if necessary, adjust the Multiplier control to obtain the 100

kHz output repetition rate. Use the Type 1A4 Channel 1 POSITION control to center the display.

- f. Set the oscilloscope Time/Cm switch to $.1 \mu\text{Sec}$.

g. Use the oscilloscope Horizontal Position control to position the rising portion of the waveform about 2.5 cm to the right of the 0-cm graticule line. Use the Type 1A4 Channel 1 POSITION control to position the top leading corner of the waveform about 1.5 cm above the graticule horizontal center-line (see Fig. 7-24A).

h. CHECK—CRT display for optimum square corner (see Fig. 7-24A). Ringing, rounding, overshoot and tilt can be adjusted to less than 1.6 mm (or 4%) peak to peak when a 4-cm positive-going square wave is displayed. High-frequency adjustments in the oscilloscope vertical amplifier will affect the aberrations on the displayed waveform. Figs. 7-24B and 7-24C show two examples of incorrect displays.

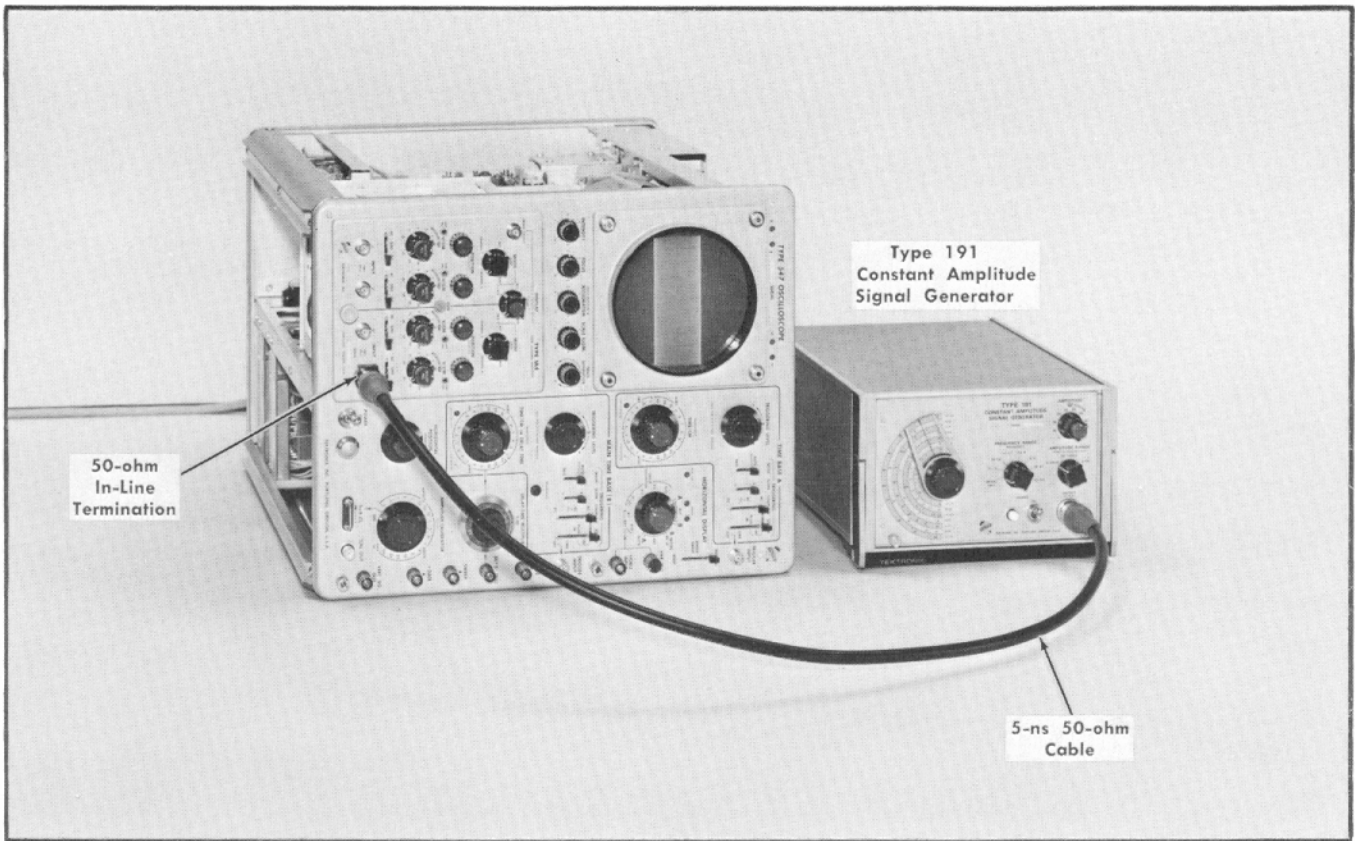


Fig. 7-25. Test equipment setup for step 20.

Control Settings

	Type 1A4
All Channels	
AC-GND-DC	DC
V/CM	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Midrange
Other controls	
Ch 1 & 2 MODE	CHANNEL 2
Ch 3 & 4 MODE	CHANNEL 4
DISPLAY	3 & 4
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK
	Type 547 Oscilloscope
A Triggering controls	
Triggering Level	Fully CW and knob pulled outward
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int

Time Base A controls

Time/Cm 50 μ Sec
Variable (Time/Cm) Calibrated

Other controls

Horizontal Display A
Sweep Magnifier $\times 1$ Off
Single Sweep switch Normal
Horizontal Position and Vernier Set so trace starts at left edge of graticule
CRT Cathode Selector External CRT Cathode
Power On

Type 191 Constant Amplitude Signal Generator

Frequency dial 45 MHz
Frequency Range 50 kHz Only
Amplitude 40
Variable CAL
Amplitude Range 5-50 mV
Power On

20. Check Output Amplifier High-Frequency Response

a. Test equipment setup, with connections made at completion of step 20c, is shown in Fig. 7-25.

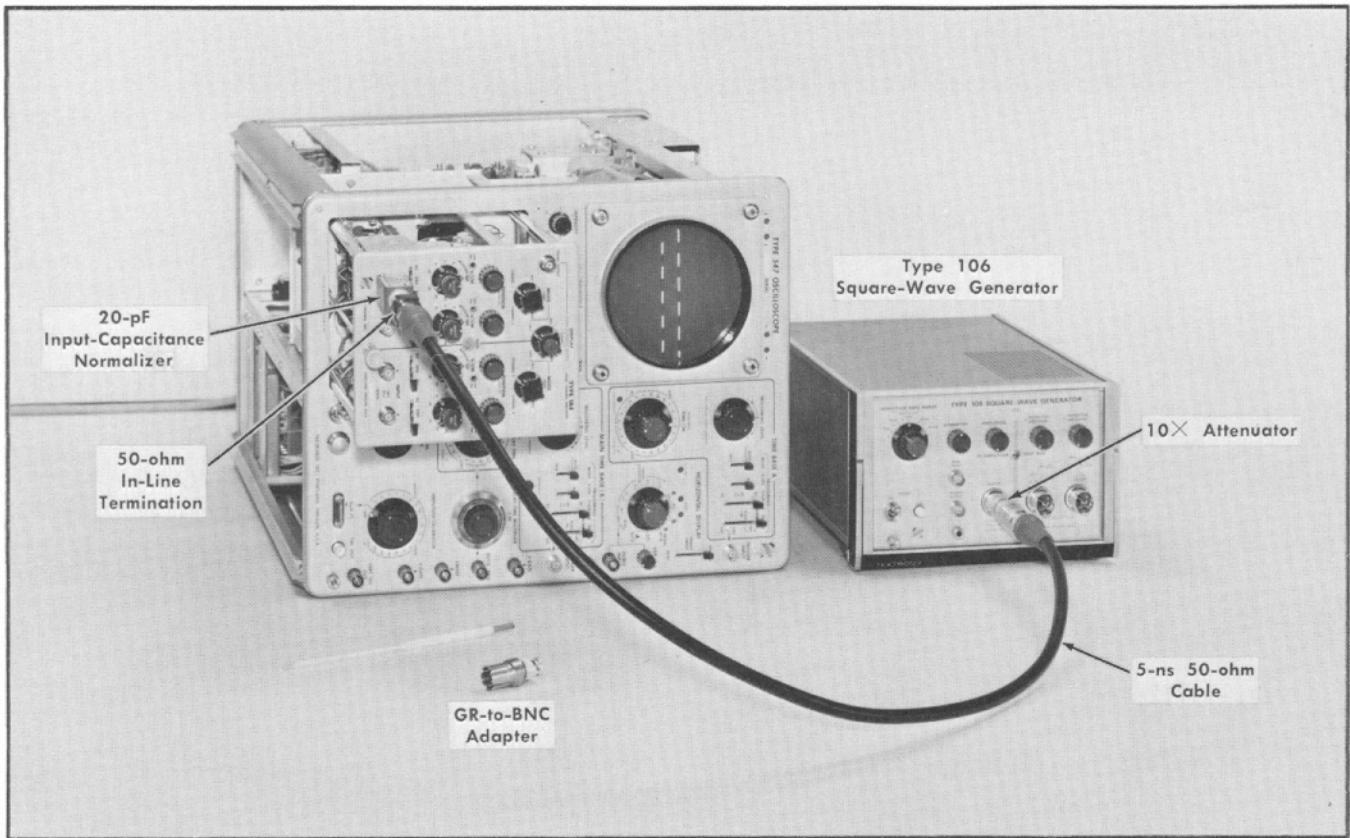


Fig. 7-27. Test equipment setup for step 21.

Control Settings

	Type 1A4	
All Channels	DC	
AC-GND-DC	.01	
V/CM	CAL	
VARIABLE	Pushed in	
INVERT	Midrange	
POSITION		
Other controls		
Ch 1 & 2 MODE	CHANNEL 1	
Ch 3 & 4 MODE	CHANNEL 3	
DISPLAY	1 & 2	
SIGNAL & TRIGGER SOURCE	1	
547 TRACE SLAVING (rear panel)	LOCK	
	Type 547 Oscilloscope	
A Triggering controls		
Triggering Level	Near 0 and knob pushed in	
Mode	Auto Stability	
Slope	+	
Coupling	AC	
Source	Norm Int	

Time Base A controls

Time/Cm	.5 mSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On

Type 106 Square-Wave Generator

Repetition Rate Range	1 kHz
Multiplier	Less than 1
Symmetry	Midrange
Amplitude	Fully CCW
Hi Amplitude Fast Rise Switch	Hi Amplitude
Fast Rise controls	Not applicable
Power	On

21. Adjust Input Capacitance and Attenuator Compensation ①

a. Test equipment setup, with connections made at completion of step 21d, is shown in Fig. 7-27.

b. Remove the Type 1A4 from the oscilloscope and insert the 6½-inch plug-in extension (item 15) between the Type 1A4 and the oscilloscope.

NOTE

Be sure to pull the plug-in sensing switch in the oscilloscope to its outward position before connecting the Type 1A4 to the rigid extension.

c. Set the Type 106 Square-Wave Generator controls to the positions given in the list that precedes step 21.

d. Apply the 1 kHz signal from the Type 106 high amplitude output connector through a 10× attenuator (item 12), 5-ns coaxial cable, 50-ohm in-line termination and a 20 pF input-capacitance normalizer (item 9) to the Channel 1 Input connector (see Fig. 7-27).

NOTE

If a 20 pF input-capacitance normalizer is not readily available and at least one channel is known to be in proper adjustment, an alternate method using a 10× attenuator probe is provided in the last portion of this procedure.

e. Set the Type 106 Amplitude control to produce a display 4 cm in amplitude.

f. Set the oscilloscope Triggering Level control, if necessary, to obtain a stable display and use the Type 1A4 Channel 1 POSITION control to center the display.

g. Set the Type 106 Symmetry control for a 50% duty factor waveform and, if necessary, adjust the Multiplier control to obtain the 1 kHz output repetition rate.

h. CHECK—The waveform should have a flat top similar to the illustration shown in Fig. 7-28A. Aberrations should not exceed 1% peak to peak (or 0.4 mm peak to peak on a 4 cm waveform). Using Table 7-14 as a guide, check the waveform for a square corner and flat top in all the other positions of the Channel 1 V/CM switch. Maintain a 4 cm display amplitude except for the 20 V/CM position.

i. ADJUST—Channel 1 input capacitance and attenuator adjustments listed in Table 7-14 for optimum square corner and flat top (see Fig. 7-28A). Readjust the generator output with each setting of the Channel 1 V/CM switch to obtain 4 cm of deflection. Remove the 10× attenuator and the 50-ohm termination when necessary to obtain more signal drive. In the 2 V/CM position, replace the 50-ohm termination with a GR-to-BNC adapter (item 13). In the 20 V/CM switch position, maximum generator output produces only about 3 cm display amplitude. Fig. 7-28F shows the location of the adjustments. Waveforms shown in Figs. 7-28B through 7-28E show effects obtained when the adjustments are misadjusted.

j. After completing the check and adjustment procedure for Channel 1, set the Type 106 for minimum output amplitude and disconnect the signal.

k. Set Ch 1 & 2 MODE switch to CHANNEL 2.

l. Using Table 7-14 and steps 19d through 19j as a guide, check and adjust the input capacitance and attenuator compensation adjustments for the remaining channels. Refer to Table 7-15 for a list of the Ch 3 & 4 MODE and DISPLAY switch positions.

TABLE 7-15

Apply Type 106 Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	Repeat Procedure (steps 19d through 19j) for:
Input 2	CHANNEL 3	1 & 2	Channel 2
Input 3	CHANNEL 3	3 & 4	Channel 3
Input 4	CHANNEL 4	3 & 4	Channel 4

TABLE 7-14

V/CM Switch	Use 10× Atten	Use 50 Ω Term	Use GR-to-BNC Adapter	Use RC Norm	Adjust for Optimum	
					Square Corner	Flat Top
.01	X	X		X		C26
.02	X	X		X	C32	C31
.05	X	X		X	C39	C38
.1	X	X		X	C6A	C5
.2		X		X	Check ²	Check ²
.5		X		X	Check ²	Check ²
1		X		X	C12A	C11
2			X	X	Check ²	Check ²
5			X	X	Check ²	Check ²
10			X	X	C19A	C18
20			X	X	Check ²	Check ²

²If necessary, make compromise adjustments to bring the waveform aberrations within the 1% peak-to-peak tolerance requirement. Use the adjustment that precedes the "Check". For example, to minimize the front corner aberration in the .5 V/CM position, slightly readjust C6A; recheck .2 and .1 positions to determine whether the waveforms for these positions are within tolerance.

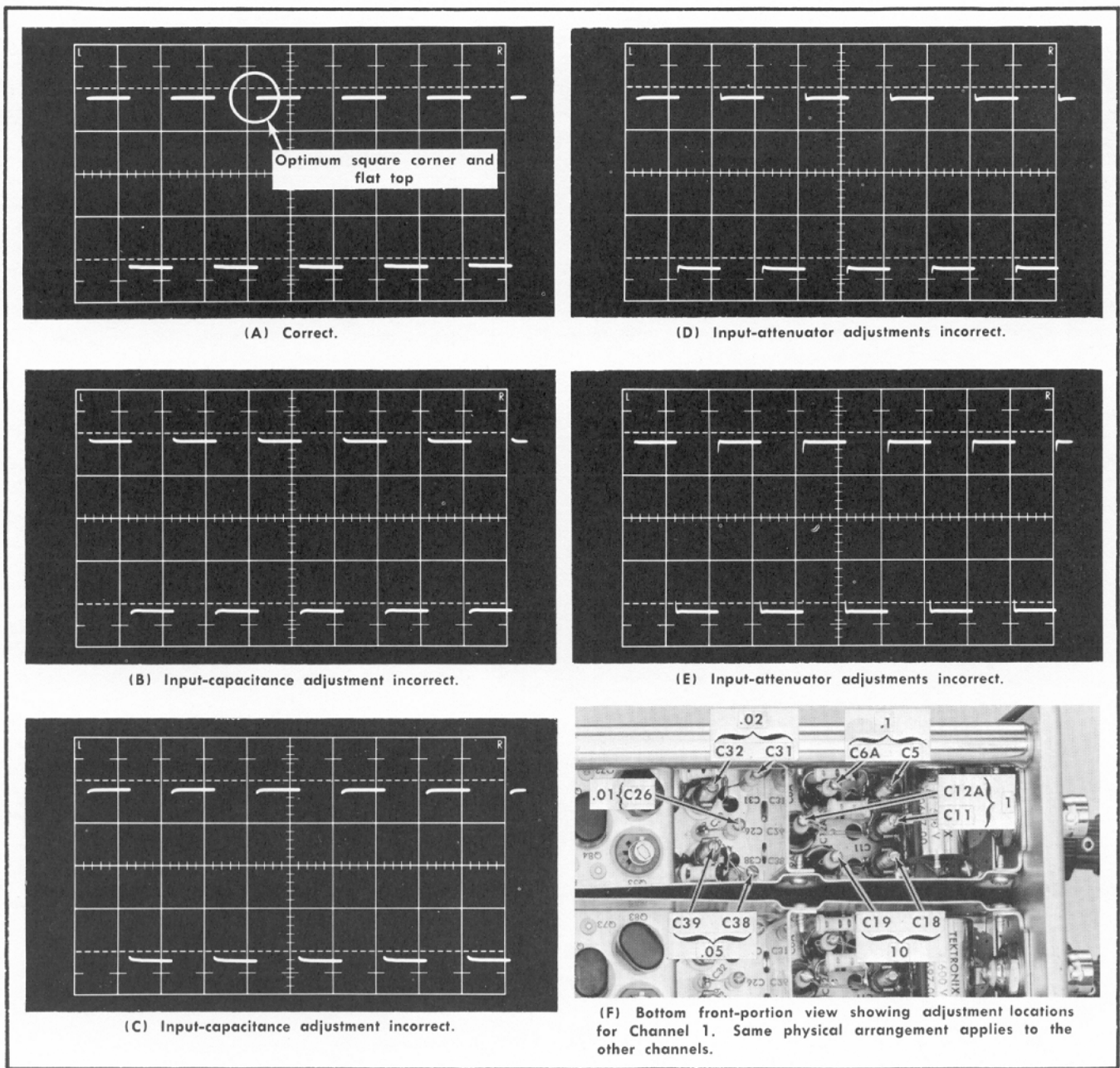


Fig. 7-28. Waveform and adjustment locations for step 21. Sweep rate for the waveforms is 0.5 ms/cm.

m. Check that the Type 106 Square-Wave Generator is disconnected from the Type 1A4.

n. Place the oscilloscope in the upright position.

Alternate Method

If a normalizer is not available, the input capacitance of one or more channels can be adjusted by using a 10X attenuator probe and a known properly-adjusted channel. To use a 10X probe in place of a normalizer, proceed as follows:

a. Connect the cable end of the 10X probe to a channel

that is properly adjusted. This channel will be used as the reference.

b. Set the V/CM switch of the reference channel to .01 and the AC-GND-DC switch to DC. (As a guide for setting the remaining controls, use the list that precedes step 21.)

c. Connect a 2X attenuator (item 11) to the output connector of the Type 106 Square-Wave Generator.

d. Connect the probe tip to the other end of the 2X attenuator and connect the probe ground lead to the generator ground. Adjust the generator Amplitude control to produce 4 cm of deflection on the oscilloscope CRT.

e. Adjust the probe compensation for best response to the square-wave signal.

The probe is now adjusted to match the input time constant of the reference channel. Do not adjust the probe further during the procedure that follows.

Disconnect the cable end of the probe from the reference channel and connect it to the channel that needs to be normalized. With the signal applied to the probe tip, the adjustments listed in step 21i and Table 7-14 can be performed in the same manner as if a 20 pF input time-constant normalizer were used.

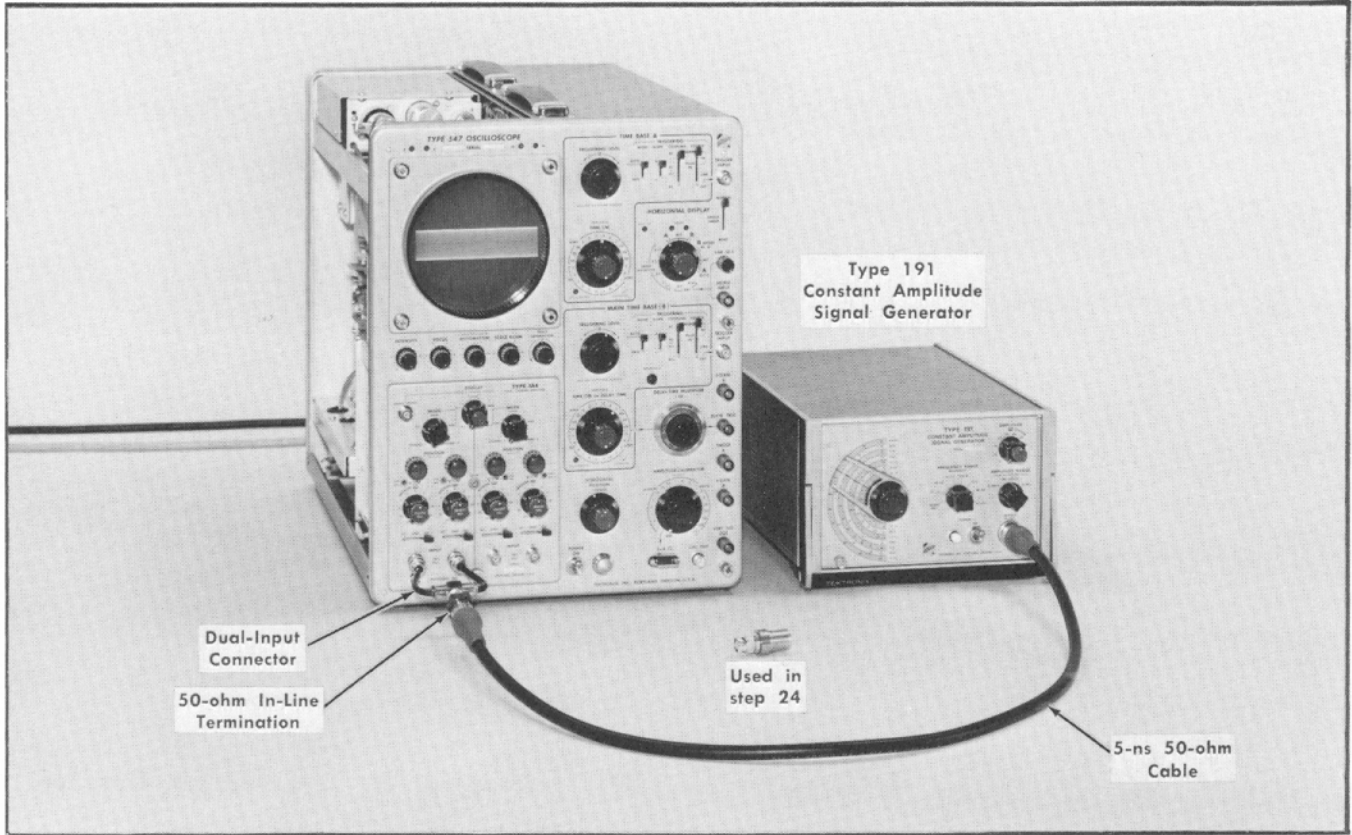


Fig. 7-29. Test equipment setup for steps 22 through 24.

Control Settings

	Type 1A4	Type 547 Oscilloscope	
All Channels		A triggering controls	
AC-GND-DC	DC	Triggering Level	Fully CW and knob pul- led outward
V/CM	.02	Mode	Auto Stability
VARIABLE	CAL	Slope	+
INVERT	Pushed in	Coupling	AC
POSITION	Midrange	Source	Norm Int
Other controls		Time Base A controls	
Ch 1 & 2 MODE	ALT	Time/Cm	.5 mSec
Ch 3 & 4 MODE	CHANNEL 3	Variable (Time/Cm)	Calibrated
DISPLAY	1 & 2	Other controls	
SIGNAL & TRIGGER SOURCE	1	Horizontal Display	A
547 TRACE SLAVING (rear panel)	LOCK	Sweep Magnifier	×1 Off
		Single Sweep switch	Normal

Calibration—Type 1A4

Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On

Type 191 Constant Amplitude Signal Generator

Frequency dial	10 MHz
Frequency Range	8-18
Amplitude	5
Variable	CAL
Amplitude Range	50-500-mV
Power	On

22. Check Common-Mode Rejection Ratio

a. Test equipment setup, with connections made at completion of step 22c, is shown in Fig. 7-29.

b. Set the Type 191 Constant Amplitude Signal Generator controls to the settings given in the list that precedes step 22.

c. Apply the 10-MHz signal from the Type 191 Output connector through a 5-ns cable, a 50-ohm in-line termination and a dual-input connector to the Type 1A4 Channel 1 and 2 Input connectors (see Fig. 7-29).

d. Adjust the Type 191 Variable control so both waveforms (superimposed using the Channel 1 and 2 POSITION controls) are exactly 5 cm in amplitude (see Fig. 7-30A).

e. Set the Type 1A4 controls as follows:

INVERT (Ch 1)	Knob pulled outward
Ch 1 & 2 MODE	ADD
V/CM (Ch 1 & 2)	.01

f. CHECK—CRT display amplitude should be 5 mm or less to obtain a 20:1 (or greater) common-mode rejection ratio at 10 MHz (see Fig. 7-30B).

g. Using Table 7-16 and step 22f as a guide, check the common-mode rejection ratio for the remaining pairs of channels.

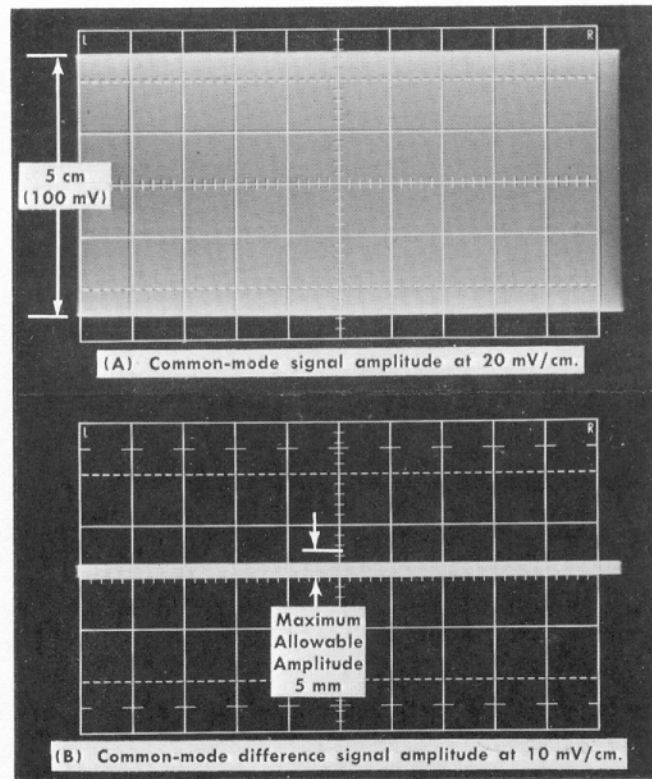


Fig. 7-30. Checking common-mode signal rejection at 10 MHz. Sweep rate is 0.5 ms/cm free running.

h. Remove the dual-input connector.

23. Check Amplifier Inter-Channel Isolation

a. Equipment required for this setup is shown in Fig. 7-29.

b. Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 2, 3, & 4)	GND
V/CM (Ch 1)	.02
INVERT (Ch 1, 2 & 3)	Knobs pushed in

TABLE 7-16

Apply Type 191 Signal to:	Preliminary Procedure	Final Procedure
Channel 2 and 3 Input connectors	V/CM (Ch 2): .02 Ch 1 & 2 MODE: CHANNEL 2 DISPLAY: ALT Adjust Type 191 Variable control for 5-cm display.	INVERT (Ch 2): Pulled outward DISPLAY: ADD V/CM (Ch 2 & 3): .01 Perform step 22f.
Channel 3 and 4 Input connectors	V/CM (Ch 3): .02 Ch 3 & 4 MODE: ALT DISPLAY: 3 & 4 Adjust Type 191 Variable control for 5-cm display.	INVERT (Ch 3): Pulled outward DISPLAY: ADD V/CM (Ch 3 & 4): .01 Perform step 22f.

Ch 1 & 2 MODE CHANNEL 1
 Ch 3 & 4 MODE CHANNEL 3
 DISPLAY 1 & 2

Type 191

Amplitude 50
 Amplitude Range .5-5 V

Type 191

Frequency dial 20 MHz
 Frequency Range 18-42
 Amplitude 10

If it is necessary to check the unchanged positions of the remaining controls, refer to the list that precedes step 22. Exceptions: V/CM (Ch 2, 3 and 4) should be set to .01.

c. Apply the 20 MHz signal from the Type 191 through a 5-ns cable and a 50-ohm in-line termination to the Channel 1 Input connector. (The dual-input connector is not used.)

d. Adjust the Type 191 Variable control to obtain a 6 cm display.

e. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE CHANNEL 2
 V/CM (Ch 1) .01

f. CHECK—Channel 2 CRT display amplitude should not exceed 2.4 mm. This is equivalent to $\geq 50:1$ isolation at 20 MHz.

g. Using Table 7-17 and step 23f as a guide, check the amplifier isolation between the remaining adjacent channels.

24. Check Attenuator Inter-Channel Isolation

a. Equipment required for this setup is the same as shown in Fig. 7-29.

b. Set the controls as follows:

Type 1A4

AC-GND-DC (Ch 4) DC
 V/CM (Ch 3) 2
 Ch 3 & 4 MODE CHANNEL 3

If it is necessary to check the unchanged positions of the remaining controls, refer to the list that precedes step 22. Exceptions: V/CM (Ch 1, 2 & 4) should be at .01, Ch 1 & 2 MODE switch should be set to CHANNEL 2, DISPLAY switch should be set to 3 & 4, Type 191 Frequency dial should be at 20 MHz and Frequency Range should be at 18-42.

c. Remove the 50-ohm in-line termination and apply the 20 MHz signal from the Type 191 through a 5-ns cable and a GR-to-BNC adapter (item 13) to the Type 1A4 Channel 3 Input connector.

d. Adjust the Type 191 Variable control for a 5 cm display.

e. Set the Ch 3 & 4 MODE switch to CHANNEL 4.

f. CHECK—Channel 4 CRT display amplitude should not exceed 2 mm. This is equivalent to $\geq 5000:1$ isolation at 20 MHz.

g. Using Table 7-18 and step 24f as a guide, check the attenuator isolation between the remaining adjacent channels.

TABLE 7-18

Preliminary Procedure	Final Procedure
V/CM (Ch 2): 2 DISPLAY: 1 & 2 Apply Type 191 signal to Channel 2 Input connector. Adjust Type 191 Variable control for 5 cm display.	DISPLAY: 3 & 4 V/CM (Ch 3): .01 Perform step 24f but check Channel 3 amplitude.
V/CM (Ch 1): 2 DISPLAY: 1 & 2 Ch 1 & 2: CHANNEL 1 Apply Type 191 signal to Channel 1 Input connector. Adjust Type 191 Variable control for 5 cm display.	Ch 1 & 2 MODE: CHANNEL 2 V/CM (Ch 2): .01 Perform step 24f but check Channel 2 amplitude.

h. Disconnect the Type 191 signal from the Channel 1 Input connector.

TABLE 7-17

Apply Type 191 Signal to:	Preliminary Procedure	Final Procedure
Input 2	AC-GND-DC (Ch 2): DC V/CM (Ch 2): .02 Adjust Type 191 Variable control for 6-cm display.	DISPLAY: 3 & 4 V/CM (Ch 2): .01 Perform step 23f but check Ch 3 amplitude.
Input 3	AC-GND-DC (Ch 3): DC V/CM (Ch 3): .02 Adjust Type 191 Variable control for 6-cm display.	Ch 3 & 4 MODE: CHANNEL 4 V/CM (Ch 3): .01 Perform step 23f but check Ch 4 amplitude.

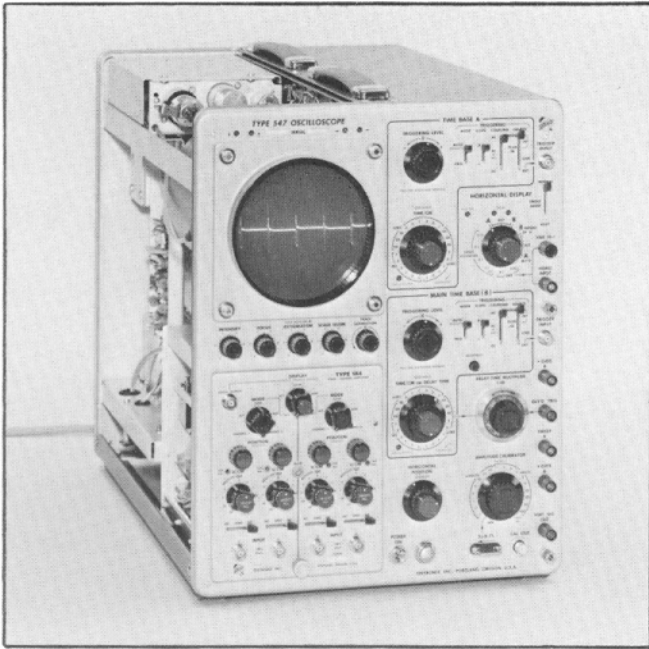


Fig. 7-31. Equipment setup for steps 25 and 26.

Control Settings

Type 1A4

All Channels	
AC-GND-DC	DC
V/CM (Ch 1)	.01
V/CM (Ch 2, 3 & 4)	.01
VARIABLE	CAL
INVERT	Pushed in
POSITION	Midrange

Other controls	
Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK

Type 547 Oscilloscope

A Triggering controls	
Triggering Level	Near 0 and knob pushed in
Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int

Time Base A controls

Time/Cm	1 μSec
Variable (Time/Cm)	Calibrated

Other controls

Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On

25. Check Chopped Mode Repetition Rate

- a. Equipment setup is shown in Fig. 7-31.
- b. Using Channel 1 and 2 POSITION controls, position the display so the graticule centerline can be used when measuring the horizontal distance of two successive segments (see Fig. 7-32A).

NOTE

For this procedure use the oscilloscope Triggering Level control to obtain a stable display. Use the Horizontal Position control for desired positioning of the display.

- c. CHECK—Two successive segments of the display should have a total time duration between 4.16 μs and 6.24 μs (4.16 cm to 6.24 cm, see Fig. 7-32A). This is equal to a chopped mode repetition rate of 480 kHz to 320 kHz (400 kHz, ±20%) using the formula:

$$\text{Chopping rate} = \frac{2}{\text{Time duration in } \mu\text{s for two segments}}$$

Using Fig. 7-32A as an example:

$$\text{Chopping rate} = \frac{2}{4.8 \mu\text{s}} = \frac{2}{4.8 \times 10^{-6}} = 417 \text{ kHz}$$

- d. Multiply 5% times the horizontal distance that was measured in step 25c. Add the product to the horizontal distance. This information will be needed when performing step 25f. (Using Fig. 7-32A as an example: 5% times 4.8 cm = 0.24 cm; 4.8 cm plus 0.24 cm = 5.04 cm.)

- e. Set the Type 1A4 controls as follows:

Ch 1 & 2 MODE	ADD
Ch 3 & 4 MODE	CHOP
DISPLAY	3 & 4

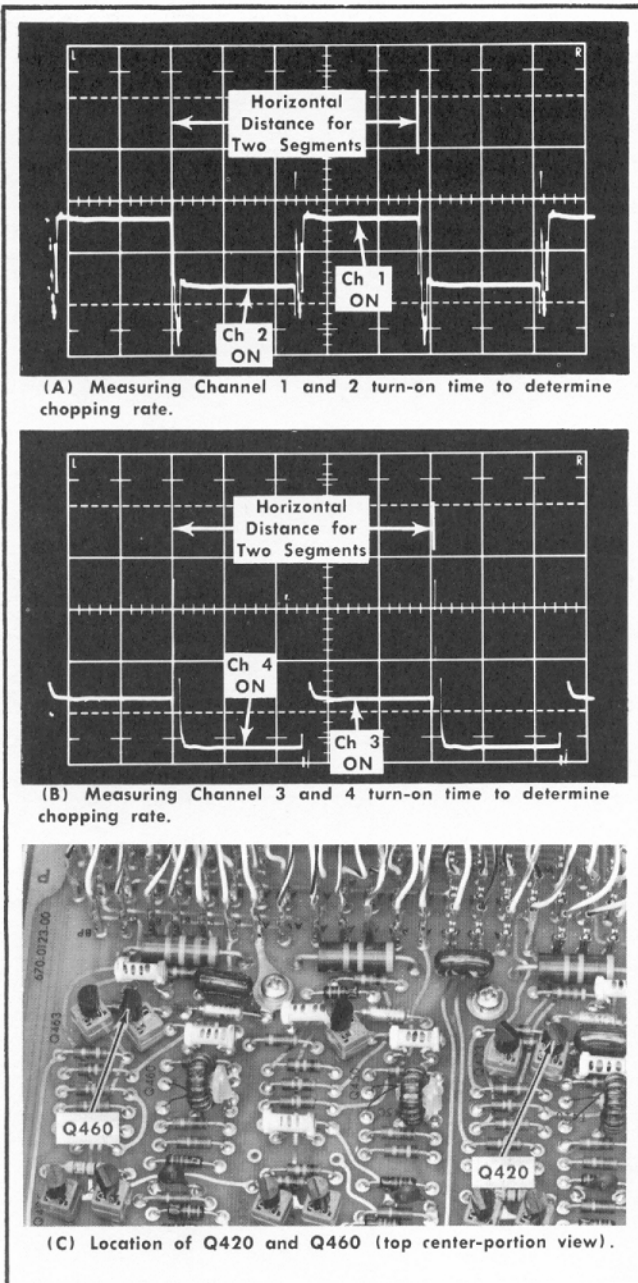


Fig. 7-32. Waveforms (A) and (B) are typical chopped-mode displays obtained at a sweep rate of $1 \mu\text{s}/\text{cm}$. Channel 3 & 4 repetition rate should be at least 5% slower than Channel 1 & 2 repetition rate. If not, interchange transistors Q420 and Q460 shown in (C).

f. CHECK—Using steps 25 b through 25c and Fig. 7-32B as a guide, check the Channel 3 and 4 chopped-mode display horizontal distance for two successive segments. This distance should be equal to or greater than the distance calculated in step 25 d but not greater than 6.24 cm.

NOTE

The purpose of this check is to determine that Channel 3 & 4 chopping rate is at least 5% slower

than the chopping rate of Channel 1 & 2. This rate difference prevents any tendency for the Type 1A4 to stop chopping (lock up) in these modes: Four channels chopping; 1 & 2 chopping added to 3 & 4 chopping. If Channel 3 & 4 rate is not 5% slower, interchange transistors Q420 and Q460 located on the Logic board (see Fig. 7-32C).

g. Set the Type 1A4 controls as follows:

Ch 3 & 4 MODE	ADD
DISPLAY	CHOP

h. Using steps 25b through 25c as a guide, check the chopped-mode display horizontal distance for two successive segments. The distance should be between 4.16 cm and 6.24 cm.

26. Check Chopped Mode Blanking

a. Equipment required for this setup is the same as shown in Fig. 7-31.

b. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	CHOP

Type 547 Oscilloscope

Coupling	AC LF Rej
Time/Cm	$2 \mu\text{Sec}$

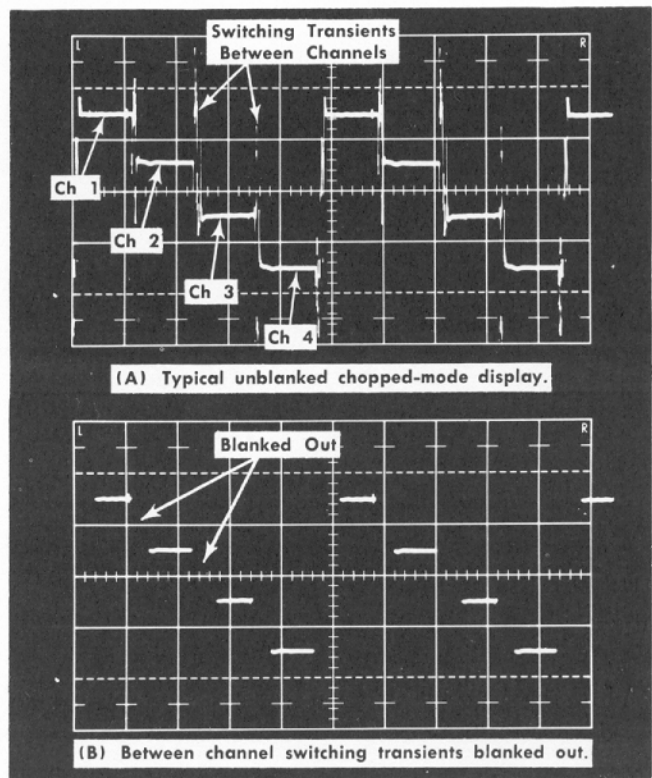


Fig. 7-33. Checking for proper chopped-mode blanking at normal intensity. Sweep rate is $2 \mu\text{s}/\text{cm}$.

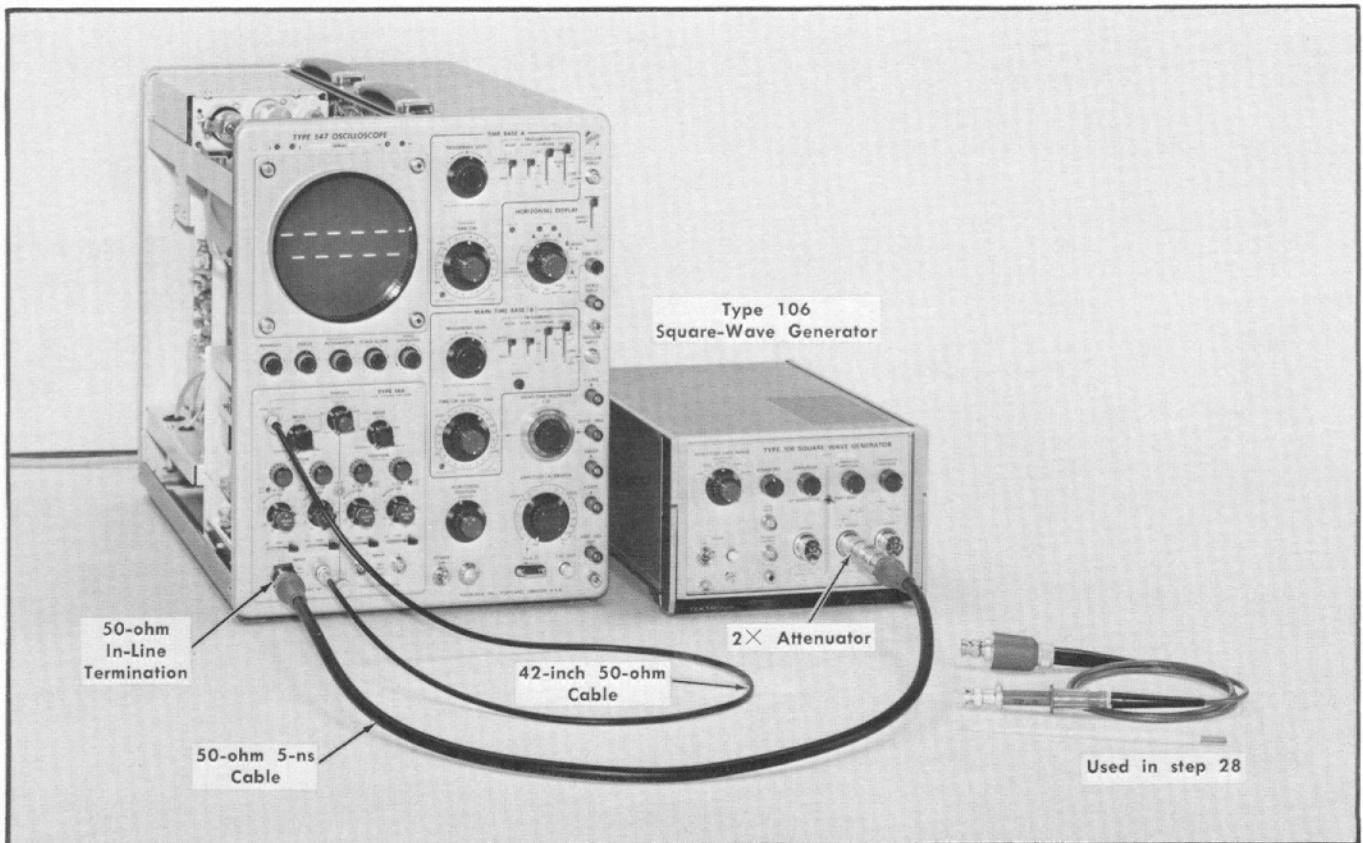


Fig. 7-34. Test equipment setup for steps 27 and 28.

Control Settings

Type 1A4

All Channels
 AC-GND-DC DC
 V/CM (Ch 1, 3 & 4) .01
V/CM (Ch 2) .5
 VARIABLE CAL
 INVERT Pushed in
 POSITION Midrange

Other controls
Ch 1 & 2 MODE **CHANNEL 1**
Ch 3 & 4 MODE **CHANNEL 3**
DISPLAY **1 & 2**
 SIGNAL & TRIGGER SOURCE 1
 547 TRACE SLAVING (rear panel) LOCK

Type 547 Oscilloscope

A Triggering controls
 Triggering Level Near 0 and knob pushed in
 Mode Auto Stability
 Slope +

Coupling Source

Time Base A controls

Time/Cm
 Variable (Time/Cm)

Other controls

Horizontal Display
 Sweep Magnifier
 Single Sweep switch
 Horizontal Position and Vernier
 CRT Cathode Selector
 Power

AC

Norm Int

.5 mSec
 Calibrated

A
 ×1 Off
 Normal
 Set so trace starts at left edge of graticule
 External CRT Cathode On

Type 106 Square-Wave Generator

Repetition Rate Range **1 kHz**
 Multiplier Less than 1
 Symmetry Midrange
Hi Amplitude Fast Rise switch **Fast Rise**
 +Transition Amplitude Fully CCW
 -Transition Amplitude Not applicable
 Power On

28. Adjust Trigger Amplifier High-Frequency Compensation



- a. Test equipment required for this step is shown in Fig. 7-34.
- b. Connect the cable end of a compensated Type P6008 10X Probe to the Channel 2 Input connector. Attach a probe-to-male BNC connector adapter (item 14) to the tip of the 10X probe. Connect the probe tip with adapter to the SIGNAL OUTPUT connector. (The connections from the Type 106 Square-Wave Generator to the Type 1A4 remain the same as shown in Fig. 7-34).
- c. Set the front-panel controls as follows:

Type 1A4

V/CM (Ch 2) .05
Ch 1 & 2 MODE CHANNEL 2

Type 547 Oscilloscope

Triggering Level Near 0 and knob pushed in
Time/Cm 5 μ Sec

Type 106

Repetition Rate Range 100 kHz

If it is necessary to check the positions of the unchanged controls, refer to the list that precedes step 27.

d. Adjust the Type 106 +Transition Amplitude control to obtain a 4-cm amplitude display. If necessary, adjust the oscilloscope Triggering Level control to obtain a stable display.

e. Adjust the Type 106 Symmetry control to obtain a symmetrical waveform and adjust the Multiplier control to obtain a 100 kHz repetition rate.

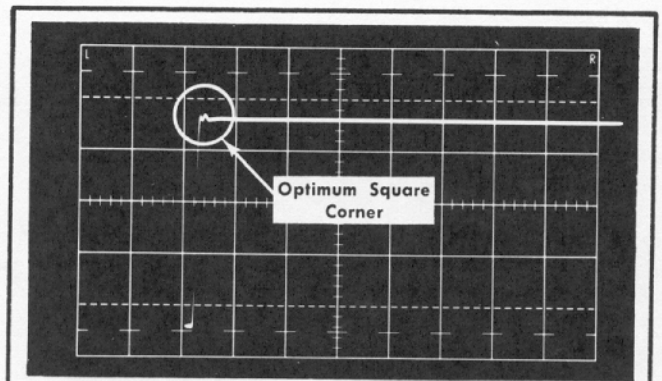
f. Set the oscilloscope Time/Cm switch to 0.5 μ Sec.

g. Using the Type 1A4 Channel 2 POSITION and oscilloscope Horizontal Position controls, position the display to a location similar to the one shown in Fig. 7-36A.

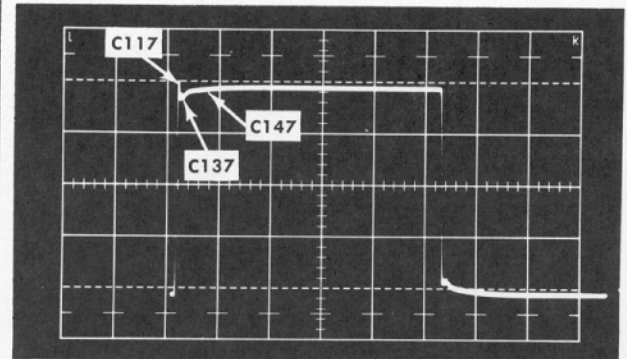
h. CHECK—CRT display for optimum top front corner on the rising portion of the waveform (see Fig. 7-36A). Minor aberrations can be expected but they should not be of the ringing type.

i. ADJUST—C117, C137 and C147 (see Fig. 7-36C) for optimum frequency response to a square wave. Fig. 7-36A shows a typical waveform obtained at a sweep rate of 0.5 μ s/cm when the adjustments are set correctly. Fig. 7-36B shows the effect of each adjustment on the waveform. Sweep rate is 1 μ s/cm.

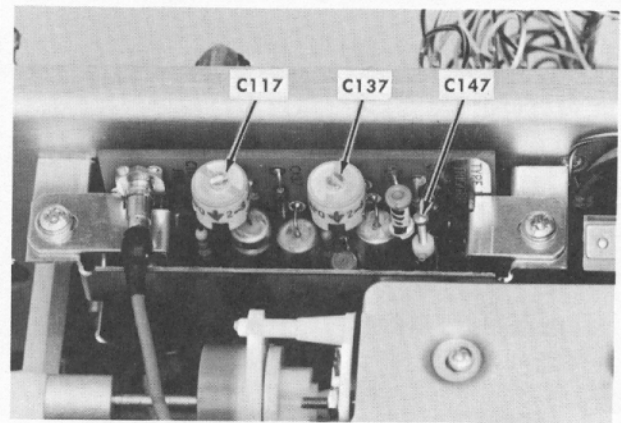
j. Disconnect the Type 106 Square-Wave Generator from the Type 1A4 Channel 1 Input connector, but do not disconnect the 10X probe. Turn off the Type 106.



(A) Correct high-frequency compensation. Sweep rate: 0.5 μ s/cm.



(B) Incorrect. Effect of each adjustment on the waveform is shown. Sweep rate: 1 μ s/cm.



(C) Adjustment locations. Left side center-portion view.

Fig. 7-36. Trigger amplifier waveforms and adjustment locations for step 28.

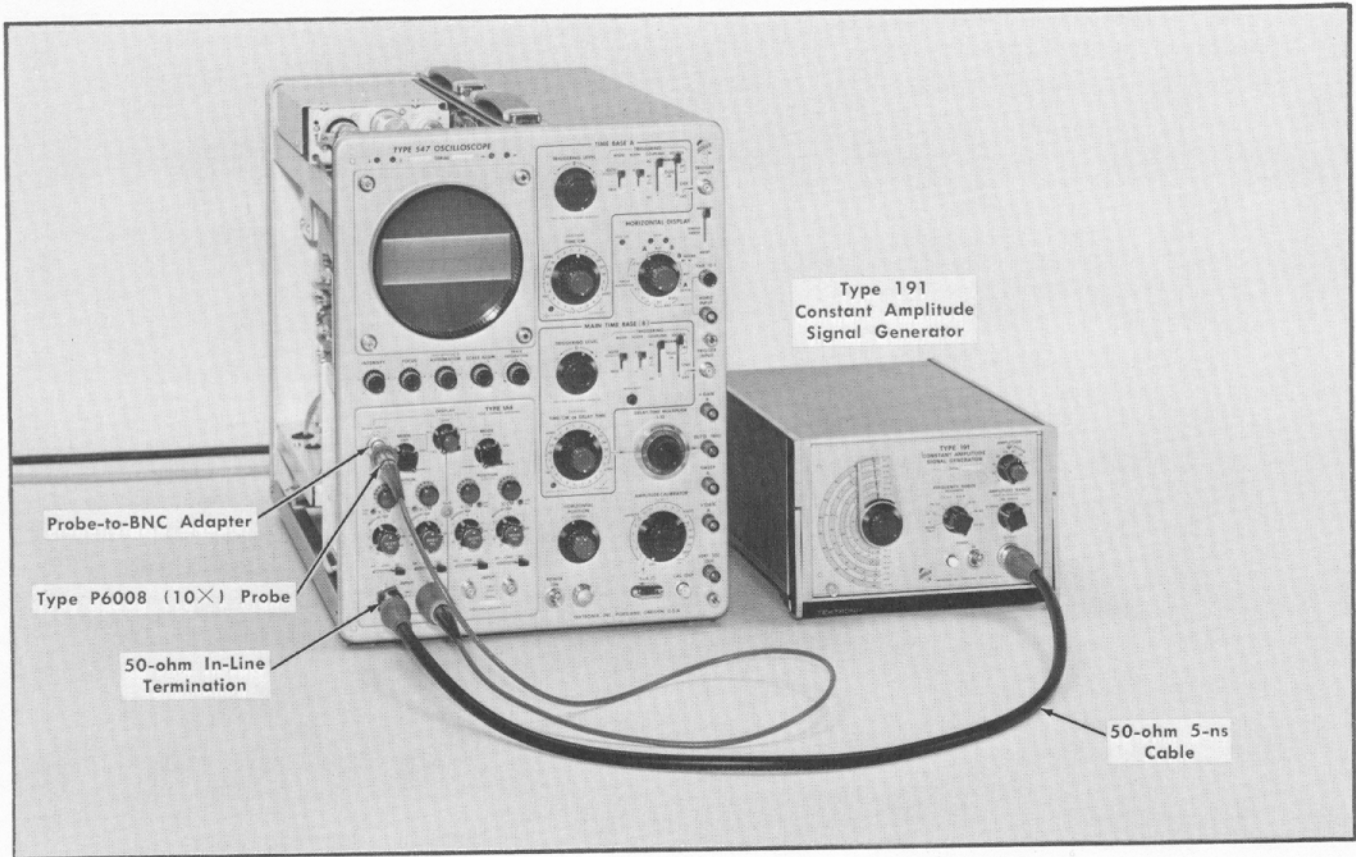


Fig. 7-37. Test equipment setup for steps 29 and 30.

Control Settings

	Type 1A4
All Channels	
AC-GND-DC	DC
V/CM (1, 3 & 4)	.01
V/CM (Ch 2)	.05
VARIABLE	CAL
INVERT	Pushed in
POSITION	Midrange
Other controls	
Ch 1 & 2 MODE	CHANNEL 2
Ch 3 & 4 MODE	CHANNEL 3
DISPLAY	1 & 2
SIGNAL & TRIGGER SOURCE	1
547 TRACE SLAVING (rear panel)	LOCK
	Type 547 Oscilloscope
A Triggering controls	
Triggering Level	Fully CW and knob pulled outward
Mode	Auto Stability
Slope	+

Coupling	AC
Source	Norm Int
Time Base A Controls	
Time/ Cm	.5 mSec
Variable (Time/Cm)	Calibrated
Other controls	
Horizontal Display	A
Sweep Magnifier	×1 Off
Single Sweep switch	Normal
Horizontal Position and Vernier	Set so trace starts at left edge of graticule
CRT Cathode Selector	External CRT Cathode
Power	On
	Type 191 Constant Amplitude Signal Generator
Frequency dial	8 MHz
Frequency Range	50 kHz Only
Amplitude Variable	30
	CAL
Amplitude Range	5-50 mV
Power	On

29. Check Trigger Amplifier High-Frequency Response

a. Test equipment setup, with connections made at completion of step 29c, is shown in Fig. 7-37.

b. Set the Type 191 Constant Amplitude Signal Generator controls to the settings given in the list that precedes step 29.

c. Apply the 50-kHz reference signal from the Type 191 Output connector through a 5-ns cable and a 50-ohm in-line termination to the Type 1A4 Channel 1 Input connector (see Fig. 7-37). Check that the $10\times$ probe is connected from the Type 1A4 Channel 2 Input connector to the SIGNAL OUTPUT connector as shown in Fig. 7-37.

d. Adjust the Type 191 Variable control and, if necessary, the Amplitude switch, to obtain a display that is exactly 4 cm in amplitude. This is the reference amplitude at 50 kHz.

e. Set the Type 191 Frequency Range switch to 8-18.

f. Without changing the Type 191 output amplitude, increase the output frequency until the deflection is reduced to 2.8 cm (see Fig. 7-38). This is the 30% down voltage point (equivalent to -3 dB). Use the Channel 2 POSITION control to position the display for convenient viewing.

g. CHECK—Output frequency should be 10 MHz or higher.

h. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	CHOP
Ch 3 & 4 MODE	ALT
DISPLAY	ALT

Type 547 Oscilloscope

CRT Cathode Selector Chopped Blanking

i. Position Channel 1, 3 and 4 traces off the screen so they will not appear with the Channel 2 display.

j. Set the Type 191 Frequency Range switch to 50 kHz Only. Adjust the Type 191 Variable control and, if necessary, the Amplitude switch so the reference amplitude is exactly 4 cm on the CRT.

k. Set the Type 191 Frequency Range switch to .35-75.

l. Without changing the Type 191 output amplitude, set the Frequency dial to a point where the Channel 2 display is exactly 2.8 cm in amplitude (see Fig. 7-38). Use the Channel 2 POSITION control to position the display for desired viewing.

m. CHECK—Output frequency should be between 400 kHz and 600 kHz. This frequency range meets the 500 kHz, $\pm 20\%$, requirement.

NOTE

Steps 28n through 28z that follow provide a means for checking the remaining trigger amplifier bandwidth control circuits.

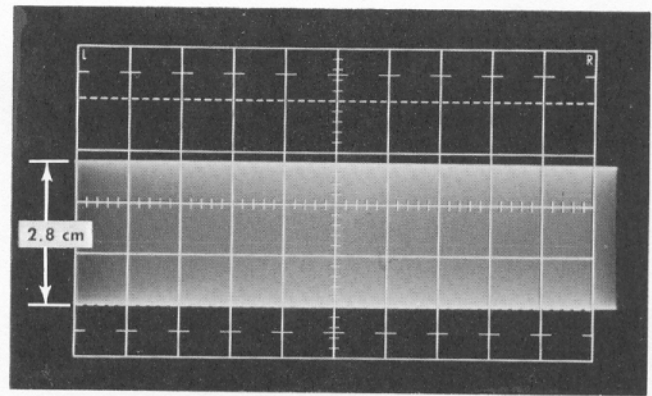


Fig. 7-38. Checking the trigger amplifier high-frequency 3-dB down point. Sweep rate: 0.5 ms/cm free running.

n. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE	ALT
DISPLAY	CHOP

o. CHECK—Channel 2 CRT display amplitude should be 2.8 cm. This indicates the trigger amplifier high-frequency response is the same as described in step 28m.

p. Set the Type 1A4 controls as follows:

Ch 3 & 4 MODE	CHOP
DISPLAY	ALT

q. CHECK—Channel 2 CRT display amplitude should be 2.8 cm. This indicates the trigger amplifier high-frequency response is the same as described in step 28m.

r. Remove the Type 1A4 from the oscilloscope plug-in compartment. Remove the gray-on-white trigger amplifier bandwidth control lead from pin "M" on the Logic board and connect this same lead to pin "N" (see Fig. 7-39). Install the Type 1A4 in the oscilloscope.

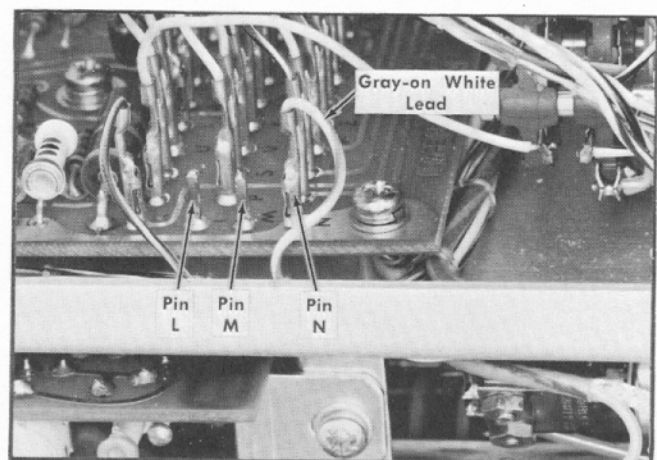


Fig. 7-39. Gray-on-white lead moved from pin "M" (normal connection) to pin "N". Pins L, M and N determine the trigger amplifier bandwidth conditions.

Calibration—Type 1A4

s. Set the Type 1A4 controls as follows:

Ch 3 & 4 MODE CHANNEL 3
 DISPLAY 1 & 2

t. CHECK—With the Ch 1 & 2 MODE switch set to ALT, the Channel 2 CRT display should be 2.8 cm in amplitude. This check indicates that the trigger amplifier high-frequency response will be limited to 500 kHz, $\pm 20\%$, for all modes of operation.

u. Remove the Type 1A4 from the oscilloscope plug-in compartment. Remove the gray-on-white trigger amplifier bandwidth control lead from pin "N" and connect this lead to pin "L". Re-install the Type 1A4 in the oscilloscope.

v. Set the controls as follows:

Type 1A4

Ch 1 & 2 MODE CHOP

Type 191

Frequency Range 50 kHz Only

w. Adjust the Type 191 Variable control and if necessary, the Amplitude switch so the reference amplitude is 4 cm.

x. Set the Frequency Range switch to 8-18.

y. Without changing the Type 191 output amplitude, set the Frequency dial to an output frequency that produces 2.8 cm of deflection on the CRT for Channel 2.

z. CHECK—Output frequency should be 10 MHz or higher. This check indicates that the trigger amplifier high-frequency response will be 10 MHz or higher for all modes of operation.

aa. Remove the Type 1A4 from the oscilloscope plug-in compartment. Remove the gray-on-white trigger amplifier bandwidth lead from pin "L" and reconnect this lead to pin "M". Re-install the Type 1A4 in the oscilloscope.

NOTE

Pin "M" is the normal switch-controlled bandwidth connection for the gray-on-white lead. If desired, the lead can be connected to either pin "L" or "N" if one of these connections is needed for special applications.

ab. Disconnect the 10X probe from the Type 1A4.

30. Check Plug-In Triggering

a. The equipment required for this procedure is shown in Fig. 7-37. (The connections are the same as shown in Fig. 7-37 except the 10X probe is not used in this procedure.)

b. Set the controls as follows:

Type 1A4

V/CM (Ch 2) .01
 POSITION (Ch 1, 3 & 4) Midrange
 Ch 1 & 2 MODE CHANNEL 1

Type 547 Oscilloscope

Triggering Level Near 0 and knob pushed in

Time/Cm .1 μ Sec
 CRT Cathode Selector External CRT Cathode

Type 191 Constant Amplitude Signal Generator

Frequency dial 10 MHz
 Amplitude 20

c. If it is necessary to check the remaining controls, refer to the list that precedes step 29 with this exception: Type 191 Frequency Range switch is set to 8-18.

d. Adjust the Type 191 Variable control so the display is exactly 2 cm in amplitude.

e. Set the oscilloscope Triggering Source switch to the Plug-In Int position.

f. CHECK—The Triggering Level control can be adjusted to obtain a stable display (see Fig. 7-40).

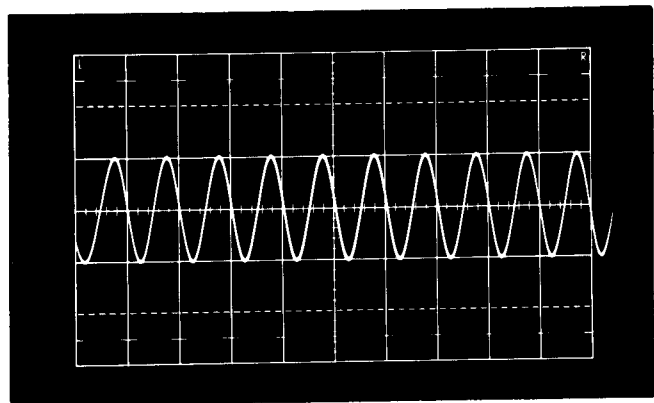


Fig. 7-40. Stable 10-MHz waveform obtained when checking internal plug-in triggering source. Sweep rate is 0.1 μ s/cm.

g. Set Ch 1 & 2 MODE switch to CHANNEL 2.

h. Using Table 7-19 and step 30f as a guide, check that stable internal plug-in triggering can be obtained for the remaining SIGNAL & TRIGGER SOURCE switch positions.

TABLE 7-19

Apply 10 MHz Signal to:	Ch 3 & 4 MODE Switch	DISPLAY Switch	SIGNAL & TRIGGER SOURCE Switch	Check:
Input 2	CHANNEL 3	1 & 2	2	Ch-2 display
Input 3	CHANNEL 3	3 & 4	3	Ch-3 display
Input 4	CHANNEL 4	3 & 4	4	Ch-4 display

i. This completes the calibration procedure for the Type 1A4. Turn off the Type 191 Constant Amplitude Signal Generator and disconnect it from the Type 1A4. Replace the left side and bottom covers on the oscilloscope. If the Type 1A4 has been completely calibrated to the tolerances given in this procedure, it will perform to the limits given in the Characteristics section of this Instruction Manual.

PARTS LIST ABBREVIATIONS

BHB	binding head brass	int	internal
BHS	binding head steel	lg	length or long
cap.	capacitor	met.	metal
cer	ceramic	mtg hdw	mounting hardware
comp	composition	OD	outside diameter
conn	connector	OHB	oval head brass
CRT	cathode-ray tube	OHS	oval head steel
csk	countersunk	P/O	part of
DE	double end	PHB	pan head brass
dia	diameter	PHS	pan head steel
div	division	plstc	plastic
elect.	electrolytic	PMC	paper, metal cased
EMC	electrolytic, metal cased	poly	polystyrene
EMT	electrolytic, metal tubular	prec	precision
ext	external	PT	paper, tubular
F & I	focus and intensity	PTM	paper or plastic, tubular, molded
FHB	flat head brass	RHB	round head brass
FHS	flat head steel	RHS	round head steel
Fil HB	fillister head brass	SE	single end
Fil HS	fillister head steel	SN or S/N	serial number
h	height or high	S or SW	switch
hex.	hexagonal	TC	temperature compensated
HHB	hex head brass	THB	truss head brass
HHS	hex head steel	thk	thick
HSB	hex socket brass	THS	truss head steel
HSS	hex socket steel	tub.	tubular
ID	inside diameter	var	variable
inc	incandescent	w	wide or width
		WW	wire-wound

PARTS ORDERING INFORMATION

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

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

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

SPECIAL NOTES AND SYMBOLS

- | | |
|-----------------|---|
| ×000 | Part first added at this serial number |
| 00× | Part removed after this serial number |
| *000-0000-00 | Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components. |
| Use 000-0000-00 | Part number indicated is direct replacement. |

SECTION 8

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Capacitors						
Tolerance $\pm 20\%$ unless otherwise indicated.						
C1 ¹	*285-0697-00	B010100	B010179	0.1 μF	MT	600 V
C1 ¹	*285-0749-00	B010180		0.1 μF	MT	600 V
C2 ¹	281-0617-00			15 pF	Cer	200 V
C5 ¹	281-0043-00			0.7-3 pF, Var	Tub.	
C6A ¹ } C6B ¹ }	281-0119-00			0.2-1.5 pF, Var	Tub.	
				50 pF	Mica	10%
C7 ¹	281-0658-00	B010100	B049999	6.2 pF	Cer	500 V ± 0.25 pF
C7 ¹	281-0544-00	B050000		5.6 pF	Cer	500 V 10%
C10 ¹	281-0547-00			2.7 pF	Cer	500 V 10%
C11 ¹	281-0043-00			0.7-3 pF, Var	Tub.	
C12A ¹ } C12B ¹ }	281-0086-00			0.2-1.5 pF, Var	Tub.	
				500 pF	Mica	10%
C13 ¹	281-0659-00			4.3 pF	Cer	500 V ± 0.25 pF
C17 ¹	281-0572-00			6.8 pF	Cer	500 V 10%
C18 ¹	281-0043-00			0.7-3 pF, Var	Tub.	
C19A ¹ } C19B ¹ }	281-0108-00			0.2-1.5 pF, Var	Tub.	
				1000 pF	Mica	
C23 ¹	281-0547-00			2.7 pF	Cer	500 V 10%
C25 ¹	281-0538-00			1 pF	Cer	500 V
C26 ¹	281-0064-00			0.2-1.5 pF, Var	Tub.	
C31 ¹	281-0064-00			0.2-1.5 pF, Var	Tub.	
C32 ¹	281-0043-00			0.7-3 pF, Var	Tub.	
C33 ¹	281-0503-00			8 pF	Cer	500 V ± 0.5 pF
C38 ¹	281-0064-00			0.2-1.5 pF, Var	Tub.	
C39 ¹	281-0043-00			0.7-3 pF, Var	Tub.	
C40 ¹	281-0592-00			4.7 pF	Cer	± 0.5 pF
C41 ¹	281-0617-00			15 pF	Cer	200 V
C46 ¹	281-0591-00	B010100	B089999	5600 pF	Cer	200 V
C46 ¹	283-0180-00	B090000		5600 pF	Cer	200 V
C54 ¹	281-0649-00	B010100	B109999	1000 pF	Cer	500 V $+80\% - 20\%$
C54 ¹	283-0039-00	B110000		0.001 μF	Cer	500 V
C60 ¹	281-0649-00	B010100	B109999	1000 pF	Cer	500 V $+80\% - 20\%$
C60 ¹	283-0039-00	B110000		0.001 μF	Cer	500 V
C64 ¹	283-0000-00	B010100	B049999	0.001 μF	Cer	500 V
C64 ¹	283-0059-00	B050000	B079999	1 μF	Cer	25 V $+80\% - 20\%$
C64 ¹	283-0177-00	B080000		1 μF	Cer	25 V $+80\% - 20\%$
C76 ¹	281-0616-00	B010100	B029999	6.8 pF	Cer	200 V
C76 ¹	281-0613-00	B030000		10 pF	Cer	200 V 10%
C86 ¹	281-0649-00	B010100	B109999	1000 pF	Cer	500 V $+80\% - 20\%$
C86 ¹	283-0039-00	B110000		0.001 μF	Cer	500 V
C91 ¹	283-0000-00			0.001 μF	Cer	500 V
C92 ¹	283-0000-00			0.001 μF	Cer	500 V
C93 ¹	281-0649-00	B010100	B109999	1000 pF	Cer	500 V $+80\% - 20\%$
C93 ¹	283-0039-00	B110000		0.001 μF	Cer	500 V
C94 ¹	281-0649-00	B010100	B109999	1000 pF	Cer	500 V $+80\% - 20\%$
C94 ¹	283-0039-00	B110000		0.001 μF	Cer	500 V

¹There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

Electrical Parts List—Type 1A4

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc		Description		
C95 ¹	290-0267-00			1 μ F	Elect.	35 V	
C101	290-0269-00	B010100	B109999	0.22 μ F	Elect.	35 V	5%
C101	283-0026-00	B110000		0.2 μ F	Cer	25 V	
C102	290-0269-00	B010100	B109999	0.22 μ F	Elect.	35 V	5%
C102	283-0026-00	B110000		0.2 μ F	Cer	25 V	
C103	290-0269-00	B010100	B109999	0.22 μ F	Elect.	35 V	5%
C103	283-0026-00	B110000		0.2 μ F	Cer	25 V	
C104	290-0269-00	B010100	B109999	0.22 μ F	Elect.	35 V	5%
C104	283-0026-00	B110000		0.2 μ F	Cer	25 V	
C301	283-0000-00			0.001 μ F	Cer	500 V	
C302	283-0000-00			0.001 μ F	Cer	500 V	
C311	283-0000-00			0.001 μ F	Cer	500 V	
C312	283-0000-00			0.001 μ F	Cer	500 V	
C321	283-0000-00			0.001 μ F	Cer	500 V	
C322	283-0000-00			0.001 μ F	Cer	500 V	
C331	283-0000-00			0.001 μ F	Cer	500 V	
C332	283-0000-00			0.001 μ F	Cer	500 V	
C341	281-0651-00	XB120000	B129999X	47 pF	Cer		5%
C344	281-0651-00	XB120000	B129999X	47 pF	Cer		5%
C347	281-0524-00	XB130000		150 pF	Cer	500 V	
C349	283-0002-00	B010100	B039999X	0.01 μ F	Cer	500 V	
C351	281-0651-00	XB120000	B129999X	47 pF	Cer		5%
C354	281-0651-00	XB120000	B129999X	47 pF	Cer		5%
C357	281-0524-00	XB130000		150 pF	Cer	500 V	
C363	283-0002-00			0.01 μ F	Cer	500 V	
C374	281-0518-00			47 pF	Cer	500 V	
C395	281-0093-00			5.5-18 pF, Var	Cer		
C396	281-0091-00			2-8 pF, Var	Cer		
C397	281-0092-00			9-35 pF, Var	Cer		
C398	290-0135-00			15 μ F	Elect.	20 V	
C403	281-0543-00			270 pF	Cer	500 V	10%
C413	281-0543-00			270 pF	Cer	500 V	10%
C417	283-0103-00			180 pF	Cer	500 V	5%
C421	290-0269-00			0.22 μ F	Elect.	35 V	5%
C422	281-0536-00			1000 pF	Cer	500 V	10%
C423	283-0594-00			0.001 μ F	Mica	100 V	1%
C424	281-0638-00			240 pF	Cer	500 V	5%
C433	281-0543-00			270 pF	Cer	500 V	10%
C443	281-0543-00			270 pF	Cer	500 V	10%
C447	283-0103-00	B010100	B059999	180 pF	Cer	500 V	5%
C447	283-0084-00	B060000		270 pF	Cer	1000 V	5%
C451	290-0269-00			0.22 μ F	Elect.	35 V	5%
C452	281-0536-00			1000 pF	Cer	500 V	10%
C453	283-0594-00			0.001 μ F	Mica	100 V	1%
C454	281-0580-00			470 pF	Cer	500 V	10%
C461	290-0269-00			0.22 μ F	Elect.	35 V	5%
C462	281-0536-00			1000 pF	Cer	500 V	10%
C465	281-0638-00			240 pF	Cer	500 V	5%
C466	283-0594-00			0.001 μ F	Mica	100 V	1%
C467	283-0103-00			180 pF	Cer	500 V	5%

¹There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

Capacitors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description			
		Eff	Disc				
C473	281-0543-00			270 pF	Cer	500 V	10%
C483	281-0543-00			270 pF	Cer	500 V	10%
C491	283-0000-00			0.001 μ F	Cer	500 V	
C493	283-0026-00			0.2 μ F	Cer	25 V	
C495	283-0000-00			0.001 μ F	Cer	500 V	
C502	290-0135-00			15 μ F	Elect.	20 V	
C504	283-0000-00			0.001 μ F	Cer	500 V	
C602	290-0218-00			500 μ F	Elect.	30 V	
C604	290-0269-00			0.22 μ F	Elect.	35 V	5%
C610	281-0523-00			100 pF	Cer	350 V	
C612	290-0162-00			22 μ F	Elect.	35 V	
C622	290-0218-00			500 μ F	Elect.	30 V	
C623	290-0267-00			1 μ F	Elect.	35 V	
C624	283-0002-00			0.01 μ F	Cer	500 V	
C632	290-0309-00			100 μ F	Elect.	25 V	
C634	281-0510-00			22 pF	Cer	500 V	

Diodes

D46*	*152-0321-00	Silicon	Dual, Tek Spec
D71*	*152-0185-00	Silicon	Replaceable by 1N4152
D306	*152-0185-00	Silicon	Replaceable by 1N4152
D307	*152-0185-00	Silicon	Replaceable by 1N4152
D308	*152-0185-00	Silicon	Replaceable by 1N4152
D309	*152-0185-00	Silicon	Replaceable by 1N4152
D316	*152-0185-00	Silicon	Replaceable by 1N4152
D317	*152-0185-00	Silicon	Replaceable by 1N4152
D318	*152-0185-00	Silicon	Replaceable by 1N4152
D319	*152-0185-00	Silicon	Replaceable by 1N4152
D326	*152-0185-00	Silicon	Replaceable by 1N4152
D327	*152-0185-00	Silicon	Replaceable by 1N4152
D328	*152-0185-00	Silicon	Replaceable by 1N4152
D329	*152-0185-00	Silicon	Replaceable by 1N4152
D336	*152-0185-00	Silicon	Replaceable by 1N4152
D337	*152-0185-00	Silicon	Replaceable by 1N4152
D338	*152-0185-00	Silicon	Replaceable by 1N4152
D339	*152-0185-00	Silicon	Replaceable by 1N4152
D341	*152-0185-00	Silicon	Replaceable by 1N4152
D342	*152-0185-00	Silicon	Replaceable by 1N4152
D343	*152-0185-00	Silicon	Replaceable by 1N4152
D344	*152-0185-00	Silicon	Replaceable by 1N4152
D351	*152-0185-00	Silicon	Replaceable by 1N4152
D352	*152-0185-00	Silicon	Replaceable by 1N4152
D353	*152-0185-00	Silicon	Replaceable by 1N4152
D354	*152-0185-00	Silicon	Replaceable by 1N4152
D405	*152-0185-00	Silicon	Replaceable by 1N4152
D415	*152-0185-00	Silicon	Replaceable by 1N4152

*There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

Electrical Parts List—Type 1A4

Diodes (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
D416	*152-0185-00		Silicon	Replaceable by 1N4152
D417	*152-0185-00		Silicon	Replaceable by 1N4152
D418	*152-0185-00		Silicon	Replaceable by 1N4152
D435	*152-0185-00		Silicon	Replaceable by 1N4152
D445	*152-0185-00		Silicon	Replaceable by 1N4152
D446	*152-0185-00		Silicon	Replaceable by 1N4152
D447	*152-0185-00		Silicon	Replaceable by 1N4152
D443	*152-0185-00		Silicon	Replaceable by 1N4152
D454	*152-0185-00		Silicon	Replaceable by 1N4152
D467	*152-0185-00		Silicon	Replaceable by 1N4152
D468	*152-0185-00		Silicon	Replaceable by 1N4152
D469	*152-0185-00		Silicon	Replaceable by 1N4152
D475	*152-0185-00		Silicon	Replaceable by 1N4152
D485	*152-0185-00		Silicon	Replaceable by 1N4152
D602A,B,C,D (4)	*152-0107-00		Silicon	Replaceable by 1N647
D603	152-0212-00		Zener	1N936 9 V, 0.005%/°C TC
D606	*152-0185-00		Silicon	Replaceable by 1N4152
D607	*152-0185-00		Silicon	Replaceable by 1N4152
D622A,B,C,D (4)	*152-0107-00		Silicon	Replaceable by 1N647
D624	*152-0185-00		Silicon	Replaceable by 1N4152
D626	*152-0185-00		Silicon	Replaceable by 1N4152
D627	*152-0185-00		Silicon	Replaceable by 1N4152
D635	*152-0185-00		Silicon	Replaceable by 1N4152

Connectors

J1 [§]	131-0342-00		1 contact, female
J140	131-0327-00		30 pin, dual contact
J149	131-0106-00		1 contact, female

Inductors

L91 [§]	276-0543-00		Core, Ferrite
L92 [§]	276-0507-00		Core, Ferramic Suppressor
LR35 [§]	*108-0270-00		0.25 μ H (wound on a 62 Ω resistor)
LR42 [§]	*108-0286-00		0.17 μ H (wound on a 36 Ω resistor)
LR43 [§]	*108-0446-00		0.2 μ H (wound on a 20 Ω resistor)
L302	276-0507-00	XB100000	Core, Ferramic Suppressor
L312	276-0507-00	XB100000	Core, Ferramic Suppressor
L322	276-0507-00	XB100000	Core, Ferramic Suppressor
L332	276-0507-00	XB100000	Core, Ferramic Suppressor

Plug

P11	131-0017-00		16 contact, male
-----	-------------	--	------------------

[§]There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

Transistors

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description
		Eff	Disc	
Q53 ³	*151-1009-00			Dual FET, Tek Spec
Q73 ³	*151-0192-00			Replaceable by MPS-6521
Q74 ³	*151-0198-00			Replaceable by MPS-918
Q83 ³	*151-0192-00			Replaceable by MPS-6521
Q84 ³	*151-0198-00			Replaceable by MPS-918
Q344	*151-0198-00			Replaceable by MPS-918
Q354	*151-0198-00			Replaceable by MPS-918
Q363	*151-0192-00			Replaceable by MPS-6521
Q373	151-0208-00			2N4036
Q374	151-0208-00			2N4036
Q384	*151-0138-00	B010100	B099999	Replaceable by 2N2857
Q384	151-0225-00	B100000	B129999	2N3563
Q384	151-0269-00	B130000		Selected from SE 3005
Q394	*151-0138-00	B010100	B099999	Replaceable by 2N2857
Q394	151-0225-00	B100000	B129999	2N3563
Q394	151-0269-00	B130000		Selected from SE 3005
Q405	151-0188-00			2N3906
Q415	151-0188-00			2N3906
Q420	*151-0192-00			Replaceable by MPS-6521
Q423	151-0188-00			2N3906
Q435	151-0188-00			2N3906
Q445	151-0188-00			2N3906
Q450	*151-0192-00			Replaceable by MPS-6521
Q460	*151-0192-00			Replaceable by MPS-6521
Q463	151-0188-00			2N3906
Q475	151-0188-00			2N3906
Q485	151-0188-00			2N3906
Q493	*151-0192-00			Replaceable by MPS-6521
Q494	151-0188-00			2N3906
Q504	*151-0192-00	B010100	B049999	Replaceable by MPS-6521
Q504	151-0190-00	B050000		2N3904
Q604	*151-0192-00			Replaceable by MPS-6521
Q614	*151-0192-00			Replaceable by MPS-6521
Q617	*151-0148-00			Selected from 40250
Q624	*151-0136-00			Replaceable by 2N3053
Q627	*151-0136-00	B010100	B039999	Replaceable by 2N3053
Q627	151-0150-00	B040000		2N3440
Q634	*151-0192-00			Replaceable by MPS-6521
Q644	151-0188-00			2N3906

Resistors

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

R2 ⁴	317-0560-00	B010100	B029999	56 Ω	1/8 W		5%
R2 ⁴	317-0220-00	B030000		22 Ω	1/8 W		5%
R6 ⁴	322-0621-01			900 k Ω	1/4 W	Prec	1/2%
R8 ⁴	321-1389-01			111 k Ω	1/8 W	Prec	1/2%
R12 ⁴	322-0624-01			990 k Ω	1/4 W	Prec	1/2%
R14 ⁴	321-1289-01			10.1 k Ω	1/8 W	Prec	1/2%

³There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

⁴There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

Electrical Parts List—Type 1A4

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No.		Description			
		Eff	Disc				
R19 ⁴	322-0629-01			999 kΩ	1/4 W	Prec	1/2%
R21 ⁴	321-0193-01			1 kΩ	1/8 W	Prec	1/2%
R32 ⁴	321-0648-00			500 kΩ	1/8 W	Prec	1/2%
R34 ⁴	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R39 ⁴	322-0620-01			800 kΩ	1/4 W	Prec	1/2%
R41 ⁴	321-0733-01	B010100	B089999	250 kΩ	1/8 W	Prec	1/2%
R41 ⁴	321-0618-01	B090000		250 kΩ	1/8 W	Prec	1/2%
R44 ⁴	317-0101-00			100 Ω	1/8 W		5%
R45 ⁴	322-0481-01			1 MΩ	1/4 W	Prec	1/2%
R46 ⁴	317-0474-00			470 kΩ	1/8 W		5%
R53 ⁴	321-0236-00			2.8 kΩ	1/8 W	Prec	1%
R54 ⁴	321-0327-00			24.9 kΩ	1/8 W	Prec	1%
R55	311-0650-00			5 kΩ, Var			
R56	311-0650-00			5 kΩ, Var			
R57	311-0650-00			5 kΩ, Var			
R58	311-0650-00			5 kΩ, Var			
R60 ⁴	311-0650-00			5 kΩ, Var			
R61 ⁴	315-0183-00			18 kΩ	1/4 W		5%
R62 ⁴	315-0123-00			12 kΩ	1/4 W		5%
R63 ⁴	315-0154-00			150 kΩ	1/4 W		5%
R66 ⁴	321-0236-00			2.8 kΩ	1/4 W	Prec	1%
R71 ⁴	317-0101-00			100 Ω	1/8 W		5%
R73 ⁴	315-0272-00			2.7 kΩ	1/4 W		5%
R74 ⁴	321-0244-00			3.4 kΩ	1/8 W	Prec	1%
R75 ⁴	*311-0603-00			185 Ω, Var			
R76 ⁴	317-0101-00			100 Ω	1/8 W		5%
R77 ⁴	311-0622-00			100 Ω, Var			
R81 ⁴	317-0101-00			100 Ω	1/8 W		5%
R83 ⁴	315-0272-00			2.7 kΩ	1/4 W		5%
R84 ⁴	321-0244-00			3.4 kΩ	1/8 W	Prec	1%
R85 ⁴	317-0470-00			47 Ω	1/8 W		5%
R86 ⁴	308-0360-00			13.3 kΩ	3 W	WW	1%
R101	315-0104-00			100 kΩ	1/4 W		5%
R102	315-0104-00			100 kΩ	1/4 W		5%
R103	315-0104-00			100 kΩ	1/4 W		5%
R104	315-0104-00			100 kΩ	1/4 W		5%
R301	315-0561-00			560 Ω	1/4 W		5%
R302	315-0621-00			620 Ω	1/4 W		5%
R303	315-0472-00			4.7 kΩ	1/4 W		5%
R304	315-0472-00			4.7 kΩ	1/4 W		5%
R305 ⁵	311-0652-00			2 x 5 kΩ, Var			
R306	315-0151-00			150 Ω	1/4 W		5%
R307	315-0151-00			150 Ω	1/4 W		5%

⁴There are four parts of this description in the instrument (Ch. 1, 2, 3, 4).

⁵Furnished as a unit with SW305.

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R311	315-0561-00			560 Ω	$\frac{1}{4}$ W	5%
R312	315-0621-00			620 Ω	$\frac{1}{4}$ W	5%
R313	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R314	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R315*	311-0652-00			2 x 5 k Ω , Var		5%
R316	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R317	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R321	315-0561-00			560 Ω	$\frac{1}{4}$ W	5%
R322	315-0621-00			620 Ω	$\frac{1}{4}$ W	5%
R323	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R324	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R325†	311-0652-00			2 x 5 k Ω , Var		5%
R326	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R327	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R331	315-0561-00			560 Ω	$\frac{1}{4}$ W	5%
R332	315-0621-00			620 Ω	$\frac{1}{4}$ W	5%
R333	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R334	315-0472-00			4.7 k Ω	$\frac{1}{4}$ W	5%
R335*	311-0652-00			2 x 5 k Ω , Var		5%
R336	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R337	315-0151-00			150 Ω	$\frac{1}{4}$ W	5%
R341	317-0150-00	XB120000	B129999X	15 Ω	$\frac{1}{8}$ W	5%
R344	317-0150-00	XB120000	B129999X	15 Ω	$\frac{1}{8}$ W	5%
R345	308-0230-00			2.7 k Ω	3 W	WW 5%
R346	321-0247-00			3.65 k Ω	$\frac{1}{8}$ W	Prec 1%
R347	317-0150-00	XB130000		15 Ω	$\frac{1}{8}$ W	5%
R348	321-0139-00			274 Ω	$\frac{1}{8}$ W	Prec 1%
R349	321-0189-00			909 Ω	$\frac{1}{8}$ W	Prec 1%
R351	317-0150-00	XB120000		15 Ω	$\frac{1}{8}$ W	5%
R354	317-0150-00	XB120000		15 Ω	$\frac{1}{8}$ W	5%
R355	308-0230-00			2.7 k Ω	3 W	WW 5%
R356	321-0247-00			3.65 k Ω	$\frac{1}{8}$ W	Prec 1%
R357	317-0150-00	XB130000		15 Ω	$\frac{1}{8}$ W	5%
R360	311-0607-00			10 k Ω , Var		
R361	315-0153-00			15 k Ω	$\frac{1}{4}$ W	5%
R362	315-0623-00			62 k Ω	$\frac{1}{4}$ W	5%
R363	315-0623-00			62 k Ω	$\frac{1}{4}$ W	5%
R364	315-0822-00			8.2 k Ω	$\frac{1}{4}$ W	5%
R371	308-0435-00			1 k Ω	3 W	WW $\frac{1}{4}$ %
R372	308-0426-00			470 Ω	3 W	WW 5%
R374	308-0303-00			750 Ω	3 W	WW 1%
R375	321-0170-00			576 Ω	$\frac{1}{8}$ W	Prec 1%
R376	321-0164-00			499 Ω	$\frac{1}{8}$ W	Prec 1%
R377	316-0470-00			47 Ω	$\frac{1}{4}$ W	
R378	321-0162-00			475 Ω	$\frac{1}{8}$ W	Prec 1%
R379	311-0651-00			10 k Ω , Var		

*Furnished as a unit with SW315.

†Furnished as a unit with SW325.

*Furnished as a unit with SW335.

Electrical Parts List—Type 1A4

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R382	321-0170-00		576 Ω	1/8 W	Prec	1%
R384	321-0164-00		499 Ω	1/8 W	Prec	1%
R385	316-0470-00		47 Ω	1/4 W		
R387	321-0162-00		475 Ω	1/8 W	Prec	1%
R389	308-0348-00		3.32 kΩ	3 W	WW	1%
R392	308-0444-00		494 Ω/29 Ω	20 W	WW	(tapped)
R393	315-0330-00		33 Ω	1/4 W		5%
R394	315-0330-00		33 Ω	1/4 W		5%
R395	311-0634-00		500 Ω, Var			
R396	311-0633-00		5 kΩ, Var			
R397	311-0644-00		20 kΩ, Var			
R398	316-0220-00		22 Ω	1/4 W		
R399	308-0336-00		7 kΩ	5 W	WW	5%
R401	321-0400-00		143 kΩ	1/8 W	Prec	1%
R402	315-0123-00		12 kΩ	1/4 W		5%
R403	321-0268-00		6.04 kΩ	1/8 W	Prec	1%
R405	321-0121-00		178 Ω	1/8 W	Prec	1%
R406	321-0193-00		1 kΩ	1/8 W	Prec	1%
R409	321-0178-00		698 Ω	1/8 W	Prec	1%
R411	321-0400-00		143 kΩ	1/8 W	Prec	1%
R412	315-0123-00		12 kΩ	1/4 W		5%
R413	321-0268-00		6.04 kΩ	1/8 W	Prec	1%
R414	315-0181-00		180 Ω	1/4 W		5%
R415	321-0121-00		178 Ω	1/8 W	Prec	1%
R416	321-0193-00		1 kΩ	1/8 W	Prec	1%
R417	315-0151-00		150 Ω	1/4 W		5%
R418	315-0222-00		2.2 kΩ	1/4 W		5%
R419	315-0101-00		100 Ω	1/4 W		5%
R420	315-0221-00		220 Ω	1/4 W		5%
R421	315-0101-00		100 Ω	1/4 W		5%
R422	315-0471-00		470 Ω	1/4 W		5%
R423	303-0623-00		62 kΩ	1 W		5%
R425	315-0472-00		4.7 kΩ	1/4 W		5%
R426	315-0562-00		5.6 kΩ	1/4 W		5%
R427*	315-0153-00		15 kΩ	1/4 W		5%
R429	315-0103-00		10 kΩ	1/4 W		5%
R431	321-0416-00		210 kΩ	1/8 W	Prec	1%
R432	315-0123-00		12 kΩ	1/4 W		5%
R433	321-0224-00		2.1 kΩ	1/8 W	Prec	1%
R435	321-0084-00		73.2 Ω	1/8 W	Prec	1%
R436	321-0140-00		280 Ω	1/8 W	Prec	1%
R439	321-0172-00		604 Ω	1/8 W	Prec	1%
R441	321-0416-00		210 kΩ	1/8 W	Prec	1%
R442	315-0123-00		12 kΩ	1/4 W		5%
R443	321-0224-00		2.1 kΩ	1/8 W	Prec	1%

*There are two parts of this description in the instrument (Ch. 1, 2).

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
R445	321-0084-00		73.2 Ω	$\frac{1}{8}$ W	Prec	1%
R446	321-0140-00		280 Ω	$\frac{1}{8}$ W	Prec	1%
R447	315-0241-00		240 Ω	$\frac{1}{4}$ W		5%
R448	315-0222-00		2.2 k Ω	$\frac{1}{4}$ W		5%
R449	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R450	315-0221-00		220 Ω	$\frac{1}{4}$ W		5%
R451	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R452	315-0471-00		470 Ω	$\frac{1}{4}$ W		5%
R453	303-0623-00		62 k Ω	1 W		5%
R454	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R455	315-0752-00		7.5 k Ω	$\frac{1}{4}$ W		5%
R456	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R457 ¹⁰	315-0153-00		15 k Ω	$\frac{1}{4}$ W		5%
R458	315-0153-00		15 k Ω	$\frac{1}{4}$ W		5%
R459	315-0562-00		5.6 k Ω	$\frac{1}{4}$ W		5%
R460	315-0221-00		220 Ω	$\frac{1}{4}$ W		5%
R461	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R462	315-0471-00		470 Ω	$\frac{1}{4}$ W		5%
R463	315-0472-00		4.7 k Ω	$\frac{1}{4}$ W		5%
R464	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R466	303-0683-00		68 k Ω	1 W		5%
R467	315-0151-00		150 Ω	$\frac{1}{4}$ W		5%
R468	315-0222-00		2.2 k Ω	$\frac{1}{4}$ W		5%
R471	321-0400-00		143 k Ω	$\frac{1}{8}$ W	Prec	1%
R472	315-0123-00		12 k Ω	$\frac{1}{4}$ W		5%
R473	321-0268-00		6.04 k Ω	$\frac{1}{8}$ W	Prec	1%
R475	321-0121-00		178 Ω	$\frac{1}{8}$ W	Prec	1%
R476	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R479	321-0178-00		698 Ω	$\frac{1}{8}$ W	Prec	1%
R481	321-0400-00		143 k Ω	$\frac{1}{8}$ W	Prec	1%
R482	315-0123-00		12 k Ω	$\frac{1}{4}$ W		5%
R483	321-0268-00		6.04 k Ω	$\frac{1}{8}$ W	Prec	1%
R484	315-0181-00		180 Ω	$\frac{1}{4}$ W		5%
R485	321-0121-00		178 Ω	$\frac{1}{8}$ W	Prec	1%
R486	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R489	315-0202-00		2 k Ω	$\frac{1}{4}$ W		5%
R490	321-0251-00		4.02 k Ω	$\frac{1}{8}$ W	Prec	1%
R491	321-0305-00		14.7 k Ω	$\frac{1}{8}$ W	Prec	1%
R492	315-0222-00		2.2 k Ω	$\frac{1}{4}$ W		5%
R493	315-0123-00		12 k Ω	$\frac{1}{4}$ W		5%
R494	315-0363-00		36 k Ω	$\frac{1}{4}$ W		5%
R495	315-0272-00		2.7 k Ω	$\frac{1}{4}$ W		5%
R496	315-0473-00		47 k Ω	$\frac{1}{4}$ W		5%
R497	315-0152-00		1.5 k Ω	$\frac{1}{4}$ W		5%
R501	315-0202-00		2 k Ω	$\frac{1}{4}$ W		5%
R502	316-0220-00		22 Ω	$\frac{1}{4}$ W		
R503	315-0242-00		2.4 k Ω	$\frac{1}{4}$ W		5%
R504	315-0473-00		47 k Ω	$\frac{1}{4}$ W		5%
R603	315-0821-00		820 Ω	$\frac{1}{4}$ W		5%
R604	315-0182-00		1.8 k Ω	$\frac{1}{4}$ W		5%

¹⁰There are two parts of this description in the instrument (Ch. 3, 4).

Electrical Parts List—Type 1A4

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
R605	315-0152-00		1.5 kΩ	1/4 W	5%
R610	311-0609-00		2 kΩ, Var		
R611	321-0249-00		3.83 kΩ	1/8 W	Prec 1%
R612	321-0239-00		3.01 kΩ	1/8 W	Prec 1%
R614	315-0152-00		1.5 kΩ	1/4 W	5%
R615	301-0471-00		470 Ω	1/2 W	5%
R617	308-0420-00		1.8 Ω	1.5 W	WW 3%
R624	308-0421-00		3 kΩ	3 W	WW 5%
R627	308-0420-00		1.8 Ω	1.5 W	WW 3%
R631	321-0297-00		12.1 kΩ	1/8 W	Prec 1%
R632	321-0306-00		15 kΩ	1/8 W	Prec 1%
R634	322-0336-00		30.9 kΩ	1/4 W	Prec 1%
R635	315-0242-00		2.4 kΩ	1/4 W	5%
R638	315-0153-00		15 kΩ	1/4 W	5%
R644	315-0153-00		15 kΩ	1/4 W	5%

Switches

Unwired or Wired

SW1 ¹¹	260-0805-00			Lever	AC-GND-DC
SW25 ¹¹	wired *262-0813-00			Rotary	V/CM
SW25 ¹¹	260-0806-00			Rotary	V/CM
SW100 ¹²	260-0802-00	B010100	B049999	Rotary	SIGNAL & TRIGGER SOURCE
SW100 ¹²	260-0802-01	B050000		Rotary	SIGNAL & TRIGGER SOURCE
SW300	260-0723-00			Slide	PULL TO INVERT
SW305 ¹³	311-0652-00				
SW310	260-0723-00			Slide	PULL TO INVERT
SW315 ¹⁴	311-0652-00				
SW320	260-0723-00			Slide	PULL TO INVERT
SW325 ¹⁵	311-0652-00				
SW330	260-0723-00			Slide	PULL TO INVERT
SW335 ¹⁶	311-0652-00				
SW415 ¹⁷	wired *262-0790-00			Rotary	MODE
SW415 ¹⁷	260-0803-00			Rotary	MODE
SW445 ¹⁸	wired *262-0791-00			Rotary	MODE
SW445 ¹⁸	260-0803-00			Rotary	MODE
SW475 ¹⁹	wired *262-0792-00	B010100	B049999	Rotary	DISPLAY
SW475 ¹⁹	wired *262-0792-01	B050000		Rotary	DISPLAY
SW475 ¹⁹	260-0802-00	B010100	B049999	Rotary	DISPLAY
SW475 ¹⁹	260-0802-01	B050000		Rotary	DISPLAY
SW490	260-0675-00			Slide	LOCK-UNLOCK

¹¹There are four switches of this description in the instrument (Ch. 1, 2, 3, 4).

¹²Furnished as a unit with SW475.

¹³Furnished as a unit with R305.

¹⁴Furnished as a unit with R315.

¹⁵Furnished as a unit with R325.

¹⁶Furnished as a unit with R335.

¹⁷There are two parts of this description in the instrument (Ch. 1, 2).

¹⁸There are two parts of this description in the instrument (Ch. 3, 4).

¹⁹Furnished as a unit with SW100.

Transformers

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
T300	*120-0482-00	B010100	B119999	Toroid, 2 turns, bifilar
T300	*120-0269-00	B120000		Toroid, 4 turns, bifilar
T310	*120-0482-00	B010100	B119999	Toroid, 2 turns, bifilar
T310	*120-0269-00	B120000		Toroid, 4 turns, bifilar
T320	*120-0482-00	B010100	B119999	Toroid, 2 turns, bifilar
T320	*120-0269-00	B120000		Toroid, 4 turns, bifilar
T330	*120-0482-00	B010100	B119999	Toroid, 2 turns, bifilar
T330	*120-0269-00	B120000		Toroid, 4 turns, bifilar
T420	*120-0493-00			Transformer Assembly
T450	*120-0493-00			Transformer Assembly
T460	*120-0493-00			Transformer Assembly
T601	*120-0481-00			Power

Electron Tube

V374	154-0187-00		6DJ8
------	-------------	--	------

TRIGGER CARD

*670-0124-00	Complete Card
--------------	---------------

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C110	290-0323-00	270 μ F	Elect.	15 V	
C115	290-0272-00	47 μ F	Elect.	50 V	
C117	281-0089-00	2-8 pF, Var	Cer		
C125	290-0272-00	47 μ F	Elect.	50 V	
C127	281-0542-00	18 pF	Cer	500 V	10%
C135	290-0272-00	47 μ F	Elect.	50 V	
C137	281-0089-00	2-8 pF, Var	Cer		
C140	283-0068-00	0.01 μ F	Cer	500 V	
C142	281-0510-00	22 pF	Cer	500 V	
C147	281-0095-00	0.2-1.5 pF, Var	Teflon		
C151	290-0135-00	15 μ F	Elect.	20 V	
C153	290-0323-00	270 μ F	Elect.	15 V	
C155	283-0002-00	0.01 μ F	Cer	500 V	

Semiconductor Device, Diodes

D101	*152-0185-00	Silicon	Replaceable by 1N4152
D102	*152-0185-00	Silicon	Replaceable by 1N4152
D103	*152-0185-00	Silicon	Replaceable by 1N4152
D104	*152-0185-00	Silicon	Replaceable by 1N4152
D105	*152-0185-00	Silicon	Replaceable by 1N4152

Electrical Parts List—Type 1A4

Semiconductor Device, Diodes (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
D106	*152-0185-00		Silicon	Replaceable by 1N4152
D107	*152-0185-00		Silicon	Replaceable by 1N4152
D108	*152-0185-00		Silicon	Replaceable by 1N4152
D142	*152-0185-00		Silicon	Replaceable by 1N4152
D143	152-0034-00	1	2 Zener	1N753 0.4 W, 6.2 V, 10%
D143	152-0280-00	3	Zener	1N753A 0.4 W, 6.2 V, 5%
D145	*152-0107-00		Silicon	Replaceable by 1N647

Connectors

J101	131-0391-00		Coaxial	50 Ω , male
J102	131-0391-00		Coaxial	50 Ω , male
J103	131-0391-00		Coaxial	50 Ω , male
J104	131-0391-00		Coaxial	50 Ω , male

Inductors

L105	276-0507-00	X4	Core, Ferramic Suppressor
L106	276-0507-00	X4	Core, Ferramic Suppressor
L107	276-0507-00	X4	Core, Ferramic Suppressor
L108	276-0507-00	X4	Core, Ferramic Suppressor

Transistors

Q114	*151-0138-00		Silicon	Replaceable by 2N2857
Q124	*151-0192-00		Silicon	Replaceable by MPS-6521
Q134	*151-0192-00		Silicon	Replaceable by MPS-6521
Q143	*151-0136-00		Silicon	Replaceable by 2N3053
Q144	*151-0192-00		Silicon	Replaceable by MPS-6521

Resistors

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

R105	317-0470-00	X2	47 Ω	$\frac{1}{8}$ W		5%
R106	317-0470-00	X2	47 Ω	$\frac{1}{8}$ W		5%
R107	317-0470-00	X2	47 Ω	$\frac{1}{8}$ W		5%
R108	317-0470-00	X2	47 Ω	$\frac{1}{8}$ W		5%
R109	308-0313-00		20 k Ω	3 W	WW	1%
R110	315-0101-00		100 Ω	$\frac{1}{4}$ W		5%
R112	321-0210-00		1.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R114	321-0266-00		5.76 k Ω	$\frac{1}{8}$ W	Prec	1%
R116	321-0222-00		2 k Ω	$\frac{1}{8}$ W	Prec	1%
R117	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%

Resistors (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
R119	321-0306-00		15 k Ω	$\frac{1}{8}$ W	Prec	1%
R122	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R124	321-0263-00		5.36 k Ω	$\frac{1}{8}$ W	Prec	1%
R126	321-0210-00		1.5 k Ω	$\frac{1}{8}$ W	Prec	1%
R127	315-0361-00		360 Ω	$\frac{1}{4}$ W		5%
R129	321-0306-00		15 k Ω	$\frac{1}{8}$ W	Prec	1%
R132	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R134	321-0263-00		5.36 k Ω	$\frac{1}{8}$ W	Prec	1%
R136	321-0293-00		3.01 k Ω	$\frac{1}{8}$ W	Prec	1%
R137	315-0202-00		2 k Ω	$\frac{1}{4}$ W		5%
R140	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R141	315-0203-00		20 k Ω	$\frac{1}{4}$ W		5%
R142	321-0193-00		1 k Ω	$\frac{1}{8}$ W	Prec	1%
R144	315-0103-00		10 k Ω	$\frac{1}{4}$ W		5%
R145	315-0102-00		1 k Ω	$\frac{1}{4}$ W		5%
R146	321-0306-00		15 k Ω	$\frac{1}{8}$ W	Prec	1%
R147	315-0683-00		68 k Ω	$\frac{1}{4}$ W		5%
R148	315-0910-00		91 Ω	$\frac{1}{4}$ W		5%
R149	315-0510-00		51 Ω	$\frac{1}{4}$ W		5%
R151	315-0100-00		10 Ω	$\frac{1}{4}$ W		5%
R153	307-0103-00		2.7 Ω	$\frac{1}{4}$ W		5%
R155	315-0470-00		47 Ω	$\frac{1}{4}$ W		5%

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations which appear either on the back of the diagrams or on pullout pages immediately following the diagrams of the instruction manual.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the Description column.

Assembly and/or Component
Detail Part of Assembly and/or Component
mounting hardware for Detail Part
Parts of Detail Part
mounting hardware for Parts of Detail Part
mounting hardware for Assembly and/or Component

Mounting hardware always appears in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Mounting hardware must be purchased separately, unless otherwise 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 ATTENUATOR SWITCHES

FIG. 3 CHASSIS & REAR

SECTION 9

MECHANICAL PARTS LIST

FIG. 1 FRONT

Fig. & Index No.	Part No. Tektronix	Serial/Model Eff	No. Disc	Q					Description	
				y	1	2	3	4		5
1-1	366-0322-01			1						KNOB, charcoal—MODE 1 & 2
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-2	262-0790-00			1						SWITCH, wired—MODE 1 & 2
	- - - - -			-						switch includes:
	260-0803-00			1						SWITCH, unwired
	131-0371-00			1						CONNECTOR, cable (not shown)
	179-1108-00			1						CABLE HARNESS (not shown)
	- - - - -			-						cable harness includes:
	131-0371-00			19						CONNECTOR, cable
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0207-00			1						LUG, solder, 3/8 ID x 5/8 inch OD, SE (not shown)
-3	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-4	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-5	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch
-6	366-0140-00			1						KNOB, red—SIGNAL & TRIGGER SOURCE
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-7	366-0322-00			1						KNOB, charcoal—DISPLAY
	- - - - -			-						knob includes:
	213-0004-00			1						SCREW, set, 6-32 x 3/16 inch, HSS
-8	262-0792-00	B010100	B049999	1						SWITCH, wired—DISPLAY
	262-0792-01	B050000		1						SWITCH, wired—DISPLAY
	- - - - -			-						switch includes:
	260-0802-00	B010100	B049999	1						SWITCH, unwired
	260-0802-01	B050000		1						SWITCH, unwired
	131-0371-00			1						CONNECTOR, cable (not shown)
	179-1107-00			1						CABLE HARNESS (not shown)
	- - - - -			-						cable harness includes:
	131-0371-00			19						CONNECTOR, cable
	- - - - -			-						mounting hardware: (not included w/switch)
	210-0207-00			1						LUG, solder, 3/8 ID x 5/8 inch OD, SE (not shown)
-9	210-0012-00			1						LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-10	210-0978-00			1						WASHER, flat, 3/8 ID x 1/2 inch OD
-11	210-0590-00			1						NUT, hex., 3/8-32 x 7/16 inch

Mechanical Parts List—Type 1A4

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † Y	Description
		Eff	Disc		
1-12	366-0322-01			1	KNOB, charcoal—MODE 3 & 4
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-13	262-0791-00			1	SWITCH, wired—MODE 3 & 4
	- - - - -			-	switch includes:
	260-0803-00			1	SWITCH, unwired
	131-0371-00			1	CONNECTOR, cable (not shown)
	179-1109-00			1	CABLE HARNESS (not shown)
	- - - - -			-	cable harness includes:
	131-0371-00			17	CONNECTOR, cable
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0207-00			1	LUG, solder, 3/8 ID x 5/8 inch OD, SE (not shown)
-14	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
-15	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD
-16	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch
-17	366-0366-00			1	KNOB, red—IDENTIFY (Channel 1)
	- - - - -			-	knob includes:
	213-0076-00			1	SCREW, set, 2-56 x 1/8 inch, HSS
-18	366-0347-00			1	KNOB, charcoal—POSITION (Channel 1)
	- - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-19	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-20	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-21	366-0366-00			1	KNOB, red—IDENTIFY (Channel 2)
	- - - - -			-	knob includes:
	213-0076-00			1	SCREW, set, 2-56 x 1/8 inch, HSS
-22	366-0347-00			1	KNOB, charcoal—POSITION (Channel 2)
	- - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-23	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-24	366-0366-00			1	KNOB, red—IDENTIFY (Channel 3)
	- - - - -			-	knob includes:
	213-0076-00			1	SCREW, set, 2-56 x 1/8 inch, HSS
-25	366-0347-00			1	KNOB, charcoal—POSITION (Channel 3)
	- - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-26	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	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 † y	Description
		Eff	Disc		
1-27	366-0366-00			1	KNOB, red—IDENTIFY (Channel 4)
	- - - - -			-	knob includes:
	213-0076-00			1	SCREW, set, 2-56 x 1/8 inch, HSS
-28	366-0347-00			1	KNOB, charcoal—POSITION (Channel 4)
	- - - - -			-	knob includes:
	213-0022-00			1	SCREW, set, 4-40 x 3/16 inch, HSS
-29	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-30	358-0301-00			4	BUSHING, sleeve
-31	- - - - -			4	RESISTOR, variable
	- - - - -			-	each resistor includes:
	407-0357-00			1	BRACKET, variable resistor
-32	358-0216-00			1	BUSHING, dove grey
-33	384-0412-00			1	SHAFT, extension
-34	376-0029-00			1	COUPLING
	- - - - -			-	coupling includes:
	213-0048-00			2	SCREW, set, 4-40 x 1/8 inch, HSS
-35	407-0302-00			1	BRACKET, angle
	- - - - -			-	mounting hardware: (not included w/bracket)
	211-0008-00			2	SCREW, 4-40 x 1/4 inch, PHS
-36	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
	210-0940-00			1	WASHER, flat, 1/4 ID x 3/8 inch OD
-37	210-0583-00			1	NUT, hex., 1/4-32 x 5/16 inch
-38	366-0125-00			1	KNOB, plug-in securing
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-39	210-0894-00			1	WASHER, plastic, 0.190 ID x 7/16 inch OD
-40	358-0305-00			1	BUSHING
	- - - - -			-	mounting hardware: (not included w/bushing)
	210-0580-00			1	NUT, hex., 5/16-32 x 3/8 inch
-41	384-0653-00			1	ROD, plug-in securing
	- - - - -			-	rod includes:
	354-0025-00			1	RING, retaining
-42	366-0365-00			1	KNOB, red—VARIABLE (Channel 1)
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-43	366-0322-00			1	KNOB, charcoal—V/CM (Channel 1)
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-44	366-0365-00			1	KNOB, red—VARIABLE (Channel 2)
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS
-45	366-0322-00			1	KNOB, charcoal—V/CM (Channel 2)
	- - - - -			-	knob includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch, HSS

Mechanical Parts List—Type 1A4

FIG. 1 FRONT (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q t y	Description				
				1	2	3	4	5
1-46	366-0365-00		1	KNOB, red—VARIABLE (Channel 3)				
	- - - - -		-	knob includes:				
	213-0004-00		1	SCREW, set, 6-32 x 3/16 inch, HSS				
-47	366-0322-00		1	KNOB, charcoal—V/CM (Channel 3)				
	- - - - -		-	knob includes:				
	213-0004-00		1	SCREW, set, 6-32 x 3/16 inch, HSS				
-48	366-0365-00		1	KNOB, red—VARIABLE (Channel 4)				
	- - - - -		-	knob includes:				
	213-0004-00		1	SCREW, set, 6-32 x 3/16 inch, HSS				
-49	366-0322-00		1	KNOB, charcoal—V/CM (Channel 4)				
	- - - - -		-	knob includes:				
	213-0004-00		1	SCREW, set, 6-32 x 3/16 inch, HSS				
-50	131-0342-00		4	CONNECTOR, BNC, female, w/mounting hardware				
-51	131-0106-00		1	CONNECTOR, coaxial, 1 contact, BNC, w/mounting hardware				
	- - - - -		-	mounting hardware: (not included w/connector)				
	210-0255-00		1	LUG, solder, 3/8 ID x 0.500 inch OD, SE				
-52	131-0251-00		2	CONNECTOR, terminal jack				
-53	210-0202-00		2	LUG, solder, SE #6				
	- - - - -		-	mounting hardware for each: (not included w/lug)				
-54	210-0407-00		1	NUT, hex., 6-32 x 1/4 inch				
-55	366-0215-01		1	KNOB, lever, charcoal—AC GND DC (Channel 1)				
-56	366-0215-01		1	KNOB, lever, charcoal—AC GND DC (Channel 2)				
-57	366-0215-01		1	KNOB, lever, charcoal—AC GND DC (Channel 3)				
-58	366-0215-01		1	KNOB, lever, charcoal—AC GND DC (Channel 4)				
-59	333-0937-01		1	PANEL, front				
-60	386-1102-00		1	PLATE, sub-panel				
	- - - - -		-	plate includes:				
-61	213-0020-00		4	SCREW, set, 6-32 x 1/8 inch, HSS				
-62	384-0653-00		4	ROD, spacer				

FIG. 2 ATTENUATOR SWITCHES

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	Description				
					1	2	3	4	5
2-	644-0016-00	B010100	B029999	1	ASSEMBLY, attenuator switch				
	644-0016-01	B030000	B049999	1	ASSEMBLY, attenuator switch				
	644-0016-02	B050000		1	ASSEMBLY, attenuator switch				
	- - - - -			-	assembly includes:				
	337-0861-00	XB030370		1	SHIELD, attenuator, left (not shown)				
	- - - - -			-	mounting hardware: (not included w/shield)				
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)				
337-0860-00	XB030370		1	SHIELD, attenuator, right (not shown)					
	- - - - -		-	mounting hardware: (not included w/shield)					
	213-0176-00	XB030370	6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)					
262-0813-00			1	SWITCH, wired—V/CM (Channel 1)					
- - - - -			-	switch includes:					
-1	260-0806-00			1	SWITCH, unwired				
-2	260-0805-00			1	SWITCH, lever—AC GND DC				
- - - - -			-	mounting hardware: (not included w/switch)					
	210-0001-00			2	LOCKWASHER, internal, #2				
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch				
-3	136-0235-00			3	SOCKET, transistor, 6 pin				
	- - - - -		-	mounting hardware for each: (not included w/socket)					
-4	354-0234-00			1	RING, socket mounting				
-5	131-0433-00			5	CONNECTOR, terminal				
	- - - - -		-	mounting hardware for each: (not included w/connector)					
	358-0241-00			1	BUSHING, plastic				
-6	131-0344-00			1	CONNECTOR, terminal, feed thru				
	- - - - -		-	mounting hardware: (not included w/connector)					
	358-0241-00			1	BUSHING, plastic				
-7	- - - - -			2	CAPACITOR				
	- - - - -		-	mounting hardware for each: (not included w/capacitor)					
	358-0300-00			1	BUSHING, insulating				
-8	337-0862-00			1	SHIELD				
-9	441-0681-00			1	CHASSIS, attenuator				
-10	214-0599-00			2	SPRING, ground clip				
-11	175-0467-00			1	ASSEMBLY, cable connector				
	- - - - -		-	assembly includes:					
	131-0374-00			4	CONNECTOR, cable				
-12	131-0371-00			2	CONNECTOR, cable				
-13	175-0466-00			1	ASSEMBLY, cable connector				
	- - - - -		-	assembly includes:					
	131-0155-00			1	CONNECTOR, coaxial				
-14	351-0107-00			1	GUIDE MOUNT, variable resistor				
	- - - - -		-	mounting hardware: (not included w/guide mount)					
	210-0001-00			2	LOCKWASHER, internal, #2				
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch				
-15	- - - - -			1	RESISTOR, variable				
	- - - - -		-	mounting hardware: (not included w/resistor)					
-16	214-0749-00			1	SPRING, detent				
	211-0130-00			1	SCREW, 4-40 x 1/4 inch, HHS (not shown)				
	210-0994-00			1	WASHER, flat, 0.125 ID x 0.250 inch OD (not shown)				
- - - - -		-	mounting hardware: (not included w/assembly)						
-17	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD				
	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD (not shown)				
	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch (not shown)				

FIG. 2 ATTENUATOR SWITCHES (cont)

Fig. & Index No.	Part No. Tektronix	Serial/Model No.		Q t Y	Description
		Eff	Disc		
2-18	200-0715-00			2	COVER, transistor
-19	376-0039-00			1	COUPLING, shaft
	- - - - -			-	coupling includes:
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS
-20	376-0058-00			1	COUPLER, plastic
-21	384-0413-00			1	PIN, slide switch actuating
-22	337-0861-00	B010100	B030369X	1	SHIELD, attenuator, left
	- - - - -			-	mounting hardware: (not included w/shield)
-23	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS
	213-0176-00	B020440	B030369X	6	SCREW, thread forming, #2 x 0.156 inch, PHS
-24	337-0860-00	B010100	B030369X	1	SHIELD, attenuator, right
	- - - - -			-	mounting hardware: (not included w/shield)
-25	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS
	213-0176-00	B020440	B030369X	6	SCREW, thread forming, #2 x 0.156 inch, PHS
	644-0016-00	B010100	B029999	1	ASSEMBLY, attenuator switch
	644-0016-01	B030000	B049999	1	ASSEMBLY, attenuator switch
	644-0016-02	B050000		1	ASSEMBLY, attenuator switch
	- - - - -			-	assembly includes:
	337-0861-00	XB030370		1	SHIELD, attenuator, left (not shown)
	- - - - -			-	mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)
	337-0860-00	XB030370		1	SHIELD, attenuator, right (not shown)
	- - - - -			-	mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)
	262-0813-00			1	SWITCH, wired—V/CM (Channel 2)
	- - - - -			-	switch includes:
-26	260-0806-00			1	SWITCH, unwired
-27	260-0805-00			1	SWITCH, lever—AC GND DC
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-28	136-0235-00			3	SOCKET, transistor, 6 pin
	- - - - -			-	mounting hardware for each: (not included w/socket)
-29	354-0234-00			1	RING, socket mounting
-30	131-0433-00			5	CONNECTOR, terminal
	- - - - -			-	mounting hardware for each: (not included w/connector)
	358-0241-00			1	BUSHING, plastic
-31	131-0344-00			1	CONNECTOR, terminal, feed thru
	- - - - -			-	mounting hardware: (not included w/connector)
	358-0241-00			1	BUSHING, plastic
-32	- - - - -			2	CAPACITOR
	- - - - -			-	mounting hardware for each: (not included w/capacitor)
	358-0300-00			1	BUSHING, insulating
-33	337-0862-00			1	SHIELD
-34	441-0681-00			1	CHASSIS, attenuator
-35	214-0599-00			2	CLIP, ground
-36	175-0467-00			4	ASSEMBLY, cable connector
	- - - - -			-	assembly includes:
	131-0374-00			4	CONNECTOR, cable

FIG. 2 ATTENUATOR SWITCHES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
2-37	131-0371-00			2	CONNECTOR, cable
-38	175-0466-00			1	ASSEMBLY, cable connector
	- - - - -			-	assembly includes:
	131-0155-00			1	CONNECTOR, coaxial
-39	351-0107-00			1	GUIDE MOUNT, variable resistor
	- - - - -			-	mounting hardware: (not included w/guide mount)
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-40	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-41	214-0749-00			1	SPRING, detent
	211-0130-00			1	SCREW, 4-40 x 1/4 inch, HHS (not shown)
	210-0994-00			1	WASHER, flat, 0.125 ID x 0.250 inch OD (not shown)
	- - - - -			-	mounting hardware: (not included w/assembly)
-42	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch (not shown)
-43	200-0715-00			2	COVER, transistor
-44	376-0039-00			1	COUPLING, shaft
	- - - - -			-	coupling includes:
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS
-45	376-0058-00			1	COUPLER, plastic
-46	384-0413-00			1	PIN, slide switch actuating
-47	337-0861-00	B010100	B030369X	1	SHIELD, attenuator, left
	- - - - -			-	mounting hardware: (not included w/shield)
-48	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS
	213-0176-00	B020440		6	SCREW, thread forming, #2 x 0.156 inch, PHS
-49	337-0860-00	B010100	B030369X	1	SHIELD, attenuator, right
	- - - - -			-	mounting hardware: (not included w/shield)
-50	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS
	213-0176-00	B020440	B030369X	6	SCREW, thread forming, #2 x 0.156 inch, PHS
	644-0016-00	B010100	B029999	1	ASSEMBLY, attenuator switch
	644-0016-01	B030000	B049999	1	ASSEMBLY, attenuator switch
	644-0016-02	B050000		1	ASSEMBLY, attenuator switch
	- - - - -			-	assembly includes:
	337-0861-00	XB030370		1	SHIELD, attenuator, left (not shown)
	- - - - -			-	mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)
	337-0860-00	XB030370		1	SHIELD, attenuator, right (not shown)
	- - - - -			-	mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)
	262-0813-00			1	SWITCH, wired—V/CM (Channel 3)
	- - - - -			-	switch includes:
-51	260-0806-00			1	SWITCH, unwired
-52	260-0805-00			1	SWITCH, lever—AC GND DC
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-53	136-0235-00			3	SOCKET, transistor, 6 pin
	- - - - -			-	mounting hardware for each: (not included w/socket)
-54	354-0234-00			1	RING, socket mounting

FIG. 2 ATTENUATOR SWITCHES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
2-55	131-0433-00 - - - - - 355-0241-00			5 - 1	CONNECTOR, terminal mounting hardware for each: (not included w/connector) BUSHING, plastic
-56	131-0344-00 - - - - - 358-0241-00			1 - 1	CONNECTOR, terminal, feed thru mounting hardware: (not included w/connector) BUSHING, plastic
-57	- - - - - - - - - - 358-0300-00			2 - 1	CAPACITOR mounting hardware for each: (not included w/capacitor) BUSHING, insulating
-58	337-0862-00			1	SHIELD
-59	441-0681-00			1	CHASSIS, attenuator
-60	214-0599-00			2	CLIP, ground
-61	175-0467-00 - - - - - 131-0374-00			1 - 4	ASSEMBLY, cable connector assembly includes: CONNECTOR, cable
-62	131-0371-00			2	CONNECTOR, cable
-63	175-0466-00 - - - - - 131-0155-00			1 - 1	ASSEMBLY, cable connector assembly includes: CONNECTOR, cable
-64	351-0107-00 - - - - - 210-0001-00 210-0405-00			1 - 2 2	GUIDE MOUNT, variable resistor mounting hardware: (not included w/guide mount) LOCKWASHER, internal, #2 NUT, hex., 2-56 x 3/16 inch
-65	- - - - - - - - - -			1 -	RESISTOR, variable mounting hardware: (not included w/resistor)
-66	214-0749-00 211-0130-00 210-0994-00 - - - - -			1 2 -	SPRING, detent SCREW, 4-40 x 1/4 inch, HHS (not shown) WASHER, flat, 0.125 ID x 0.250 inch OD (not shown) mounting hardware: (not included w/assembly)
-67	210-0012-00 210-0590-00			1 1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD NUT, hex., 3/8-32 x 7/16 inch (not shown)
-68	200-0715-00			2	COVER, transistor
-69	376-0039-00 - - - - - 213-0075-00			1 - 2	COUPLING, shaft coupling includes: SCREW, set, 4-40 x 3/32 inch, HSS
-70	376-0058-00			1	COUPLER, plastic
-71	384-0413-00			1	PIN, slide switch actuating
-72	337-0861-00 - - - - -	B010100	B030369X	1 -	SHIELD, attenuator, left mounting hardware: (not included w/shield)
-73	213-0055-00 213-0176-00	B010100 B020440	B020439 B030369X	6 6	SCREW, thread forming, 2-32 x 3/16 inch, PHS SCREW, thread forming, #2 x 0.156 inch, PHS
-74	337-0860-00 - - - - -	B010100	B030369X	1 -	SHIELD, attenuator, right mounting hardware: (not included w/shield)
-75	213-0055-00 213-0176-00	B010100 B020440	B020439 B030369X	6 1	SCREW, thread forming, 2-32 x 3/16 inch, PHS SCREW, thread forming, #2 x 0.156 inch, PHS
	644-0016-00 644-0016-01 644-0016-02 - - - - -	B010100 B030000 B050000	B029999 B040000	1 1 1	ASSEMBLY, attenuator switch ASSEMBLY, attenuator switch ASSEMBLY, attenuator switch
	337-0861-00 - - - - -	XB030370		1 -	SHIELD, attenuator, left (not shown) mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, #2 x 0.156 inch, PHS (not shown)

FIG. 2 ATTENUATOR SWITCHES (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
					1 2 3 4 5
2-	337-0860-00	XB030370		1	SHIELD, attenuator, right (not shown)
	- - - - -			-	mounting hardware: (not included w/shield)
	213-0176-00	XB030370		6	SCREW, thread forming, # x 0.156 inch, PHS (not shown)
	262-0813-00			1	SWITCH, wired—V/CM (Channel 4)
	- - - - -			-	switch includes:
-76	260-0806-00			1	SWITCH, unwired
-77	260-0805-00			1	SWITCH, lever—AC GND DC
	- - - - -			-	mounting hardware: (not included w/switch)
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-78	136-0235-00			3	SOCKET, transistor, 6 pin
	- - - - -			-	mounting hardware for each: (not included w/socket)
-79	354-0234-00			1	RING, socket mounting
-80	131-0433-00			1	CONNECTOR, terminal
	- - - - -			-	mounting hardware for each: (not included w/connector)
	358-0241-00			5	BUSHING, plastic
-81	131-0344-00			1	CONNECTOR, terminal, feed thru
	- - - - -			-	mounting hardware: (not included w/connector)
	358-0241-00			1	BUSHING, plastic
-82	- - - - -			2	CAPACITOR
	- - - - -			-	mounting hardware for each: (not included w/capacitor)
	358-0300-00			1	BUSHING, insulating
-83	337-0862-00			1	SHIELD
-84	441-0681-00			1	CHASSIS, attenuator
-85	214-0599-00			2	CLIP, ground
-86	175-0467-00			1	ASSEMBLY, cable connector
	- - - - -			-	assembly includes:
	131-0374-00			4	CONNECTOR, cable
-87	131-0371-00			2	CONNECTOR, cable
-88	175-0466-00			1	ASSEMBLY, cable connector
	- - - - -			-	assembly includes:
	131-0155-00			1	CONNECTOR, cable
-89	351-0107-00			1	GUIDE MOUNT, variable resistor
	- - - - -			-	mounting hardware: (not included w/guide mount)
	210-0001-00			2	LOCKWASHER, internal, #2
	210-0405-00			2	NUT, hex., 2-56 x 3/16 inch
-90	- - - - -			1	RESISTOR, variable
	- - - - -			-	mounting hardware: (not included w/resistor)
-91	214-0749-00			1	SPRING, detent
	211-0130-00			1	SCREW, 4-40 x 1/4 inch, HHS (not shown)
	210-0994-00			1	WASHER, flat, 0.125 ID x 0.250 inch OD (not shown)
	- - - - -			-	mounting hardware: (not included w/switch)
-92	210-0012-00			1	LOCKWASHER, internal, 3/8 ID x 1/2 inch OD
	210-0978-00			1	WASHER, flat, 3/8 ID x 1/2 inch OD (not shown)
	210-0590-00			1	NUT, hex., 3/8-32 x 7/16 inch (not shown)
-93	200-0715-00			2	COVER, transistor

Mechanical Parts List—Type 1A4

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description	
		Eff	Disc			1
2-94	376-0039-00			1	COUPLING, shaft	
	- - - - -			-	coupling includes:	
	213-0075-00			2	SCREW, set, 4-40 x 3/32 inch, HSS	
-95	376-0058-00			1	COUPLER, plastic	
-96	384-0413-00			1	PIN, slide switch actuating	
-97	337-0861-00	B010100	B030369X	1	SHIELD, attenuator, left	
	- - - - -			-	mounting hardware: (not included w/shield)	
-98	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS	
	213-0176-00	B020440	B030369X	6	SCREW, thread forming, #2 x 0.156 inch, PHS	
-99	337-0860-00	B010100	B030369X	1	SHIELD, attenuator, right	
	- - - - -			-	mounting hardware: (not included w/shield)	
-100	213-0055-00	B010100	B020439	6	SCREW, thread forming, 2-32 x 3/16 inch, PHS	
	213-0176-00	B020440	B030369X	6	SCREW, thread forming, #2 x 0.156 inch, PHS	

FIG. 3 CHASSIS & REAR

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q † y	Description
		Eff	Disc		
3-1	670-0125-00			1	ASSEMBLY, circuit board—OUTPUT
	- - - - -			-	assembly includes:
	388-0756-00			1	BOARD, circuit
-2	136-0220-00	B010100	B099999	4	SOCKET, transistor, 3 pin
	136-0220-00	B100000		6	SOCKET, transistor, 3 pin
-3	136-0228-00			1	SOCKET, tube, 9 pin
-4	136-0219-00	B010100	B099999X	2	SOCKET, transistor, 4 pin
-5	260-0723-00			4	SWITCH, slide
-6	344-0119-00			6	CLIP, lead
-7	214-0798-00			1	HEATSINK, double
	- - - - -			-	mounting hardware: (not included w/heat sink)
-8	211-0040-00			2	SCREW, 4-40 x 1/4 inch, BH Plastic
-9	214-0817-00			2	HEAT SINK
-10	214-0506-00			55	PIN, connector
	- - - - -			-	mounting hardware: (not included w/assembly)
-11	211-0116-00			2	SCREW, sems, 4-40 x 5/16 inch, PHB
-12	220-0455-00			2	NUT, block
-13	211-0097-00			2	SCREW, 4-40 x 5/16 inch, PHS
-14	129-0099-00			2	POST
-15	407-0261-00			1	BRACKET, attenuator support
-16	179-1110-00			1	CABLE HARNESS
	- - - - -			-	cable harness includes:
-17	131-0371-00			8	CONNECTOR, cable
-18	131-0327-00			1	CONNECTOR, 30 contact
	- - - - -			-	mounting hardware: (not included w/connector)
-19	211-0014-00			2	SCREW, 4-40 x 1/2 inch, PHS
-20	210-0201-00			1	LUG, solder, SE #4
-21	210-0586-00			2	NUT, keps, 4-40 x 1/4 inch
-22	407-0262-00			1	BRACKET, connector mounting
	- - - - -			-	mounting hardware: (not included w/bracket)
-23	211-0008-00	B010100	B059999	2	SCREW, 4-40 x 1/4 inch, PHS
	211-0007-00	B060000		2	SCREW, 4-40 x 3/16 inch, PHS
-24	337-0886-00			1	SHIELD, circuit board
	- - - - -			-	mounting hardware: (not included w/shield)
-25	211-0008-00			4	SCREW, 4-40 x 1/4 inch, PHS

FIG. 3 CHASSIS & REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q					Description	
				†	Y	1	2	3		4
3-26	670-0124-00			1						ASSEMBLY, circuit CARD—TRIGGER
	-----			-						assembly includes:
	388-0803-00			1						CARD, circuit
-27	136-0252-00	B010100	B051109	16						SOCKET, pin connector
	136-0252-01	B051110		16						SOCKET, pin connector
-28	131-0391-00			4						CONNECTOR, coaxial
-29	407-0301-00			1						BRACKET, ground spring
	-----			-						mounting hardware: (not included w/assembly)
-30	210-0994-00			2						WASHER, flat, 0.125 ID x 0.250 inch OD
-31	211-0008-00			2						SCREW, 4-40 x 1/4 inch, PHS
-32	441-0682-00			1						CHASSIS
	-----			-						mounting hardware: (not included w/chassis)
	212-0040-00			2						SCREW, 8-32 x 3/8 inch, 100° csk, FHS (not shown)
-33	210-0458-00			2						NUT, keps, 8-32 x 11/32 inch
-34	212-0004-00			2						SCREW, 8-32 x 5/16 inch, PHS
-35	348-0063-00			1						GROMMET, plastic, 1/2 inch diameter
-36	344-0016-00			4						CLIP, capacitor mounting
	-----			-						mounting hardware for each: (not included w/clip)
-37	211-0008-00	B010100	B059999	1						SCREW, 4-40 x 1/4 inch, PHS
	211-0007-00	B060000		1						SCREW, 4-40 x 1/4 inch, PHS
-38	-----			1						RESISTOR
	-----			-						mounting hardware: (not included w/resistor)
-39	212-0004-00			1						SCREW, 8-32 x 5/16 inch, PHS
-40	210-0462-00			1						NUT, resistor mounting
-41	210-0808-00			1						WASHER, centering
-42	212-0037-00			1						SCREW, 8-32 x 1 3/4 inches, Fil HS
-43	179-1106-00	B010100	B099999	1						CABLE HARNESS, chassis
	179-1106-01	B050000		1						CABLE HARNESS, chassis
	-----			-						cable harness includes:
	131-0371-00			49						CONNECTOR, cable (not shown)
-44	131-0371-00			32						CONNECTOR, cable
-45	670-0123-00			1						ASSEMBLY, circuit board—LOGIC
	-----			-						assembly includes:
	388-0755-00			1						BOARD, circuit
-46	214-0579-00			3						PIN, test point
-47	214-0506-00			86						PIN, connector
-48	136-0220-00			17						SOCKET, transistor, 3 pin
-49	136-0183-00			2						SOCKET, transistor, 3 pin
-50	214-0668-00			1						HEAT SINK
-51	136-0234-00			2						RECEPTACLE
-52	-----			1						TRANSISTOR
	-----			-						mounting hardware: (not included w/transistor)
-53	211-0511-00			2						SCREW, 6-32 x 1/2 inch, PHS
-54	220-0435-00			2						NUT, captive, 6-32 x 0.187 inch long
-55	210-0457-00			2						NUT, keps, 6-32 x 5/16 inch
	-----			-						mounting hardware: (not included w/assembly)
-56	211-0116-00			7						SCREW, sems, 4-40 x 5/16 inch, PHB

FIG. 3 CHASSIS & REAR (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description
				t	y	1	2	3	
3-57	- - - - -			1					TRANSFORMER
	- - - - -			-					mounting hardware: (not included w/transformer)
-58	211-0021-00			2					SCREW, 4-40 x 1 1/4 inches, RHS
	210-0054-00			2					LOCKWASHER, split spring #4
-59	220-0413-00			2					NUT, mounting
-60	- - - - -			1					RESISTOR, variable
	- - - - -			-					mounting hardware: (not included w/resistor)
-61	211-0128-00			2					SCREW, 2-56 x 1 3/8 inches, PHS
	166-0024-00			2					TUBE, spacer, 1/8 inch long
-62	210-0850-00			2					WASHER, flat, 0.093 ID x 9/32 inch OD
	210-0001-00			2					LOCKWASHER, internal, #2
-63	210-0405-00			2					NUT, hex., 2-56 x 3/16 inch
-64	260-0675-00			1					SWITCH, slide—LOCK UNLOCK
	- - - - -			-					mounting hardware: (not included w/switch)
	211-0008-00			2					SCREW, 4-40 x 1/4 inch, PHS (not shown)
-65	210-0406-00			2					NUT, hex., 4-40 x 3/16 inch
-66	131-0017-00			1					CONNECTOR, 16 contact
	- - - - -			-					mounting hardware: (not included w/connector)
-67	211-0008-00			2					SCREW, 4-40 x 1/4 inch, PHS
-68	210-0586-00			2					NUT, keps, 4-40 x 1/4 inch
-69	386-1103-00			1					PLATE, rear
	- - - - -			-					mounting hardware: (not included w/plate)
-70	212-0044-00			4					SCREW, 8-32 x 1/4 inch, RHS
STANDARD ACCESSORIES									
	012-0076-00			1					CABLE, BNC, 18 inches (not shown)
	070-0545-00			2					MANUAL, instruction (not shown)

IMPORTANT

VOLTAGE AND WAVEFORM CONDITIONS

Circuit voltages were measured with a 20,000 Ω/V DC VOM. All readings are in volts. Voltages were measured with respect to ground unless indicated otherwise.

Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera equipped with a projected graticule. Each division of the graticule represents one cm.

Voltages and waveforms (shown in blue) on the diagrams are not absolute and may vary between Type 1A4 units. A 30 inch flexible cable plug-in extension (012-0038-00) was used to operate the Type 1A4 outside the oscilloscope plug-in opening and a rigid extender card (018-0009-00) was used for access to the Trigger Circuit test points. Any apparent differences between the voltages measured with the voltmeter and the DC levels when shown at the right side of the waveforms are due to such differences as circuit loading, operating mode and measurement resolution.

The waveforms were obtained using a test oscilloscope with a 10 \times probe. The system characteristics are as follows: Minimum vertical deflection factor of 0.05 V/cm with probe 10 \times attenuation factor included; frequency response of DC to 10 MHz. The procedure for obtaining the time-related waveforms and DC levels is described in the Maintenance section.

CAUTION

If the Type 1A4 is used with a Type 544, 546 or 547 Oscilloscope and the plug-in extension is used, be sure to pull the oscilloscope plug-in sensing switch to its outward position before turning on the oscilloscope power. The switch connects the +75-V supply to pin 15 of the 16-pin interconnecting plug. Use care when obtaining voltage and waveform measurements in an operating unit. An inadvertent movement of the test prods or probe may cause a short between circuits.

Type 1A4

(See diagrams for remaining control settings)

AC-GND-DC Ch 2, 3 & 4)	GND
V/CM (all)	.5
VARIABLE (all)	CAL
INVERT (all)	Pushed in
POSITION (Ch 2, 3 & 4)	Midrange
SIGNAL & TRIGGER SOURCE	1

Type 547 Oscilloscope with 1A4

Triggering controls

Triggering Level

Near 0 and knob pushed in for all voltages and waveforms except ALT waveforms.

Fully CW and knob pulled outward to free run sweep for ALT waveforms on 4.




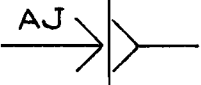

Mode	Auto Stability
Slope	+
Coupling	AC
Source	Norm Int
Time Base controls	
Time/Cm	.5 mSec, to display 1-kHz calibrator signal on CRT. (Diagrams 1 and 3)
Variable (Time/Cm)	.1 mSec, to obtain proper repetition rate for ALT waveforms on 4 . Leave at .1 mSec for CHOP waveforms.
Other controls	Calibrated
Sweep Magnifier	Off ($\times 1$)
Power	On

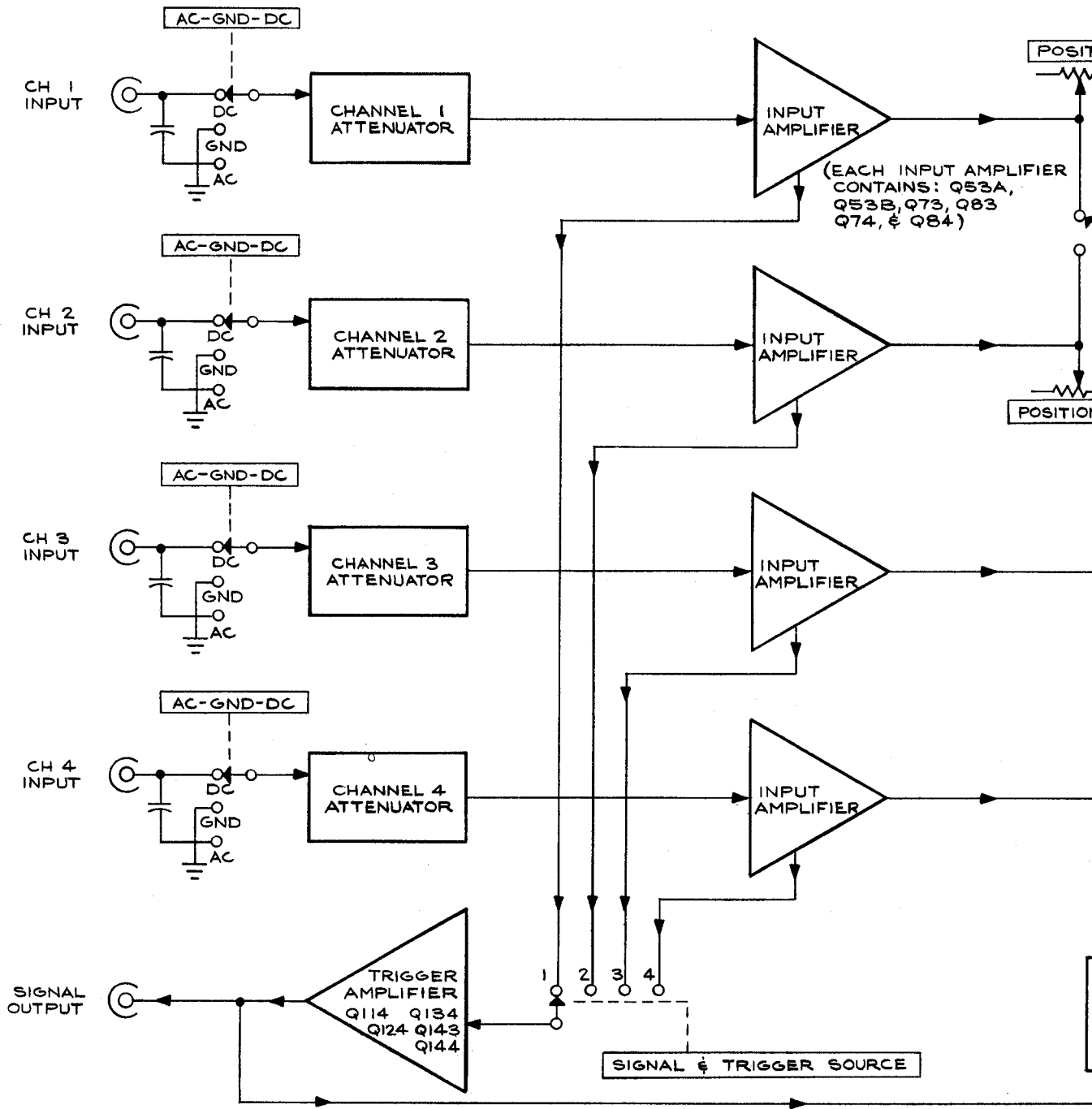
Test Oscilloscope (for signal tracing)

Trigger signal applied to Trigger Input connector	2-V peak-to-peak 1-kHz calibrator signal to obtain time-related waveforms on diagrams 1 and 3 .
	4-V peak-to-peak switching signal from pin CB on Logic board to obtain time-related ALT and CHOP waveforms on diagram 4 .
Time/Cm	See waveforms
V/Cm	See waveforms
Input Coupling	AC, to photograph waveforms. DC, to obtain DC levels (when shown) at right side of waveforms. Used appropriate V/CM setting (not given).

Schematic Symbols

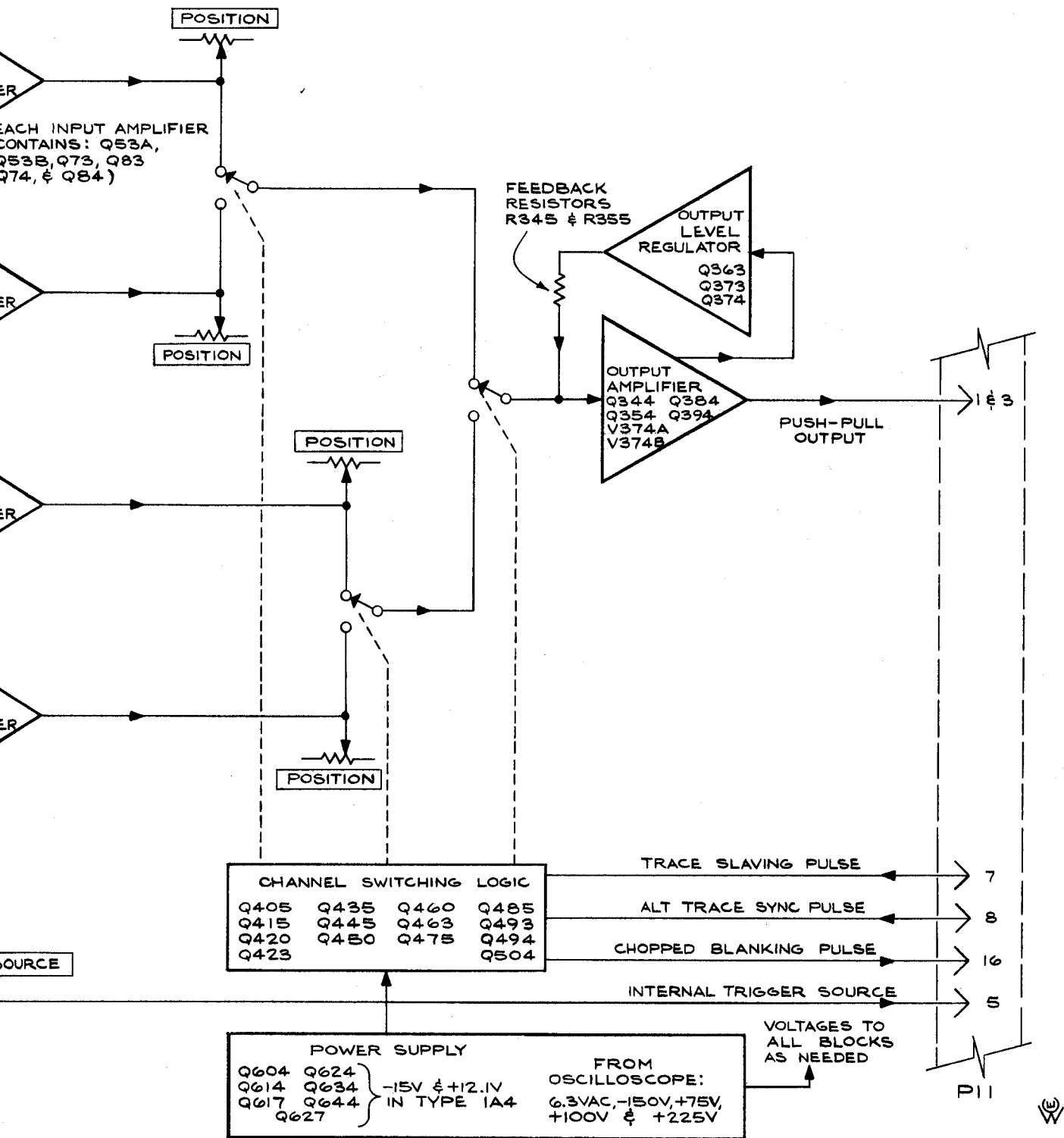
The following symbols are used on the diagrams:

	Screwdriver adjustment.
	Front- or rear-panel control.
	Refer to indicated diagram.
	Connection to circuit board made with pin connector at indicated pin.
	Blue line encloses components located on circuit board.



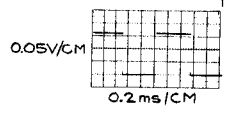
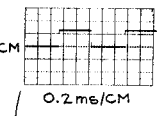
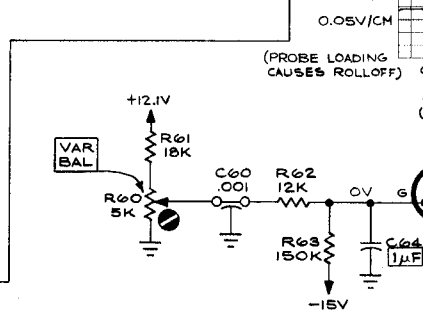
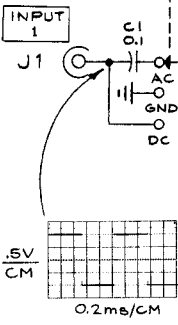
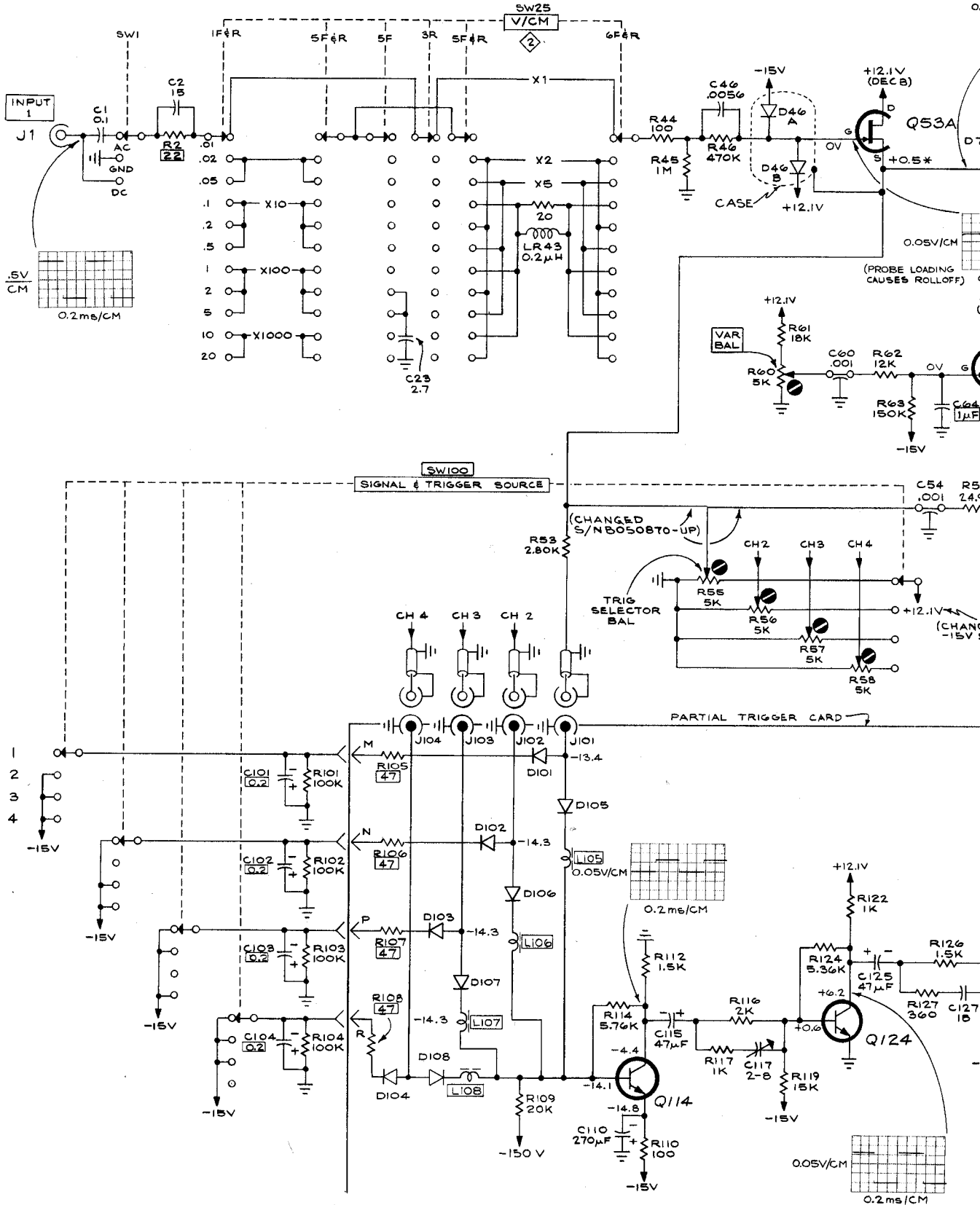
SEE IMPORTANT NOTE
FOR VOLTAGE AND
WAVEFORM CONDITIONS

TYPE 1A4 PLUG-IN



A

467
BLOCK DIAGRAM



TYPE 1A4 PLUG-IN

+

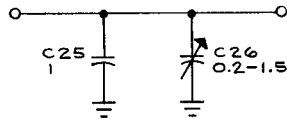
Type 1A4	VOLTAGES	WAVEFORMS
Input signal to Ch 1	Not required	2-V P-P 1-kHz square-wave calibrator
AC-GND-DC (Ch 1)	GND	AC
POSITION (Ch 1)		Midrange
Ch 1 & 2 MODE		CHANNEL 1
Ch 3 & 4 MODE		CHANNEL 3
DISPLAY		1 & 2

Also see IMPORTANT note on inside section of Block Diagram.

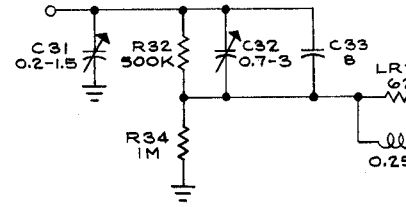
*VOLTAGE SUBJECT TO WIDE VARIATION DUE TO FET CHARACTERISTICS. VOLTAGES AT Q73, Q83, Q74 & Q84 EMITTERS WILL VARY ACCORDINGLY.

SEE P SEMIC

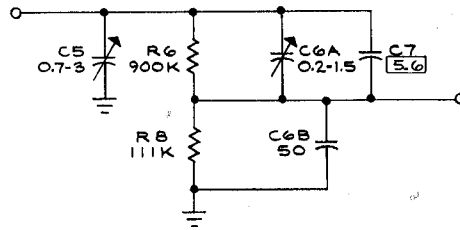
X 1



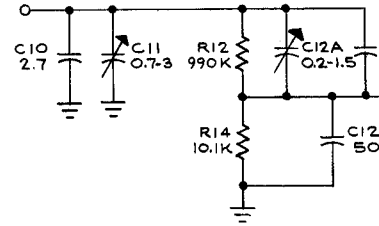
X 2



X10



X100

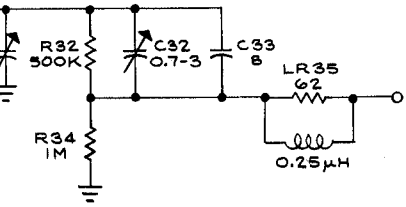


TYPE 1A4 PLUG-IN

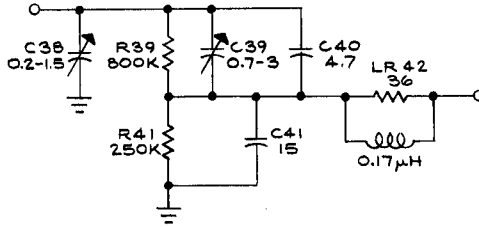
+

B

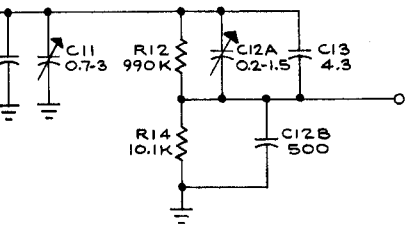
X2



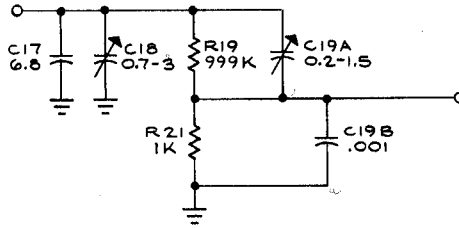
X5



X100



X1000



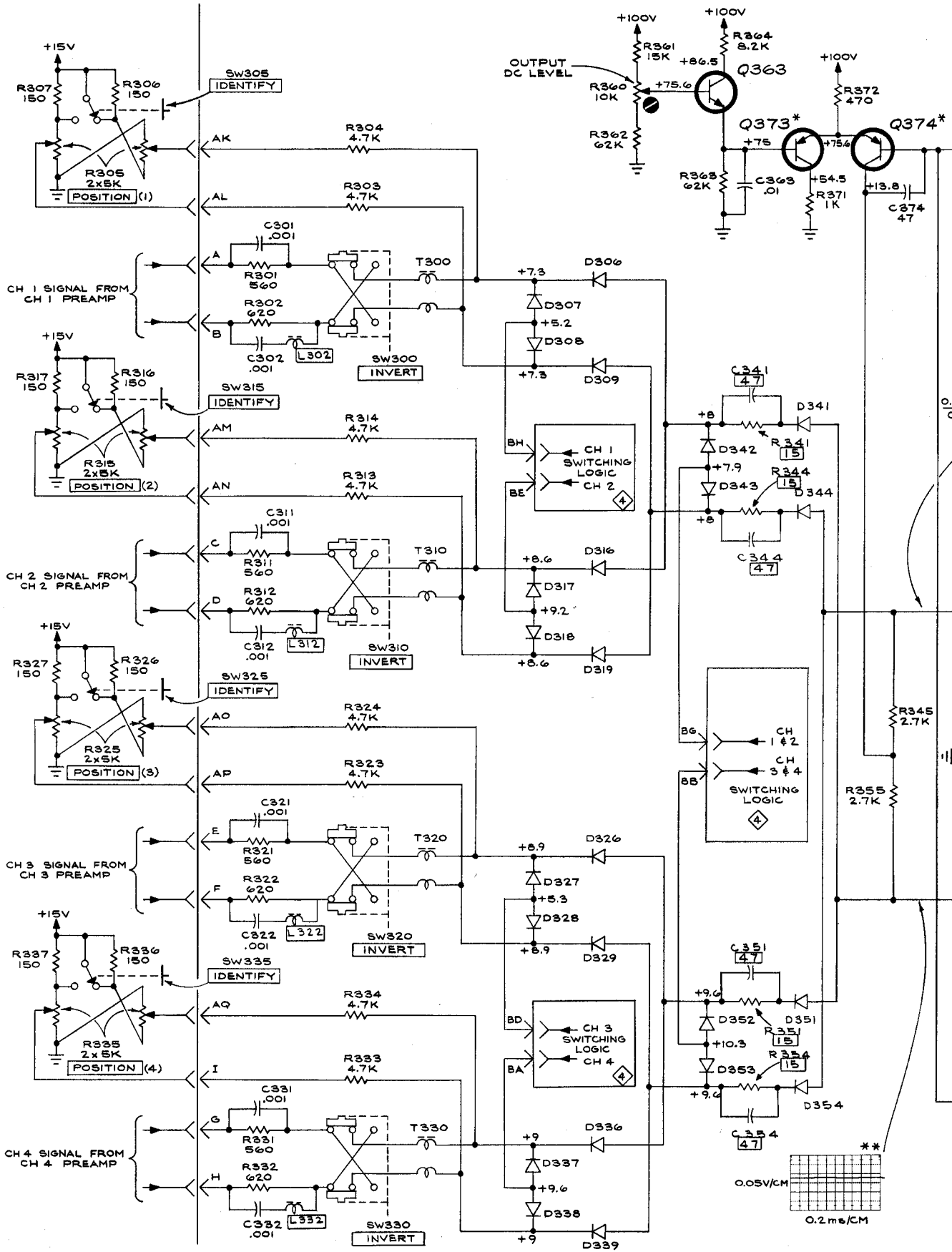
SEE PARTS LIST FOR EARLIER
VALUES AND SERIAL NUMBER
RANGES OF PARTS MARKED
WITH BLUE OUTLINE.

B



168

2 ATTENUATORS
(4 CHANNELS)



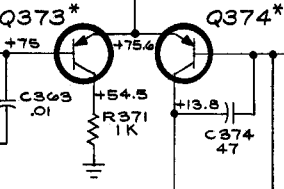
TYPE 1A4 PLUG-IN

+

SEE PA
VALUE
RANGE
WITH

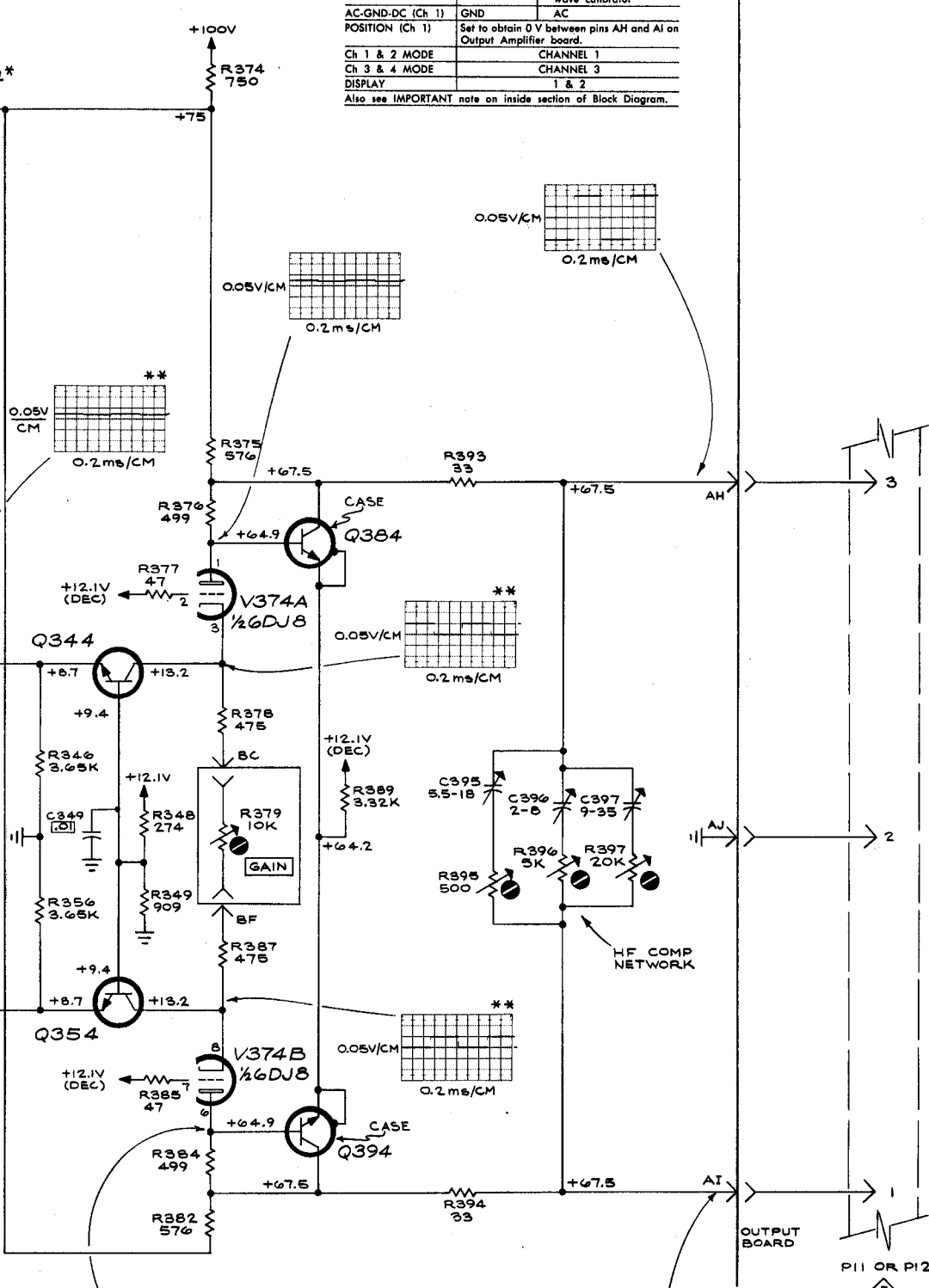
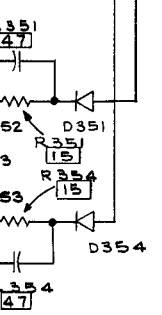
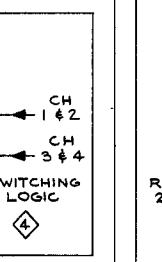
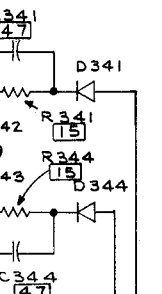
D

364
3.2K
Q363



Type 1A4	VOLTAGES	WAVEFORMS
Input signal to Ch 1	Not required	2-V P-P 1 kHz square-wave calibrator
AC-GND-DC (Ch 1)	GND	AC
POSITION (Ch 1)	Set to obtain 0 V between pins AH and AI on Output Amplifier board.	
Ch 1 & 2 MODE	CHANNEL 1	
Ch 3 & 4 MODE	CHANNEL 3	
DISPLAY	1 & 2	

Also see IMPORTANT note on inside section of Block Diagram.



REFERENCE DIAGRAMS
 4 CHANNEL SWITCHING LOGIC
 5 POWER SUPPLY

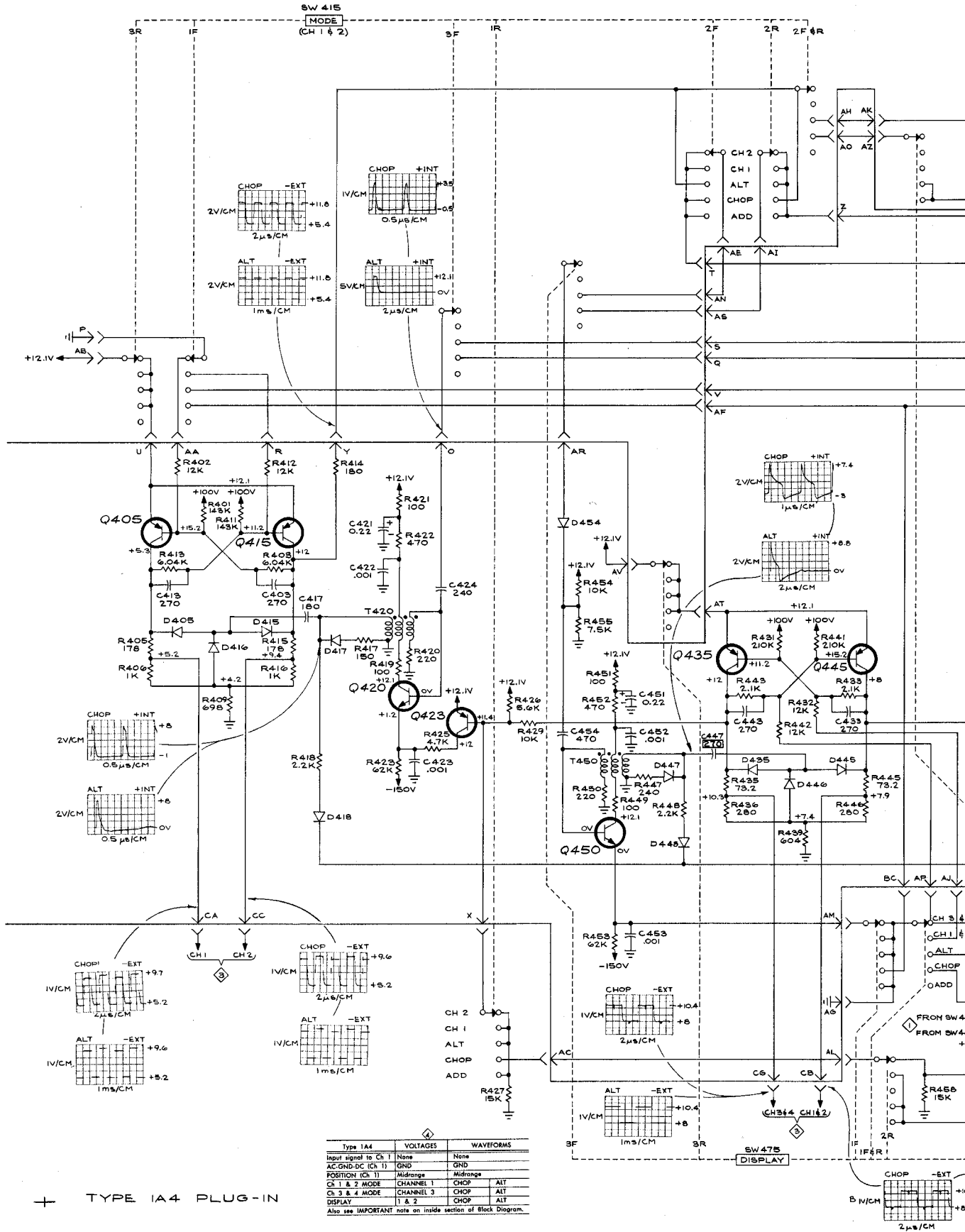
SEE PARTS LIST FOR SEMICONDUCTOR TYPES

*DENOTES THERMAL COUPLED TRANSISTORS
 **CURRENT DRIVEN CIRCUITS CAUSE LOW-AMPLITUDE VOLTAGE WAVEFORMS

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

3 OUTPUT AMPLIFIER

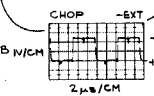
0870

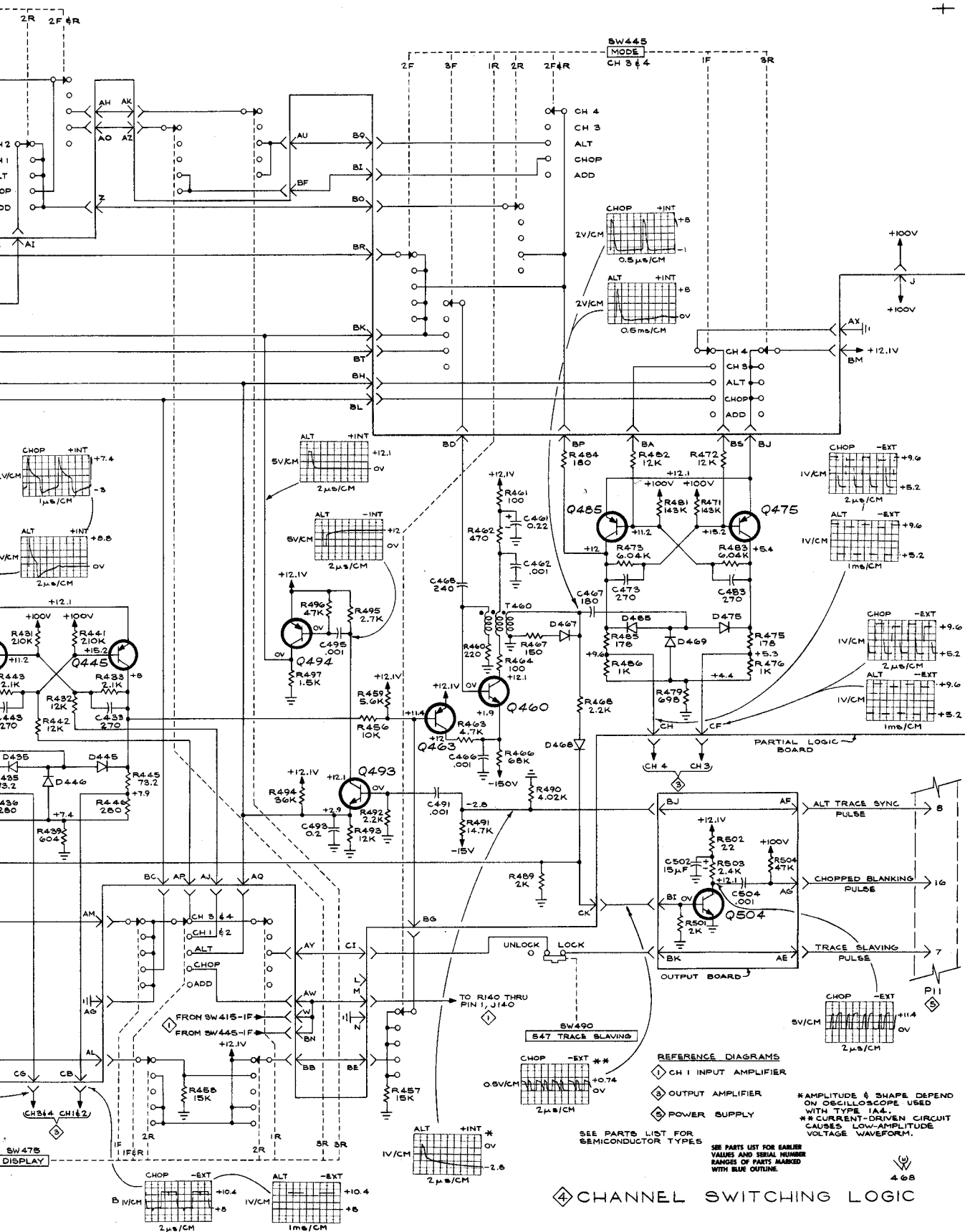


+ TYPE IA4 PLUG-IN

Type IA4	VOLTAGES	WAVEFORMS
Input signal to Ch 1	None	None
AC-GND-DC (Ch 1)	GND	GND
POSITION (Ch 1)	Midrange	Midrange
Ch 1 & 2 MODE	CHANNEL 1	CHOP ALT
Ch 3 & 4 MODE	CHANNEL 3	CHOP ALT
DISPLAY	1 & 2	CHOP ALT

Also see IMPORTANT note on inside section of Block Diagram.





REFERENCE DIAGRAMS

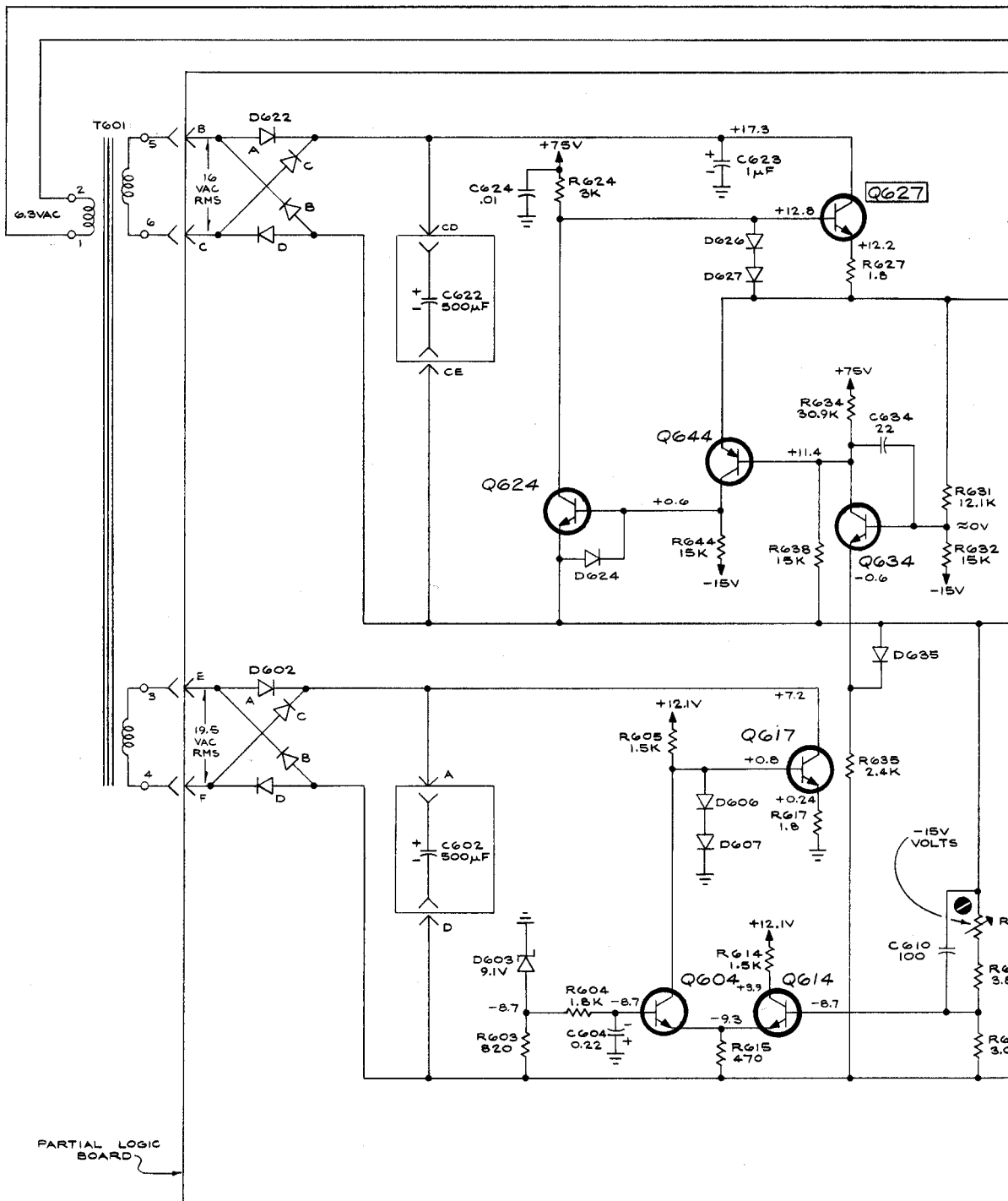
- ① CH 1 INPUT AMPLIFIER
- ② OUTPUT AMPLIFIER
- ③ POWER SUPPLY

* AMPLITUDE & SHAPE DEPEND ON OSCILLOSCOPE USED WITH TYPE 1A4.
 ** CURRENT-DRIVEN CIRCUIT CAUSES LOW-AMPLITUDE VOLTAGE WAVEFORM.

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

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

④ CHANNEL SWITCHING LOGIC



REFERENCE DIAGRAMS

- ① CH 1 INPUT AMPLIFIER
- ③ OUTPUT AMPLIFIER
- ④ CHANNEL SWITCHING LOGIC

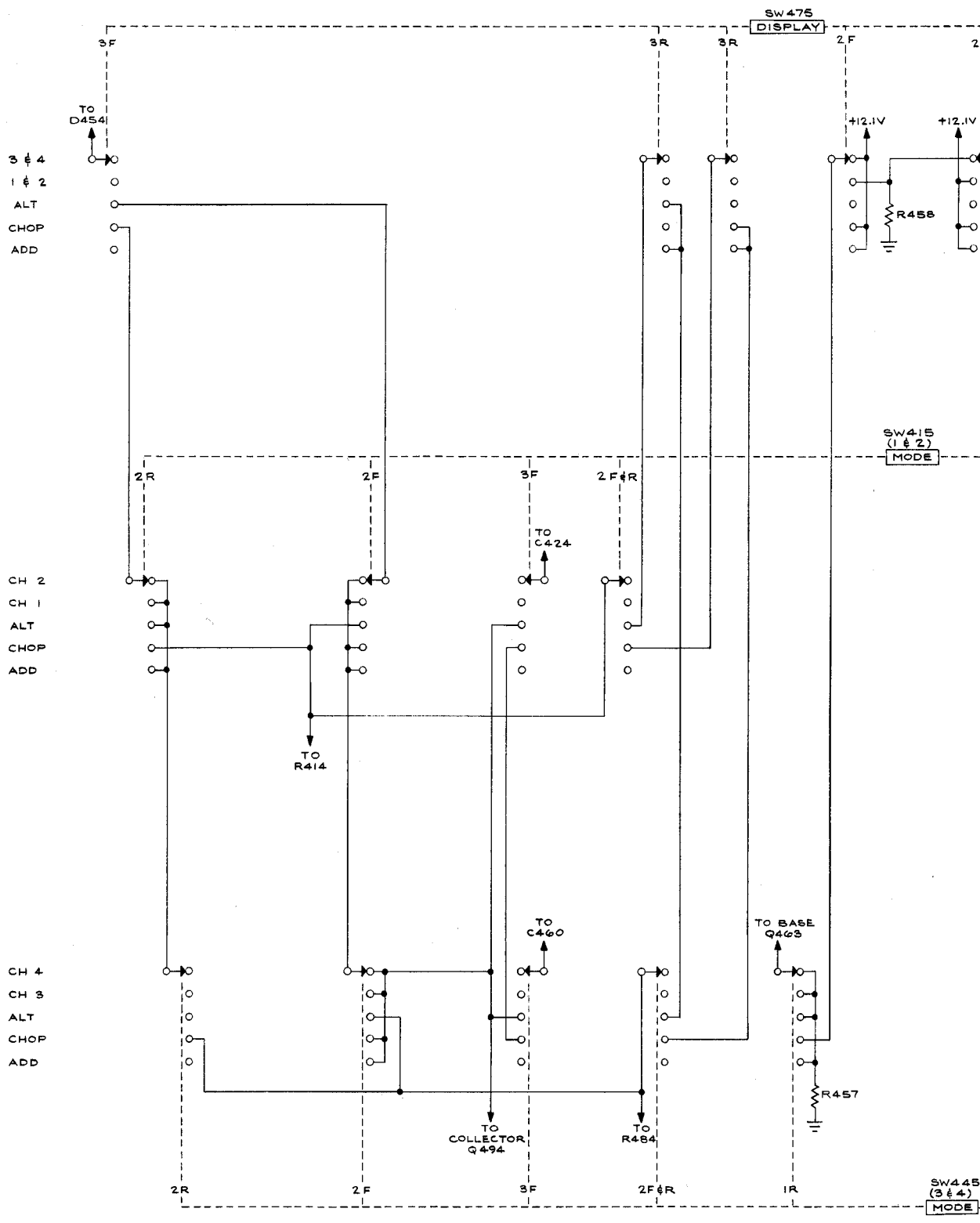
SEE PARTS LIST
SEMICONDUCTOR

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

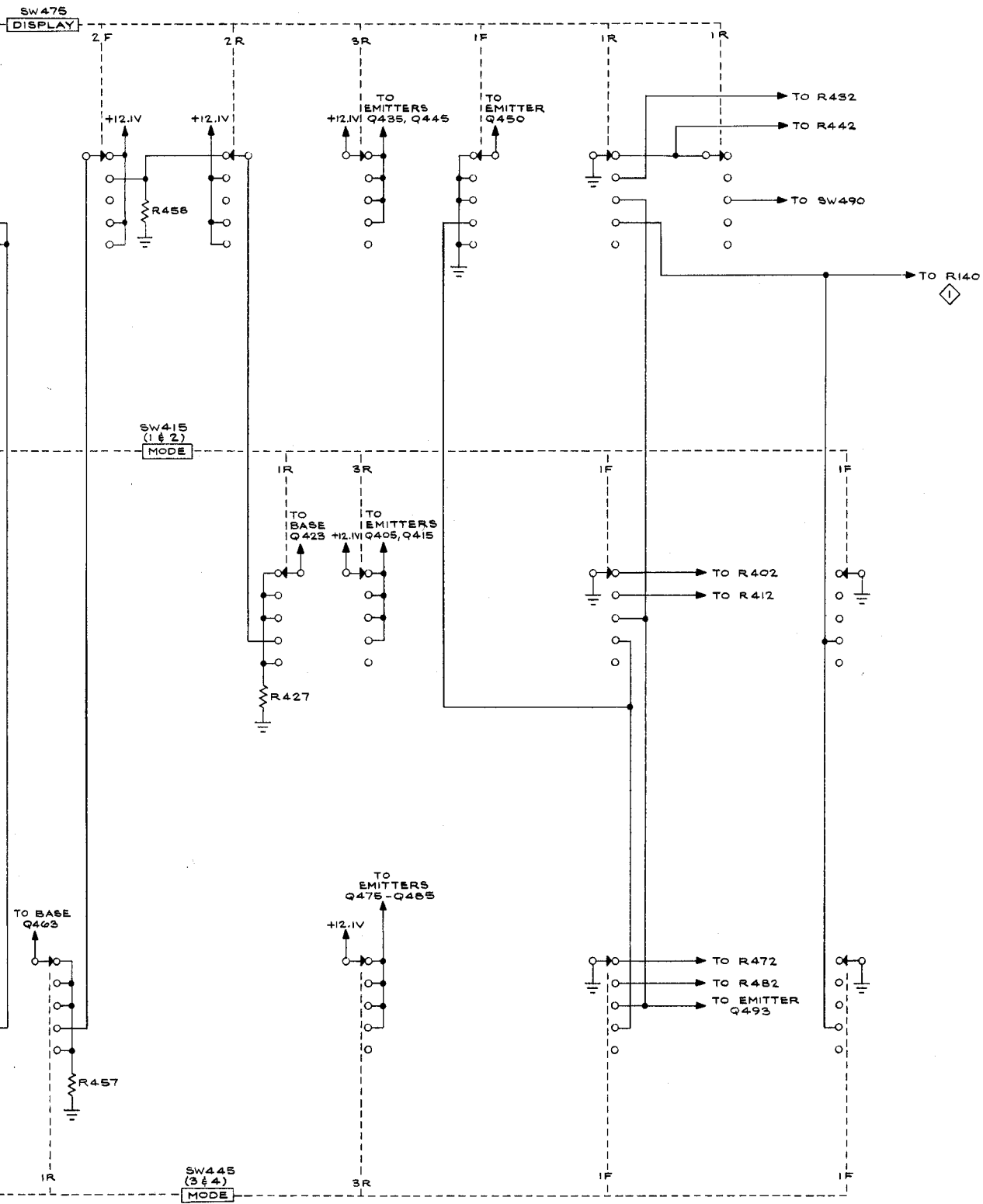
TYPE 1A4 PLUG-IN

+

B



TYPE 1A4 PLUG-IN



REFERENCE DIAGRAMS

① CH I INPUT AMPLIFIER

④ CHANNEL SWITCHING LOGIC

⑥ MODE SWITCHING

467

A

FIG. 1 FRONT

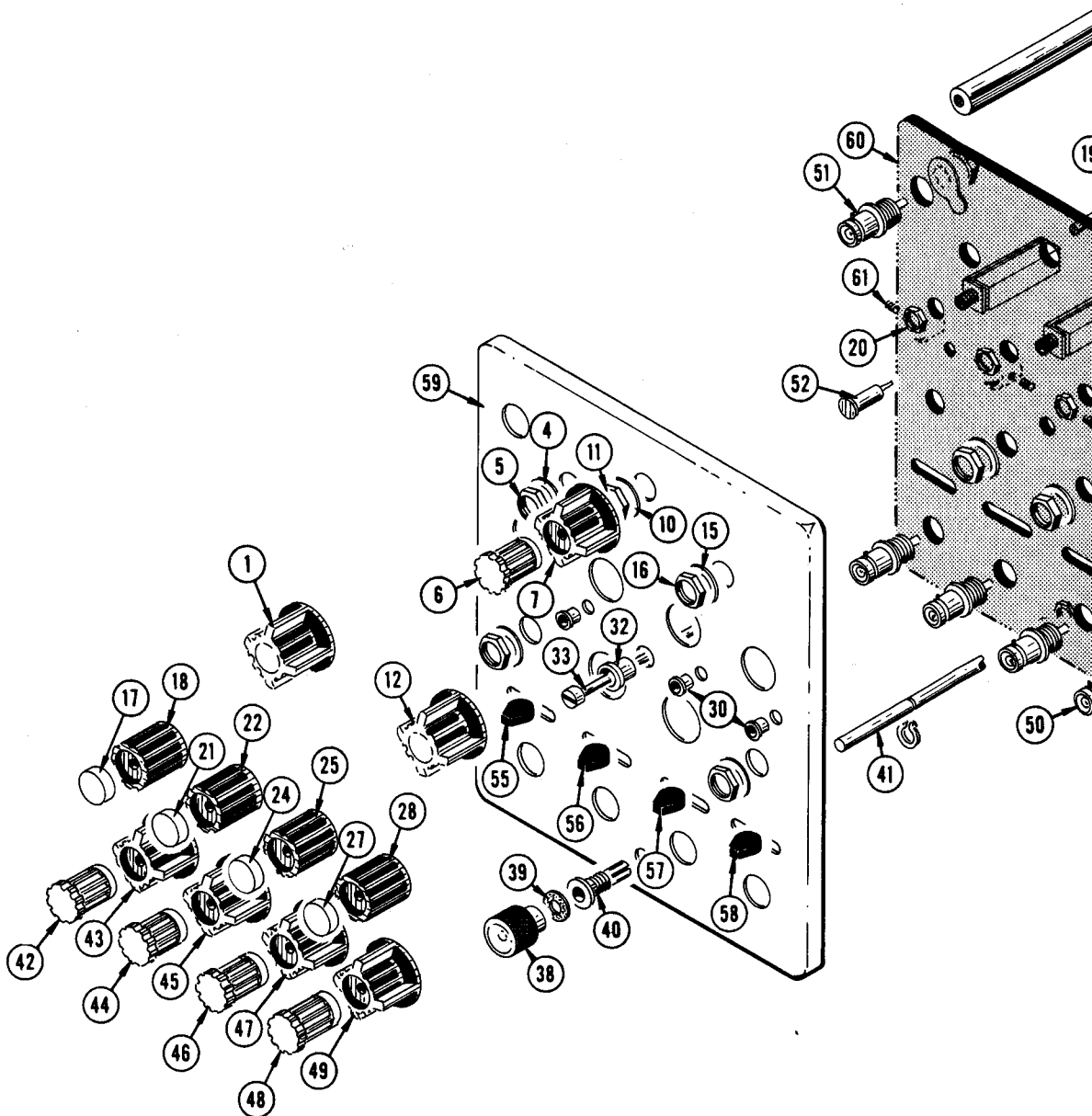
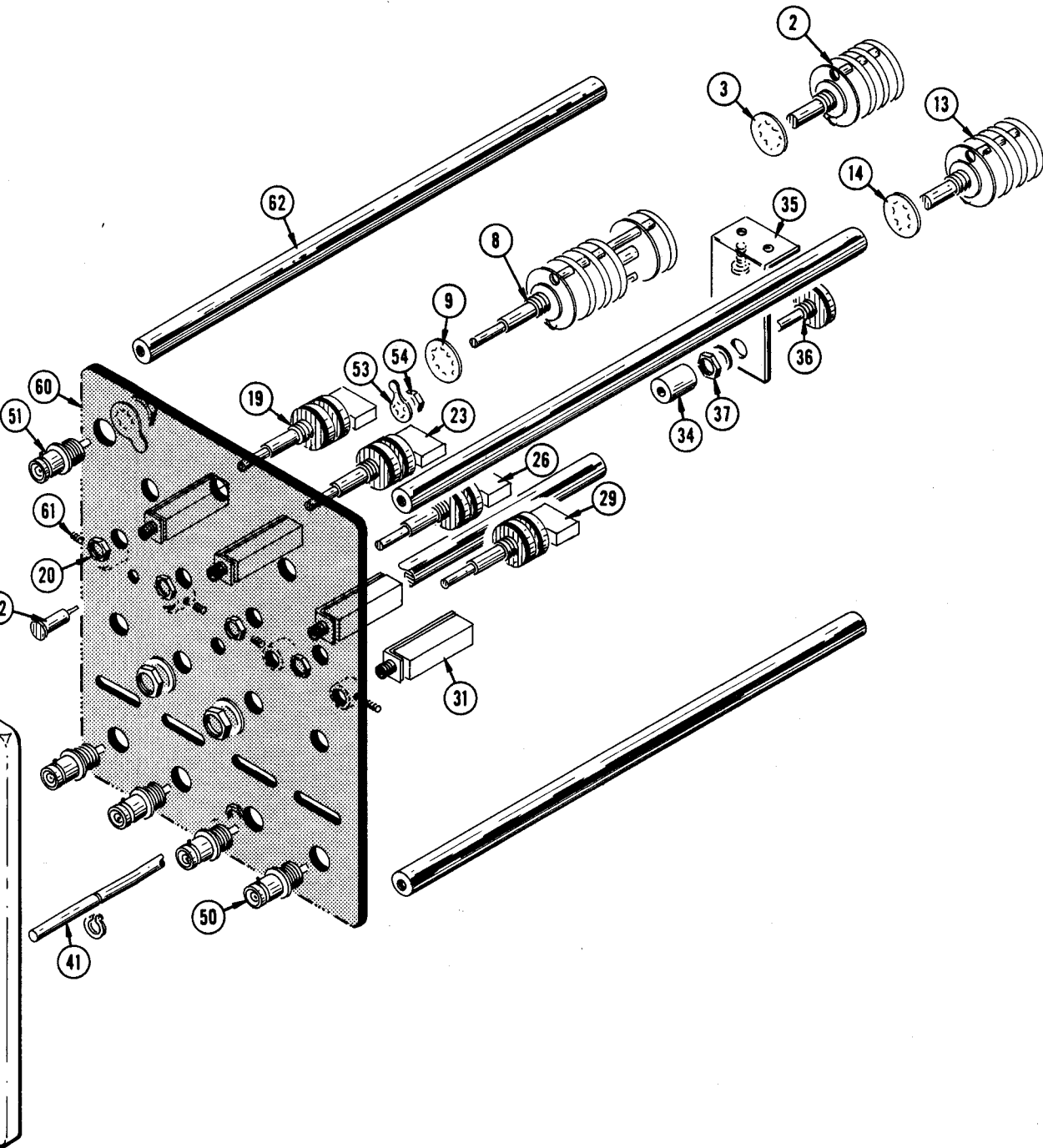


FIG. 1 FRONT



TYPE 1A4 PLUG-IN UNIT

FIG. 2 ATTENUATOR SWI

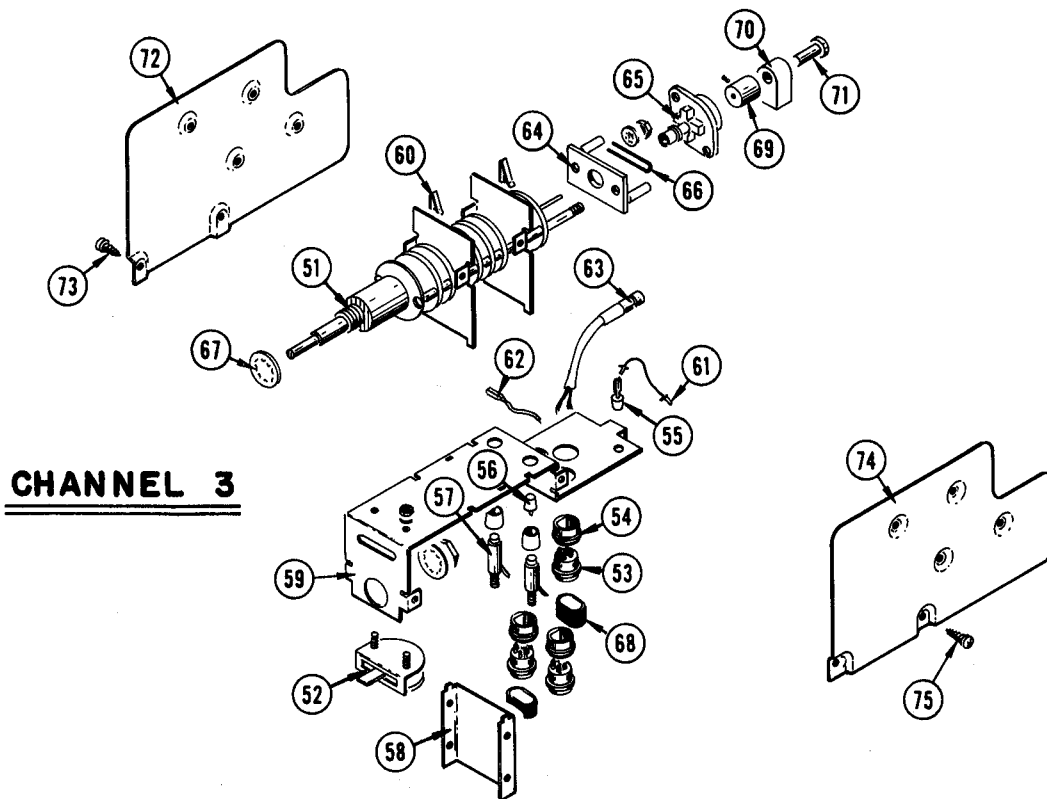
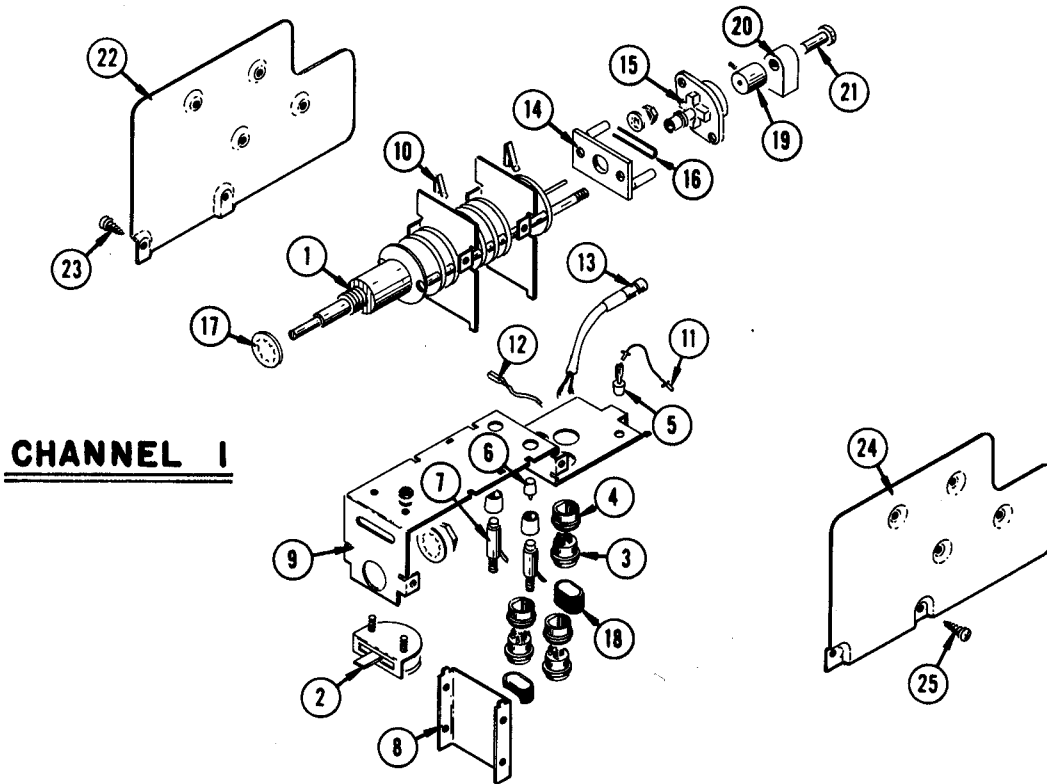


FIG. 2 ATTENUATOR SWITCHES

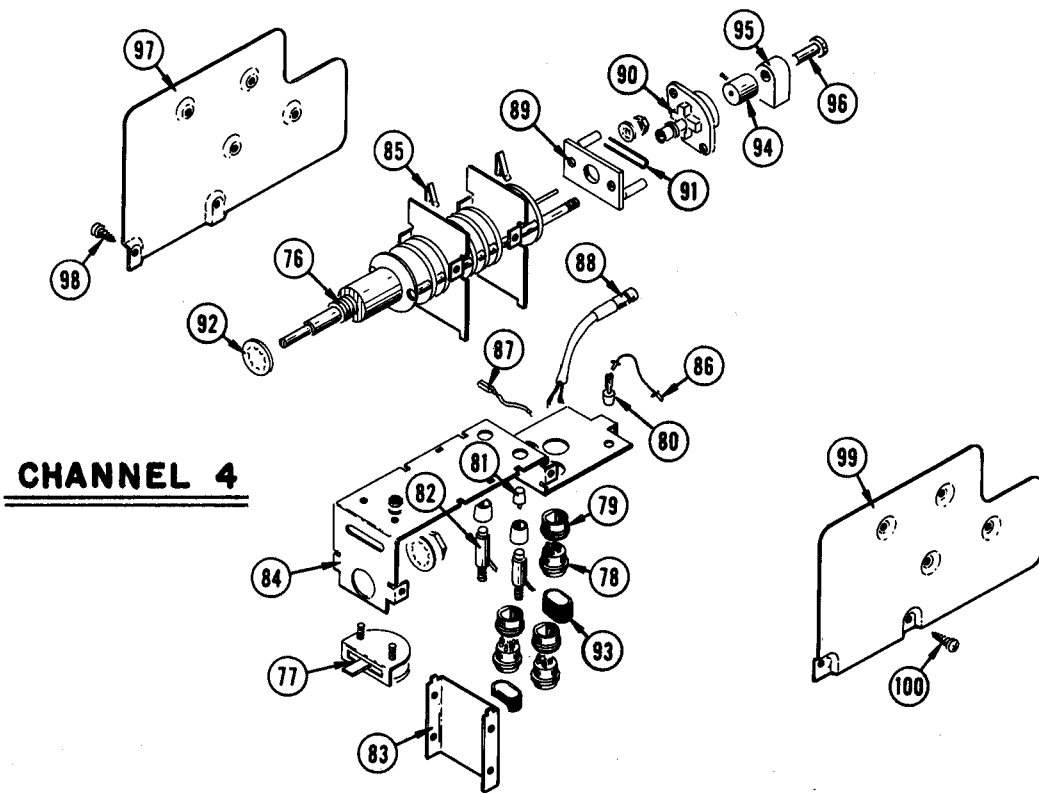
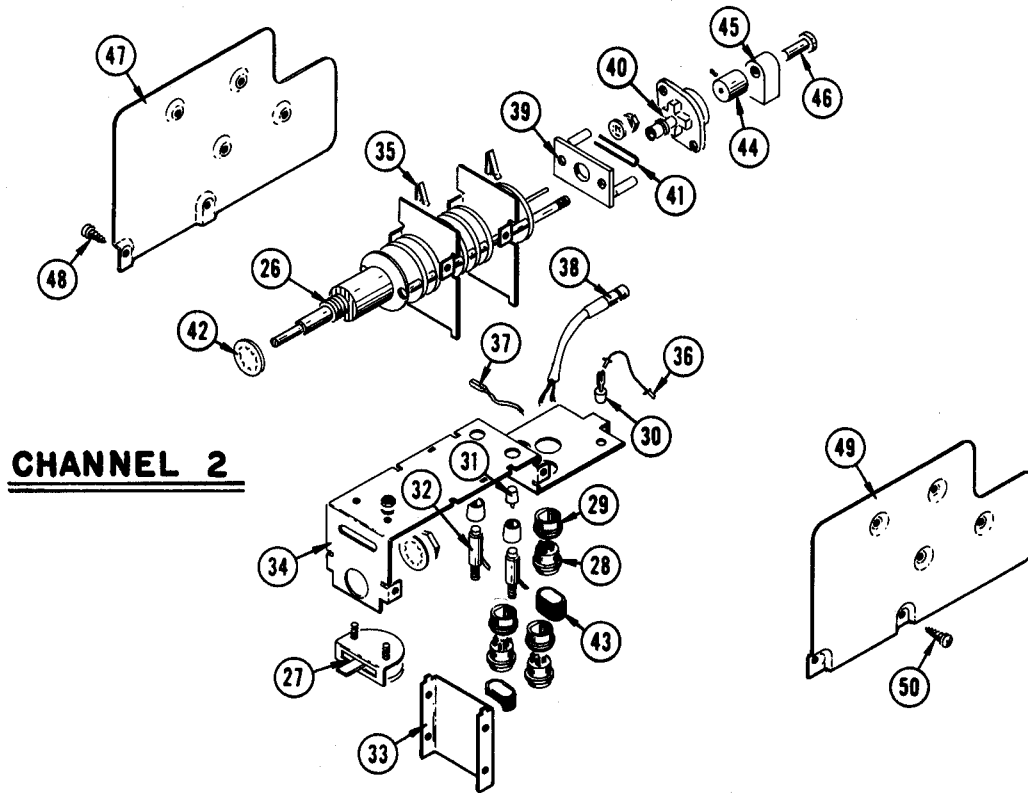


FIG. 3 CHASSIS & REAR

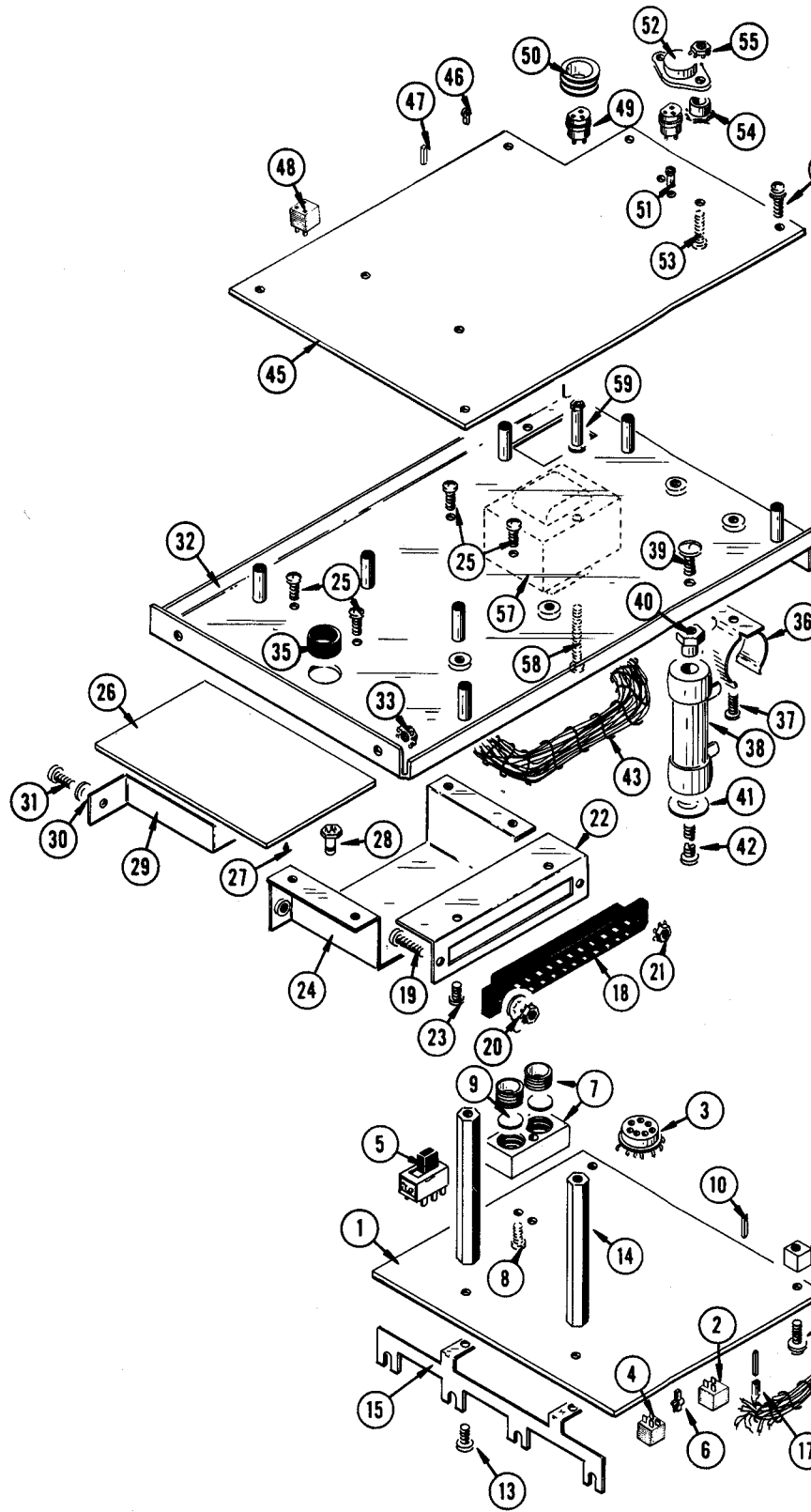
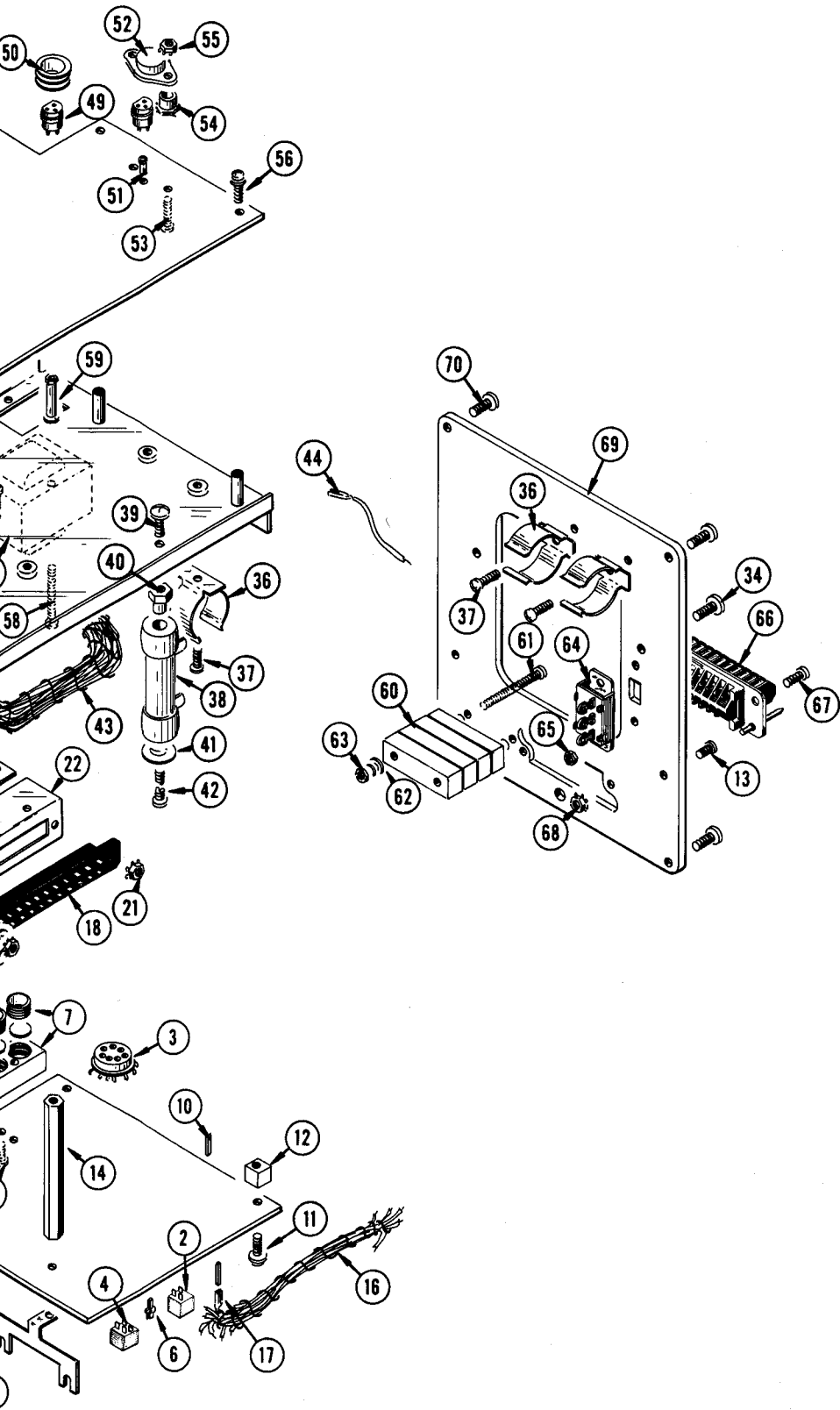


FIG. 3 CHASSIS & REAR



MANUAL CHANGE INFORMATION

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

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

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

ELECTRICAL PARTS LIST AND SCHEMATIC CORRECTION

REMOVE :

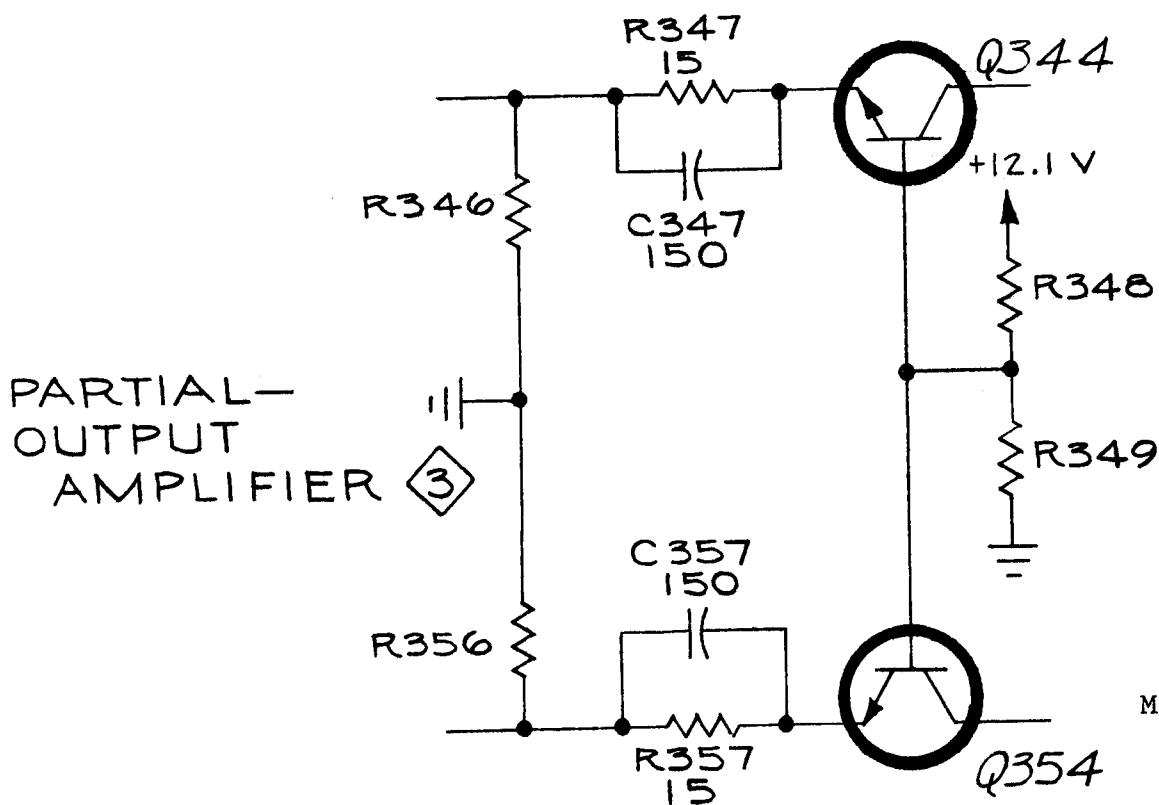
C341	281-0651-00	47 pF	Cer	5%
C344	281-0651-00	47 pF	Cer	5%
C351	281-0651-00	47 pF	Cer	5%
C354	281-0651-00	47 pF	Cer	5%
R341	317-0150-00	15 Ω	1/8 W	5%
R344	317-0150-00	15 Ω	1/8 W	5%
R351	317-0150-00	15 Ω	1/8 W	5%
R354	317-0150-00	15 Ω	1/8 W	5%

CHANGE TO:

Q384	151-0269-00	Silicon	Selected from SE3005
Q394	151-0269-00	Silicon	Selected from SE3005

ADD:

C347	281-0524-00	150 pF	Cer	500 V	± 0.5 pF
C357	281-0524-00	150 pF	Cer	500 V	± 0.5 pF
R347	317-0150-00	15 Ω	1/8 W		5%
R357	317-0150-00	15 Ω	1/8 W		5%



ELECTRICAL PARTS LIST CORRECTION

CHANGE: the following circuit numbers as indicated:

L302	to	L301
L312	to	L311
L322	to	L321
L332	to	L331

These Ferramic Suppressor cores are located in series with C301, C311, C321 and C331 respectively, and should be shown accordingly on Output Amplifier schematic and Fig. 5-12.

K4XL's BAMA

This manual is provided **FREE OF CHARGE** from the "BoatAnchor Manual Archive" as a service to the Boatanchor community.

It was uploaded by someone who wanted to help you repair and maintain your equipment.

If you paid anyone other than BAMA for this manual, you paid someone who is making a profit from the free labor of others without asking their permission.

You may pass on copies of this manual to anyone who needs it. But do it without charge.

Thousands of files are available without charge from BAMA. Visit us at <http://bama.sbc.edu>