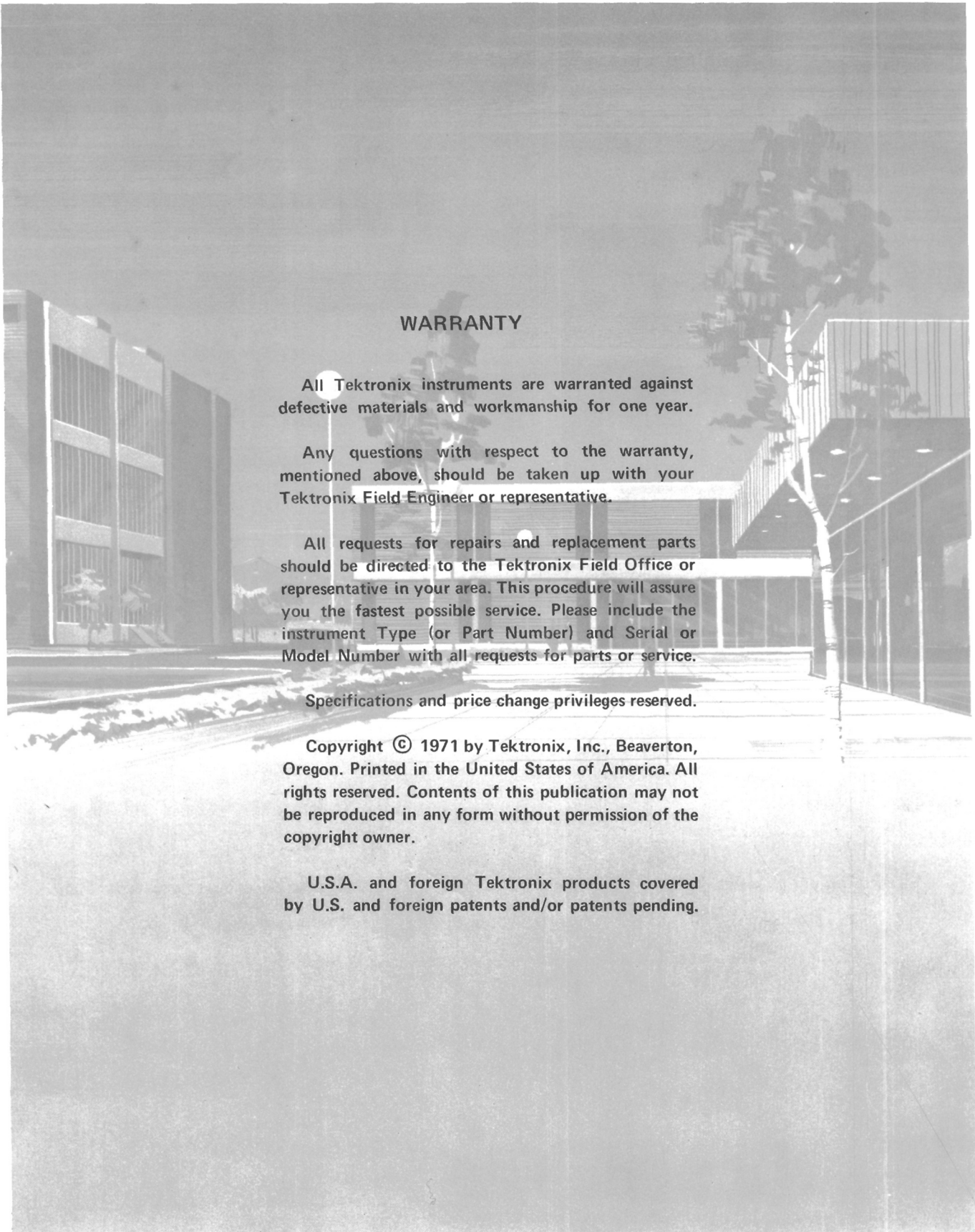


INSTRUCTION MANUAL

Serial Number B126706



**7A12
DUAL TRACE
AMPLIFIER**



WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year.

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

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 (or Part Number) and Serial or Model Number with all requests for parts or service.

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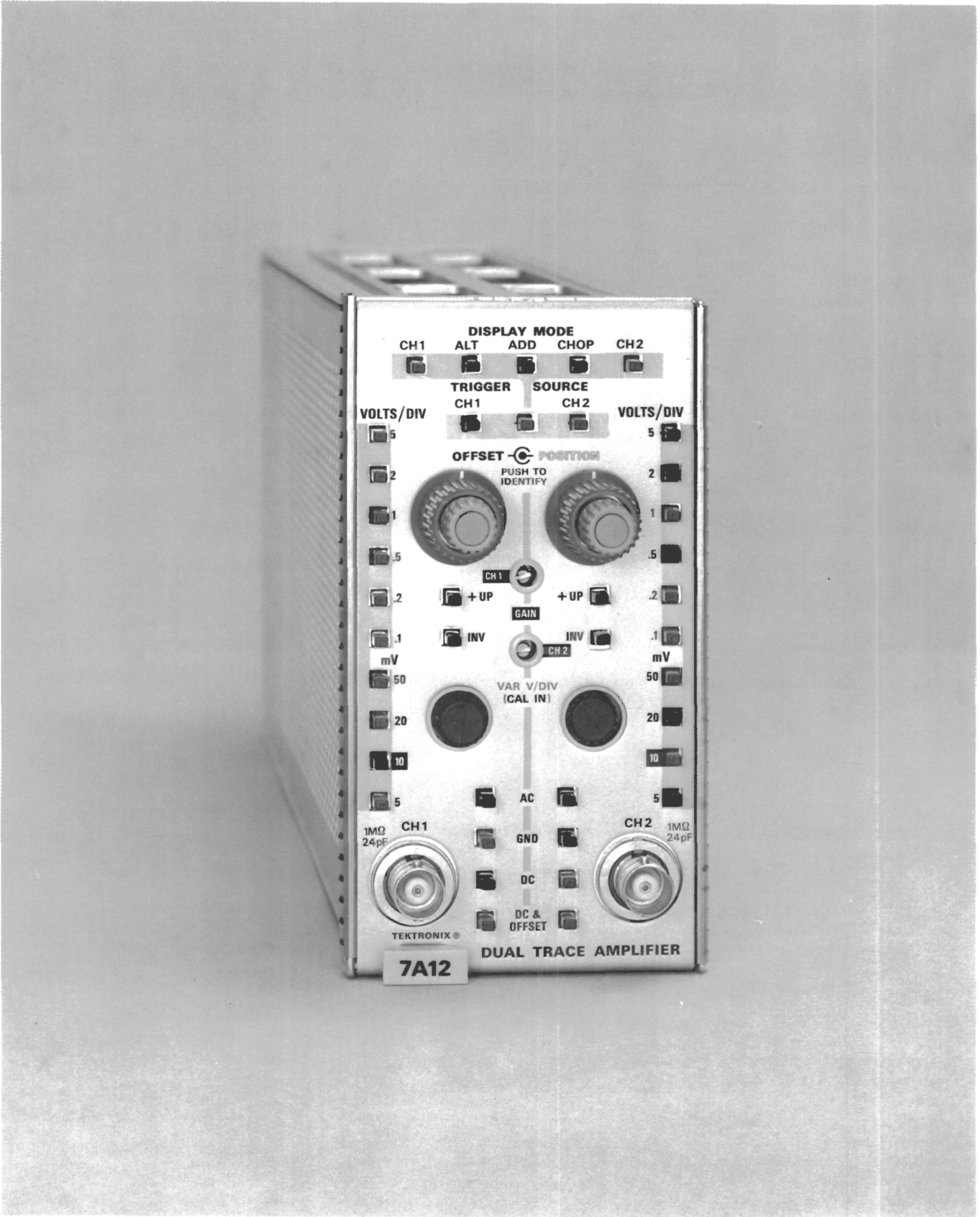


Fig. 1-1. 7A12 Dual Trace Amplifier.

7A12

SECTION 1

SPECIFICATION

Introduction

The 7A12 vertical amplifier plug-in is designed for use with Tektronix 7000-Series Oscilloscopes. The 7A12 is a dual-channel, wide band amplifier with the upper frequency limit mainly determined by the oscilloscope mainframe in which it is used. For example, the 7A12 used with the 7504 oscilloscope will have an upper bandwidth limit of about 75 MHz. When used with a 7704 oscilloscope, the upper bandwidth limit is about 105 MHz. Internal gain and compensation circuits are automatically switched to correspond to the setting of the VOLTS/DIV switch. A +UP/INV switch for each channel allows either channel to be inverted for differential measurements. The 7A12 features a DC offset circuit with a DC offset of at least ± 500 divisions for

viewing low level AC signals in the presence of a high-level DC component.

This instrument will meet the electrical characteristics listed in Table 1-1 following complete calibration as given in Section 5. The performance check procedure given in Section 5 provides a convenient method of checking instrument performance without making internal adjustments.

The following electrical characteristics are valid over the stated environmental range for instruments calibrated at an ambient temperature of $+20^{\circ}\text{C}$ to $+30^{\circ}\text{C}$, after a five minute warmup unless otherwise stated.

TABLE 1-1
ELECTRICAL

Characteristic	Performance Requirement	Supplemental Information
Deflection Factor Calibrated Range	5 mV/div to 5 V/div, 10 pushbuttons in a 1, 2, 5 sequence	
Deflection Factor Accuracy	Within 2% with GAIN adjustment at 10 mV/div	
Uncalibrated	Continuously variable; VAR V/DIV extends deflection factor to at least 12.5 V/div	
+UP to INVERT Gain Ratio	1:1 within 1%	
Frequency Response	See Table A	
AC (Capacitive) Coupled Input Lower Bandwidth Frequency	10 Hz or less without probe, 1 Hz or less with P6053	
Time Delay Between Channels		500 ps or less
Channel Isolation	At least 3000:1 or 0.3 div with 5 div reference signal at 75 MHz. At least 100:1 with equal deflection factors at 50 MHz or less	

TABLE 1-1 (cont)

Characteristic	Performance Requirement	Supplemental Information
Maximum Input Voltage		
DC Direct Couple 5 mV/div & 10 mV/div		350 V, DC or DC + Peak AC at 1 kHz or less
20 mV/div to 5 V/div		500 V, DC or DC + Peak AC at 1 kHz or less
AC (Capacitive) Coupled Input		
5 mV/div & 10 mV/div		350 V, DC or DC + Peak AC at 1 kHz or less
20 mV/div to 5 V/div		500 V, DC or DC + Peak AC
Input R and C Resistance	1 Megohm \pm 2%	
Capacitance	Approximately 24.0 pF	
R and C Product		Within \pm 1% between all deflection factors
Recommended X10 Probe	P6053, 6ft	
Maximum Input Gate Current		0.4 nA at 0 to +35°C 2 nA at +35°C to +50°C
IDENTIFY		Trace deflects up 0.2 div to 0.4 div
Display Noise (Tangentially Measured)		250 μ V at 5 mV/div. 0.1 div or less at other deflection factors
Chopped Mode (when installed in vertical compartment. Mainframe dependent.)		
Repetition Rate		500 kHz within 20%
Channel Time Segment		0.8 μ s to 1.2 μ s
DC Drift Drift With Ambient Temperature (Line Voltage Constant)		100 μ V/ $^{\circ}$ C or 0.01 div/ $^{\circ}$ C whichever is greater
DC OFFSET Range	At least +1000 div to -1000 div at 5 mV/div At least +500 div to -500 div from 10 mV/div to 5 V/div	
Common Mode Rejection Ratio	At least 10:1 at 40 MHz or less	

TABLE A

7A12 AND MAINFRAME FREQUENCY RESPONSE (five division reference)

With 7900 Series 120 MHz	With 7700 Series 105 MHz	With 7500 Series 75 MHz	With 7400 Series 55 MHz
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**TABLE 1-2
ENVIRONMENTAL**

Refer to the Specification for the associated oscilloscope.

**TABLE 1-3
PHYSICAL**

Size	Fits all 7000-Series Plug-in Compartments
Weight	

SECTION 2

OPERATING INSTRUCTIONS

General

To effectively use the 7A12, the operation and capabilities of the instrument must be known. This section describes front-panel control functions, general information on signal input connections, and other subjects that pertain to various measurement applications.

Installation

The 7A12 is calibrated and ready for use as received. It can be installed in any compartment of Tektronix 7000-Series Oscilloscopes, but is intended for principal use in vertical plug-in compartments. To install, align the upper and lower rails of the 7A12 with the oscilloscope tracks and insert it. The front panel will be flush with the front of the oscilloscope when the 7A12 is fully inserted, and the latch at the bottom-left corner of the 7A12 will be in place against the front panel.

To remove the 7A12, pull on the latch (which is inscribed with the unit identification "7A12") and the 7A12 will unlatch. Continue pulling on the latch to slide the 7A12 out of the oscilloscope.

FRONT PANEL CONTROLS AND CONNECTORS

The following descriptions apply to the controls and connectors of both Input Amplifier channels when applicable. See Fig. 2-1.

Input Connector	Provides signal connection to the channel.
AC-GND-DC-DC & OFFSET	Four position pushbutton switch selects signal input coupling mode.
	AC—The AC component of the signal is coupled to the amplifier input while the DC component is blocked.
	DC—Both AC and DC components of the signal are coupled to the amplifier input.

GND—Grounds the amplifier input while maintaining the same load for the input signal. Provides a charge path for the AC coupling capacitor to precharge the input circuit before switching the input to AC.

DC & OFFSET—Direct couples the signal to the amplifier and provides DC offset of at least ± 500 divisions (± 1000 divisions at 5 mV/Div).

POSITION	Controls vertical position of the trace.
IDENTIFY	Deflects trace up about 0.3 div for trace identification. Also replaces readout with the word "IDENTIFY" when used with oscilloscopes equipped with a readout system.
VOLTS/DIV	Volts per major graticule division.
Pushbuttons	Selects calibrated deflection factors from 5 mV/Div to 5 V/Div; 10 steps in a 1-2-5 sequence.
VAR V/DIV	Provides continuously variable uncalibrated deflection factor settings between calibrated steps. Extends deflection factor range to at least 12.5 volts/division.
+UP/INV	Provides means of inverting the display.
Pushbuttons	+UP—A positive-going signal at the input deflects the CRT display upward.
	INV—A positive-going signal at the input deflects the CRT display downward.

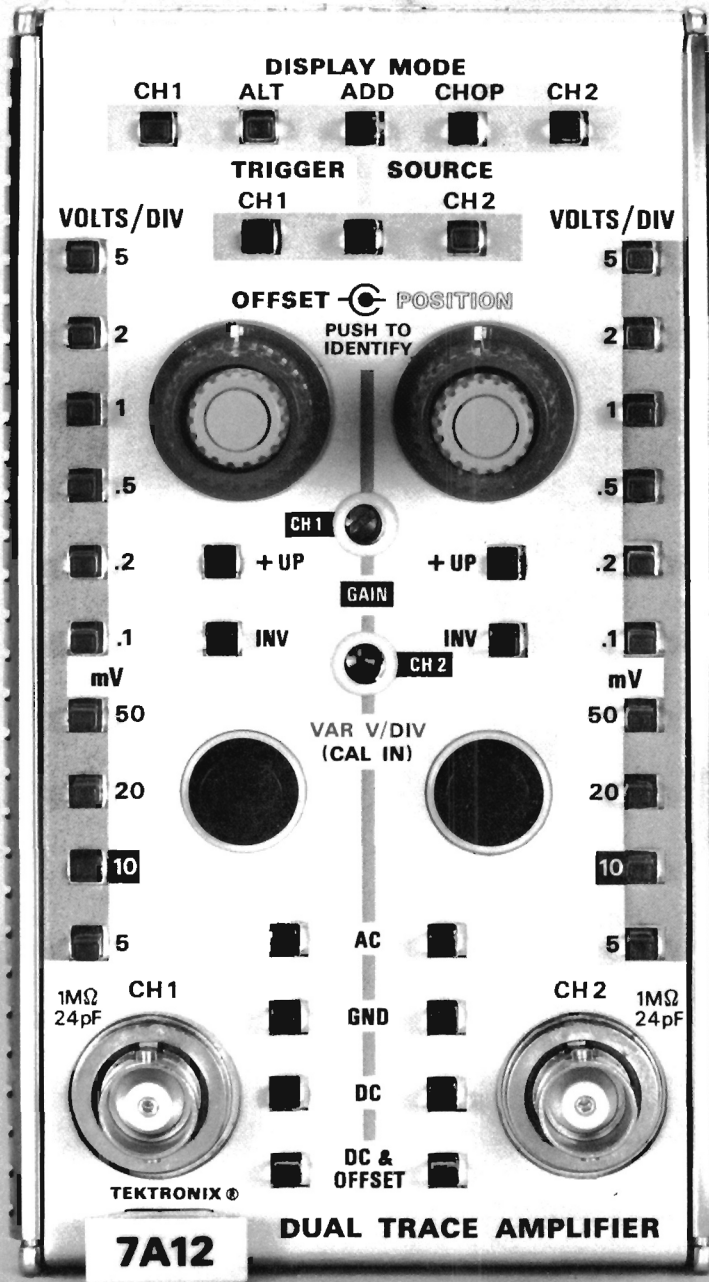


Fig. 2-1. Front-Panel Controls and Connectors.

OFFSET	Variable control permits on-screen display of small signal variations superimposed upon relatively large DC levels.
DISPLAY MODE Pushbuttons	<p>Pushbutton selection of the following modes of operation:</p> <p>CH 1—A single trace display of the signal applied to Channel 1 input connector.</p> <p>ALT—A dual trace display of the signals applied to both channels. The channels are alternately displayed and switching occurs at the end of each sweep.</p> <p>ADD—Algebraically adds the signals applied to the CH 1 and CH 2 input connectors and the algebraic sum is displayed on the CRT.</p> <p>CHOP—A dual trace display of the signal applied to both channels. The two channels time-share the sweep at a rate determined by the main-frame. An output signal is provided for trace blanking during the channel switching interval.</p>
TRIGGER SOURCE Pushbuttons	<p>Selects source of trigger signal. The trigger signals provide internal triggering for the oscilloscope time-base.</p> <p>CH 1—Internal triggering signal obtained from signal applied to Channel 1 Input connector.</p> <p>Mode—(Center pushbutton) internal trigger automatically follows DISPLAY MODE selection. In ADD or CHOP display modes, the trigger signal is the algebraic sum of CH 1 and CH 2 trigger.</p> <p>CH 2—Internal trigger signal obtained from signal applied to Channel 2 Input connector.</p>

GENERAL OPERATING INFORMATION

Introduction

For single trace operation, either of the two identical amplifier channels can be used independently by setting the DISPLAY MODE and TRIGGER SOURCE switches to CH 1 or CH 2 and connecting the signal to be observed to the appropriate input. In the discussions to follow, single-trace operation using CH 1 applies equally to CH 2.

Signal Connections

In general probes offer the most convenient means of connecting a signal to the input of the 7A12. A X10 attenuator probe offers a high input impedance and allows the circuit under test to perform very close to operating conditions. The Tektronix P6053 6 foot probe, with its readout-coding ring, is designed specifically for use with the Tektronix 7A series vertical amplifiers. The readout coding ring on the probe connects to a circuit in the 7A12 which automatically corrects the readout displayed on the CRT to the actual deflection factor at the tip of the probe. The Tektronix P6053 3.5 foot probe is not recommended because it may compromise the aberration limits of this amplifier.

Vertical Gain Adjustment

To check the gain of either channel, set the VOLTS/DIV switch to 10 mV and connect a 40 mV, 1 kHz signal from the oscilloscope calibrator to the Input connector of the channel being checked. The vertical deflection should be exactly four divisions. If not, adjust the front-panel GAIN for exactly four divisions of deflection. Both channels should be checked and adjusted, if necessary, before making measurements.

NOTE

If the gain of the two channels must be closely matched (as in differential measurements using the ADD MODE), use the adjustment procedure in Section 5.

Input Coupling

The Channel 1 and Channel 2 Input Coupling switches allow a choice of input coupling methods. The type of display desired and the applied signal will determine the coupling to use.

The DC coupling position can be used for most applications. It must be used to display AC signals below about 30 hertz (10 hertz with a X10 probe) and squarewaves with low frequency components, as these signals will be attenuated in the AC position.

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In the AC coupling position, the DC component of the signal is blocked by a capacitor in the input circuit. The AC coupling position provides the best display of signals with a DC component much larger than the AC components. The precharge feature should be used when there is a possibility of having a residual charge on the input capacitor of polarity opposite to that of the intended input, and whose algebraic sum may be greater than the maximum input limitations of the amplifier. To use this feature, first set the coupling switch to GND, then connect the probe to the circuit and wait about two seconds for the coupling capacitor to become charged. Push the AC coupling switch to AC GND.

The GND position provides a ground reference at the input of the amplifier without externally grounding the input connectors. However, the signals connected to the inputs are not grounded, and the same DC load is presented to the signal source.

With the DC & OFFSET position, it is possible to use the 7A12 to observe small signals whose DC component may be quite large. The OFFSET control is continuously variable and has a range of at least +500 divisions to -500 divisions except in the 5 mV/DIV position, the range is at least ± 1000 divisions.

VOLTS/DIV Pushbuttons and VAR V/DIV Control

The amount of vertical deflection produced by a signal is determined by the signal amplitude, the attenuation factor of the probe, the setting of the VOLTS/DIV switch and the setting of the VAR V/DIV control. Calibrated deflection factors indicated by the settings of the VOLTS/DIV switch apply only when the VAR V/DIV control is in the CAL IN position.

The VAR V/DIV control provides variable, uncalibrated settings between the calibrated steps of the VOLTS/DIV switch. With the VAR V/DIV switch set to 5 Volts/Div, the uncalibrated vertical deflection factor is extended to at least 12.5 volts/div. By applying a calibrated voltage source to the input connector, any specific deflection factor can be set within the range of the VAR V/DIV control.

+UP/INV Switch

The polarity of the displayed waveform may be inverted by the +UP/INV switch. This is particularly useful in added operation of the 7A12 when differential measurements are to be made.

In the +UP position, the displayed waveform will have the same polarity as the applied signal, and a positive DC voltage will move the CRT trace up. In the INV position, a positive-going waveform at the input of the 7A12 will be displayed in an inverted form and a positive DC voltage will move the trace down.

DISPLAY MODE Switch

The CH 1 position of the DISPLAY MODE switch is used to display only that signal present at the CH 1 Input connector. To display the signal present at the CH 2 Input connector, simply select the CH 2 mode of operation.

NOTE

Source of triggering signal does not necessarily follow the DISPLAY MODE. To obtain stable display, refer to TRIGGER SOURCE.

The ALT position of the DISPLAY MODE switch produces a display which alternates between Channel 1 and Channel 2 with each sweep on the CRT. Although the ALT mode can be used at all sweep rates, the CHOP mode provides a more satisfactory display at sweep rates below about 0.5 millisecond/division. At slow sweep rates, alternate mode switching becomes visually perceptible.

The ADD position of the display mode switch can be used to display the sum or difference of two signals, for common mode rejection to remove an undesired signal, or for applying DC offset (apply a DC voltage to one channel to offset a DC component on the other channel). The overall deflection factor in the ADD mode, with both VOLTS/DIV switches set to the same position, is the deflection factor indicated by either VOLTS/DIV switch. However, if the CH 1 and CH 2 VOLTS/DIV switches are set to different deflection factors, the resultant amplitude is difficult to determine from the CRT display. In this case, the voltage amplitude of the resultant display can be determined accurately only if the amplitude of the signal applied to one channel is known.

The CHOP position of the DISPLAY MODE switch produces a display which is electronically switched between channels at a rate determined by the mainframe. In general, the CHOP mode provides the best display at sweep rates slower than about 0.5 millisecond/division or whenever dual-trace, non-repetitive phenomena are to be displayed. At faster sweep rates, the chopped switching transients may cause improper triggering of the display.

TRIGGER SOURCE Switch

The Ch 1 position of the TRIGGER SOURCE switch provides a trigger signal obtained from the signal applied to

the CH 1 Input connector. This provides a stable display of the signal applied to the CH 1 Input connector.

The CH 2 position of the TRIGGER SOURCE switch provides a trigger signal obtained from the signal applied to the CH 2 Input connector. This provides a stable display of the signal applied to the CH 2 Input connector.

In the Mode (center pushbutton) position of the TRIGGER SOURCE switch, the trigger signal for the time-base unit is dependent on the setting of the DISPLAY MODE switch. The trigger source for each position of the DISPLAY MODE switch is as follows:

MODE	TRIGGER SIGNAL SOURCE
CH 1	Channel 1
CH 2	Channel 2
ADD	Algebraic sum of Channel 1 and Channel 2
CHOP	Algebraic sum of Channel 1 and Channel 2
ALT	Alternates between Channel 1 and Channel 2,

Trace Identification

When the POSITION Control is pressed, the trace is deflected about 0.3 division to identify the 7A12 trace. This feature is particularly useful when multiple traces are displayed. In mainframes with readout, it also replaces deflection factor with the word "IDENTIFY."

BASIC APPLICATIONS

General

The following information describes the procedures and techniques for making basic measurements with a 7A12 and the associated Tektronix oscilloscope and time-base. These applications are not described in detail, since each application must be adapted to the requirements of the individual measurements. This instrument can also be used for many applications which are not described in this manual. Contact your local Tektronix Field Office or representative for assistance in making specific measurements with this instrument.

Peak-to-Peak Voltage Measurements (AC)

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

1. Apply the signal to either Input connector.
2. Set the DISPLAY MODE and TRIGGER SOURCE switches to display the channel used.
3. Set the Coupling switch to AC.

NOTE

For low-frequency signals below about 30 hertz, use the DC position to prevent attenuation of the signal.

4. Set the VOLTS/DIV switch to display about five vertical divisions of the waveform.

5. Set the time-base Triggering controls for a stable display. Set the Time Base to a sweep rate which displays several cycles of the waveform.

6. Turn the 7A12 POSITION control so the lower portion of the waveform coincides with one of the graticule lines below the center horizontal line, and the top of the waveform is within the viewing area. With the time base Position control, move the display so one of the upper peaks lies near the center vertical line (see Fig. 2-2).

7. Measure the divisions of vertical deflection peak-to-peak. Check that the VAR V/DIV control is in the CAL IN position.

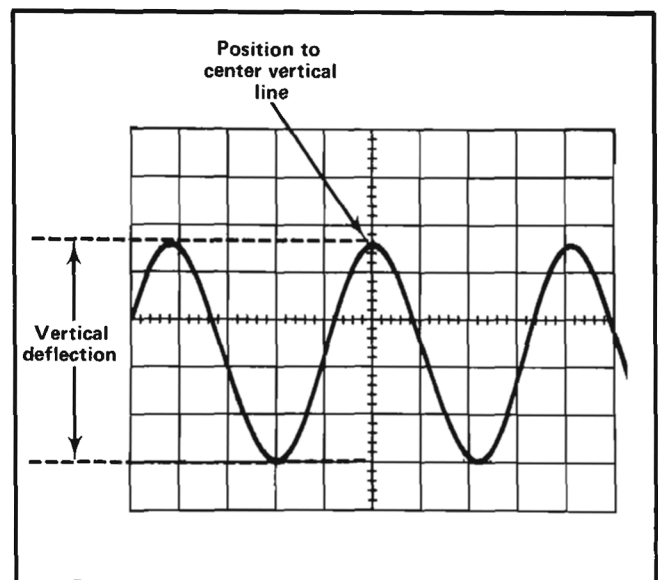


Fig. 2-2. Measuring the Peak-to-Peak Voltage of a waveform.

NOTE

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

8. Multiply the distance measured in step 7 by the VOLTS/DIV switch setting. Include the attenuation factor of the probe if used.

EXAMPLE: Assume that the peak-to-peak vertical deflection is 4.5 divisions (see Fig. 2-2) using a 10X attenuator probe and the VOLTS/DIV switch is set to 1 V.

$$\text{Volts P-P} = \text{vertical deflection (divisions)} \times \text{VOLTS/DIV setting} \times \text{probe attenuation factor}$$

Substituting the given values:

$$\text{Volts Peak-to-Peak} = 4.5 \times 1 \times 10$$

The peak-to-peak voltage is 45 volts.

Instantaneous Voltage Measurements (DC)

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

1. Connect the signal to either Input connector.
2. Set the DISPLAY MODE and TRIGGER SOURCE switches to display the channel used.
3. Set the VOLTS/DIV switch to display about five divisions of the waveform.
4. Set the Coupling switch to GND and position the trace to the bottom graticule line or other reference line. If the voltage is negative with respect to ground, position the trace to the top graticule line. Do not move the POSITION control after this reference line has been established.

NOTE

To measure a voltage level with respect to a voltage rather than ground, make the following changes to Step 4. Set the Coupling switch to DC and apply the reference voltage to the Input connector. Then position the trace to the reference line and disconnect the reference voltage.

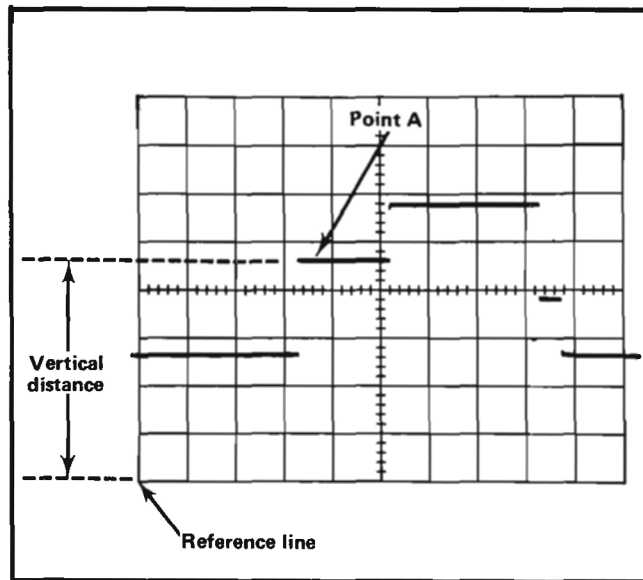


Fig. 2-3. Measuring instantaneous voltage with respect to some reference.

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

6. Set the time-base Triggering controls for a stable display. Set the Time Base sweep rate for an optimum display of the waveform.

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

8. Establish the polarity of the waveform. With the +UP/INV switch in the +UP position, any point above the reference line is positive.

9. Multiply the distance measured in step 7 by the VOLTS/DIV switch setting. Include the attenuation factor of the probe, if used.

EXAMPLE: Assume the vertical distance measured is 3.6 divisions (see Fig. 2-3) and the waveform is above the reference line using a 10X probe with a VOLTS/DIV switch setting of 0.5 V.

Using the formula:

$$\text{vertical distance (divisions)} \times \text{polarity} \times \text{VOLTS/DIV setting} \times \text{probe attenuation factor}$$

Substituting the given values:

$$\text{Instantaneous Voltage} = 3.6 \times 1 \times 0.5 \text{ V} \times 10$$

The instantaneous voltage is 18 volts.

Comparison Measurements

In some applications, it may be desirable to establish arbitrary units of measurement other than those indicated by the VOLTS/DIV switch. This is particularly useful when comparing unknown signals to a reference amplitude. One use for the comparison-measurement technique is to facilitate calibration of equipment where the desired amplitude does not produce an exact number of divisions of deflection. The adjustment will be easier and more accurate if arbitrary units of measurement are established so that the correct adjustment is indicated by an exact number of divisions of deflection. The following procedure describes how to establish arbitrary units of measure for comparison measurements.

To establish an arbitrary vertical deflection factor based upon a specific reference amplitude, proceed as follows:

1. Connect the reference signal to the Input connector. Set the time-base sweep rate to display several cycles of the signal.

2. Set the VOLTS/DIV switch and the VAR V/DIV control to produce a display which is an exact number of vertical divisions in amplitude. Do not change the VAR V/DIV control after obtaining the desired deflection.

3. To establish an arbitrary vertical deflection factor so the amplitude of an unknown signal can be measured accurately at any setting of the VOLTS/DIV switch, the amplitude of the reference signal must be known. If it is not known, it can be measured before the VAR V/DIV control is set in step 2.

4. Divide the amplitude of the reference signal (volts) by the product of the vertical deflection (divisions) established in step 2 and the setting of the VOLTS/DIV switch. This is the vertical conversion factor.

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

5. To measure the amplitude of an unknown signal, disconnect the reference signal and connect the unknown signal to the Input connector. Set the VOLTS/DIV switch

to a setting that provides sufficient vertical deflection to make an accurate measurement. Do not readjust the VAR V/DIV control.

6. Measure the vertical deflection in divisions and calculate the amplitude of the unknown signal using the following formula:

$$\text{Signal Amplitude} = \frac{\text{VOLTS/DIV setting}}{\text{vertical conversion factor}} \times \text{vertical deflection (divisions)}$$

EXAMPLE: Assume a reference signal amplitude of 30 volts, a VOLTS/DIV setting of 5 V and the VAR V/DIV control adjusted to provide a vertical deflection of four divisions.

Substituting these values in the vertical conversion factor formula (step 4):

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

Then with a VOLTS/DIV setting of 2 V, the peak-to-peak amplitude of an unknown signal which produces a vertical deflection of five divisions can be determined by using the signal amplitude formula (step 6):

$$\text{Signal Amplitude} = 2 \text{ V} \times 1.5 \times 5 = 15 \text{ volts}$$

Dual-Trace Phase Difference Measurement

Phase comparison between two signals of the same frequency can be made using the dual-trace feature of the 7A12. This method of phase difference measurement can be used up to the frequency limit of the oscilloscope system. To make the comparison, use the following procedure.

1. Set the CH 1 and CH 2 Coupling switches to the same position, depending on the type of coupling desired.

2. Set the DISPLAY MODE to ALT or CHOP. In general, CHOP is more suitable for low frequencies and ALT is more suitable for high frequencies. Set the TRIGGER SOURCE to CH 1.

3. Connect the reference signal to the CH 1 Input and the comparison signal to the CH 2 Input. Use coaxial cables

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or probes which have similar time delay characteristics to connect the signals to the Input connectors.

4. If the signals are of opposite polarity, push the channel 2 INV button to invert the channel 2 display. (Signals may be of opposite polarity due to 180° phase difference; if so, take this into account in the final calculation.)

5. Set the VOLTS/DIV switches and the VAR V/DIV controls of the two channels so the displays are equal and about five divisions in amplitude.

6. Set the time-base for a sweep rate which displays about one cycle of the waveforms. Set the Triggering controls for a stable display.

7. Center the waveforms on the graticule with the 7A12 POSITION controls.

8. Adjust the time-base Variable Sweep Rate until one cycle of the reference signal occupies exactly eight horizontal divisions between the second and tenth vertical lines of the graticule (see Fig. 2-4). Each division of the graticule represents 45° of the cycle ($360^\circ \div 8 \text{ divisions} = 45^\circ/\text{division}$). The sweep rate can now be stated in terms of degrees as 45°/division.

9. Measure the horizontal difference between corresponding points on the two waveforms.

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

EXAMPLE: Assume a horizontal difference of 0.3 division with a sweep rate of 45°/division as shown in Fig. 2-4. Using the formula:

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

Substituting the given values:

$$\text{Phase Difference} = 0.3 \times 45^\circ$$

The phase difference is 13.5°.

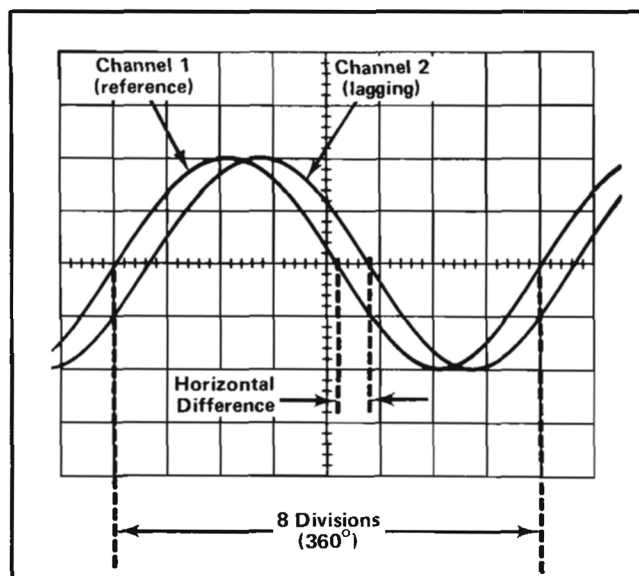


Fig. 2-4. Measuring phase difference between two signals.

High Resolution Phase Measurements

More accurate dual-trace phase measurements can be made by increasing the sweep rate (without changing the Variable Sweep rate control). One of the easiest ways to increase the sweep rate is with the time-base Magnifier switch. Set the Magnifier to X10 and determine the magnified sweep rate by dividing the sweep rate obtained previously by the amount of sweep magnification.

EXAMPLE: If the sweep rate is increased 10 times by the Magnifier, the magnified sweep rate is $45^\circ/\text{division} \div 10 = 4.5^\circ/\text{division}$. Fig. 2-5 shows the same signals as used in Fig. 2-4 but with the Magnifier set to X10. With a horizontal difference of 3 divisions, the phase difference is:

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

Substituting the given values:

$$\text{Phase Difference} = 3 \times 4.5^\circ$$

The phase difference is 13.5°.

Common Mode Rejection

The ADD feature of the 7A12 can be used to display signals which contain undesirable components. These undesirable components can be eliminated through common-mode rejection. The procedure is as follows:

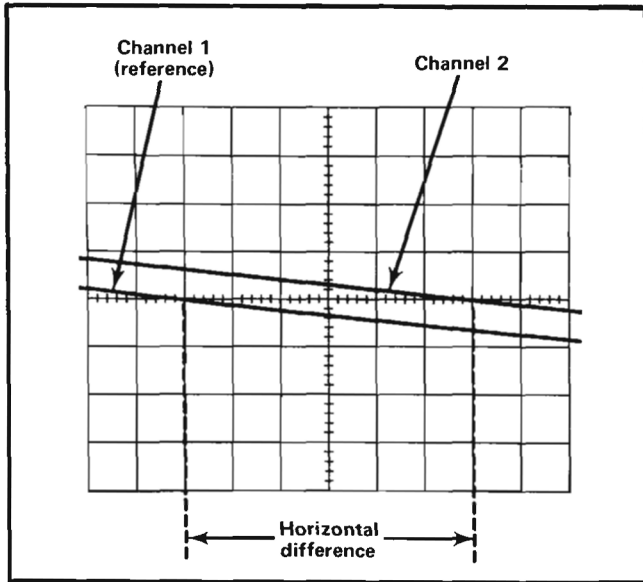


Fig. 2-5. High resolution phase measurement using sweep magnifier.

1. Set the DISPLAY MODE switch to ALT or CHOP and TRIGGER SOURCE switch to MODE.
2. Connect the signal containing both the desired and undesired information to the CH 1 Input.
3. Connect a signal similar to the unwanted portion of the CH 1 signal to the CH 2 Input. For example, in Fig. 2-6

a line-frequency signal is connected to Channel 2 to cancel out the line-frequency component of the Channel 1 signal.

4. Set both Coupling switches to the same setting, DC or AC, depending on the applied signal.
5. Set the VOLTS/DIV switches so the signals are about equal in amplitude.
6. Set the DISPLAY MODE switch to ADD. Push the channel 2 INV pushbutton so the common-mode signals are of opposite polarity.
7. Adjust the channel 2 VOLTS/DIV and VAR V/DIV control for maximum cancellation of the common-mode signal. The signal which remains should be only the desired portion of the channel 1 signal.

EXAMPLE: An example of this mode of operation is shown in Fig. 2-6. The signal applied to channel 1 contains unwanted line frequency components (Fig. 2-6A). A corresponding line frequency signal is connected to channel 2 (Fig. 2-6B). Fig. 2-6C shows the desired portion of the signal as displayed when common-mode rejection is used.

The above procedure can also be used for examining a signal superimposed on some DC level when DC Coupling must be used. A DC voltage of the proper polarity applied to channel 2 can be used to cancel out the DC portion of the signal applied to channel 1.

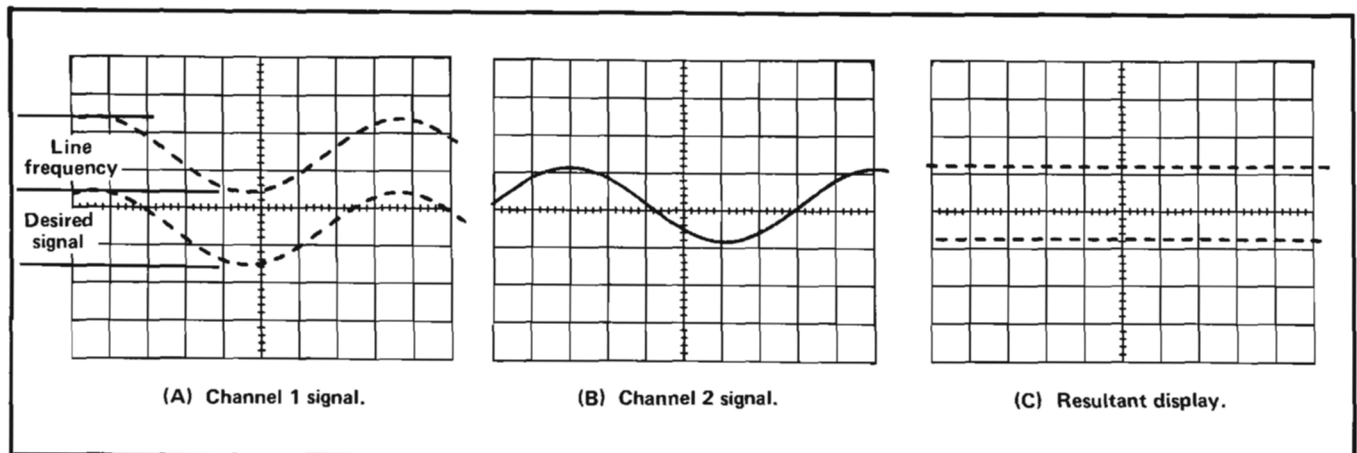


Fig. 2-6. Using the ADD feature for common-mode rejection. (A) Channel 1 signal contains desired information along with line-frequency component, (B) Channel 2 signal contains line-frequency only, (C) CRT display using common-mode rejection.

SECTION 3

CIRCUIT DESCRIPTION

Introduction

This section of the manual contains a description of the circuitry used in the 7A12 dual-trace amplifier. The description begins with a discussion of the instrument using the block diagrams shown in the Diagrams Section. Then, each circuit is described in detail using block diagrams to show the interconnections between stages in each major circuit and the relationship of the front-panel controls to the individual stages.

Complete schematics of each circuit are given in the Diagrams Section. Refer to these schematics throughout the following circuit description for electrical values and relationship.

BLOCK DIAGRAM

The following discussion is provided to aid in understanding the overall concept of the 7A12 before the individual circuits are discussed in detail. Only the basic interconnections between the individual blocks are shown on the block diagram (see Diagrams Section). Each block represents a major circuit within the instrument. The number on each block refers to the schematic on which the complete circuit is found.

Block Diagram Description. The signal to be displayed on the CRT is applied to the Input connector. The signal passes through the input coupling relay, where the appropriate coupling is selected, to the attenuators. The VOLTS/DIV switch selects the correct attenuator(s). The signal is passed through an isolation stage to the input amplifier. DC offset signal is provided by this stage.

The amplifier stage provides signal polarity inversion, gain setting, variable gain circuit, and vertical positioning. The output of this stage is applied push-pull to the signal and trigger channel switching stages.

The channel switching stage electronically selects the proper signal and trigger according to the logic supplied by the switching logic state. The signal and trigger outputs of the channel switching stages correspond to the setting of the DISPLAY MODE and TRIGGER SOURCE switches.

The switching logic stage provides the control signals for the channel switching stages. The digital logic techniques

used in this stage will be described under Detailed Circuit Description.

In addition to the functions of the amplifier just explained, the 7A12 also provides readout logic for the oscilloscope. Logic is supplied identifying the polarity, the deflection factor, the uncalibrated symbol (when the VAR V/DIV control is in the out position) and the plug-in mode. When the IDENTIFY button is pressed, the readout is replaced by the word IDENTIFY and the trace representing the plug-in is deflected upward about 0.3 division for identification.

DETAILED CIRCUIT DESCRIPTION

Introduction

The 7A12 consists of two identical channels. Therefore, the following description of channel 1 applies equally to channel 2. Any functional differences will be pointed out in the description. Throughout the discussion, you should refer to the block and circuit diagrams located near the back of this manual.

ATTENUATORS

Input Coupling

Input signals applied to the Input connector can be AC-coupled, DC-coupled or internally disconnected. The input coupling relay, K5 is actuated by S9 (S10 for CH 2). When the AC button is pressed, K5B is actuated, providing a signal path through C1-R1 and C2 to the attenuators. C2 blocks the DC component of the signal. With the GND button pressed, K5 is not actuated and the signal path is through C1-R1, C2 and R3 to ground. In this position, the amplifier input is grounded while the impedance presented to the load remains the same. R3 allows C2 to be pre-charged in the GND position so the trace remains on screen when the AC button is pressed with a high DC level applied. With the DC button pressed, K5A is actuated, providing a signal path through C1-R1 to the attenuators. The signal path for DC & OFFSET is the same as for DC.

Input Attenuator

The effective overall deflection factor of the 7A12 is determined by the setting of the VOLTS/DIV switch. The

Circuit Description—7A12

basic deflection factor is 10 millivolts per division of CRT deflection. To increase this basic deflection factor to the values indicated on the front panel, precision attenuators are switched into the circuit. In the 5 and 10 millivolt positions, input attenuation is not used. Instead, the gain of the integrated circuit (U225) is changed in the 5 millivolt positions by switching off Q205, which turns on emitter-coupled Q215 to decrease the deflection factor.

For switch positions above 10 millivolts, the attenuators are switched into the circuit singly or in pairs to produce the vertical deflection factor indicated on the front panel. These attenuators are frequency-compensated voltage dividers. For DC and low-frequency signals, the attenuators are primarily resistance dividers and the voltage attenuation is determined by the resistance ratio in the circuit. The reactance of the capacitors in the circuit is so high at low frequencies that their effect is negligible. However, at higher frequencies, the reactance of the capacitors decreases and the attenuator becomes primarily a capacitance divider.

In addition to providing constant attenuation at all frequencies within the bandwidth of the instrument, the input attenuators are designed to maintain the same input RC characteristics (one megohm X 24 pF) for each setting of the VOLTS/DIV switch. Each attenuator contains an adjustable series capacitor to provide correct attenuation at high frequencies, and an adjustable shunt capacitor to provide correct input capacitance.

INPUT AMPLIFIER and OFFSET GENERATOR

The input amplifier and offset generator incorporates a single ended input for use in driving a paraphase type differential amplifier (integrated circuit U225). The outputs include a signal line, an offset line, and a bootstrap line. The DC mode is used to balance DC currents through the entire amplifier. The DC OFFSET mode works in a similar manner to balance out the DC component of the input signal. This allows an offset range of at least +1000 divisions to -1000 divisions.

The signal from the attenuator is coupled to the gate of the high input impedance, unity gain amplifier Q25A-Q27A. Current stabilization for the pair is provided by Q29. R21, along with the attenuators, provides a constant one megohm input. C23 and R28 provide frequency compensation. Dual diode clipper CR23 and CR24 protects the input against being overdriven by limiting the gate of Q25A to ± 15 volts.

Offset generator Q25B and Q27B is a unity gain amplifier stabilized by constant current source Q35. In the DC & OFFSET coupling mode, an offset voltage from about +5 volts to about -5 volts is supplied to the gate of

Q25B by variable resistor R56. Emitter follower Q27B supplies the offset voltage used to balance the differential input of U225. CR33 and CR34 limit the differential input to U225 to ± 0.6 volt, thus protecting the integrated circuit.

In addition to a balanced output, the generator provides a bootstrap voltage to the integrated circuit U225. This voltage maintains the quiescent operating parameters of the paraphase amplifier (see Fig. 3-1). Q32 is a constant current generator giving a fixed potential across R33. Therefore, in a balanced condition the potential between the signal out and the bootstrap out is kept constant.

The potential from the base of the floating power supply Q30 to the emitter of Q27B is held constant by constant-current generator Q32 and resistors R32 and R33. The voltage between drain and source of Q25A and Q25B is therefore kept at a constant potential. Temperature stabilization is increased through the use of dual FET (Field Effect Transistor) Q25 and dual transistor Q27.

AMPLIFIER CIRCUIT

The amplifier circuit converts the single-ended signal input to a differential output for use in oscilloscope vertical deflection system. It also furnishes a trigger signal for internal triggering of the time base unit.

Gain-switching circuit Q205-Q215 increases the sensitivity in the 5 mV position of the VOLTS/DIV switch. For all positions of the VOLTS/DIV switch except 5 mV/div, Q205 is conducting and Q215 is turned off. The current for U225 is from Pins 2 and 15 through Q205. When the 5 mV pushbutton is pressed, the junction of R200-R201 is grounded through CR60 on the VOLTS/DIV switch board. This makes the base of Q205 more negative, turning it off. Now the current generator for U225 is from Pins 1 and 16 through Q215. R217 is adjustable to DC balance the amplifier in the 5 mV position. CR215 is adjustable for high-frequency compensation in the 5 mV position of the VOLTS/DIV switch. C205 provides high-frequency compensation for the remaining positions of the VOLTS/DIV switch.

The Tektronix-made integrated circuit (IC) U225 provides gain control, polarity switching, and vertical positioning. Refer to the block diagram in Fig. 3-1, keeping in mind that it is only a representation to be used in explaining the overall operation of the IC.

The signal from the Input Amplifier is applied to U225 at Pin 14. A DC level is applied to Pin 3 to balance out DC levels present at Pin 14. Proper quiescent operating conditions for the Paraphase Amplifier are provided by the

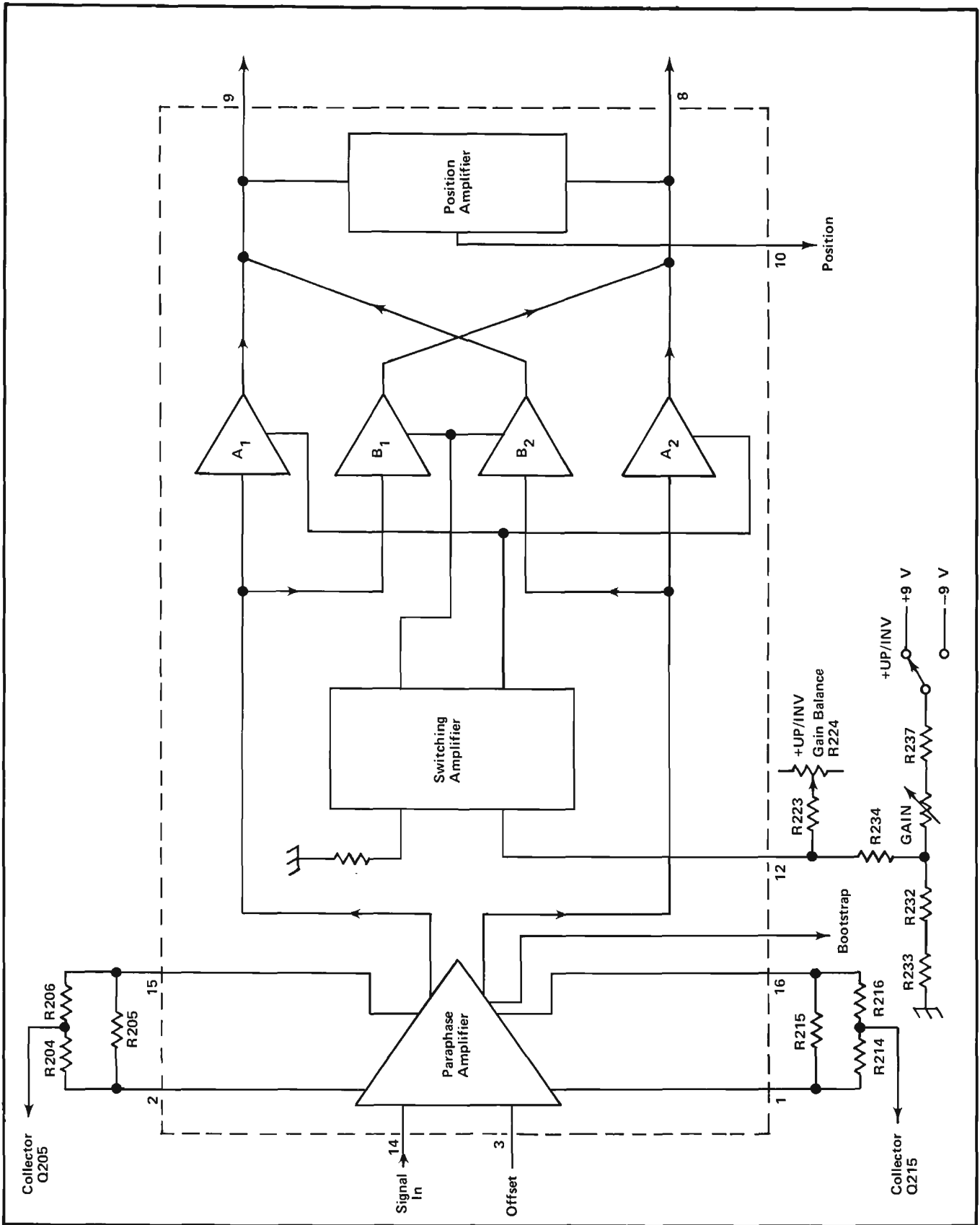


Fig. 3-1. Block representation of U225.

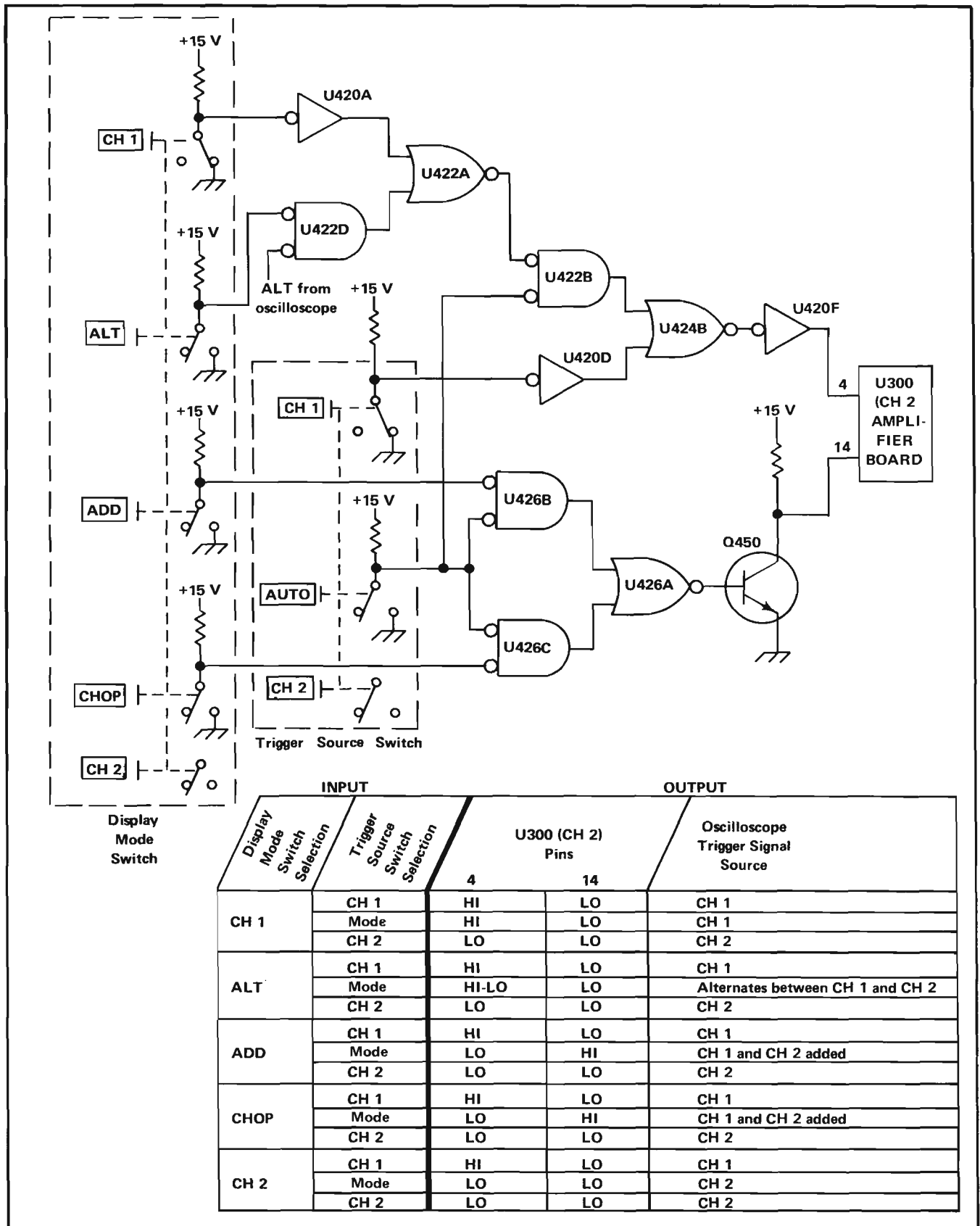


Fig. 3-2. Logic diagram and input/output table for trigger selection.

Bootstrap Amplifier (see circuit description for bootstrap). The resultant output of the Paraphase Amplifier is a DC compensated differential (push-pull) signal. This differential output is routed thru a pair of "steering" amplifiers labeled A1, A2, B1 and B2 on Fig. 3-1.

The switching amplifier determines the polarity of the output by allowing only one pair of "steering" amplifiers to be on at one time. With the +UP-INV switch in +UP, a positive voltage is applied to the Switching Amplifier through pin 12. The Switching Amplifier detects this and allows A1 and A2 to operate while holding B1 and B2 off. The result is no phase shift in the displayed signal. In the INV position, a negative voltage is applied to the Switching Amplifier. B1 and B2 are turned on while A1 and A2 are held off. The result is a 180° phase shift in the displayed signal. In addition to polarity switching, the Switching Amplifier controls the gain and balance of the "steering" amplifiers.

Positioning is achieved by varying the voltage to the Position Amplifier at pin 10. This shifts the DC level at Pins 8 and 9 in opposite directions resulting in vertical trace shift. The amount of vertical deflection is proportional to the voltage change at Pin 10. When the IDENTIFY button is pressed, a small positive voltage is applied to the Position Amplifier, (Pin 10), causing a fixed trace shift of approximately 0.3 division.

SWITCHING LOGIC

General

The logic techniques used in the following discussions are in terms of positive logic. Graphic symbols used for describing the operation of these circuits are set forth in the military standard MIL-STD-806B. For more information, refer to the logic discussions in the circuit description section of the oscilloscope mainframe manual. Switching logic provides the correct logic levels to Pins 4 and 14 of the Signal Switching IC and Trigger Switching IC (U300 CH 1 and CH 2). A complete schematic is shown on Diagram 4 in the diagrams section.

Signal Switching Logic

Signal Switching logic is controlled by the DISPLAY MODE switch. A logic diagram and truth table for this circuit is shown in Fig. 3-2.

Trigger Switching Logic

Trigger Switching logic is controlled by the TRIGGER SOURCE switch and DISPLAY MODE switch. The truth table for this circuit is shown in Fig. 3-3.

CHANNEL SWITCHES

General

The channel switch circuits provide signal and trigger outputs to the oscilloscope as selected by the DISPLAY MODE and TRIGGER SOURCE switches and associated logic. Refer to AMPLIFIERS schematic, Diagram 3, for diagram of U300 and associated circuits.

Signal Switch

The Signal switch stage consists of integrated circuit U300 and its external components (located on CH 1 Amp board). This IC selects one, or mixes two, analog signals in response to logic inputs at Pins 4 and 14. The Channel Switch determines which input (CH 1 or CH 2) provides the signal to the oscilloscope as controlled by the DISPLAY MODE switch setting and its associated logic circuitry. Resistors R290-R296-R297 and R300-R306-R307 set the current gain for each channel. Frequency compensation is set by the RC combinations shown in the schematic. An Input/Output (truth) table for U300 signal switching is shown in Fig. 3-4.2 to Channel 1.

When the level at Pin 14 is LO, a LO at Pin 4 will pass the Channel 1 signal to the output while the Channel 2 signal is blocked. With Pin 14 still LO, a HI at pin 4 will pass the Channel 2 signal to the output and block the Channel 1 signal. With the DISPLAY MODE switch set to CHOP, Pin 14 remains LO while Pin 4 is switched between HI and LO at a rate (determined by mainframe circuitry) to pass segments of the Channel 1 and Channel 2 signals. With the DISPLAY MODE switch set to ALT, Pin 14 is LO and Pin 4 switches between the LO and HI level at the end of each sweep as determined by the oscilloscope time base TIME/DIV switch setting. This produces alternate displays of the Channel 1 and Channel 2 signals. When the level at Pin 4 is LO and the level at Pin 14 is HI, the signals from both Channel 1 and Channel 2 are passed to the output pins. This condition occurs only when the DISPLAY MODE switch is set to ADD. In this operating mode, the signal output is the algebraic sum of CH 1 and CH 2 signals and the resultant signal determines the oscilloscope vertical deflection.

Trigger Switching

The trigger switch stage is identical to the Signal Switch state (located on the CH 2 Amp board). This stage determines which input signal (CH 1 and CH 2) provides the trigger signal to the oscilloscope time base unit. The selection of the trigger signal is controlled by the TRIGGER SOURCE switch, DISPLAY MODE switch, and the associated logic. An input/output (truth) table for U300 trigger switching is shown in Fig. 3-5.

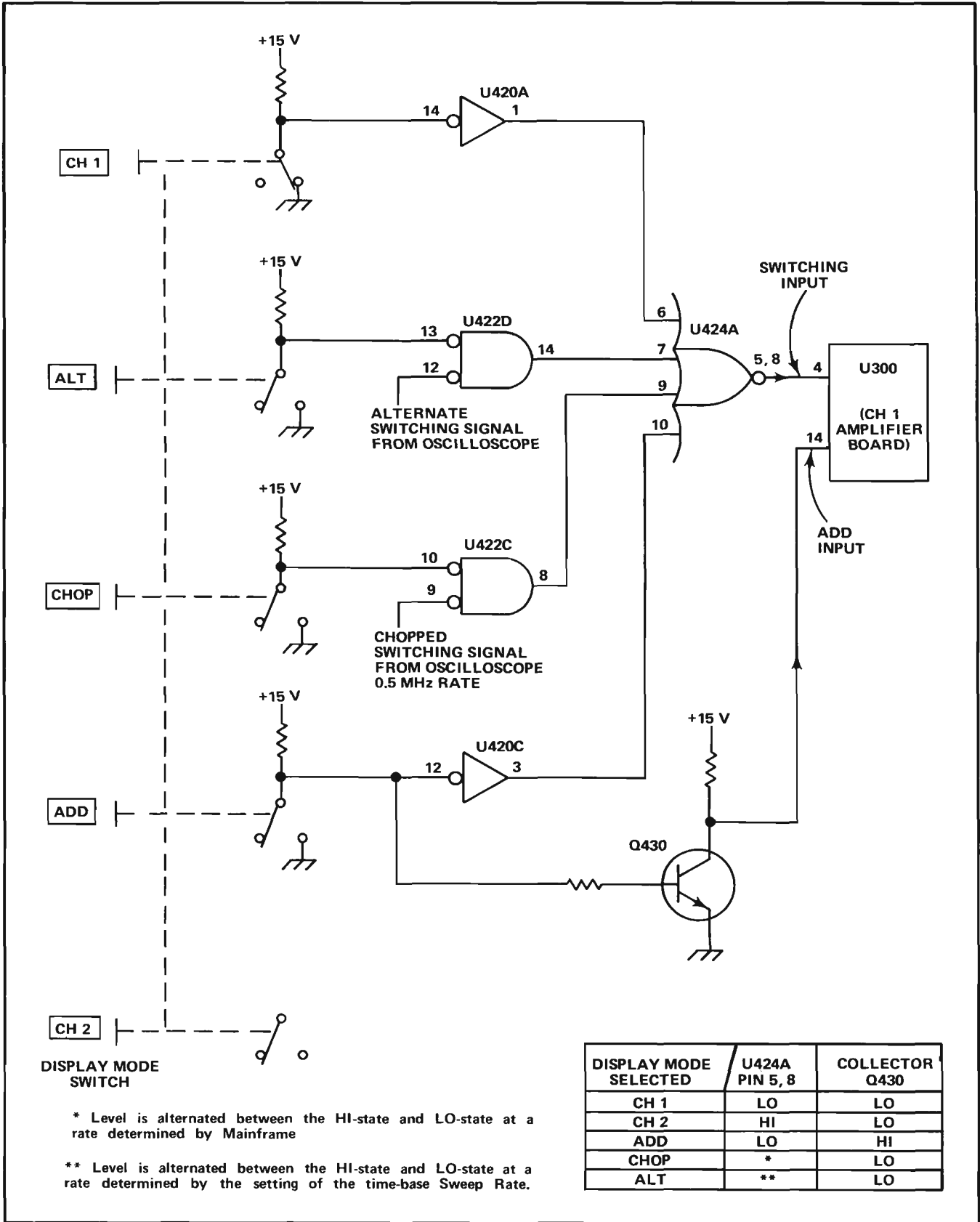


Fig. 3-3. Logic diagram and table of input/output combinations for signal selection.

Channel Switch	Channel Add	Signal Output
4	14	12,13
LO	LO	Channel 1
HI	LO	Channel 2
LO	HI	Ch 1 and Ch 2 (add)

Fig. 3-4. Input/output table for signal switching, U300 (on Ch 1 board).

When the level at Pin 14 is LO, a LO at Pin 4 will pass the Channel 2 trigger to the output while the Channel 1 trigger is blocked. With the level at Pin 4 HI, the Channel 1 trigger will be passed to the output while the Channel 2 trigger is blocked. With the level at Pin 4 LO and the level at Pin 14 HI, the Channel 1 and Channel 2 triggers are added algebraically. When the DISPLAY MODE switch is set to ALT and the TRIGGER SOURCE to Mode, the level at Pin 14 is LO and the level at Pin 4 switches between LO and HI at a rate determined by the setting of the time base unit TIME/DIV switch to select the Channel 1 trigger when Channel 1 is being displayed, and Channel 2 trigger when Channel 2 is being displayed.

Power Supplies

In addition to the power supplied by the oscilloscope, the 7A12 provides three supply voltages (see Diagram 5) for internal use in the amplifier.

The positive 3.5 volt supply provides the operating voltage (V_{CC}) for the integrated circuits in the Switching Logic stage. Q560 provides feedback to the base of Q565 for regulation of the +3.5 volt output.

INPUT		OUTPUT
CHANNEL SWITCHING	CHANNEL ADD	TRIGGER OUTPUT SIGNAL
4	14	12, 13
HI	LO	CHANNEL 1
LO	LO	CHANNEL 2
LO	HI	BOTH (added algebraically)
*	LO	ALTERNATE CH 1 and CH 2

*Switches between LO and HI at a rate determined by oscilloscope time base unit.

Fig. 3-5. Input/output table for trigger switch U300 (on Ch 2 board).

The positive 9 volt supply is used in the polarity-switching and gain-setting circuitry. Zener diode VR550 provides a -9 volt reference for this supply. The gain of error amplifier U550 is set by the ratio of feedback resistor R554 to the input resistance R552 and R551. R551 is adjustable to set a +9 volt output level. Q555 operates as a series regulator to provide the +9 volt output.

The negative 9 volt supply is used as a reference voltage in the offset circuit and in the polarity switching and gain setting circuitry. The output of the +9 volt supply is used as the reference voltage at the input to this circuit. The circuit operation is the same as for the +9 volt supply. R570 is adjustable to set a -9 volt output level.

SECTION 4

MAINTENANCE

Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, and troubleshooting of the 7A12.

Further maintenance information relating to general maintenance can be found in the instruction manuals for the 7000-series oscilloscopes.

PREVENTIVE MAINTENANCE

General

Preventive maintenance, consisting of cleaning, visual inspection, etc., performed on a regular basis, will improve the reliability of this instrument. Periodic checks of the semiconductor devices used in the unit are not recommended as a preventive maintenance measure. See semiconductor-checking information given under Troubleshooting.

Cleaning

CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Special care should be taken when cleaning the Polyphenylene Oxide attenuator boards. Do not apply any solvent containing ketones, esters or halogenated hydrocarbons. To clean, use only water soluble detergents, ethyl, methyl or isopropyl alcohol.

Front Panel. Loose dust may be removed with a soft cloth or a dry brush. Water and mild detergent may be used; however, abrasive cleaners should not be used.

Interior. Cleaning the interior of the unit should precede calibration, since the cleaning process could alter the settings of the calibration adjustments. Use low-velocity compressed air to blow off the accumulated dust. Hardened dirt can be removed with a soft, dry brush, cotton-tipped swab, or cloth dampened with a mild detergent and water solution.

TROUBLESHOOTING

General

The following is provided to augment information contained in other sections of this manual when troubleshooting the 7A12. The schematic diagrams, circuit description, and calibration sections should be used to full advantage. The circuit description section gives detailed information on circuit behavior and output requirements.

Troubleshooting Aids

Diagrams. Circuit diagrams are given on foldout pages in Section 7. The circuit number and electrical value of each component in this instrument are shown on the diagrams. Important voltages are also shown.

Circuit Boards. The circuit boards used in the 7A12 are outlined on the schematic diagrams, and photographs of the boards are shown on the backs of the schematic diagrams. Each board-mounted electrical component is identified on the photograph by its circuit number.

Component and Wiring Color Code. Colored stripes or dots on resistors and capacitors signify electrical values, tolerances, etc., according to the EIA standard color code. Components not color coded usually have the value printed on the body.

The insulated wires used for interconnection in the 7A12 are color coded to facilitate tracing a wire from one point to another in the unit.

Semiconductor Lead Configuration. Fig. 4-1 shows the lead configuration of the semiconductor devices used in this instrument.

Troubleshooting Equipment

The following equipment is useful for troubleshooting the 7A12.

1. Semiconductor Tester—Some means of testing the transistors, diodes, and FET's used in this instrument is helpful. A transistor-curve tracer such as the Tektronix Type 576 will give the most complete information.

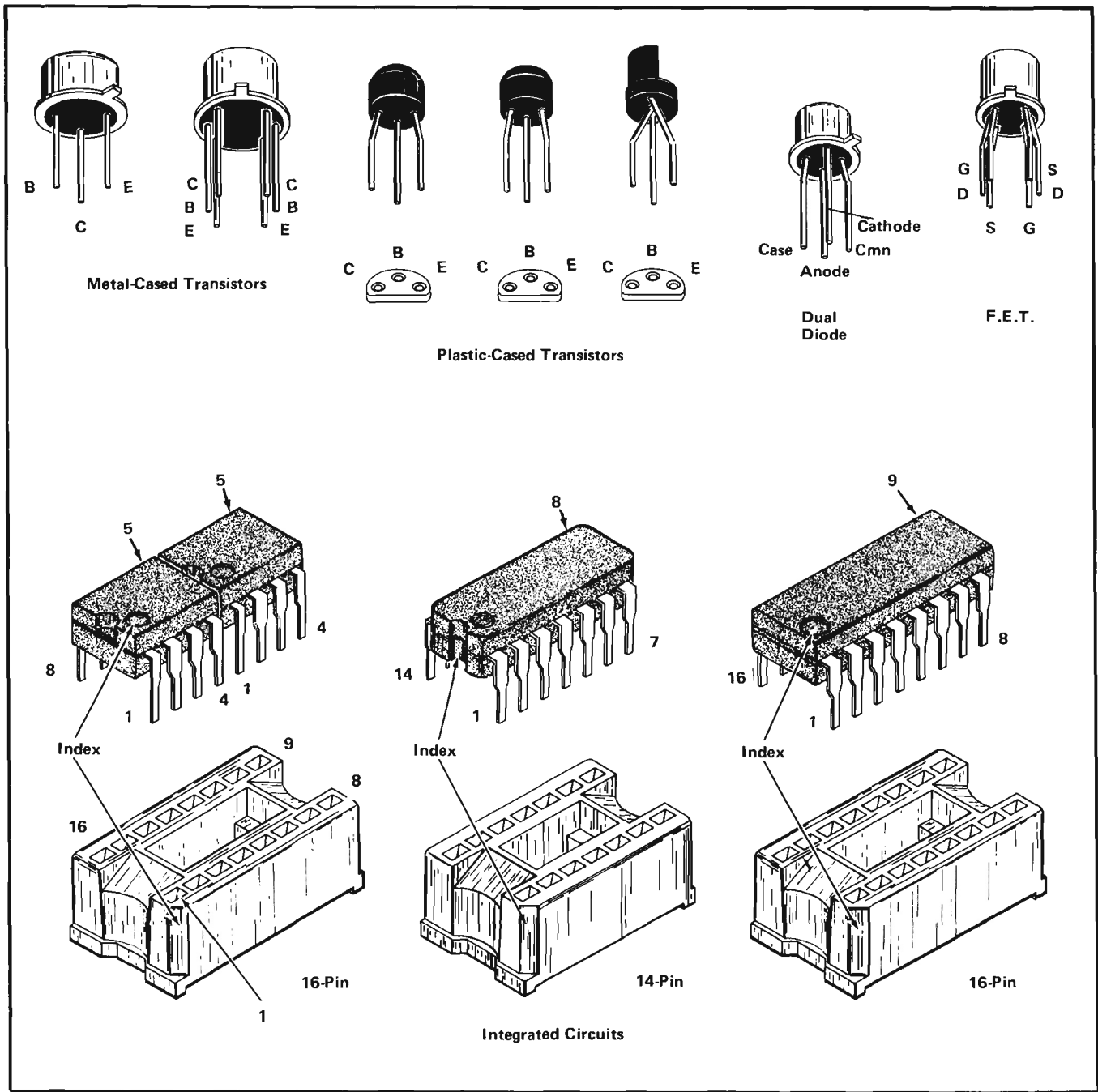


Fig. 4-1. Electrode Configuration for Semiconductors used in this instrument.

2. DC Voltmeter and Ohmmeter—A voltmeter for checking voltages within the circuit and an ohmmeter for checking resistors and diodes are required.

unit, and a 7A-series Amplifier unit with a 10X probe will meet the needs for items 2 and 3.

3. Test Oscilloscope—A test oscilloscope is required to view waveforms at different points in the circuit. A Tektronix 7000-series Oscilloscope equipped with a readout system, 7D13 Digital Multimeter unit, 7B-series Time-Base

4. Plug-in Extender—A fixture that permits operation of the unit outside of the plug-in compartment for better accessibility during troubleshooting. Order Tektronix Part Number 067-0589-00.

Troubleshooting Procedure

This troubleshooting procedure is arranged in an order which checks the simple trouble possibilities before proceeding with extensive troubleshooting.

1. Check Control Settings. An incorrect setting of the 7A12 controls can indicate a trouble that does not exist. If there is any question about the correct function or operation of a control or front-panel connector, see the Operating Instructions section.

2. Check Associated Equipment. Before proceeding with troubleshooting of the 7A12, check that the equipment used with this instrument is operating correctly. If possible, substitute an amplifier unit known to be operating correctly into the indicator unit and see if the problem persists. Check that the inputs are properly connected and that the interconnecting cables are not defective.

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

4. Check Instrument Performance. Check the calibration of the unit, or the affected circuit by performing Part I Performance Check of Section 5. The apparent trouble may only be a result of misadjustment and may be corrected by calibration. Complete calibration instructions are given in Part II of Section 5.

5. Check Voltages. Often the defective component or stage can be located by checking for the correct voltage in the circuit. Typical voltages are given on the diagrams; however, these are not absolute and may vary slightly between instruments. To obtain operating conditions similar to those used to take these readings, see the instructions in the Diagrams section.

6. Check Individual Components. The following methods are provided for checking the individual components in the 7A12. Components which are soldered in place are best checked by disconnecting one end to isolate the measurement from the effects of surrounding circuitry.

NOTE

To locate intermittent or temperature sensitive components mounted on the attenuator boards, Quik Freeze (Miller Stephenson, MS-240, Tektronix Part

Number 006-0173-01) is recommended. Dry ice or dichlorodi-fluorremethane (Freon 12, Dupont or Can-O-Gas) may also be used. Other types of circuit coolant may damage the polyphenylene oxide boards.

A. TRANSISTORS AND INTEGRATED CIRCUITS.

The best check of transistor and integrated circuit operation is actual performance under operating conditions. If a transistor or integrated circuit is suspected of being defective, it can best be checked by substituting a component known to be good; however, be sure that circuit conditions are not such that a replacement might also be damaged. If substitute transistors are not available, use a dynamic tester (such as Tektronix Type 576). Static-type testers may be used, but since they do not check operation under simulated operating conditions, some defects may go unnoticed. Fig. 4-1 shows base pin and socket arrangements of semiconductor devices. Be sure the power is off before attempting to remove or replace any transistor or integrated circuit.

Integrated circuits can be checked with a voltmeter, test oscilloscope, or by direct substitution. A good understanding of the circuit description is essential to troubleshooting circuits using integrated circuits. Use care when checking voltages and waveforms around the integrated circuits so that adjacent leads are not shorted together. A convenient means of clipping a test probe to the 14- and 16-pin integrated circuits is with an integrated-circuit test clip. This device also doubles as an integrated-circuit extraction tool.

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



Do not use an ohmmeter scale that has a high internal current. High currents may damage the diodes.

C. RESISTORS. Check resistors with an ohmmeter. Resistor tolerance is given in the Electrical Parts List. Resistors normally do not need to be replaced unless the measured value varies widely from the specified value.

D. CAPACITORS. A leaky or shorted capacitor can be detected by checking resistance with an ohmmeter on the highest scale. Use an ohmmeter which will not exceed the voltage rating of the capacitor. The resistance reading should be high after initial charge of the capacitor. An open capacitor can best be detected with a capacitance meter, or by checking whether the capacitor passes AC signals.

7. Repair and Readjust the Circuit. Special techniques required to replace components in this unit are given under Component Replacement. Be sure to check the performance of any circuit that has been repaired or that has had any electrical components replaced. Recalibration of the affected circuit may be necessary.

CORRECTIVE MAINTENANCE

General

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

Obtaining Replacement Parts

Standard Parts.All electrical and mechanical part replacements for the 7A12 can be obtained through your local Tektronix Field Office or representative. However, many of the electronic components can be obtained locally in less time than is required to order them from Tektronix, Inc. Before purchasing or ordering replacement parts, check the parts list for value, tolerance, rating and description.

NOTE

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

Special Parts. In addition to the standard electronic components, some special parts are used in the 7A12. These parts are manufactured or selected by Tektronix, Inc. in accordance with our specifications. These special parts are indicated in the parts list by an asterisk preceding the part number. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. Order all special parts directly from your local Tektronix Field Office or representative.

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

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

Soldering Techniques

WARNING

Disconnect the instrument from the power source before soldering.

Attenuator Circuit Boards. The Attenuator circuit boards are made from polyphenylene oxide because of its excellent electrical characteristics. Use more than normal care when cleaning or soldering this material. The following rules should be observed when removing or replacing parts:

1. Use a low-wattage soldering iron (not over 15 watts).
2. Do not apply more heat, or apply heat for a longer time, than is absolutely necessary.
3. Use some form of vacuum solder remover when removing multi-lead devices.
4. Do not apply any solvent containing ketones, esters, or halogenated hydrocarbons.
5. To clean, use only water-soluble detergents, ethyl, methyl, or isopropyl alcohol.

Circuit Boards (except Attenuator boards). The components mounted on the circuit boards in the amplifier can be replaced using normal circuit board soldering techniques. Keep the following points in mind when soldering on the circuit boards:

1. Use a pencil-type soldering iron with a wattage rating from 15 to 50 watts.
2. Apply heat from the soldering iron to the junction between the component and the circuit board.
3. Heat-shunt the lead to the component by means of a pair of long-nose pliers.
4. Avoid excessive heating of the junction with the circuit board, as this could separate the circuit board wiring from the base material.
5. Use electronic grade 60-40 tin-lead solder.
6. Clip off any excess lead length extending beyond the circuit board. Clean off any residual flux with a flux-removing solvent. Be careful that the solvent does not remove any printing from the circuit board.

Metal Terminals. When soldering metal terminals (potentiometer, etc.) use 60-40 tin-lead solder and a 15 to 50 watt soldering iron. Observe the following precautions when soldering metal terminals:

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

Component Replacement

WARNING

Disconnect the equipment from the power source before replacing components.

Relay Replacement. The relays in the 7A12 are manufactured by Tektronix, Inc. If a relay fails, a replacement may be ordered from your local Tektronix Field Office or representative. The eight-pin DPDT (double pole, double throw) relays are symmetrical and may be replaced in their sockets facing either direction. The DPAT (double pole, alternate throw) relay is not symmetrical and can be replaced in its socket in only one direction.

Semiconductor Replacement. Transistors and integrated circuits should not be replaced unless actually defective. If removed from their sockets during routine maintenance, return them to their original sockets. Unnecessary replacement of transistors may affect the calibration of this instrument. When transistors or integrated circuits are replaced, check the performance of the part of the instrument which may be affected.

Replacement semiconductors should be of the original type or a direct replacement. Fig. 4-1 shows the lead configuration of the semiconductors used in this instrument. If the replacement semiconductor is not of the original type, check the manufacturer's basing diagram for proper basing. An extracting tool should be used to remove the 14 and 16 pin integrated circuits to prevent damage to the pins. This tool is available from Tektronix, Inc. Order Tektronix Part No. 003-0619-00. If an extracting tool is not available when removing one of these integrated circuits, pull slowly and evenly on both ends of the device. Try to avoid having one

end of the integrated circuit disengage from the socket before the other, as the pins may be damaged.

Circuit Board and Pushbutton Switch Replacement. If a circuit board is damaged beyond repair, either the entire assembly including all soldered-on components, or the board only, can be replaced. Part numbers are given in the Mechanical Parts List for either the wired or unwired board.

The pushbutton switches are not repairable and should be replaced as a unit if defective. Components which are mounted on the circuit board associated with the pushbutton switch can be replaced using the normal replacement procedures. See the information under Light-Bulb Replacement for instructions on replacing the light bulbs.

Use the following Procedures for removing major circuit components. Procedures marked (CH 1 or CH 2) apply equally to either channel. Perform Procedures on only the side (CH 1 or CH 2) that the part being removed is located.

A. VOLTS/DIV Switch and Circuit Board (CH 1 or CH 2)

1. Remove the POSITION and OFFSET knobs.

2. Remove the front panel of the instrument by inserting a wide blade screwdriver in the slot located at the bottom of the front panel, and prying outward. (A fiber blade screwdriver is recommended to prevent marring the front panel.)

3. Remove the three screws that secure the VOLTS/DIV switch. Lift rear of switch circuit board up and out.

4. To replace the switch, reverse steps 1 through 3 making sure that the interconnecting pins and sockets mate properly (A pair of tweezers is useful for mating interconnecting pins to their sockets).

B. Attenuator Circuit Board (CH 1 or CH 2)

1. Remove VOLTS/DIV switch, Procedure A.

2. Remove the shield covering the Attenuator board.

3. Unsolder the connections from the Input connector. Unscrew nut from the rear of the Input connector and remove the Input connector.

Maintenance—7A12

4. (For CH 1 only) Remove spring from release bar (marked 7A12). Move release bar to expose screw underneath.

5. Remove the screw, spacer, nut, and washer located near the front of the Attenuator board. (Under the release bar for channel 1).

6. Remove the two screws located at the bottom of the Attenuator board (The channel 1 side has two holes in the bottom rail that permit access to these screws).

7. Remove the screw located directly under the input coupling capacitor (C2).

8. Remove shield gasket located on either side of the front panel casting. Use care in removing so as to not crease these shields.

9. Loosen the two securing screws and lift the board away from the Interface circuit board until the Attenuator board clears the interconnecting pins.

10. To replace the Attenuator board, position it so the securing-screw holders mate with the guide posts on the Interface board. Gently press the board down, making sure that all of the interconnecting pins and sockets have properly mated.

11. Uniformly tighten the securing screws. Recommended torque, four to six inch-pounds. Re-assemble the instrument by reversing the removal procedure.

C. COUPLING Switch and Circuit Board (CH 1 or CH 2)

1. Remove Attenuator circuit board, Procedure B.

2. Remove the two screws that secure the coupling switch.

3. (For CH 1 only.) Remove the bottom rail.

4. Lift rear of COUPLING switch circuit board up and out.

5. To replace the COUPLING board, position it so that the interconnecting pins and sockets are properly mated. Press down on the board until it is seated against the interface board.

6. Re-assemble by reversing the removal procedures.

D. Polarity Switch and Circuit Board (CH 1 or CH 2)

1. Remove VOLTS/DIV switch, Procedure A.

2. Remove the screw that secures the Polarity switch.

3. Lift the rear of the Polarity switch circuit board up and out.

4. To replace the Polarity board, position it so that the interconnecting pins and sockets are properly mated. Press down on the board until it is about level with the Attenuator board. (A pair of tweezers is useful for mating interconnecting pins with their sockets.)

5. Re-assemble by reversing the removal procedures.

E. DISPLAY MODE Switch and Circuit Board

1. Remove the front panel, steps 1 and 2 of Procedure A.

2. Remove top rail.

3. Remove the two screws that secure the DISPLAY MODE switch.

4. Disconnect the DISPLAY MODE multi-pin connector from the interface board. Remove the DISPLAY MODE switch and circuit board.

5. Re-assemble by reversing the removal procedures.

F. TRIGGER SOURCE Switch and Circuit Board

1. Remove DISPLAY MODE switch, Procedure E.

2. Remove the two securing screws from the TRIGGER SOURCE switch.

3. Disconnect the TRIGGER SOURCE multi-pin connector from the interface board. Remove the TRIGGER SOURCE switch and circuit board.

4. Re-assemble by reversing the removal procedures.

G. VAR V/DIV Potentiometer and CAL IN Switch (CH 1 or CH 2)

The VAR V/DIV potentiometer and CAL switch are furnished as a unit.

1. Remove the Attenuator circuit board, Procedure B.
2. Using a 5/16 inch nut driver, remove the nut which secures the potentiometer to the front of the instrument.
3. Slide the potentiometer to the rear until the shaft clears the front panel. Unsolder the wires and lift out. (Note the color code and position of each wire to insure proper replacement.)
4. Replace by reversing the removal procedures.

H. POSITION Potentiometer, IDENTIFY Switch and OFFSET Potentiometer (CH 1 or CH 2)

The POSITION and OFFSET potentiometer and IDENTIFY switch is furnished as a unit.

1. Remove VOLTS/DIV switch, Procedure A.
2. Remove the nut that secures the unit to the front panel.
3. Disconnect the multi-pin connector and remove the unit.
4. Re-assemble by reversing the removal procedures.

I. GAIN Potentiometer (CH 1 or CH 2)

1. Remove Polarity switch, Procedure D.
2. Remove the nut securing the GAIN potentiometer to the front panel with a spanner wrench.
3. Slide the GAIN potentiometer to the rear until the shaft clears the front panel.
4. Unsolder the wires after noting the color code and location of each wire.
5. Re-assemble by reversing the removal procedures.

Interconnecting Pins and Pin Socket Replacement. Two types of mating connectors are used for these interconnecting pins. If the mating connector is mounted on a plug-on circuit board, a special socket is soldered onto the board. If the mating connector is on the end of a lead, a pin connector is used to mate with the interconnecting pin. The following information provides the replacement procedure for the various types of pins and pin sockets:

A. CIRCUIT BOARD PINS

NOTE

A pin replacement kit including necessary tools, instructions and replacement pins is available from Tektronix, Inc. Order Part No. 040-0542-00.

To replace a pin which is mounted on a circuit board, first disconnect any pin connectors. Then, unsolder the damaged pin and pull it out of the circuit board. Observe the precautions given under Soldering Techniques to prevent damage to the circuit board. Ream out the hole in the circuit board with a 0.031 inch drill. Remove the ferrule from the new interconnecting pin and press the new pin into the hole in the circuit board. Position the pin in the same manner as the old pin. Solder the pin on both sides of the circuit board. If the old pin was bent at an angle to mate with a connector, bend the new pin to match the associated pins.

B. CIRCUIT BOARD PIN SOCKETS

The pin sockets on the circuit boards are soldered to the rear of the board. To replace one of these sockets, first unsolder the pin (use a vacuum-type desoldering tool to remove excess solder). Straighten the tabs on the socket and remove it from the board. Place the new socket in the circuit board hole and press the tabs down against the board. Solder the tabs to the circuit board. Do not allow the solder to get into the socket.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit board and the pin. This spring tension can be destroyed by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.

C. LEAD PIN CONNECTORS

The pin connectors used to connect the wires to the interconnecting pins are clamped to the ends of the associated leads. To replace damaged lead pin connectors, remove the old pin connector from the end of the lead and clamp the replacement connector to the lead.

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Some of the pin connectors are grouped together and mounted in a plastic holder. These connectors are referred to as multi-pin connectors and are removed and re-installed as a unit. To provide correct orientation of this multi-pin connector when it is replaced, an arrow is stamped on the circuit board and a matching arrow is molded into the plastic housing of the multi-pin connector. Align these arrows when replacing the multi-pin connector. If individual end-lead pin connectors are removed from the plastic holder, note the color of the wire for replacement.

Light Bulb Replacement. Two types of pushbutton switches which have different light designs are available. One switch type uses a metal cover over the light bulb(s) on the back of the switch; the other type does not. Either or both types of switches may be used in the 7A12.

To replace light bulbs in the pushbutton switches with the metal cover, use the following replacement procedure; delete step 2 and 6 for switches without the cover.

1. Remove the applicable pushbutton switch, using the previously described procedure.
2. Remove the screw which holds the metal cover on the back of the switch to expose the light bulb.
3. Note the position of the bulb on the switch. Unsolder the defective bulb from the circuit board.

4. Install the new bulb so it is positioned in the same manner as the original bulb.

5. Solder the bulb to the circuit board. If possible, use a heat sink to protect the bulb during soldering.

6. Replace the metal cover on the switch.

7. Re-install the switch using the previously described procedure.

Instrument Repackaging

If the 7A12 is to be shipped for long distance by commercial means of transportation, it is recommended that the instrument be repackaged in the original manner for maximum protection. Refer to the repackaging illustration in the back of the manual for details. The original carton can be saved and used for this purpose, or new shipping cartons can be obtained from Tektronix, Inc. Contact your local Tektronix Field Office or representative for information or assistance.

NOTE

The plug-ins should not be shipped installed in an oscilloscope. The oscilloscope packaging is not designed to protect the plug-ins.

SECTION 5

CALIBRATION

Introduction

To assure instrument accuracy, check the calibration of the 7A12 every 1000 hours of operation, or every six months if used infrequently. Before complete calibration, thoroughly clean and inspect this instrument as outlined in the Maintenance section.

Tektronix Field Service

Tektronix, Inc., provides complete instrument repair and recalibration service at local Field Service Centers and Factory Service Center. Contact your local Tektronix Field Office or representative for further information.

Using This Procedure

General. This section provides several features to facilitate checking or adjusting the 7A12. These are:

Index. To aid in locating a step in the adjustment procedure or Performance Check, an index is given preceding Part II – Adjustment procedure and Part I – Performance Check.

Performance Check. The performance of this instrument can be checked without removing the side shields or making internal adjustments by performing only Part I – Performance Check. This procedure checks the instrument against the tolerances listed in the Performance Requirement column of Section 1. In addition, a cross-reference is provided to the step in Part II – Adjustment, which will return the instrument to correct calibration. In most cases, the Adjustment step can be performed without changing control settings or equipment connections.

Adjustment. To return this instrument to correct calibration with the minimum of steps, perform only Part II – Adjustment. The Adjustment procedure gives the recommended calibration procedure for all circuits in this instrument.

Complete Performance Check/Adjustment. To completely check and adjust all parts of this instrument, perform both Parts I and II. Start the complete procedure by performing the Adjustment procedure and follow this with the Performance Check. This method will assure that the instrument is both correctly adjusted, and performing within all Performance Requirements given in Section 1.

Test Equipment Required

General. The following test equipment and accessories, or equivalent, are required for complete calibration of the 7A12. Specifications given are minimum necessary for accurate calibration. Therefore, some of the recommended equipment may have specifications which exceed those given. 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 test equipment.

1. Calibration Oscilloscope. Tektronix 7704 or equivalent 7700-Series Oscilloscope.

2. 7B-Series Time Base. 7B71 used in this procedure.

3. Standard Amplitude Calibrator. Amplitude accuracy, within 0.25%; signal amplitude, 5 millivolts to 50 volts; frequency, 1 kHz and DC. Tektronix Calibration Fixture 067-0502-01 recommended.

4. Square Wave Generator. Frequency, 1 kHz to 100 kHz; output amplitude about +200 millivolts into 50 ohms and about 25 volts into 1 megohm. Tektronix Type 106 Square Wave Generator recommended.

5. Low-Frequency constant amplitude sine-wave generator. Frequency range, 40 megahertz to 50 megahertz; reference, 50 kHz; output amplitude, 0.5 volt to 5 volts peak-to-peak into 50 ohms; amplitude accuracy, within 3% of reference frequency as output frequency changes. Tektronix Type 191 Constant Amplitude Signal Generator recommended.

6. High-Frequency constant amplitude signal generator. Reference frequency, 3 megahertz; frequency range, 65 megahertz to over 125 megahertz; output amplitude, 0.5 volt to 5 volts peak-to-peak into 50 ohms; amplitude accuracy, within 1% of reference frequency as output frequency changes. Tektronix Calibration Fixture 067-0532-01 recommended.

7. Precision DC Voltmeter. Range, 0 to 15 volts; input impedance, 10 megohms; accuracy, 0.1%. Tektronix 7D13 plug-in recommended.

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8. Plug-in Extender. Tektronix Part No. 067-0589-00.

Accessories

9. Dual Input Coupler. Matched signal transfer to each input. Tektronix Calibration Fixture 067-0525-00.

10. Termination, Feedthru. Impedance, 50 ohms; connectors, BNC. Tektronix Part Number 011-0060-01.

11. Cable (2 each). Impedance, 50 ohms; length, 42 inches; connectors, BNC. Tektronix Part Number 012-0057-01.

12. 5 nanosecond GR Cable. Tektronix Part Number 017-0512-00.

13. RC Normalizer.. Time constant, 1 megohm X 24 picofarad; connectors, BNC. Tektronix Part Number 067-0539-01.

14. Adapter. GR to BNC female. Tektronix Part Number 017-0063-00.

15. Termination, endline. Impedance, 50 ohms; connector, GR to BNC male. Tektronix Part Number 017-0083-00.

16. Attenuator. Impedance, 50 ohms; attenuation, 5X; connectors, GR. Tektronix Part Number 017-0079-00.

17. Attenuator. Impedance, 50 ohms; attenuation, 10X; connectors, GR. Tektronix Part Number 017-0078-00.

Preliminary Control Settings

7A12 (Left Vert Compartment)

DISPLAY MODE	CH 1
TRIGGER SOURCE	MODE
VOLTS/DIV (both)	10 mV
POLARITY (both)	+UP
VAR V/DIV (both)	CAL IN
COUPLING (both)	DC
POSITION (both)	Midrange

7B71 (B Horiz Compartment)

Level/Slope	Centered On Positive Slope
Triggering Mode	P-P Auto or Auto
Coupling Source	AC Int
Position	Midrange
Time/Div	1 ms
Variable Time/Div	Cal In
B Delay Mode	Independent
Magnifier	X1

7704

Vertical Mode	Left
Horizontal Mode	B
A Intensity	CCW
B Intensity	Optimum
B Trigger Source	Left Vert

PART I - PERFORMANCE CHECK

Introduction

The following procedure checks the performance of the 7A12 without removing the covers or making internal adjustments. All tolerances given in this procedure are based on Section 1 of this manual.

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	Page
1. Check GAIN	5-3
2. Check +UP to INVERT Gain Balance	5-3
3. Check VAR V/DIV Range	5-3
4. Check Deflection Factor Accuracy	5-4
5. Check OFFSET Range	5-4
6. Check Trace IDENTIFY	5-4
7. Check Upper Bandwidth Limit	5-4
8. Check Common Mode Rejection Ratio	5-5
9. Check Channel Isolation	5-5
10. Check Alternate Operation	5-5
11. Check Chopped Operation	5-6
12. Check Trigger Source Operation	5-6

Preliminary Procedure for Performance Check

NOTE

The performance of this instrument can be checked at any temperature within the operative range.

1. Install the 7A12 in the left vertical plug-in compartment of the 7704 oscilloscope.
2. Connect the oscilloscope to a power source which meets its frequency and voltage requirements.
3. Turn the oscilloscope on and allow at least twenty minutes for warmup.
4. Set the controls as given under Preliminary Control Settings.

NOTE

The checks titled Channel 1 and Channel 2 apply equally to both channels. Perform the checks on the channel selected by the DISPLAY MODE switch.

PERFORMANCE CHECK

1. Check Channel 1 and Channel 2 Gain

a. Connect the standard amplitude calibrator output to the CH 1 and CH 2 Input connectors with the 42-inch BNC cable and dual-input coupler.

b. Set the standard amplitude calibrator for a 50-millivolt square-wave output.

c. CHECK—CRT display for five divisions ± 0.05 division of vertical deflection.

d. If necessary, adjust the front-panel GAIN adjustment for exactly five divisions of vertical deflection.

e. Set the DISPLAY MODE switch to CH 2 and repeat parts b through d of this step.

2. Check Channel 1 and 2 +UP to INVERT Gain Balance

a. Set the POLARITY switch to INV.

b. CHECK—CRT display for five divisions vertical deflection within 0.05 division.

c. CALIBRATION—See step 5 of the Adjustment procedure.

d. Set the POLARITY switch to +UP.

e. Set the DISPLAY MODE switch to CH 1 and repeat parts a through d of this step.

3. Check Channel 1 and 2 VAR V/DIV Range.

a. Press and release the VAR V/DIV control to its outward position.

b. Rotate the VAR V/DIV control fully counterclockwise.

Performance Check—7A12

c. CHECK—CRT display for two divisions or less vertical deflection.

d. Return the VAR V/DIV control to the CAL IN position.

e. Set the DISPLAY MODE switch to CH 2 and repeat parts a through d of this step.

4. Check Channel 1 and 2 Deflection Factor Accuracy

a. CHECK—Using the VOLTS/DIV switch and standard amplitude calibrator settings given in Table 5-1, check vertical deflection within the limit given for each VOLTS/DIV switch setting.

b. Set the DISPLAY MODE switch to CH 1 and repeat Part a.

d. Set the input coupling switch to DC & OFFSET.

e. CHECK—Using the OFFSET control, check that the trace can be returned to graticule center.

f. Set the standard amplitude calibrator for a minus (–) five-volt DC output.

g. CHECK—Using the OFFSET control, check that the trace can be returned to graticule center.

h. Change the following control settings:

Input Coupling	GND
VOLTS/DIV	5 mV

i. Repeat parts b through g of this step.

j. Set the DISPLAY MODE switch to CH 2 and repeat parts a through i of this step.

TABLE 5-1
Vertical Deflection Accuracy

VOLTS/DIV Switch Setting	Standard Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for ±2% Accuracy (divisions)
5 mV	20 mV	4	±0.08
10 mV	50 mV	5	Set in step 4
20 mV	0.1 V	5	±0.1
50 mV	0.2 V	4	±0.08
.1 V	0.5 V	5	±0.1
.2 V	1 V	5	±0.1
.5 V	2 V	4	±0.08
1 V	5 V	5	±0.1
2 V	10 V	5	±0.1
5 V	20 V	4	±0.08

5. Check Channel 1 and 2 OFFSET Range

a. Change the following control settings:

Input coupling	GND
VOLTS/DIV	10 mV

b. Position the trace to the center horizontal graticule line.

c. Set the standard amplitude calibrator for a five-volt +DC output.

6. Check Channel 1 and 2 Trace IDENTIFY

a. Change the following control settings:

Input coupling	DC
VOLTS/DIV	10 mV

b. Set the standard amplitude calibrator for a 20-millivolt square-wave output.

c. Center the display vertically with the POSITION control.

d. CHECK—Press the IDENTIFY button and check that the trace moves upward about 0.25 division, and for main-frames equipped with readout, check that the word “IDENTIFY” is displayed.

e. Set the DISPLAY MODE switch to CH 1 and repeat parts a through d of this step.

f. Disconnect all test equipment.

7. Check Channel 1 and 2 Upper Bandwidth Limit

a. Set both VOLTS/DIV switches to 10 mV.

b. Connect the high-frequency constant-amplitude signal generator to the CH 1 Input connector through the 10X GR attenuator, 5X GR attenuator, and in-line 50-ohm GR termination.

c. Set the generator for five-division display (50 millivolts) at the three-megahertz reference frequency.

d. Increase the generator frequency until the display amplitude decreases to 3.5 division.

e. CHECK—Generator frequency; must be at least 105 megahertz. Actual frequency megahertz.

f. Set the DISPLAY MODE switch to CH 2, connect generator to CH 2 and repeat parts a through e of this step.

g. CALIBRATION—See step 8 of the Adjustment procedure.

h. Disconnect all test equipment.

8. Check Common Mode Rejection Ratio

a. Change the following control settings:

DISPLAY MODE	CH 1
CH 2 polarity	INVERT
CH 1 and 2 VOLTS/DIV	10 mV
CH 1 and 2 Input coupling	DC

b. Connect the low-frequency constant-amplitude sine-wave generator to the CH 1 and CH 2 Input connectors with the 42-inch BNC cable, 50-ohm BNC termination, GR to BNC adapter, and dual-input coupler.

c. Set the generator for an eight-division display (80 millivolts) at the 50-kilohertz reference frequency.

d. Set the generator frequency to 40 megahertz.

e. Set the DISPLAY MODE switch to ADD.

f. CHECK—CRT display for no more than 0.8 division vertical deflection (common-mode rejection ratio 10:1 or better).

g. Disconnect all test equipment.

9. Check Channel Isolation

a. Change the following control settings:

DISPLAY MODE	CH 1
CH 1 VOLTS/DIV	.1 V
CH 2 VOLTS/DIV	5 mV

b. Connect the low-frequency generator to the CH 1 Input connector with the 42-inch BNC cable, GR and BNC adapter and 50-ohm BNC termination.

c. Set the generator for a two-division display (200 millivolts) at 50 megahertz.

d. Change the following control settings:

DISPLAY MODE	CH 2
CH 1 VOLTS/DIV	10 mV

e. CHECK—CRT display for 0.4 division or less deflection.

f. Disconnect the generator from CH 1 and connect it to the CH 2 Input connector.

g. Set the CH 2 VOLTS/DIV switch to .1 V.

h. Set the generator for a two-division display (200 millivolts) at 50 megahertz.

i. Change the following control settings:

CH 1 VOLTS/DIV	5 mV
DISPLAY MODE	CH 1

j. CHECK—CRT display for 0.4 division or less deflection.

k. Disconnect all test equipment.

10. Check Alternate Operation

a. Set the DISPLAY MODE switch to ALT.

b. Position the traces about two divisions apart.

Performance Check—7A12

c. Turn the time-base unit time/division switch through-out its range.

d. CHECK—Trace alternation between channel 1 and 2 at all sweep rates. At faster sweep rates, alternation will not be apparent; instead display appears as two traces on the screen.

11. Check Chopped Operation

a. Set the DISPLAY MODE switch to CHOP.

b. CHECK—CRT display for two traces.

12. Check Trigger Source Operation

a. Change the following control settings;

DISPLAY MODE	ALT
TRIGGER SOURCE	CH 1
+UP/INV Switch	+UP
VOLTS/DIV	10 mV

b. Connect the Indicator Oscilloscope Cal Out connector to the CH 1 Input connector with the 42-inch BNC cable.

c. Set the Indicator Oscilloscope Calibrator to 40 mV at a 1 kHz rate.

d. Set the time-base unit for a triggered display at a sweep rate of 0.1 millisecond/division.

e. Connect the low-frequency generator to the CH 2 Input connector with the 42-inch BNC cable.

f. Set the generator for a two-division (40 millivolts) one-kilohertz signal.

g. CHECK—CRT display for square wave and sine wave; square wave only is triggered.

h. Set the TRIGGER SOURCE switch to Mode.

i. CHECK—CRT display; square wave and sine wave are both triggered.

j. Set the TRIGGER SOURCE switch to CH 2.

k. CHECK—CRT display; sine wave only is triggered.

l. Disconnect all test equipment.

This completes the Performance Check procedure for the 7A12. If the instrument has met all tolerances given in this procedure, it is correctly calibrated and within the specified tolerances.

PART II - ADJUSTMENT

Introduction

The following procedure returns the 7A12 to correct calibration. All limits and tolerances given in this procedure are calibration guides, and should not be interpreted as instrument specifications except as listed in the Performance Requirement column of Section 1. The actual operation of the instrument may exceed the given limits or tolerances if the instrument meets the Performance Requirements checked in Part I - Performance Check of this section.

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1. Adjust +9 volt and -9 volts Power Supplies	5-7
2. Check +3.5 volt Power Supply	5-8
3. Adjust CH 1 DC Balance	5-8
4. Adjust CH 2 DC Balance	5-8
5. Adjust +UP to INVERT Gain Balance	5-9
6. Adjust GAIN	5-9
7. Adjust Input Capacitance and Attenuator compensation	5-9
8. Adjust High-Frequency Response	5-10

Preliminary Procedure for Adjustment

NOTE

This instrument should be adjusted at an ambient temperature of +25°C ±5°C for best overall accuracy.

1. Remove both side shields from the 7A12.
2. Place the 7A12 on the plug-in extender and plug the extender into the Left Vertical plug-in compartment of the Indicator Oscilloscope.
3. Connect the Indicator Oscilloscope to a power source

which meets the frequency and voltage requirements of the oscilloscope power supply.

4. Turn the Indicator Oscilloscope power on. Allow at least twenty minutes warmup before proceeding.

5. Set the controls as given under Preliminary Control Settings.

6. Adjust the Focus and Astigmatism as necessary to obtain a well-defined display.

NOTE

Titles for external controls of this instrument are capitalized in this procedure (e.g., VOLTS/DIV). Internal adjustments are initial capitalized only (e.g., DC Balance).

Location of Adjustments and test points are shown in Fig. 5-1.

1. Adjust +9 Volt and -9 Volt Power Supplies

a. Connect the precision DC voltmeter between the +9 V and GND test points.

b. CHECK—Voltmeter reading of +9.00 volts within 50 millivolts (+8.95 to +9.05 volts).

c. ADJUST—+9 V Adjustment R551 for a voltmeter reading of exactly +9.00 volts.

d. Connect the digital voltmeter between the -9 V and GND test points.

e. CHECK—Voltmeter reading of -9.00 volts within 50 millivolts (-8.95 to -9.05 volts).

f. ADJUST— -9 V Adjustment R570 for a voltmeter reading of exactly -9.00 volts.

g. Disconnect all test equipment.

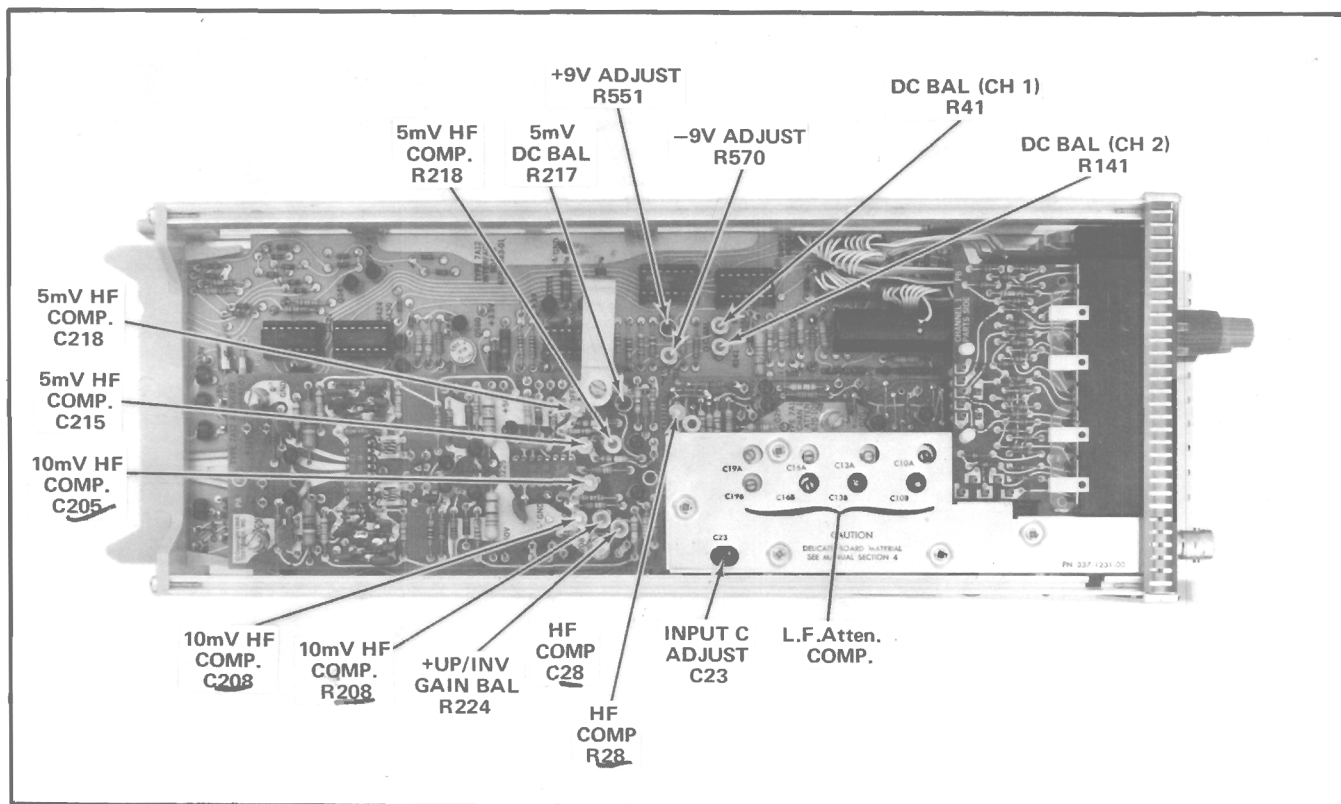


Fig. 5-1. Location of adjustments and test points for Ch 1 side (Ch 2 side identical).

2. Check +3.5 Volt Power Supply

- a. Connect the Precision DC voltmeter between the +3.5 V and GND test points.
- b. CHECK—Voltmeter reading; must be +3.5 volts within 350 millivolts (+3.15 to +3.85 volts).
- c. Disconnect all test equipment.

3. Adjust CH 1 DC Balance

- a. Position the trace to the center horizontal graticule line.
- b. Set the CH 1 polarity switch to INV.
- c. CHECK—Trace shift; not more than 0.5 division.
- d. ADJUST—DC Bal adjustment R41 for minimum trace shift while alternately switching the CH 1 polarity switch between +UP and INV.

- e. Set the CH 1 polarity switch to +UP.
- f. Position the trace to the center horizontal graticule line.
- g. Set the CH 1 VOLTS/DIV switch to 5 mV.
- h. CHECK—Trace shift; not more than 0.5 division.
- i. ADJUST—DC Bal adjustment R217 for minimum trace shift while alternately switching the CH 1 VOLTS/DIV switch between 5 mV and 10 mV.

4. Adjust CH 2 DC Balance

- a. Set the DISPLAY MODE switch to CH 2.
- b. Position the trace to the center horizontal graticule line.
- c. Set the CH 2 polarity switch to INV.

- d. CHECK—Trace shift; not more than 0.5 division.
- e. ADJUST—DC Bal adjustment R141 for minimum trace shift while alternately switching the CH 2 polarity switch between +UP and INV.
- f. Set the CH 2 polarity switch to +UP.
- g. Position the trace to the center horizontal graticule line.
- h. Set the CH 2 VOLTS/DIV switch to 5 mV.
- i. CHECK—Trace shift; not more than 0.5 division.
- j. ADJUST—DC Bal adjustment R217 for minimum trace shift while alternately switching the CH 2 VOLTS/DIV switch between 5 mV and 10 mV.

5. Adjust +UP to INVERT Gain Balance

- a. Change the following control settings:

CH1 and CH 2	
VOLTS/DIV	10 mV
CH 1 and CH 2 Input coupling	AC
- b. Connect the standard amplitude calibrator to the CH 1 and CH 2 Input connectors with the 42-inch BNC cable and dual-input coupler.
- c. Set the standard amplitude calibrator for a 50-millivolts square-wave output.
- d. CHECK—While switching the polarity switch from +UP to INV, check for equal deflection in both switch positions.
- e. ADJUST—R224 for equal vertical deflection in both positions of the polarity switch.
- f. Set the polarity switch to +UP.
- g. Set the DISPLAY MODE switch to CH 1 and repeat parts b through f of this step.

6. Adjust Front-Panel GAIN

- a. Set the CH 1 and CH 2 input coupling switches to DC.
- b. CHECK—CRT display for five divisions ± 0.05 division of vertical deflection.
- c. ADJUST—Front-panel GAIN control for exactly five divisions of vertical deflection.
- d. Set the DISPLAY MODE switch to CH 2 and repeat parts b and c of this step.
- e. Disconnect all test equipment.

7. Adjust Input Capacitance and Attenuator Compensation

- a. Connect the square-wave generator to the 7A12 input connector with the five-nanosecond GR cable, 10X GR attenuator, GR to BNC male adapter, and 24 pF normalizer.
- b. Set the square-wave generator for a five-division display (50 millivolts) at one kilohertz.
- c. Set the time-base unit for a triggered display at a one-millisecond/division sweep rate.
- d. CHECK—CRT display for square wave with good flat top (minimum tilt).
- e. ADJUST—C23 for best flat top on square-wave display.
- f. ADJUST—Using Table 5-2 as a guide, adjust attenuator compensation for best front corner and flat top. Maintain a five division display for all positions of the VOLTS/DIV switch.
- g. Set the DISPLAY MODE switch to CH 1, connect square wave generator to CH 1, and repeat parts a through f of this step.
- h. Disconnect all test equipment.

TABLE 5-2
Attenuator Compensation

VOLTS/DIV Switch Setting	Adjust for Optimum	
	Square Corner	Flat Top
20 mV	C19B	C19A
50 mV	C16B	C16A
0.1 V	C13B	C13A
0.2 V	Check	Check
0.5 V	Check	Check
1 V	C10B	C10A
2 V	Check	Check
5 V	Check	Check

8. Adjust High-Frequency Response

- a. Set both VOLTS/DIV switches to 10 mV.

- b. Connect the fast-rise + output of the square-wave generator to the CH 1 Input connector with the five-nanosecond GR cable, 5X GR attenuator, and in-line 50-ohm GR termination.

- c. Set the generator for fast-rise operation at 100 kilohertz. Set the output amplitude for a five-division display.

- d. Set the time-base unit for a triggered display at a sweep rate of 0.02 microsecond/division.

- e. CHECK—CRT display for optimum square-wave response with aberrations not to exceed 0.25 division.

- f. ADJUST—High-frequency compensation in the order given in Table 5-3, for minimum risetime with aberrations not to exceed 0.25 division. Repeat these adjustments until optimum response is obtained. It may be necessary to compromise between minimum risetime and minimum aberrations.

TABLE 5-3
10 mV High-Frequency Compensation

Adjustment	Most Noticeable Effect
R28	Ringing
C28	Front corner and level
C205	First 3 to 5 nanoseconds; spike on front corner
R208	Level
C208	Front corner

- g. Set the VOLTS/DIV switch to 5 mV.

- h. Set the square-wave generator for a five-division display.

- i. CHECK—CRT display for optimum square-wave response with aberrations not to exceed 0.25 division.

- j. ADJUST—High-frequency compensation in the order given in Table 5-4, for minimum risetime with aberrations not to exceed 0.25 division. Repeat these adjustments until optimum response is obtained.

TABLE 5-4
5 mV High-Frequency Compensation

Adjustment	Most Noticeable Effect
C215	First 3 to five nanoseconds; spike on front corner
R218	Level
C218	Front corner

- k. Set the DISPLAY MODE switches to CH 2, connect square-wave generator to CH 2 Input connector and repeat parts c through j of this step.

This completes the Calibration of the 7A12. Disconnect all test equipment. Replace the side shields on the 7A12.

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.

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SECTION 6

ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
CHASSIS						
Capacitors						
Tolerance $\pm 20\%$ unless otherwise indicated.						
C1(2)	281-0611-00			2.7 pF	Cer	200 V
C3(2)	283-0111-00			0.1 μ F	Cer	50 V
Connectors						
J1	131-0679-00			Receptacle, electrical, BNC		
J2	131-0679-00			Receptacle, electrical, BNC		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R1(2)	317-0560-00			56 Ω	$\frac{1}{8}$ W	5%
R56	*311-0958-01			10 k Ω , Var		
R156	*311-0958-01			10 k Ω , Var		
R232 ¹	*311-0988-01			250 Ω , Var		
R238	311-1064-00			500 Ω , Var		
R239	317-0680-00	B010100	B079999X	68 Ω	$\frac{1}{8}$ W	5%
R241 ²	*311-0988-02			250 Ω , Var		
R332 ³	*311-0988-01			250 Ω , Var		
R338	311-1064-00			500 Ω , Var		
R339	317-0680-00	B010100	B079999X	68 Ω	$\frac{1}{8}$ W	5%
R341 ⁴	*311-0988-02			250 Ω , Var		
Switches						
Wired or Unwired						
S5 ⁵						
S6 ⁶						
S11 ⁷						
S12 ⁸						

¹Furnished as a unit with S11.

²Furnished as a unit with S5.

³Furnished as a unit with S12.

⁴Furnished as a unit with S6.

⁵Furnished as a unit with R241.

⁶Furnished as a unit with R341.

⁷Furnished as a unit with R232.

⁸Furnished as a unit with R332.

ATTENUATOR (CHANNEL 2) Circuit Board Assembly

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-1059-00	B010100	B019999	Complete Board
	*670-1059-01	B020000	B069999	Complete Board
	*670-1059-03	B070000	B089999	Complete Board
	*670-1059-04	B090000	B099999	Complete Board
	*670-1059-05	B100000		Complete Board

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C2	285-0841-00			0.185 μ F	Plastic	500 V	
C5	283-0204-00			0.01 μ F	Cer	50 V	
C8	283-0156-00			1000 pF	Cer	200 V	+100%—0%
C10A	281-0152-00			0.8-10 pF, Var	Air		
C10B } C10C }	281-0085-00			200 pF/0.2-1.5 pF	Mica		10%
C10D	281-0537-00			0.68 pF	Cer	500 V	
C10E	281-0544-00			5.6 pF	Cer	500 V	10%
C12	283-0000-00			0.001 μ F	Cer	500 V	
C13A	281-0152-00			0.8-10 pF, Var	Air		
C13B } C13C }	281-0083-00			50 pF/0.2-1.5 pF	Mica		10%
C13D	281-0544-00			5.6 pF	Cer	500 V	10%
C14	283-0156-00			1000 pF	Cer	200 V	+100%—0%
C15	283-0000-00			0.001 μ F	Cer	500 V	
C16A	281-0152-00			0.8-10 pF, Var	Air		
C16B	281-0152-00			0.8-10 pF, Var	Air		
C16C	283-0159-00			18 pF	Cer	50 V	5%
C17	283-0111-00			0.1 μ F	Cer	50 V	
C18	283-0156-00			1000 pF	Cer	200 V	+100%—0%
C19A	281-0152-00			0.8-10 pF, Var	Air		
C19B	281-0152-00			0.8-10 pF, Var	Air		
C19C	283-0159-00			18 pF	Cer	50 V	5%
C20	283-0111-00			0.1 μ F	Cer	50 V	
C22	281-0591-00			5600 pF	Cer	200 V	
C23	281-0064-00			0.25-1.5 pF, Var	Plastic		
C24	281-0538-00	B010100	B019999	1 pF	Cer	500 V	
C24	281-0537-00	B020000		0.68 pF	Cer	500 V	
C25	283-0204-00			0.01 μ F	Cer	50 V	
C27	283-0159-00	B010100	B019999X	18 pF	Cer	50 V	5%
C28	281-0123-00			5-25 pF, Var	Cer		
C32	283-0156-00	B010100	B010199	1000 pF	Cer	200 V	+100%—0%
C32	283-0204-00	B010200	B049999	0.01 μ F	Cer	50 V	
C32	283-0178-00	B050000		0.1 μ F	Cer	100 V	+80%—20%
C36	283-0065-00			0.001 μ F	Cer	100 V	5%
C38	283-0065-00			0.001 μ F	Cer	100 V	5%
C39	283-0156-00	B010100	B010199	1000 pF	Cer	200 V	+100%—0%
C39	283-0204-00	B010200	B049999	0.01 μ F	Cer	50 V	
C39	283-0178-00	B050000		0.1 μ F	Cer	100 V	+80%—20%

ATTENUATOR (CHANNEL 2) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Semiconductor Device, Diodes				
CR7	*152-0185-00			Silicon Replaceable by 1N4152
CR12	*152-0185-00			Silicon Replaceable by 1N4152
CR15	*152-0185-00			Silicon Replaceable by 1N4152
CR18	*152-0185-00			Silicon Replaceable by 1N4152
CR23	*152-0321-00			Silicon Dual, Tek Spec
CR24	*152-0321-00			Silicon Dual, Tek Spec
CR25	*152-0185-00	XB070000		Silicon Replaceable by 1N4152
CR33	*152-0185-00			Silicon Replaceable by 1N4152
CR34	*152-0185-00			Silicon Replaceable by 1N4152
CR35	*152-0185-00	XB070000		Silicon Replaceable by 1N4152
CR79	*152-0185-00			Silicon Replaceable by 1N4152
Relays				
K5	*148-0063-00			Polarized, 200 mW, dpdt, 5 pin
K7	*148-0034-01	B010100	B019999	Armature, dpdt, 15 V DC
K7	*148-0034-02	B020000		Armature, dpdt, 15 V, DC
K12	*148-0034-01			Armature, dpdt, 15 V DC
K15	*148-0034-01			Armature, dpdt, 15 V DC
K18	*148-0034-01			Armature, dpdt, 15 V DC
Inductors				
L5	276-0543-00			Core, ferrite
LR16E	*108-0270-00			0.25 μ H (wound on a 62 Ω resistor)
LR19D	*108-0257-00			0.1 μ H (wound on a 27 Ω resistor)
Transistors				
Q25A,B	151-1031-00			FET N channel, dual TO-18
Q27A,B	151-0267-00			Silicon NPN TO-77 Dual, Tek Spec
Q29	*151-0190-01			Silicon NPN TO-106 Tek Spec
Q30	*151-0190-01			Silicon NPN TO-106 Tek Spec
Q32	151-0188-00			Silicon PNP TO-92 2N3906
Q35	*151-0190-01			Silicon NPN TO-106 Tek Spec
Q60	*151-0190-01			Silicon NPN TO-106 Tek Spec
Q70	*151-0190-01			Silicon NPN TO-106 Tek Spec
Resistors				
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.				
R3	317-0105-00			1 M Ω $\frac{1}{8}$ W 5%
R10A	317-0560-00	B010100	B019999	56 Ω $\frac{1}{8}$ W 5%
R10A	317-0220-00	B020000		82 Ω $\frac{1}{8}$ W 5%
R10B	322-0624-01			990 k Ω $\frac{1}{8}$ W Prec $\frac{1}{2}\%$
R10C	321-1289-01			10.1 k Ω $\frac{1}{8}$ W Prec $\frac{1}{2}\%$
R10D	317-0620-00	B010100	B019999	62 Ω $\frac{1}{8}$ W 5%
R10D	317-0820-00	B020000		82 Ω $\frac{1}{8}$ W 5%
R10E	317-0680-00	XB020000		68 Ω $\frac{1}{8}$ W 5%
R13	Selected	XB020000		
R13B	322-0621-01			900 k Ω $\frac{1}{4}$ W Prec $\frac{1}{2}\%$

ATTENUATOR (CHANNEL 2) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R13C	321-1389-01			111 kΩ	1/8 W	Prec 1/2%
R13D	317-0360-00			36 Ω	1/8 W	5%
R13E	317-0151-00			150 Ω	1/8 W	5%
R16A	317-0150-00			15 Ω	1/8 W	5%
R16B	322-0620-01			800 kΩ	1/4 W	Prec 1/2%
R16C	321-0618-01			250 kΩ	1/8 W	Prec 1/2%
R16D	316-0276-00			27 MΩ	1/4 W	
R19A	317-0270-00			27 Ω	1/8 W	5%
R19B	322-0610-01			500 kΩ	1/4 W	Prec 1/2%
R19C	321-0481-01			1 MΩ	1/8 W	Prec 1/2%
R21	321-0481-01			1 MΩ	1/8 W	Prec 1/2%
R22	317-0564-00			560 kΩ	1/8 W	5%
R23	317-0681-00			680 Ω	1/8 W	5%
R25	321-0189-00			909 Ω	1/8 W	Prec 1%
R27	321-0182-00			768 Ω	1/8 W	Prec 1%
R28	311-0622-00			100 Ω, Var		
R29	321-0167-00			536 Ω	1/8 W	Prec 1%
R30	321-0340-00			34 kΩ	1/8 W	Prec 1%
R32	321-0273-00			6.81 kΩ	1/8 W	Prec 1%
R33	321-0222-00	B010100	B039999	2 kΩ	1/8 W	Prec 1%
R33	321-0210-00	B040000	B089999	1.5 kΩ	1/8 W	Prec 1%
R33	321-0193-00	B090000	B099999	1 kΩ	1/8 W	Prec 1%
R33	321-0222-00	B100000		2 kΩ	1/8 W	Prec 1%
R35	321-0189-00			909 Ω	1/8 W	Prec 1%
R36	321-0174-00			634 Ω	1/8 W	Prec 1%
R38	321-0163-00			487 Ω	1/8 W	Prec 1%
R60	317-0123-00			12 kΩ	1/8 W	5%
R70	317-0123-00			12 kΩ	1/8 W	5%

ATTENUATOR (CHANNEL 1) Circuit Board Assembly

*670-1060-00	B010100	B019999	Complete Board
*670-1060-01	B020000	B069999	Complete Board
*670-1060-03	B070000	B089999	Complete Board
*670-1060-04	B090000	B099999	Complete Board
670-1060-05	B100000		Complete Board

Capacitors

Tolerance ±20% unless otherwise indicated.

C2	285-0841-00	0.0185 μF	Plastic	500 V	10%
C4	283-0156-00	1000 pF	Cer	200 V	+100%—0%
C5	283-0204-00	0.01 μF	Cer	50 V	
C8	283-0156-00	1000 pF	Cer	200 V	+100%—0%
C10A	281-0152-00	0.8-10 pF, Var	Air		
C10B } C10C }	281-0085-00	200 pF/0.2-1.5 pF	Mica		10%
C10D	281-0537-00	0.68 pF	Cer	500 V	
C10E	281-0544-00	5.6 pF	Cer	500 V	10%
C12	283-0000-00	0.001 μF	Cer	500 V	

ATTENUATOR (CHANNEL 1) Circuit Board Assembly (cont)

Kct. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Capacitors (cont)				
C13A	281-0152-00			0.8-10 pF, Var Air
C13B } C13C } C13D }	281-0083-00			50 pF/0.2-1.5 pF Mica 10%
C14	281-0544-00			5.6 pF Cer 500 V 10%
	283-0156-00			1000 pF Cer 200 V +100%—0%
C15	283-0000-00			0.001 μ F Cer
C16A	281-0152-00			0.8-10 pF, Var Air
C16B	281-0152-00			0.8-10 pF, Var Air 50 V 5%
C16C	283-0159-00			18 pF Cer 50 V
C17	283-0111-00			0.1 μ F Cer 500 V
C18	283-0156-00			1000 pF Cer 200 V +100%—0%
C19A	281-0152-00			0.8-10 pF, Var Air
C19B	281-0152-00			0.8-10 pF, Var Air
C19C	283-0069-00			15 pF Cer 50 V
C20	283-0111-00			0.1 μ F Cer 50 V
C22	281-0591-00			5600 pF Cer 200 V
C23	281-0064-00			0.25-1.5 pF, Var Plastic
C24	281-0538-00	B010100	B019999	1 pF Cer 500 V
C24	281-0537-00	B020000		0.68 pF Cer 500 V
C25	283-0204-00			0.01 μ F Cer 50 V
C27	283-0159-00	B010100	B019999X	18 pF Cer 50 V 5%
C28	281-0123-00			5-25 pFn Var Cer 100 V
C32	283-0156-00	B010100	B010199	1000 pF Cer 200 V +100%—0%
C32	283-0204-00	B010200	B049999	0.01 μ F Cer 50 V
C32	283-0178-00	B050000		0.1 μ F Cer 100 V +80%—20%
C36	283-0065-00			0.001 μ F Cer 100 V 5%
C38	283-0065-00			0.001 μ F Cer 100 V 5%
C39	283-0156-00	B010100	B010199	1000 pF Cer 200 V +100%—0%
C39	283-0204-00	B010200	B049999	0.01 μ F Cer 50 V
C39	283-0178-00	B050000		0.1 μ F Cer 100 V +80%—20%
Semiconductor Device, Diodes				
CR7	*152-0185-00			Silicon Replaceable by 1N4152
CR12	*152-0185-00			Silicon Replaceable by 1N4152
CR15	*152-0185-00			Silicon Replaceable by 1N4152
CR18	*152-0185-00			Silicon Replaceable by 1N4152
CR23	*152-0321-00			Silicon Dual, Tek Spec
CR24	*152-0321-00			Silicon Dual, Tek Spec
CR25	*152-0185-00	XB070000		Silicon Replaceable by 1N4152
CR33	*152-0185-00			Silicon Replaceable by 1N4152
CR34	*152-0185-00			Silicon Replaceable by 1N4152
CR35	*152-0185-00	XB070000		Silicon Replaceable by 1N4152
CR79	*152-0185-00			Silicon Replaceable by 1N4152
Relays				
K5	*148-0063-00			Polarized, 200 mW, dpdt, 5 pin
K7	*148-0034-01	B010100	B019999	Armature, dpdt, 15 V DC
K7	*148-0034-02	B020000		Armature, dpdt, 15 V, DC
K12	*148-0034-01			Armature, dpdt, 15 V DC
K15	*148-0034-01			Armature, dpdt, 15 V DC
K18	*148-0034-01			Armature, dpdt, 15 V DC

ATTENUATOR (CHANNEL 1) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Inductors						
L5	276-0543-00			Core, ferrite		
LR16E	*108-0270-00			0.25 μ H (wound on a 62 Ω resistor)		
LR19D	*108-0257-00			0.1 μ H (wound on a 27 Ω resistor)		
Transistors						
Q25A,B	151-1031-00			FET	N channel, Dual TO-18	
Q27A,B	151-0267-00			Silicon	NPN	TO-77 Dual, Tek Spec
Q29	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q30	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q32	151-0188-00			Silicon	PNP	TO-92 2N3906
Q35	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q60	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q70	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R3	317-0105-00			1 M Ω	1/8 W	5%
R10A	317-0560-00	B010100	B019999	56 Ω	1/8 W	5%
R10A	317-0100-00	B020000		10 Ω	1/8 W	5%
R10B	322-0624-01			990 k Ω	1/4 W	Prec 1/2%
R10C	321-1289-01			10.1 k Ω	1/8 W	Prec 1/2%
R10D	317-0680-00	B010100	B019999	68 Ω	1/8 W	5%
R10D	317-0750-00	B020000		75 Ω	1/8 W	5%
R10E	317-0820-00	XB020000		82 Ω	1/8 W	5%
R13	Selected	XB020000				
R13B	322-0621-01			900 k Ω	1/4 W	Prec 1/2%
R13C	321-1389-01			111 k Ω	1/8 W	Prec 1/2%
R13D	317-0360-00			36 Ω	1/8 W	5%
R13E	317-0151-00			150 Ω	1/8 W	5%
R16A	317-0270-00			27 Ω	1/8 W	5%
R16B	322-0620-01			800 k Ω	1/4 W	Prec 1/2%
R16C	321-0618-01			250 Ω	1/8 W	Prec 1/2%
R16D	316-0276-00			27 M Ω	1/4 W	
R19A	317-0390-00			39 Ω	1/8 W	5%
R19B	322-0610-01			500 k Ω	1/4 W	Prec 1/2%
R19C	321-0481-01			1 M Ω	1/8 W	Prec 1/2%
R21	321-0481-01			1M Ω	1/8 W	Prec 1/2%
R22	317-0554-00			560 k Ω	1/8 W	5%
R23	317-0681-00			680 Ω	1/8 W	5%
R25	321-0189-00			909 Ω	1/8 W	Prec 1%
R27	321-0182-00			768 Ω	1/8 W	Prec 1%
R28	311-0622-00			100 Ω , Var		
R29	321-0167-00			536 Ω	1/8 W	Prec 1%
R30	321-0340-00			34 k Ω	1/8 W	Prec 1%
R32	321-0273-00			6.81 k Ω	1/8 W	Prec 1%
R33	321-0222-00	B010100	B039999	2 k Ω	1/8 W	Prec 1%
R33	321-0210-00	B040000	B089999	1.5 k Ω	1/8 W	Prec 1%

ATTENUATOR (CHANNEL 1) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Resistors (cont)							
R33	321-0193-00	B090000	B099999	1 k Ω	1/8 W	Prec	1%
R33	321-0222-00	B100000		2 k Ω	1/8 W	Prec	1%
R35	321-0189-00			909 Ω	1/8 W	Prec	1%
R36	321-0174-00			634 Ω	1/8 W	Prec	1%
R38	321-0163-00			487 Ω	1/8 W	Prec	1%
R60	317-0123-00			12 k Ω	1/8 W		5%
R70	317-0123-00			12 k Ω	1/8 W		5%

INVERT SWITCH Circuit Board Assembly (2)

*670-1076-00	B010100	B059999	Complete Board
*670-1076-01	B060000		Complete Board

Bulbs

DS235	*150-0093-01	B010100	B059999	Incandescent T 3/4, selected
DS235	*150-0048-01	B060000		Incandescent #683, selected
DS335	*150-0093-01	B010100	B059999	Incandescent T 3/4, selected
DS335	*150-0048-01	B060000		Incandescent #683, selected

Switches

Wired or Unwired

S7 ^o	*670-1076-00	B010100	B059999	Pushbutton	INVERT
S7 ^o	*670-1076-01	B060000		Pushbutton	INVERT
S8 ^o	*670-1076-00	B010100	B059999	Pushbutton	INVERT
S8 ^o	*670-1076-01	B060000		Pushbutton	INVERT

VOLTS/DIV SWITCH (CHANNEL 1) Circuit Board Assembly

*670-1077-00	B010100	B059999	Complete Board
*670-1077-01	B060000		Complete Board

Bulbs

DS80	*150-0098-01	B010100	B059999	Incandescent T 3/4, selected
DS80	*150-0048-01	B060000		Incandescent #683, selected
DS81	*150-0098-01	B010100	B059999	Incandescent T 3/4, selected
DS81	*150-0048-01	B060000		Incandescent #683, selected

Semiconductor Device, Diodes

CR60	*152-0185-00		Silicon	Replaceable by 1N4152
CR61	*152-0185-00		Silicon	Replaceable by 1N4152
CR62	*152-0185-00		Silicon	Replaceable by 1N4152
CR63	*152-0185-00		Silicon	Replaceable by 1N4152
CR64	*152-0185-00		Silicon	Replaceable by 1N4152

*See Mechanical Parts List for replacement parts.

VOLTS/DIV SWITCH (CHANNEL 1) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
Semiconductor Device, Diodes (cont)				
CR65	*152-0185-00			Silicon Replaceable by 1N4152
CR66	*152-0185-00			Silicon Replaceable by 1N4152
CR67	*152-0185-00			Silicon Replaceable by 1N4152
CR68	*152-0185-00			Silicon Replaceable by 1N4152
CR69	*152-0185-00			Silicon Replaceable by 1N4152
CR70	*152-0185-00			Silicon Replaceable by 1N4152
CR71	*152-0185-00			Silicon Replaceable by 1N4152
CR72	*152-0185-00			Silicon Replaceable by 1N4152
CR73	*152-0185-00			Silicon Replaceable by 1N4152
CR74	*152-0185-00			Silicon Replaceable by 1N4152
CR75	*152-0185-00			Silicon Replaceable by 1N4152
CR76	*152-0185-00			Silicon Replaceable by 1N4152
CR77	*152-0185-00			Silicon Replaceable by 1N4152
CR78	*152-0185-00			Silicon Replaceable by 1N4152

Resistors

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

R61	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R61	315-0154-00	B110000		150 k Ω	1/4 W	5%
R63	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R63	315-0154-00	B110000		150 k Ω	1/4 W	5%
R64	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R64	315-0154-00	B110000		150 k Ω	1/4 W	5%
R66	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R66	315-0154-00	B110000		150 k Ω	1/4 W	5%
R67	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R67	315-0154-00	B110000		150 k Ω	1/4 W	5%
R69	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R69	315-0154-00	B110000		150 k Ω	1/4 W	5%
R71	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R71	315-0154-00	B110000		150 k Ω	1/4 W	5%
R73	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R73	315-0154-00	B110000		150 k Ω	1/4 W	5%
R75	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R75	315-0154-00	B110000		150 k Ω	1/4 W	5%
R77	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R77	315-0154-00	B110000		150 k Ω	1/4 W	5%
R78	321-0344-00			37.4 k Ω	1/8 W	1% Prec

Switch

Wired or Unwired

S3 ¹⁰	*670-1077-00	B010100	B059999	Pushbutton	VOLTS/DIV
S3 ¹⁰	*670-1077-01	B060000		Pushbutton	VOLTS/DIV

TRIGGER SELECTION SWITCH Circuit Board Assembly

*670-1078-00	B010100	B059999	Complete Board
*670-1078-01	B060000		Complete Board

Bulb

DS15	*150-0093-01	B010100	B059999	Incandescent T 3/4, selected
DS15	*150-0048-01	B060000		Incandescent #683, selected

VOLTS/DIV SWITCH (CHANNEL 1) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description	
Switch					
Wired or Unwired					
S2 ¹¹	*670-1078-00	B010100	B059999	Pushbutton	TRIGGER SOURCE
S2 ¹¹	*670-1078-01	B060000		Pushbutton	TRIGGER SOURCE

OFFSET SWITCH Circuit Board Assembly (2)

*670-1079-00	B010100	B059999	Complete Board
*670-1079-01	B060000		Complete Board

Bulbs

DS9	*150-0093-01	B010100	B059999	Incandescent T 3/4, selected
DS9	*150-0048-01	B060000		Incandescent #683, selected
DS10	*150-0093-01	B010100	B059999	Incandescent T 3/4, selected
DS10	*150-0048-01	B060000		Incandescent #683, selected

Switches

Wired or Unwired					
S9 ¹¹	*670-1079-00	B010100	B059999	Pushbutton	OFFSET
S9 ¹¹	*670-1079-01	B060000		Pushbutton	OFFSET
S10 ¹¹	*670-1079-00	B010100	B059999	Pushbutton	OFFSET
S10 ¹¹	*670-1079-01	B060000		Pushbutton	OFFSET

DISPLAY MODE SWITCH Circuit Board Assembly

*670-1080-00	B010100	B059999	Complete Board
*670-1080-01	B060000		Complete Board

Bulb

DS410	*150-0098-01	B010100	B059999	Incandescent T 3/4, selected
DS410	*150-0048-01	B060000		Incandescent #683, selected

Resistors

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

R400	317-0223-00	B010100	B109999	22 k Ω	1/8 W	5%
R400	315-0223-00	B110000		22 k Ω	1/4 W	5%
R405	317-0223-00	B010100	B109999	22 k Ω	1/8 W	5%
R405	315-0223-00	B110000		22 k Ω	1/4 W	5%
R406	317-0241-00	B010100	B109999	240 Ω	1/8 W	5%
R406	315-0241-00	B110000		240 Ω	1/4 W	5%
R408	317-0752-00	B010100	B109999	7.5 k Ω	1/8 W	5%
R408	315-0752-00	B110000		7.5 k Ω	1/4 W	5%
R410	317-0621-00	B010100	B109999	620 Ω	1/8 W	5%
R410	315-0621-00	B110000		620 Ω	1/4 W	5%
R412	317-0103-00	B010100	B109999	10 k Ω	1/8 W	5%
R412	315-0103-00	B110000		10 k Ω	1/4 W	5%
R414	317-0392-00	B010100	B109999	3.9 k Ω	1/8 W	5%
R414	315-0392-00	B110000		3.9 k Ω	1/4 W	5%

Switch

Wired or Unwired					
S1 ¹¹	*670-1080-00	B010100	B059999	Pushbutton	DISPLAY MODE
S1 ¹¹	*670-1080-01	B060000		Pushbutton	DISPLAY MODE

¹¹See Mechanical Parts List for replacement parts.

AMPLIFIER Circuit Board Assembly (2)

Kct. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-1081-00	B010100	B049999	Complete Board
	*670-1081-01	B050000	B079999	Complete Board
	*670-1081-02	B080000	B089999	Complete Board
	*670-1081-03	B090000	B099999	Complete Board
	*670-1081-04	B100000		Complete Board

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C205	281-0123-00			5-25 pF, Var	Cer	100	
C208	281-0122-00			2.5-9 pF, Var	Cer	100 V	
C215	281-0123-00			5-25 pF, Var	Cer	100 V	
C216	283-0154-00			22 pF	Cer	50 V	5%
C218	281-0122-00			2.5-9 pF, Var	Cer	100 V	
C219	281-0617-00	XB100000		15 pF	Cer	200 V	
C220	283-0003-00			0.01 μ F	Cer	150 V	
C224	283-0065-00	B010100	B089999X	0.001 μ F	Cer	100 V	5%
C227	283-0065-00			0.001 μ F	Cer	100 V	5%
C253	283-0186-00			27 pF	Cer	50 V	5%
C262	283-0186-00			27 pF	Cer	50 V	5%
C282	283-0186-00			27 pF	Cer	50 V	5%
C291	283-0177-00			1 μ F	Cer	25 V	+ 80% - 20%
C292	283-0111-00			0.1 μ F	Cer	50 V	
C293	283-0191-00			0.022 μ F	Cer	50 V	
C294	283-0114-00			0.0015 μ F	Cer	200 V	5%
C295	283-0182-00			51 pF	Cer	400 V	5%
C298	283-0175-00	B010100	B049999	10 pF	Cer	200 V	5%
C298	283-0201-00	B050000		27 pF	Cer	200 V	10%
C300	283-0156-00			1000 pF	Cer	200 V	+ 100% - 0%
C301	283-0177-00			1 μ F	Cer	25 V	+ 80% - 20%
C302	283-0111-00			0.1 μ F	Cer	50 V	
C303	283-0191-00			0.022 μ F	Cer	50 V	
C304	283-0114-00			0.0015 μ F	Cer	200 V	5%
C305	283-0182-00			51 pF	Cer	400 V	5%
C308	283-0175-00	B010100	B049999	10 pF	Cer	200 V	5%
C308	283-0201-00	B050000		27 pF	Cer	200 V	10%
C309	283-0065-00			0.001 μ F	Cer	100 V	5%
C314	283-0186-00			27 pF	Cer	50 V	5%
C315	283-0065-00			0.001 μ F	Cer	100 V	5%

Semiconductor Device, Diode

CR225	152-0075-00	XB050000		Germanium	Tek Spec
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Inductors

L207	*108-0608-00			85 nH	
L208	*108-0607-00	B010100	B079999X	33 nH	
LR220	*108-0330-00			0.4 μ H (wound on a 56 Ω resistor)	

AMPLIFIER Circuit Board Assembly (2) (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Transistors						
Q205	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q215	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q224	151-1025-00	XB090000		Silicon	FET	TO-18 N channel, junction type
Q250	151-0221-00			Silicon	PNP	TO-18 2N4258
Q260	*151-0259-00	B010100	B010199	Silicon	NPN	TO-106 Selected from 2N3563
Q260	*151-0269-00	B010200	B049999	Silicon	NPN	TO-106 Selected from SE 3005
Q260	*151-0259-00	B050000		Silicon	NPN	TO-106 Selected from 2N3563
Q270	151-0221-00			Silicon	PNP	TO-18 2N4258
Q280	*151-0259-00	B010100	B010199	Silicon	NPN	TO-106 Selected from 2N3563
Q280	*151-0269-00	B010200	B049999	Silicon	NPN	TO-106 Selected from SE 3005
Q280	*151-0259-00	B050000		Silicon	NPN	TO-106 Selected from 2N3563
Q315	151-0221-00			Silicon	PNP	TO-18 2N4258
Q325	151-0221-00			Silicon	PNP	TO-18 2N4258

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

R200	321-0260-00			4.99 k Ω	$\frac{1}{8}$ W	Prec	1%
R201	321-0266-00			5.76 k Ω	$\frac{1}{8}$ W	Prec	1%
R202	321-0240-00			3.09 k Ω	$\frac{1}{8}$ W	Prec	1%
R204	321-0164-00			499 Ω	$\frac{1}{8}$ W	Prec	1%
R205	321-0103-00			115 Ω	$\frac{1}{8}$ W	Prec	1%
R206	321-0164-00			499 Ω	$\frac{1}{8}$ W	Prec	1%
R208	311-0635-00			1 k Ω , Var			
R210	321-0256-00			4.53 k Ω	$\frac{1}{8}$ W	Prec	1%
R211	321-0240-00			3.09 k Ω	$\frac{1}{8}$ W	Prec	1%
R212	321-0167-00			536 Ω	$\frac{1}{8}$ W	Prec	1%
R214	321-0164-00			499 Ω	$\frac{1}{8}$ W	Prec	1%
R215	321-0064-00	B010100	B099999	45.3 Ω	$\frac{1}{8}$ W	Prec	1%
R215	321-0064-00	B100000	B109999	45.3 Ω	(nominal value)	Selected	
R215	321-0063-00	B110000		44.2 Ω	$\frac{1}{8}$ W	Prec	1%
R216	321-0164-00			499 Ω	$\frac{1}{8}$ W	Prec	1%
R217	311-1007-00			20 Ω , Var			
R218	311-0635-00			1 k Ω , Var			
R219	317-0330-00	XB100000		33 Ω	$\frac{1}{8}$ W		5%
R221	316-0101-00			100 Ω	$\frac{1}{4}$ W		
R223	321-0431-00			301 k Ω	$\frac{1}{8}$ W	Prec	1%
R224	311-0614-00			30 k Ω , Var			
R226	321-0275-00			7.15 k Ω	$\frac{1}{8}$ W	Prec	1%
R251	323-0246-00			3.57 Ω	$\frac{1}{2}$ W	Prec	1%
R253	315-0221-00			200 Ω	$\frac{1}{4}$ W		5%
R254	321-0228-00			2.32 k Ω	$\frac{1}{8}$ W	Prec	1%
R256	321-0114-00			150 Ω	$\frac{1}{8}$ W	Prec	1%
R260	321-0097-00			100 Ω	$\frac{1}{8}$ W	Prec	1%
R262	317-0330-00	B010100	B109999	33 Ω	$\frac{1}{8}$ W		5%
R262	315-0330-00	B110000		33 Ω	$\frac{1}{4}$ W		5%
R266	321-0239-00			3.01 k Ω	$\frac{1}{8}$ W	Prec	1%
R271	323-0246-00			3.57 Ω	$\frac{1}{2}$ W	Prec	1%
R273	315-0221-00			200 Ω	$\frac{1}{4}$ W		5%

AMPLIFIER Circuit Board Assembly (2) (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description			
Resistors (cont)							
R274	321-0261-00			5.11 kΩ	1/8 W	Prec	1%
R276	321-0114-00			150 Ω	1/8 W	Prec	1%
R282	317-0330-00	B010100	B109999	33 Ω	1/8 W		5%
R282	315-0330-00	B110000		33 Ω	1/4 W		5%
R286	321-0239-00			3.01 kΩ	1/8 W	Prec	1%
R290	321-0217-00			1.78 kΩ	1/8 W	Prec	1%
R291	317-0822-00	B010100	B109999	8.2 kΩ	1/8 W		5%
R291	315-0822-00	B110000		8.2 kΩ	1/4 W		5%
R292	317-0562-00	B010100	B109999	5.6 kΩ	1/8 W		5%
R292	315-0562-00	B110000		5.6 kΩ	1/4 W		5%
R293	317-0222-00	B010100	B109999	2.2 kΩ	1/8 W		5%
R293	315-0222-00	B110000		2.2 kΩ	1/4 W		5%
R294	317-0202-00	B010100	B109999	2 kΩ	1/8 W		5%
R294	315-0202-00	B110000		2 kΩ	1/4 W		5%
R295	317-0622-00	B010100	B109999	6.2 kΩ	1/8 W		5%
R295	315-0622-00	B110000		6.2 kΩ	1/4 W		5%
R296	321-0040-00			25.5 Ω	1/8 W	Prec	1%
R297	321-0217-00			1.78 kΩ	1/8 W	Prec	1%
R298	317-0102-00	B010100	B049999	1 kΩ	1/8 W		5%
RT298	307-0126-00	B050000		100 Ω		Thermal	
R300	321-0217-00			1.78 kΩ	1/8 W	Prec	1%
R301	317-0822-00	B010100	B109999	8.2 kΩ	1/8 W		5%
R301	315-0822-00	B110000		8.2 kΩ	1/4 W		5%
R302	317-0552-00	B010100	B109999	5.6 kΩ	1/8 W		5%
R302	315-0562-00	B110000		5.6 kΩ	1/4 W		5%
R303	317-0222-00	B010100	B109999	2.2 kΩ	1/8 W		5%
R303	315-0222-00	B110000		2.2 kΩ	1/4 W		5%
R304	317-0202-00	B010100	B109999	2 kΩ	1/8 W		5%
R304	315-0202-00	B110000		2 kΩ	1/4 W		5%
R305	317-0622-00	B010100	B109999	6.2 kΩ	1/8 W		5%
R305	315-0622-00	B110000		6.2 kΩ	1/4 W		5%
R306	321-0040-00			25.5 Ω	1/8 W	Prec	1%
R307	321-0217-00			1.78 kΩ	1/8 W	Prec	1%
R308	317-0102-00	B010100	B049999	1 kΩ	1/8 W		5%
RT308	307-0126-00	B050000		100 Ω		Thermal	
R309	321-0217-00			1.78 kΩ	1/8 W	Prec	1%
R312	323-0154-00			392 Ω	1/2 W	Prec	1%
R314	315-0221-00			200 Ω	1/4 W		5%
R318	321-0222-00			2 kΩ	1/8 W	Prec	1%
R322	323-0154-00			392 Ω	1/2 W	Prec	1%
R324	315-0221-00			200 Ω	1/4 W		5%
R328	321-0222-00			2 kΩ	1/8 W	Prec	1%
Transformers							
T263	*120-0444-00			Toroid, 5 turns, bifilar			
T264	*120-0444-00			Toroid, 5 turns, bifilar			
Integrated Circuits							
U225	*155-0032-00			Pol. inv. and trig. pick-off			
U300	*155-0022-00	B010100	B113659	Monolithic			
U300	*155-0022-01	B113660		Monolithic, checked			

INTERFACE Circuit Board Assembly

Kct. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
	*670-1083-00	B010100	B079999	Complete Board
	*670-1083-01	B080000	B109999	Complete Board
	*670-1083-02	B110000		Complete Board

Capacitors

Tolerance $\pm 20\%$ unless otherwise indicated.

C30	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C60	283-0204-00	0.01 μF	Cer	50 V	
C130	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C160	283-0204-00	0.01 μF	Cer	50 V	
C239	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C339	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C454	283-0177-00	1 μF	Cer	25 V	+80%—20%
C455	283-0177-00	1 μF	Cer	25 V	+80%—20%
C520	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C522	290-0301-00	10 μF	Elect.	20 V	10%
C524	290-0301-00	10 μF	Elect.	20 V	10%
C526	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C528	290-0301-00	10 μF	Elect.	20 V	10%
C530	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C536	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C540	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C542	283-0178-00	0.1 μF	Cer	100 V	+80%—20%
C554	283-0047-00	270 pF	Cer	500 V	5%
C575	283-0047-00	270 pF	Cer	500 V	5%

Semiconductor Device, Diodes

CR230	*152-0185-00	XB110000	Silicon	Replaceable by 1N4152
CR244	*152-0185-00		Silicon	Replaceable by 1N4152
CR330	*152-0185-00	XB110000	Silicon	Replaceable by 1N4152
CR344	*152-0185-00		Silicon	Replaceable by 1N4152
VR550	152-0212-00		Zener	1N936 00 mW, 9 V, 5% TC

Inductors

L520	*108-0598-00	200 μH		
L522	*108-0598-00	200 μH		
L524	*108-0598-00	200 μH		
L526	*108-0598-00	200 μH		
L528	*108-0598-00	200 μH		
L530	*108-0598-00	200 μH		
L536	*108-0598-00	200 μH		
L540	*108-0598-00	200 μH		
LR521	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR523	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR525	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR527	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR529	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR531	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	
LR542	*108-0520-00	2.2 μH	(wound on a 22 Ω resistor)	

INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Inductors (cont)						
LR543	*108-0520-00			2.2 μ H	(wound on a 22 Ω resistor)	
LR556	*108-0520-00			2.2 μ H	(wound on a 22 Ω resistor)	
LR557	*108-0520-00			2.2 μ H	(wound on a 22 Ω resistor)	
LR577	*108-0520-00			2.2 μ H	(wound on a 22 Ω resistor)	
LR578	*108-0520-00			2.2 μ H	(wound on a 22 Ω resistor)	
Transistors						
Q245	151-0254-00			Silicon	NPN	TO-98 2N5308
Q345	151-0254-00			Silicon	NPN	TO-98 2N5308
Q430	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q450	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q555	151-0220-00			Silicon	PNP	TO-18 2N4122
Q560	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Q565	151-0260-00			Silicon	NPN	TO-39 2N5189
Q575	*151-0190-01			Silicon	NPN	TO-106 Tek Spec
Resistors						
Tolerance $\pm 20\%$ unless otherwise indicated.						
R40	321-0252-00			4.12 k Ω	$\frac{1}{8}$ W	Prec 1%
R41	311-0607-00			10 k Ω , Var		
R42	321-0097-00			100 Ω	$\frac{1}{8}$ W	Prec 1%
R47	321-0291-00			10.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R50	321-0319-00			20.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R51	321-0260-00			4.99 k Ω	$\frac{1}{8}$ W	Prec 1%
R53	321-0260-00			4.99 k Ω	$\frac{1}{8}$ W	Prec 1%
R54	321-0319-00			20.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R140	321-0252-00			4.12 k Ω	$\frac{1}{8}$ W	Prec 1%
R141	311-0607-00			10 k Ω , Var		
R142	321-0097-00			100 Ω	$\frac{1}{8}$ W	Prec 1%
R147	321-0291-00			10.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R150	321-0319-00			20.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R151	321-0260-00			4.99 k Ω	$\frac{1}{8}$ W	Prec 1%
R153	321-0260-00			4.99 k Ω	$\frac{1}{8}$ W	Prec 1%
R154	321-0319-00			20.5 k Ω	$\frac{1}{8}$ W	Prec 1%
R230	317-0133-00			13 k Ω	$\frac{1}{8}$ W	5%
R233	321-0107-00			127 Ω	$\frac{1}{8}$ W	Prec 1%
R234	321-0300-00	B010100	B029999	13 k Ω	$\frac{1}{8}$ W	Prec 1%
R234	321-0297-00	B030000	B039999	12.1 k Ω	$\frac{1}{8}$ W	Prec 1%
R234	Selected	B040000				
R235	317-0154-00	B010100	B109999	150 k Ω	$\frac{1}{8}$ W	5%
R235	315-0154-00	B110000		150 k Ω	$\frac{1}{4}$ W	5%
R237	321-0160-00			453 Ω	$\frac{1}{8}$ W	Prec 1%
R239	317-0680-00	XB080000	B109999	68 Ω	$\frac{1}{8}$ W	5%
R239	315-0680-00	B110000		68 Ω	$\frac{1}{4}$ W	5%
R240	321-0202-00			1.24 k Ω	$\frac{1}{8}$ W	Prec 1%
R242	321-0240-00			3.09 k Ω	$\frac{1}{8}$ W	Prec 1%
R243	321-0344-00			37.4 k Ω	$\frac{1}{8}$ W	Prec 1%
R244	317-0514-00	B010100	B109999	510 k Ω	$\frac{1}{8}$ W	5%
R244	315-0514-00	B110000		510 k Ω	$\frac{1}{4}$ W	5%
R245	317-0205-00	B010100	B109999	2 M Ω	$\frac{1}{8}$ W	5%
R245	315-0205-00	B110000		2 M Ω	$\frac{1}{4}$ W	5%
R246	317-0244-00	B010100	B109999	240 k Ω	$\frac{1}{8}$ W	5%
R246	315-0244-00	B110000		240 k Ω	$\frac{1}{4}$ W	5%

INTERFACE Circuit Board Assembly (cont)

Kct. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R247	321-0223-00			2.05 k Ω	1/8 W	Prec 1%
R248	321-0344-00			37.4 k Ω	1/8 W	Prec 1%
R249	321-0299-00			12.7 k Ω	1/8 W	Prec 1%
R330	317-0133-00			13 k Ω	1/8 W	5%
R333	321-0107-00			127 Ω	1/8 W	Prec 1%
R334	321-0300-00	B010100	B029999	13 k Ω	1/8 W	Prec 1%
R334	321-0297-00	B030000	B039999	12.1 k Ω	1/8 W	Prec 1%
R334	Selected	B040000				
R335	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R335	315-0154-00	B110000		150 k Ω	1/4 W	5%
R337	321-0160-00			453 Ω	1/8 W	Prec 1%
R339	317-0680-00	XB080000	B109999	68 Ω	1/8 W	5%
R339	315-0680-00	B110000		68 Ω	1/4 W	5%
R340	321-0202-00			1.24 k Ω	1/8 W	Prec 1%
R342	321-0240-00			3.09 k Ω	1/8 W	Prec 1%
R343	321-0344-00			37.4 k Ω	1/8 W	Prec 1%
R344	317-0514-00	B010100	B109999	510 k Ω	1/8 W	5%
R344	315-0514-00	B110000		510 k Ω	1/4 W	5%
R345	317-0205-00	B010100	B109999	2 M Ω	1/8 W	5%
R345	315-0205-00	B110000		2 M Ω	1/4 W	5%
R346	317-0244-00	B010100	B109999	240 k Ω	1/8 W	5%
R346	315-0244-00	B110000		240 k Ω	1/4 W	5%
R347	321-0223-00			2.05 k Ω	1/8 W	Prec 1%
R348	321-0344-00			37.4 k Ω	1/8 W	Prec 1%
R349	321-0299-00			12.7 k Ω	1/8 W	Prec 1%
R402	317-0103-00	B010100	B039999	10 k Ω	1/8 W	5%
R402	317-0123-00	B040000	B109999	12 k Ω	1/8 W	5%
R402	315-0123-00	B110000		12 k Ω	1/4 W	5%
R403	317-0103-00	B010100	B039999	10 k Ω	1/8 W	5%
R403	317-0123-00	B040000	B109999	12 k Ω	1/8 W	5%
R403	315-0123-00	B110000		12 k Ω	1/4 W	5%
R415	317-0103-00	B010100	B039999	10 k Ω	1/8 W	5%
R415	317-0123-00	B040000	B109999	12 k Ω	1/8 W	5%
R415	315-0123-00	B110000		12 k Ω	1/4 W	5%
R416	317-0103-00	B010100	B039999	10 k Ω	1/8 W	5%
R416	317-0123-00	B040000	B109999	12 k Ω	1/8 W	5%
R416	315-0123-00	B110000		12 k Ω	1/4 W	5%
R418	317-0223-00	B010100	B109999	22 k Ω	1/8 W	5%
R418	315-0223-00	B110000		22 k Ω	1/4 W	5%
R419	317-0752-00	B010100	B109999	7.5 k Ω	1/8 W	5%
R419	315-0752-00	B110000		7.5 k Ω	1/4 W	5%
R422	317-0511-00	B010100	B109999	510 Ω	1/8 W	5%
R422	315-0511-00	B110000		510 Ω	1/4 W	5%
R423	317-0331-00	B010100	B109999	330 Ω	1/8 W	5%
R423	315-0331-00	B110000		330 Ω	1/4 W	5%
R424	317-0153-00	B010100	B109999	15 k Ω	1/8 W	5%
R424	315-0153-00	B110000		15 k Ω	1/4 W	5%
R430	317-0621-00	B010100	B109999	620 Ω	1/8 W	5%
R430	315-0621-00	B110000		620 Ω	1/4 W	5%
R432	317-0103-00	B010100	B109999	10 k Ω	1/8 W	5%

INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors (cont)						
R432	315-0103-00	B110000		10 kΩ	1/4 W	5%
R442	317-0511-00	B010100	B109999	510 Ω	1/8 W	5%
R442	315-0511-00	B110000		510 Ω	1/4 W	5%
R443	317-0331-00	B010100	B109999	330 Ω	1/8 W	5%
R443	315-0331-00	B110000		330 Ω	1/4 W	5%
R444	317-0153-00	B010100	B109999	15 kΩ	1/8 W	5%
R444	315-0153-00	B110000		15 kΩ	1/4 W	5%
R450	317-0621-00	B010100	B109999	620 Ω	1/8 W	5%
R450	315-0621-00	B110000		620 Ω	1/4 W	5%
R452	317-0103-00	B010100	B109999	10 kΩ	1/8 W	5%
R452	315-0103-00	B110000		10 kΩ	1/4 W	5%
R500	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R500	315-0753-00	B110000		75 kΩ	1/4 W	5%
R501	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R501	315-0753-00	B110000		75 kΩ	1/4 W	5%
R502	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R502	315-0753-00	B110000		75 kΩ	1/4 W	5%
R503	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R503	315-0753-00	B110000		75 kΩ	1/4 W	5%
R506	317-0154-00	B010100	B109999	150 kΩ	1/8 W	5%
R506	315-0154-00	B110000		150 kΩ	1/4 W	5%
R507	317-0154-00	B010100	B109999	150 kΩ	1/8 W	5%
R507	315-0154-00	B110000		150 kΩ	1/4 W	5%
R508	317-0513-00	B010100	B109999	51 kΩ	1/8 W	5%
R508	315-0513-00	B110000		51 kΩ	1/4 W	5%
R509	317-0513-00	B010100	B109999	51 kΩ	1/8 W	5%
R509	315-0513-00	B110000		51 kΩ	1/4 W	5%
R511	321-0344-00			37.4 kΩ	1/8 W	1% Prec
R512	321-0344-00			37.4 kΩ	1/8 W	1% Prec
R513	317-0154-00	B010100	B109999	150 kΩ	1/8 W	5%
R513	315-0154-00	B110000		150 kΩ	1/4 W	5%
R514	317-0154-00	B010100	B109999	150 kΩ	1/8 W	5%
R514	315-0154-00	B110000		150 kΩ	1/4 W	5%
R515	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R515	315-0753-00	B110000		75 kΩ	1/4 W	5%
R516	317-0753-00	B010100	B109999	75 kΩ	1/8 W	5%
R516	315-0753-00	B110000		75 kΩ	1/4 W	5%
R520	317-0200-00			20 Ω	1/8 W	5%
R522	317-0200-00			20 Ω	1/8 W	5%
R524	317-0200-00			20 Ω	1/8 W	5%
R526	317-0200-00			20 Ω	1/8 W	5%
R528	317-0200-00			20 Ω	1/8 W	5%
R530	317-0200-00			20 Ω	1/8 W	5%
R532	315-0510-00			51 Ω	1/4 W	5%
R534	315-0510-00			51 Ω	1/4 W	5%
R536	317-0200-00			20 Ω	1/8 W	5%
R540	317-0200-00			20 Ω	1/8 W	5%
R550	323-0259-00			4.87 kΩ	1/2 W	1% Prec
R551	311-0609-00			2 kΩ, Var		
R552	321-0285-00			9.09 kΩ	1/8 W	1% Prec

INTERFACE Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description		
Resistors (cont)						
R554	321-0289-00		10 k Ω	1/8 W	Prec	1%
R555	301-0201-00		200 Ω	1/2 W		5%
R559	301-0241-00		240 Ω	1/2 W		5%
R561	321-0234-00		2.67 k Ω	1/8 W	Prec	1%
R563	321-0169-00		562 Ω	1/8 W	Prec	1%
R565	321-0241-00		3.16 k Ω	1/8 W	Prec	1%
R570	311-0635-00		1 k Ω , Var			
R571	321-0287-00		9.53 k Ω	1/8 W	Prec	1%
R573	301-0241-00		240 Ω	1/2 W		5%
R575	321-0289-00		10 k Ω	1/8 W	Prec	1%
R576	301-0221-00		220 Ω	1/2 W		5%

Integrated Circuits

U420	156-0021-00		Hex. inv.	Replaceable by MOT MC889P
U422	156-0020-00		Quad 2 input gate.	Replaceable by MC824P
U424	156-0020-00		Quad 2 input gate.	Replaceable by MC824P
U426	156-0020-00		Quad 2 input gate.	Replaceable by MC824P
U550	156-0067-00		Op. amp.	Replaceable by Fairchild UA741C
U570	156-0067-00		Op. amp.	Replaceable by Fairchild UA741C

VOLTS/DIV SWITCH (CHANNEL 2) Circuit Board Assembly

*670-1084-00	B010100	B059999	Complete Board
*670-1084-01	B060000		Complete Board

Bulbs

DS80	*150-0098-01	B010100	B059999	Incandescent T 3/4, selected
DS80	*150-0048-01	B060000		Incandescent #683, selected
DS81	*150-0098-01	B010100	B059999	Incandescent T 3/4, selected
DS81	*150-0048-01	B060000		Incandescent #683, selected

Semiconductor Device, Diodes

CR60	*152-0185-00		Silicon	Replaceable by 1N4152
CR61	*152-0185-00		Silicon	Replaceable by 1N4152
CR62	*152-0185-00		Silicon	Replaceable by 1N4152
CR63	*152-0185-00		Silicon	Replaceable by 1N4152
CR64	*152-0185-00		Silicon	Replaceable by 1N4152
CR65	*152-0185-00		Silicon	Replaceable by 1N4152
CR66	*152-0185-00		Silicon	Replaceable by 1N4152
CR67	*152-0185-00		Silicon	Replaceable by 1N4152
CR68	*152-0185-00		Silicon	Replaceable by 1N4152
CR69	*152-0185-00		Silicon	Replaceable by 1N4152
CR70	*152-0185-00		Silicon	Replaceable by 1N4152
CR71	*152-0185-00		Silicon	Replaceable by 1N4152
CR72	*152-0185-00		Silicon	Replaceable by 1N4152
CR73	*152-0185-00		Silicon	Replaceable by 1N4152
CR74	*152-0185-00		Silicon	Replaceable by 1N4152
CR75	*152-0185-00		Silicon	Replaceable by 1N4152
CR76	*152-0185-00		Silicon	Replaceable by 1N4152
CR77	*152-0185-00		Silicon	Replaceable by 1N4152
CR78	*152-0185-00		Silicon	Replaceable by 1N4152

VOLTS/DIV SWITCH (CHANNEL 2) Circuit Board Assembly (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description		
Resistors						
Resistors are fixed, composition, $\pm 10\%$ unless otherwise indicated.						
R61	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R61	315-0154-00	B110000		150 k Ω	1/4 W	5%
R63	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R63	315-0154-00	B110000		150 k Ω	1/4 W	5%
R64	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R64	315-0154-00	B110000		150 k Ω	1/4 W	5%
R66	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R66	315-0154-00	B110000		150 k Ω	1/4 W	5%
R67	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R67	315-0154-00	B110000		150 k Ω	1/4 W	5%
R69	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R69	315-0154-00	B110000		150 k Ω	1/4 W	5%
R71	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R71	315-0154-00	B110000		150 k Ω	1/4 W	5%
R73	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R73	315-0154-00	B110000		150 k Ω	1/4 W	5%
R75	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R75	315-0154-00	B110000		150 k Ω	1/4 W	5%
R77	317-0154-00	B010100	B109999	150 k Ω	1/8 W	5%
R77	315-0154-00	B110000		150 k Ω	1/4 W	5%
R78	321-0344-00			37.4 k Ω	1/8 W	Prec 1%

Switch

Wired or Unwired

S4 ¹²	*670-1084-00	B030000	B059999	Pushbutton	VOLTS/DIV
S4 ¹²	*670-1084-01	B060000		Pushbutton	VOLTS/DIV

¹²See Mechanical Parts List for replacement parts.

SECTION 7

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols and Reference Designators

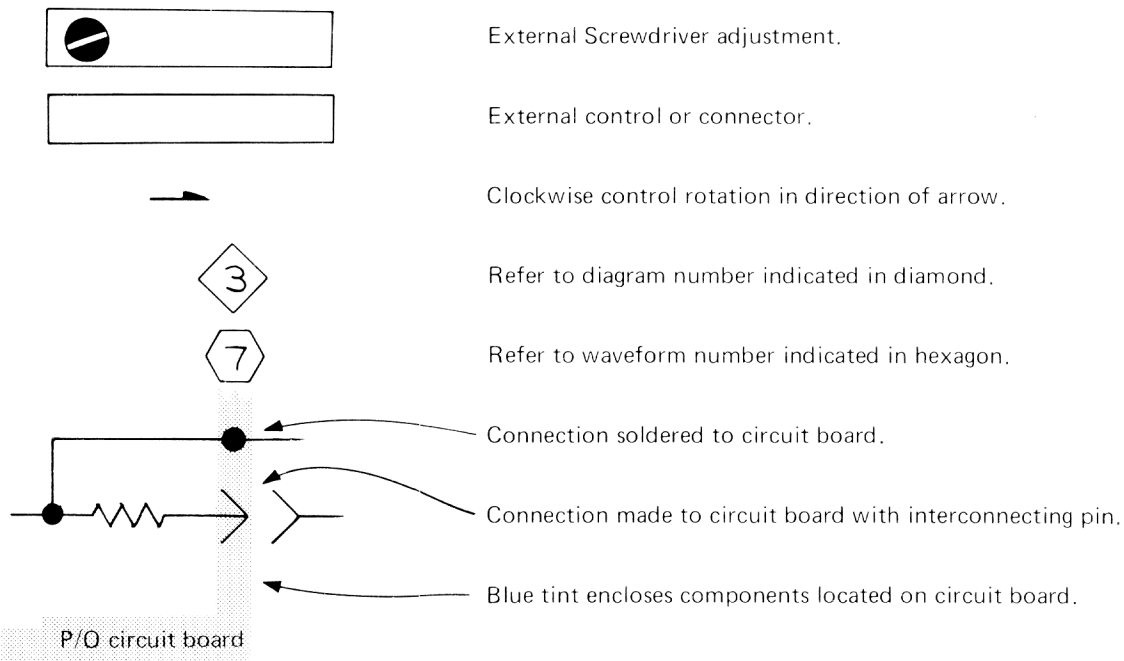
Electrical components shown on the diagrams are in the following units unless noted otherwise:

- Capacitors = Values one or greater are in picofarads (pF).
 Values less than one are in microfarads (μ F).
 Resistors = Ohms (Ω)

Symbols used on the diagrams are based on USA Standard Y32.2-1967.

Logic symbology is based on MIL-STD-806B in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The following special symbols are used on the diagrams:



The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

A	Assembly, separable or repairable (circuit board, etc.)	LR	Inductor/resistor combination
AT	Attenuator, fixed or variable	M	Meter
B	Motor	Q	Transistor or silicon-controlled rectifier
BT	Battery	P	Connector, movable portion
C	Capacitor, fixed or variable	R	Resistor, fixed or variable
CR	Diode, signal or rectifier	RT	Thermistor
DL	Delay line	S	Switch
DS	Indicating device (lamp)	T	Transformer
F	Fuse	TP	Test point
FL	Filter	U	Assembly, inseparable or non-repairable (integrated circuit, etc.)
H	Heat dissipating device (heat sink, heat radiator, etc.)	V	Electron tube
HR	Heater	VR	Voltage regulator (zener diode, etc.)
J	Connector, stationary portion	Y	Crystal
K	Relay		
L	Inductor, fixed or variable		

VOLTAGE AND WAVEFORM TEST CONDITIONS

Typical voltage measurements were obtained under the following conditions unless noted otherwise on the individual diagrams:

	Voltmeter
Type	Non-loading digital multimeter
Input impedance	0 to 1.5 volts; 1 kMΩ 15 to 1000 volts; 10 MΩ
Range	0 to 1000 volts
Recommended type (as used for voltages on diagrams)	Fairchild Model 7050

7A12 (left vertical compartment)

DISPLAY MODE	CH 1
TRIGGER SOURCE	CH 1
	CH 1 and CH 2
VOLTS/DIV	10 mV
POLARITY	+UP
COUPLING	DC
POSITION	Centered
VARIABLE	CAL IN
Signal Applied	No signal for voltage measurements, 40 mV square wave from oscilloscope Calibrator applied to CH 1 INPUT connector for waveforms.

7A16 (right vertical compartment using a 10X probe with readout coding ring. P6053 probe used for waveforms on diagrams)

Polarity	+UP
Bandwidth	Full
Position	Centered
Coupling	AC
Volts/Div	5 mV
Variable	Cal In

7B71 (A Horizontal compartment)

Level/Slope	Centered on positive slope
Triggering	
Mode	P-P Auto
Coupling	AC
Source	Ext
Magnifier	X1
Time/Div	1 ms
Variable	Cal In
B Delay Mode	Independent
Ext Trig In connector	No connection for voltage measurements. For waveforms Sig Out from oscilloscope connected to Ext Trig In connector.

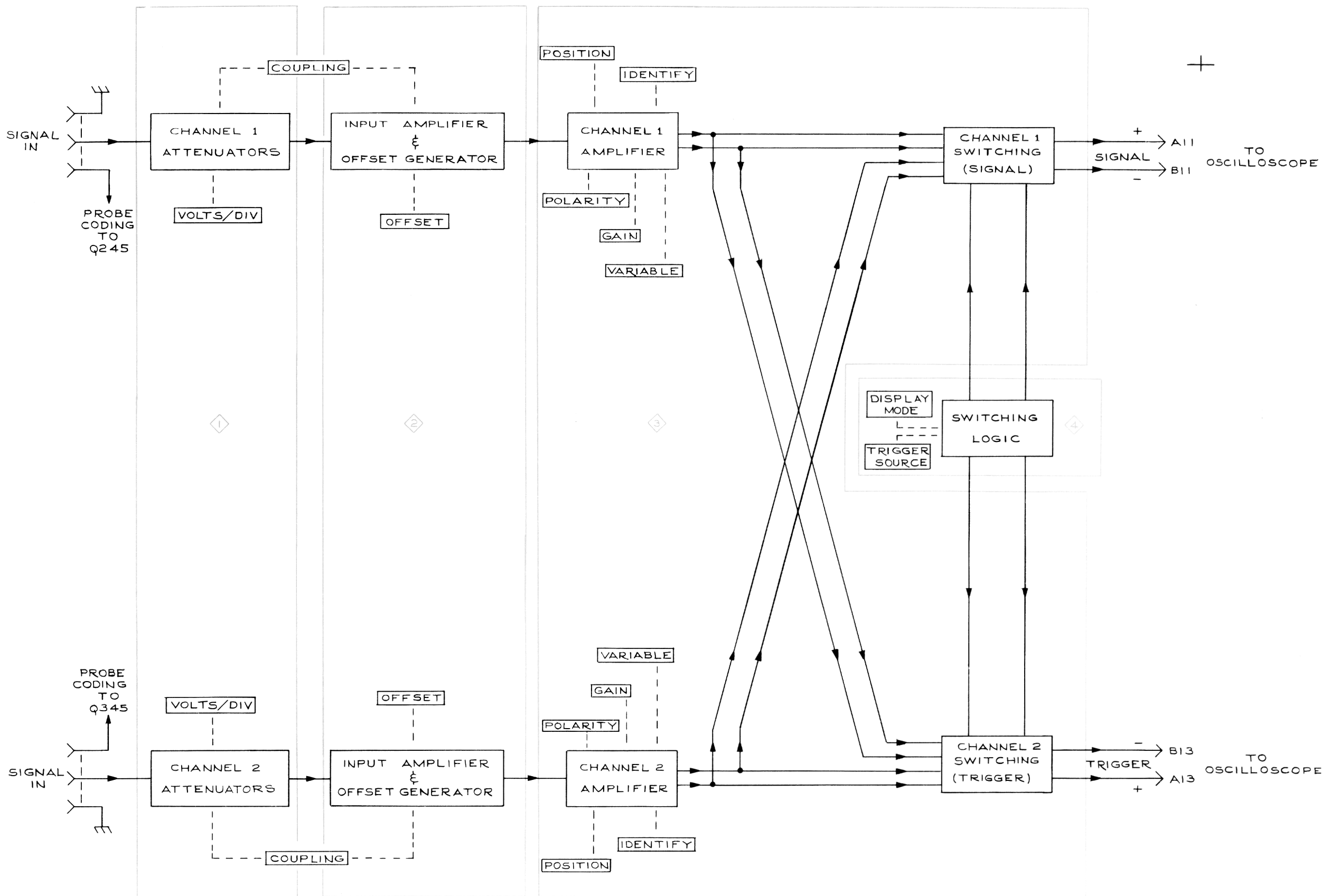
7704

Vertical Mode	Right
Horizontal Mode	A
A Intensity	Optimum
B Intensity	Counterclockwise
Calibrator	
Volts	40 mV
Rate	1 kHz
A Trigger Source	Right Vert
B Trigger Source	Left Vert

All voltages given on the diagrams are in volts. All currents are in milliamps. Waveforms shown are actual waveform photographs taken with a Tektronix Oscilloscope Camera System and Projected Graticule. Vertical deflection factor shown on waveform is the actual deflection factor from the probe tip. Voltages and waveforms on the diagrams (shown in blue) are not absolute and may vary between instruments because of component tolerances, internal calibration or front panel settings. Readouts are simulated in larger-than-normal type.

NOTE

The spring tension of the pin sockets ensures a good connection between the circuit board and pin. This spring tension may be damaged by using the pin sockets as a connecting point for spring-loaded probe tips, alligator clips, etc.



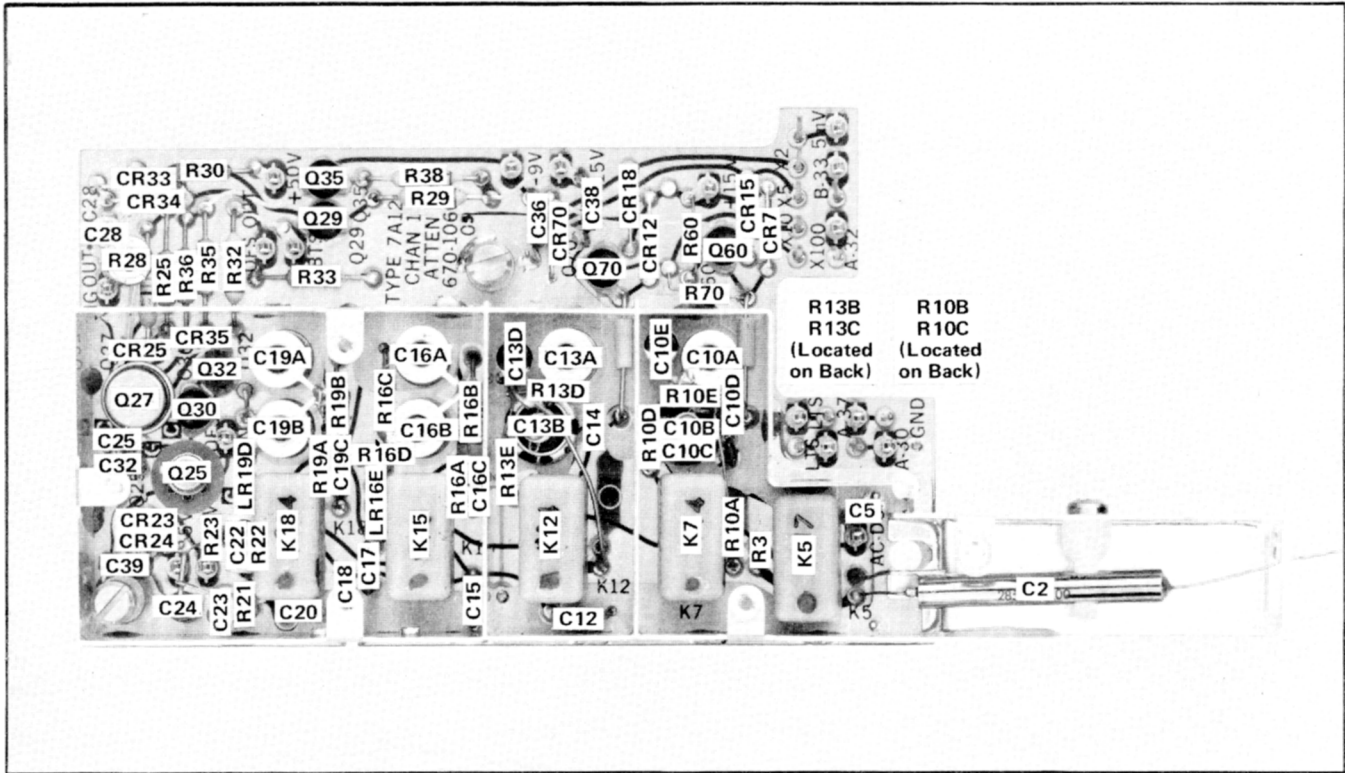


Fig. 7-1. Channel 1 Attenuator circuit board showing location of components.

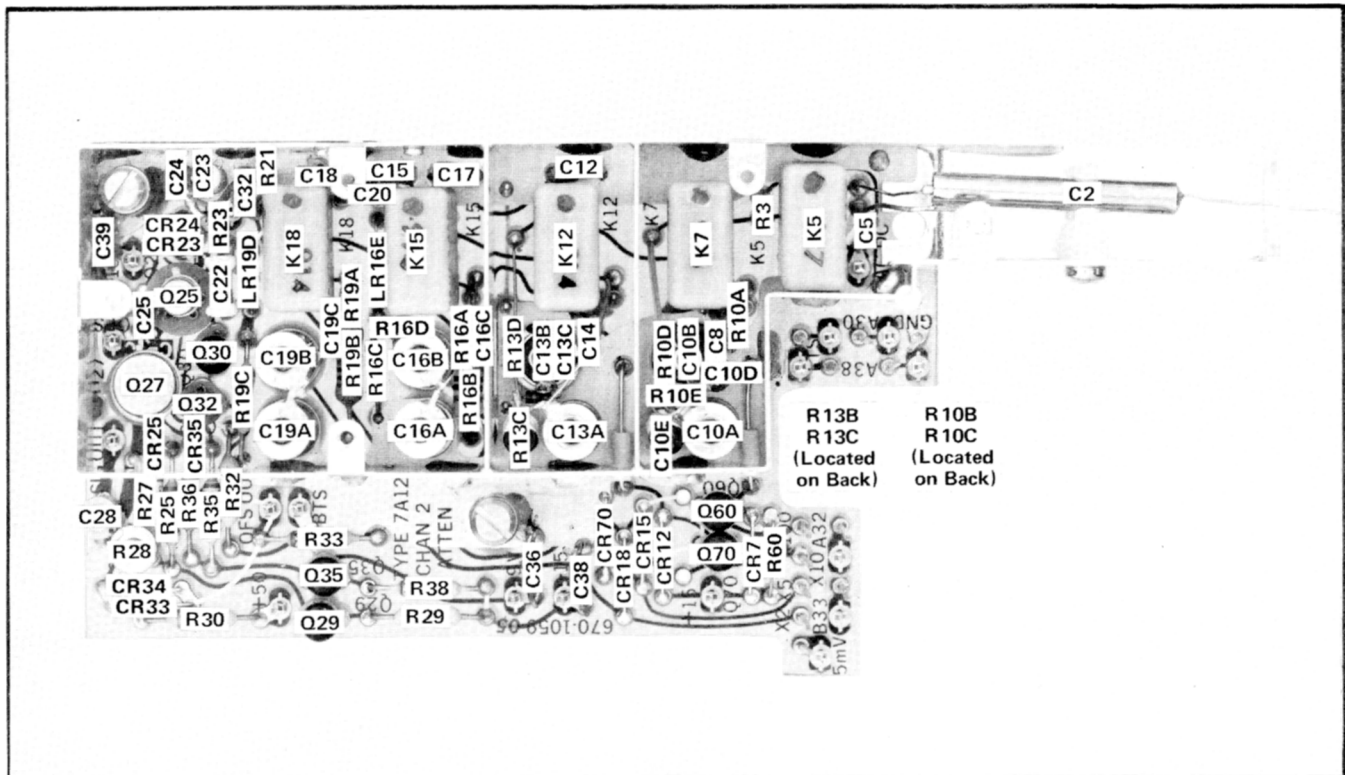


Fig. 7-2. Channel 2 Attenuator board showing location of components.

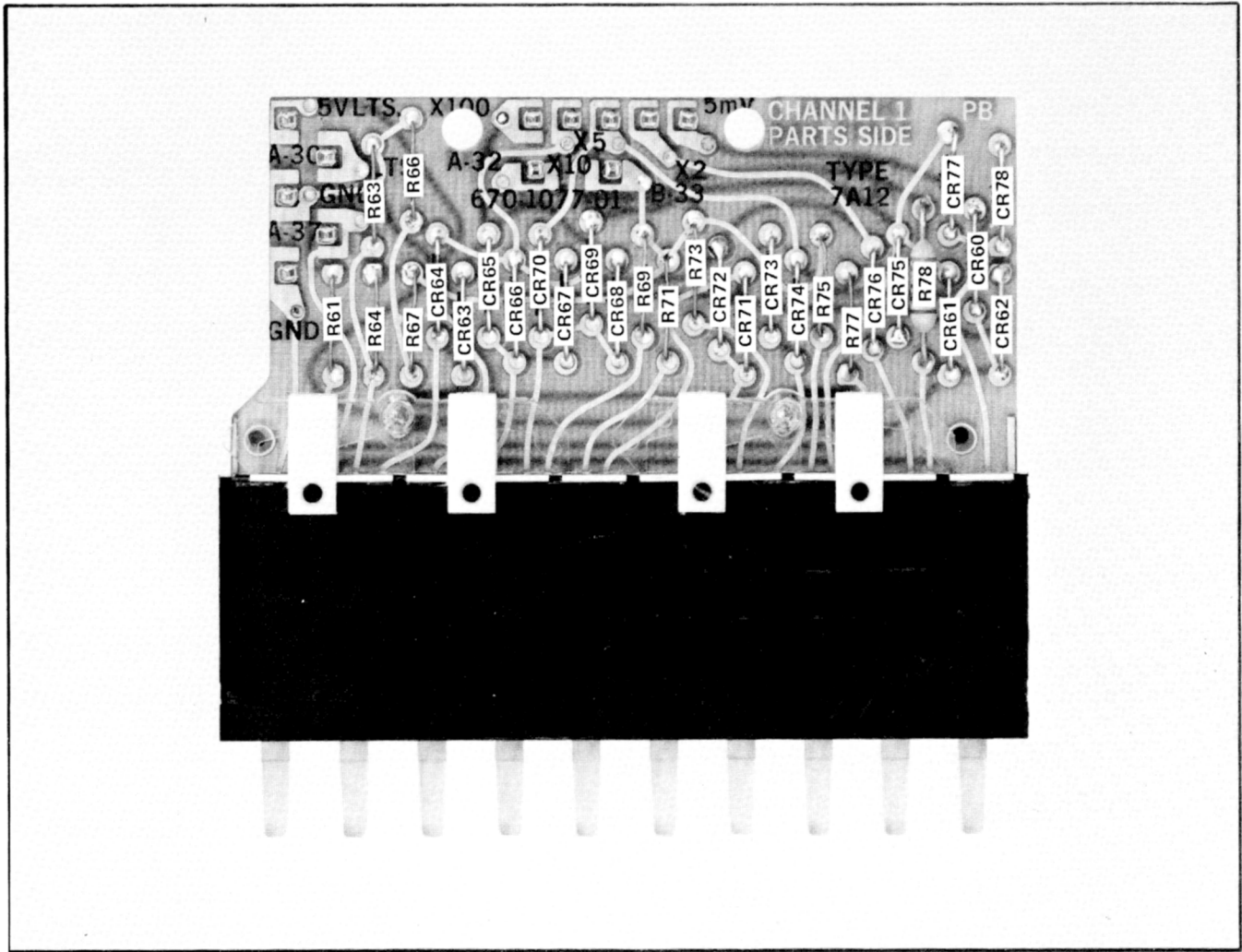


Fig. 7-3. Channel 1 Volts/Div switch and circuit board showing location of components.

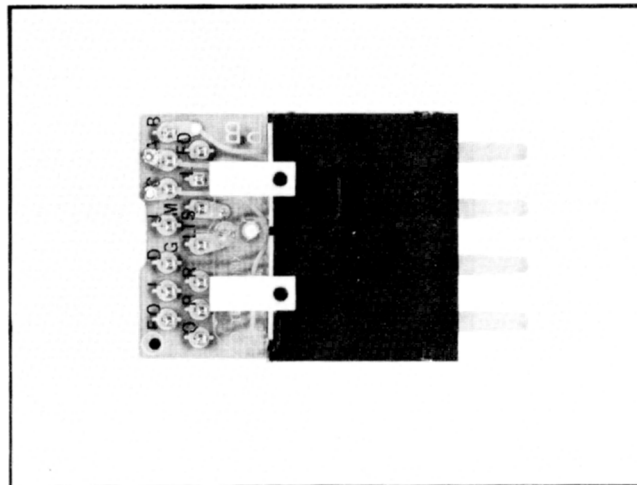


Fig. 7-6. Channel 1 and Channel 2 Coupling switch and circuit board.

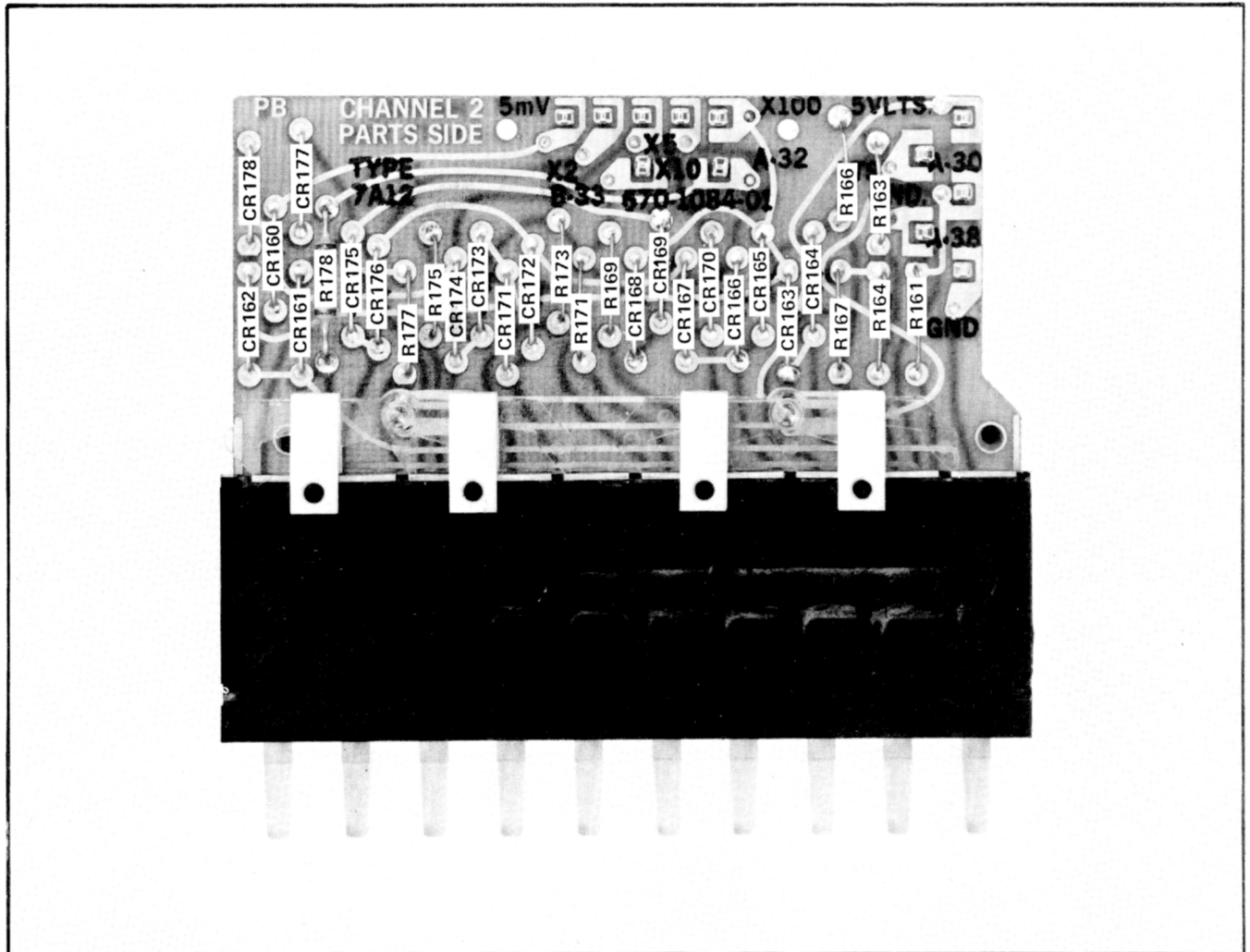
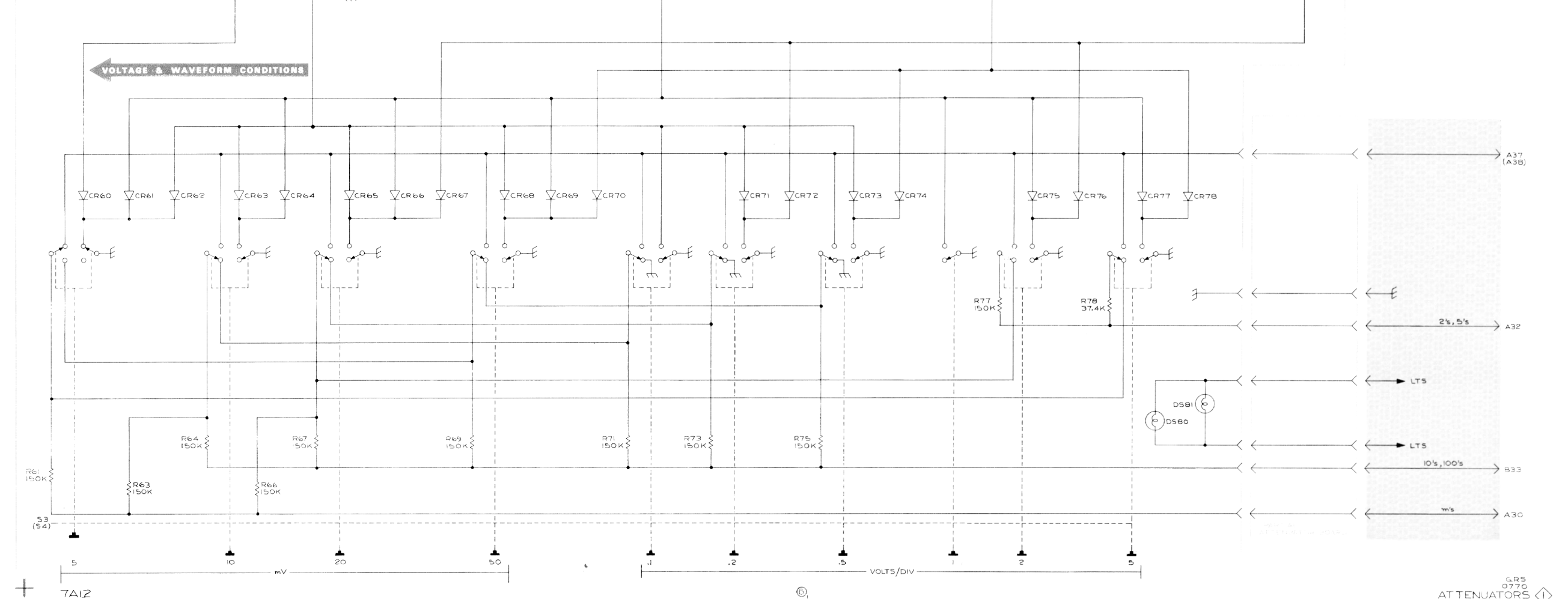
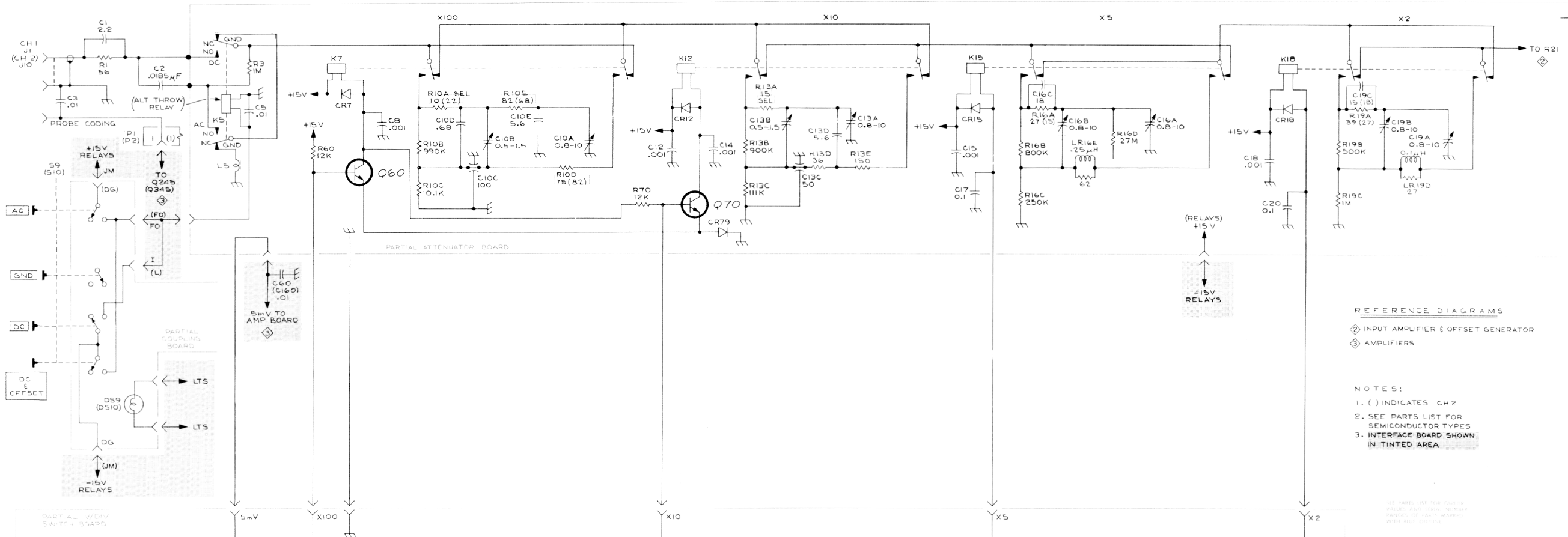


Fig. 7-4. Channel 2 Volts/Div switch and circuit board showing location of components.



Diagrams and Circuit Board Illustrations—7A12

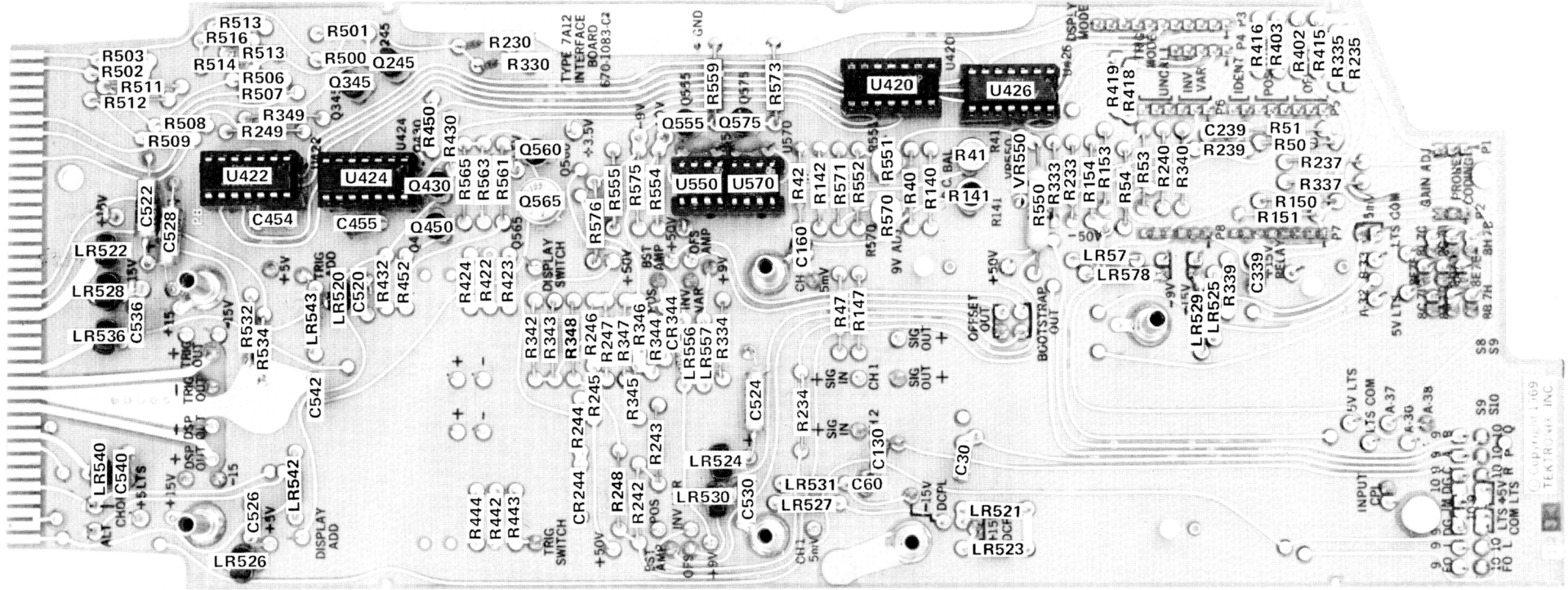
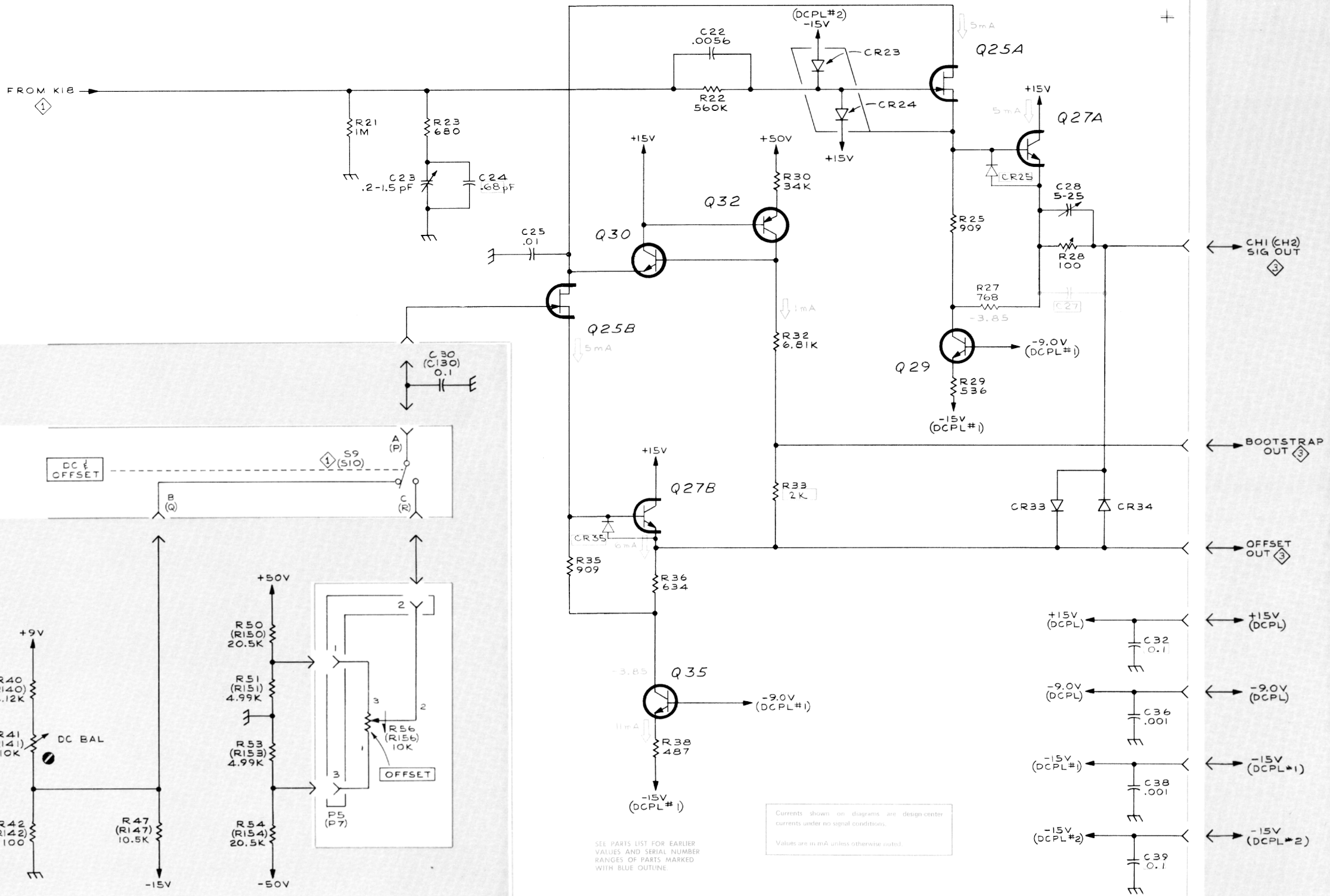


Fig. 7-5. Interface circuit board showing location of components.



REFERENCE DIAGRAMS
① AMPLIFIERS

ATTENUATOR BOARD

Currents shown on diagrams are design center currents under no signal conditions.
Values are in mA unless otherwise noted.

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

- NOTES:
- () INDICATES CH2.
 - SEE PARTS LIST FOR SEMICONDUCTOR TYPES.
 - INTERFACE BOARD SHOWN IN TINTED AREA.

↓ INDICATES DIRECTION OF CURRENT FLOW

VOLTAGES obtained under conditions given in Diagram ①

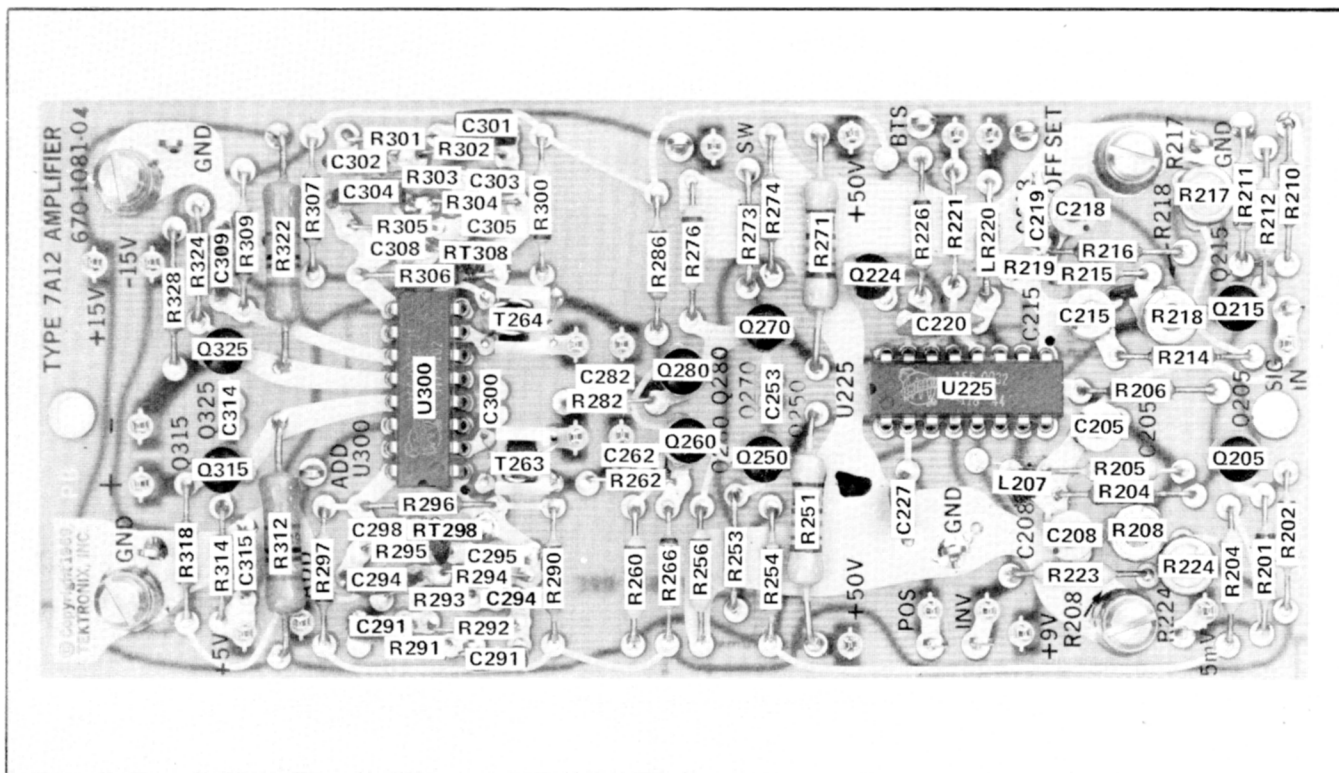


Fig. 7-7. Channel 1 and Channel 2 Amplifier circuit board showing location of components.

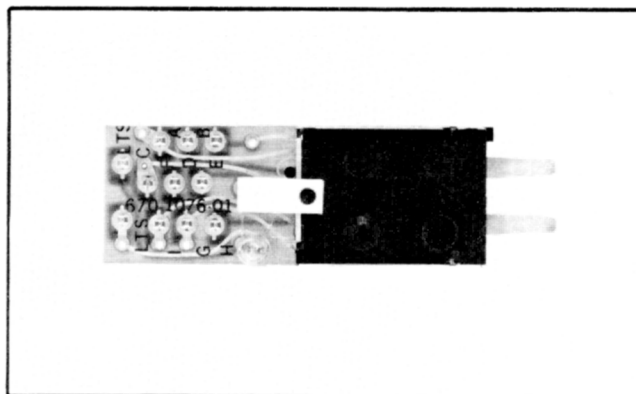
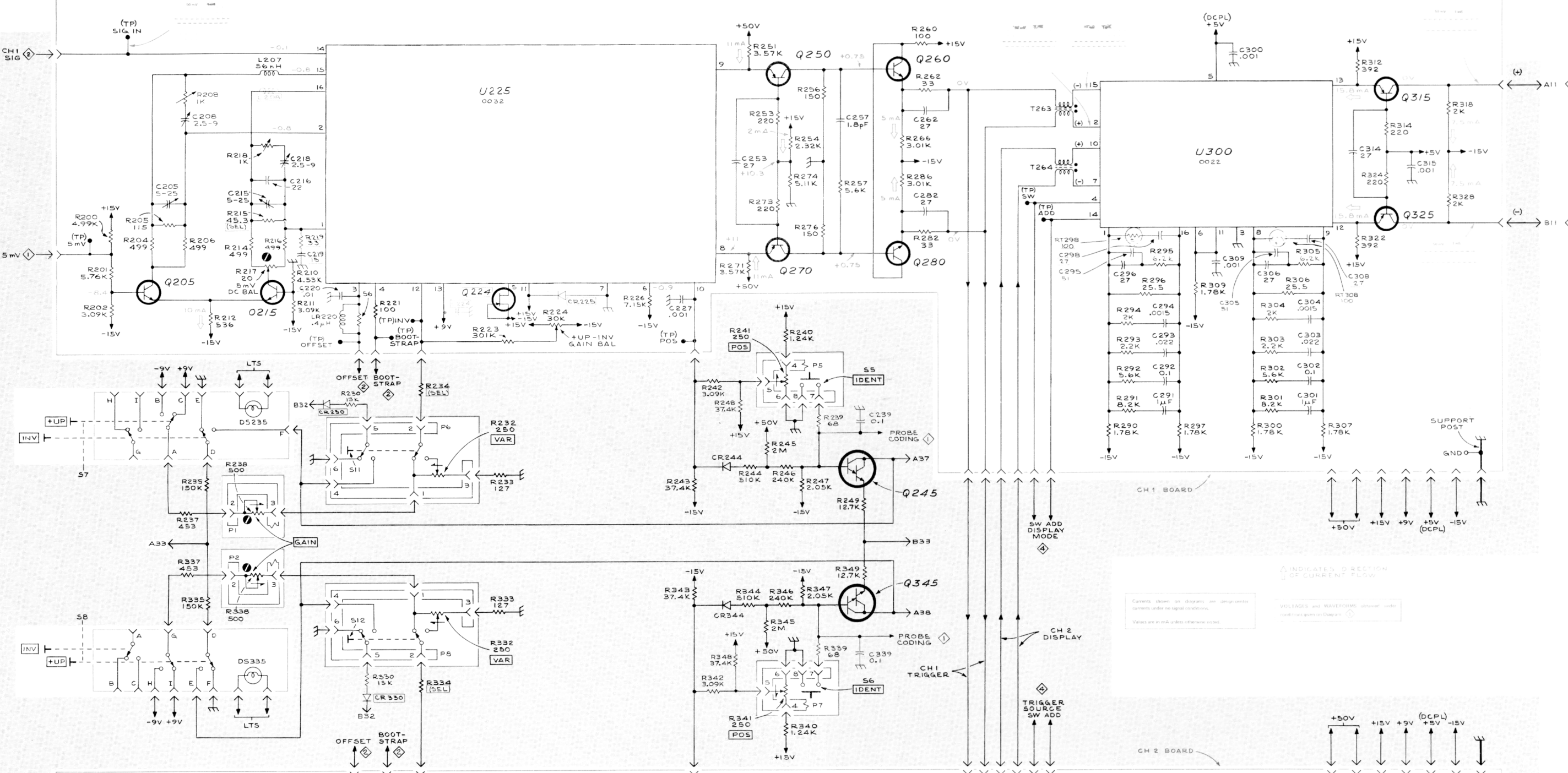


Fig. 7-8. Channel 1 and Channel 2 +UP/INV switch and circuit board.



NOTE: CHANNEL 2 IS IDENTICAL TO CHANNEL 1

INDICATES DIRECTION OF CURRENT FLOW

Currents shown on diagrams are single center currents under no signal conditions.

Values are in mA unless otherwise noted.

VOLTAGES and WAVEFORMS obtained under conditions given on Diagrams.

- REFERENCE DIAGRAM
- ① ATTENUATORS
 - ② SWITCHING & LOGIC
 - ③ CONNECTOR DETAILS & POWER SUPPLIES

- NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES.
 2. INTERFACE BOARD SHOWN IN TINTED AREA.

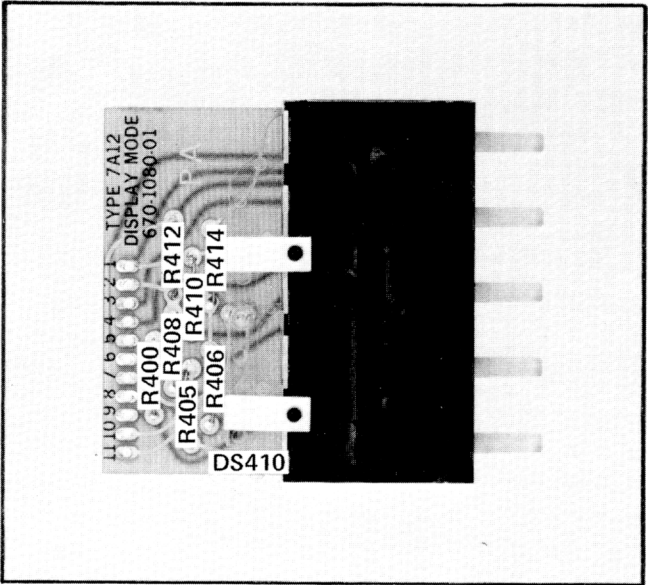


Fig. 7-9. Display Mode switch and circuit board showing location of components.

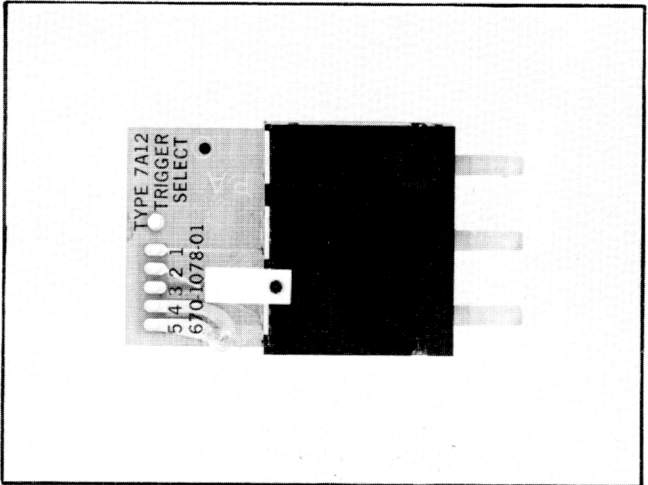
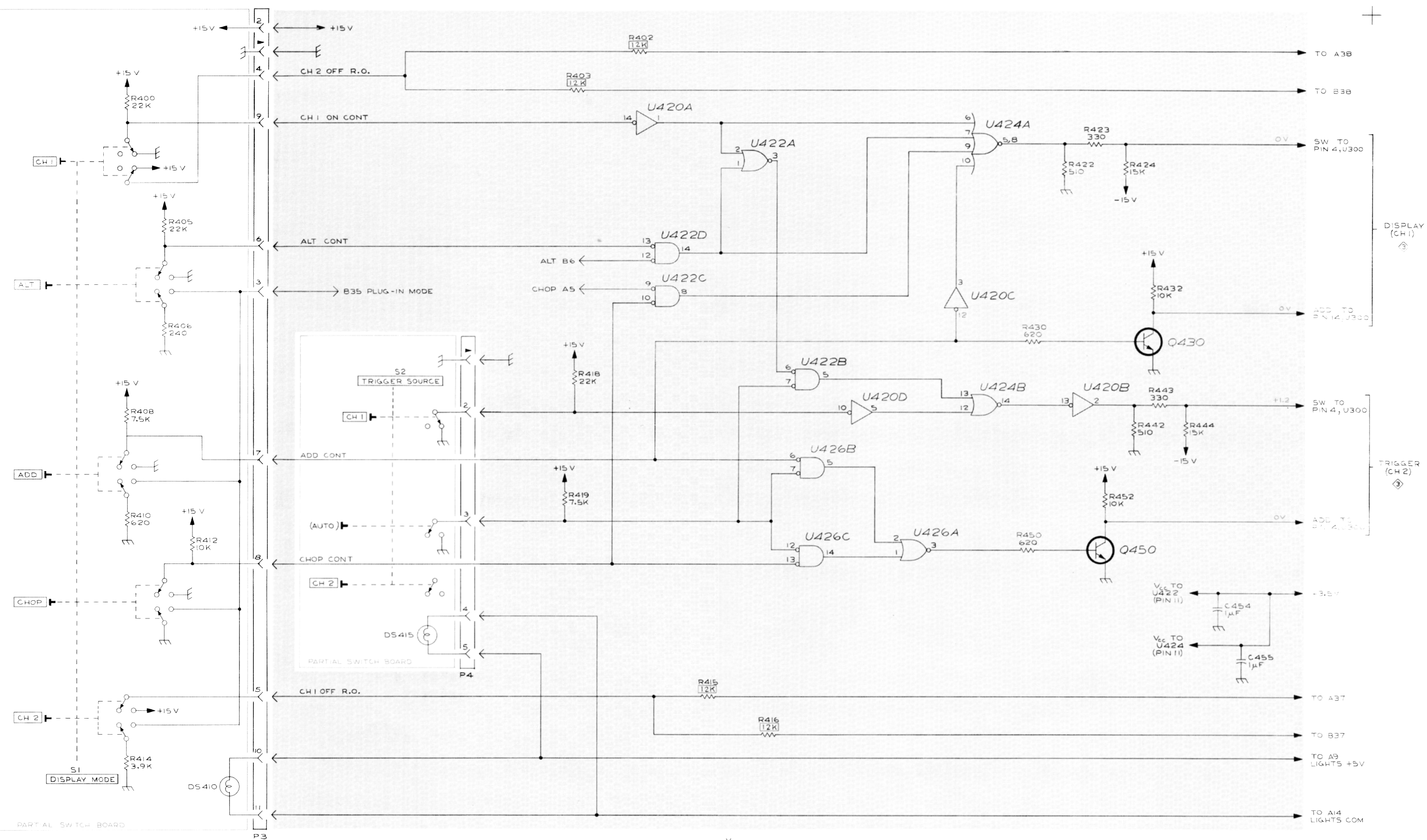
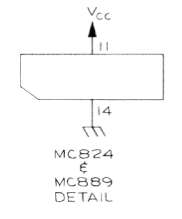


Fig. 7-10. Trigger Source switch and circuit board.



- NOTES:
1. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
 2. ALL UNUSED IC INPUT PINS ARE GROUND
 3. INTERFACE BOARD SHOWN IN TINTED AREA

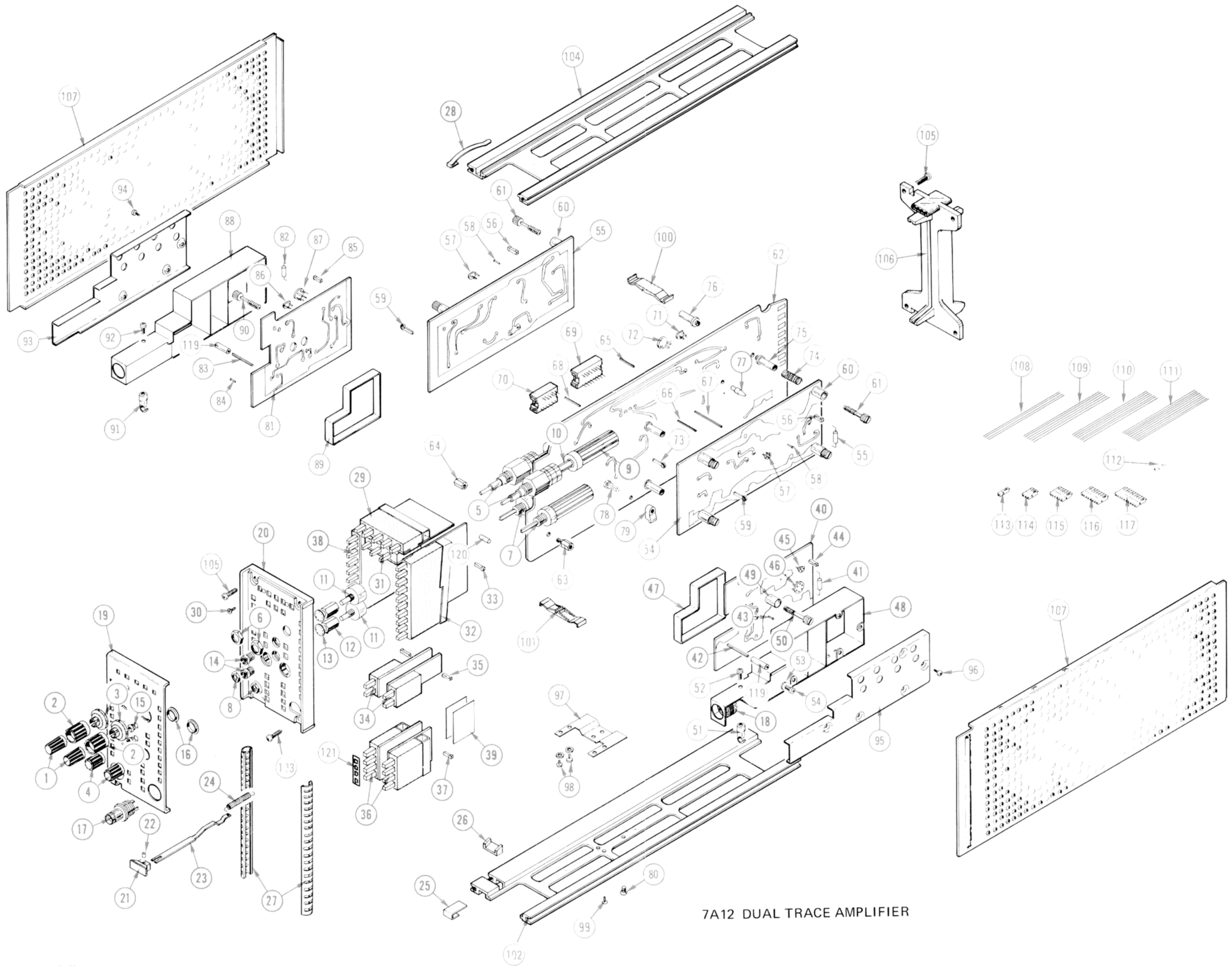
VOLTAGES obtained under conditions given in Diagram



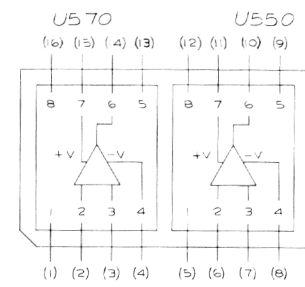
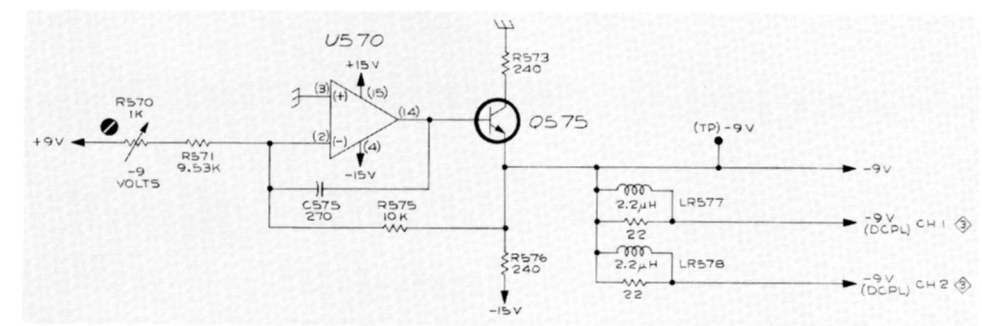
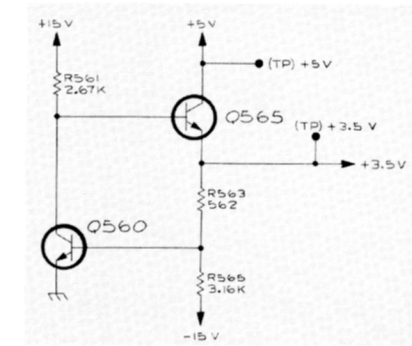
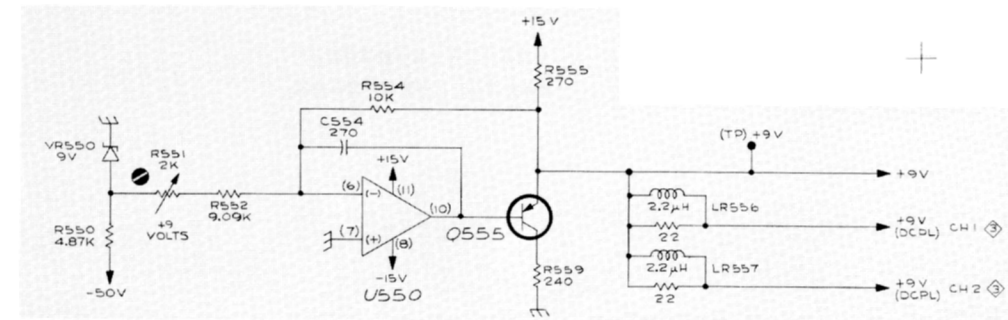
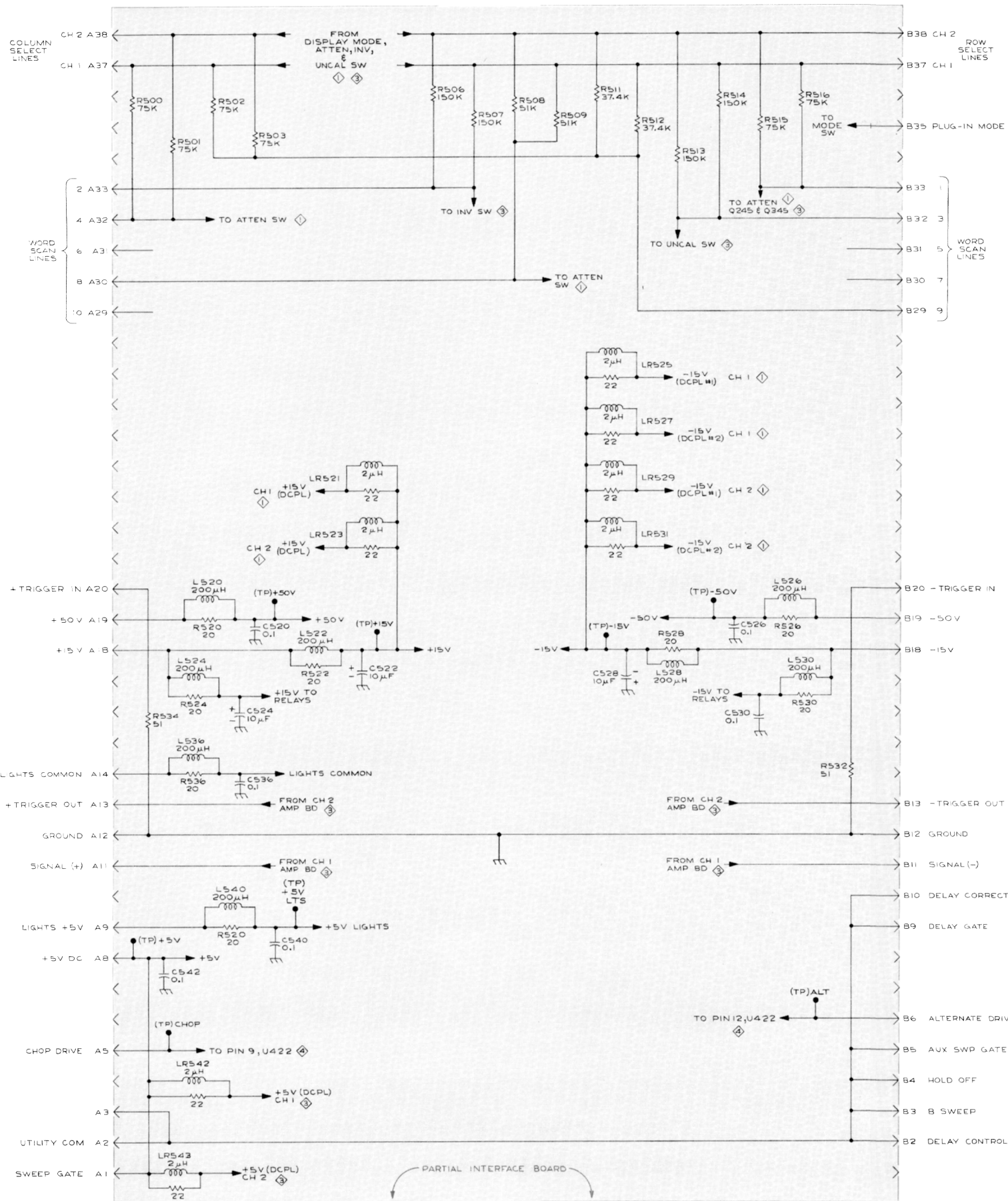
REFERENCE DIAGRAMS

AMPLIFIERS

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



7A12 DUAL TRACE AMPLIFIER



- NOTES:
1. PINS 12 & 6 OF U.C. ARE 0V, OTHER UNUSED PINS ARE -15V
 2. SEE PARTS LIST FOR SEMICONDUCTOR TYPES
 3. INTERFACE BOARD SHOWN IN TINTED AREA

REFERENCE DIAGRAMS

- ⊠ ATTENUATORS
- ⊡ AMPLIFIERS
- ⊛ SWITCHING & LOGIC

CONNECTOR DETAILS & POWER SUPPLIES

CARTON ASSEMBLY
 (Part No. 065-0125-00)

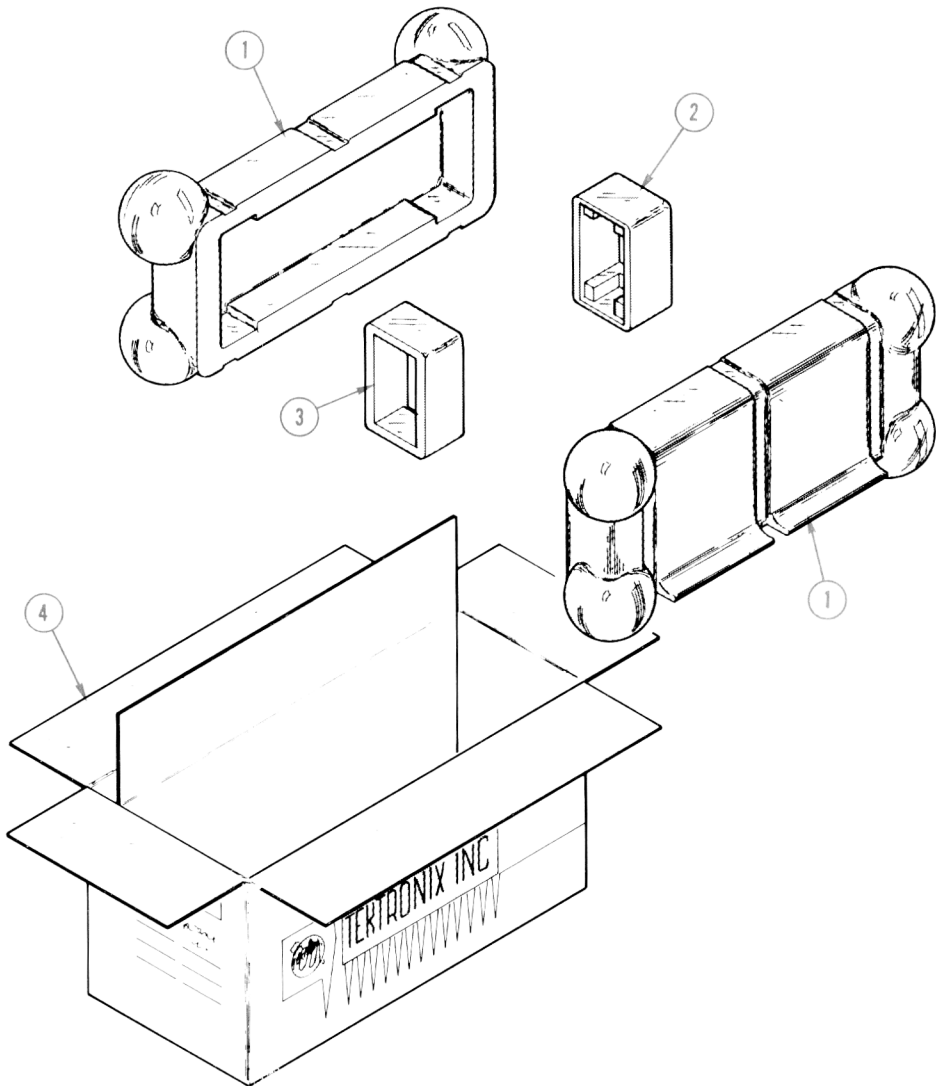


Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
2-	065-0125-00			1						ASSEMBLY, carton assembly includes:
-1	004-0241-00			2						CASE HALF
-2	004-0242-00			1						END CAP, rear
-3	004-0243-00			1						END CAP, front
-4	004-0748-00			1						CARTON

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

Title	Location (reverse side of)
Figure 1 Exploded	Switching & Logic Diagram
Figure 2 Repackaging	Connector Details & Power Supply Diagram

SECTION 8

MECHANICAL PARTS LIST

FIGURE 1 EXPLODED

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q					Description	
				t	y	1	2	3		4
1-1	366-1167-00			2						KNOB, gray—POSITION (CH 1 & 2)
	- - - - -			-						each knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-2	366-1130-00			2						KNOB, gray—OFFSET (CH 1 & 2)
	- - - - -			-						each knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-3	354-0354-00			2						RING, knob, skirt (CH 1 & 2)
-4	366-1166-00			2						KNOB, red—VAR V/DIV (CAL IN) (CH 1 & 2)
	- - - - -			-						each knob includes:
	213-0153-00			1						SETSCREW, 5-40 x 0.125 inch, HSS
-5	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-6	210-0590-00			1						NUT, hex., 0.375-32 x 0.438 inch
-7	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-8	210-0583-00			1						NUT, hex., 0.25-32 x 0.312 inch
-9	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
	210-0583-00			1						NUT, hex., 0.375-32 x 0.438 inch
-10	129-0252-00			1						POST, hex., 0.450 inch long
-11	- - - - -			2						RESISTOR, variable
	- - - - -			-						mounting hardware for each: (not included w/resistor)
-12	129-0252-00			1						POST, hex., 0.450 inch long
-13	210-0046-00			1						WASHER, lock, internal, 0.261 ID x 0.400 inch OD
-14	358-0409-00			1						BUSHING
-15	358-0301-02			2						BUSHING, sleeve, plastic, 0.250 inch OD
-16	358-0360-00			2						BUSHING, sleeve, plastic, 0.575 inch OD
-17	131-0679-00 <i>0.2</i>			2						CONNECTOR, receptacle, BNC
	- - - - -			-						mounting hardware for each: (not included w/connector)
-18	220-0569-00 <i>469</i>			1						NUT, plain, knurled
-19	333-1204-00			1						PANEL, front
-20	386-1447-15			1						SUBPANEL, front
-21	366-1058-08			1						KNOB, latch
	- - - - -			-						mounting hardware: (not included w/knob)
-22	214-1095-00			1						PIN, spring, split

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † Y	1 2 3 4 5					Description
					1	2	3	4	5	
1-23	105-0076-00			1						RELEASE BAR, latch
-24	214-1280-00			1						SPRING, helical compression
-25	214-1054-00			1						SPRING, flat, latch detent
-26	105-0075-00			1						BOLT, latch
-27	348-0235-00			2						SHIELDING GASKET, electrical
-28	214-1061-00			1						SPRING, flat, sliding ground
-29	670-1080-00	B010100	B059999	1						ASSEMBLY, circuit board—DISPLAY MODE
	670-1080-01	B060000		1						ASSEMBLY, circuit board—DISPLAY MODE
	- - - - -			-						assembly includes:
	380-0151-01			1						HOUSING, light
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
	- - - - -			-						mounting hardware: (not included w/assembly)
-30	211-0156-00			2						SCREW, 1-72 x 0.250 inch, 82° csk, FHS
-31	670-1078-00	B010100	B059999	1						ASSEMBLY, circuit board—TRIGGER SOURCE
	670-1078-01	B060000		1						ASSEMBLY, circuit board—TRIGGER SOURCE
	- - - - -			-						assembly includes:
	380-0149-01			1						HOUSING, light
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
	- - - - -			-						mounting hardware: (not included w/assembly)
	211-0156-00			2						SCREW, 1-72 x 0.250 inch, 82° csk, FHS
-32	670-1084-00	B010100	B059999	1						ASSEMBLY, circuit board—VOLTS/DIV (CH 2)
	670-1084-01	B060000		1						ASSEMBLY, circuit board—VOLTS/DIV (CH2)
	- - - - -			-						assembly includes:
	380-0152-02			1						HOUSING, light
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-33	136-0263-03			12						SOCKET, pin terminal
	- - - - -			-						mounting hardware: (not included w/assembly)
	211-0156-00			3						SCREW, 1-72 x 0.250 inch, 82° csk, FHS
-34	670-1076-00	B010100	B059999	2						ASSEMBLY, circuit board—+ UP INV (CH 1 & 2)
	670-1076-01	B060000		2						ASSEMBLY, circuit board—+UP INV (CH1 & 2)
	- - - - -			-						each assembly includes:
	380-0152-02			1						HOUSING, light
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-35	136-0263-03			11						SOCKET, pin terminal
	- - - - -			-						mounting hardware for each: (not included w/assembly)
	211-0156-00			1						SCREW, 1-72 x 0.250 inch, 82° csk, FHS
-36	670-1079-00	B010100	B059999	2						ASSEMBLY, circuit board—AC GND DC (CH 1 & 2)
	670-1079-01	B060000		2						ASSEMBLY, circuit board—AC GND DC (CH 1 & 2)
	- - - - -			-						each assembly includes:
	380-0155-02			1						HOUSING, light
	- - - - -			-						mounting hardware: (not included w/housing)
	213-0181-00			1						SCREW, thread forming, #2 x 0.375 inch, PHS
-37	136-0263-03			14						SOCKET, pin terminal
	- - - - -			-						mounting hardware for each: (not included w/assembly)
	211-0156-00			2						SCREW, 1-72 x 0.250 inch, 82° csk, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q f y	Description
1-38	670-1077-00	B010100	B059999	1	ASSEMBLY, circuit board—VOLTS/DIV (CH 1)
	670-1077-01	B060000		1	ASSEMBLY, circuit board—VOLTS/DIV (CH1)
	- - - - -			-	assembly includes:
	136-0263-03			12	SOCKET, pin terminal
	380-0152-02			1	HOUSING, light
	- - - - -			-	mounting hardware: (not included w/housing)
	213-0181-00			1	SCREW, thread forming, #2 x 0.375 inch, PHS
	- - - - -			-	mounting hardware: (not included w/assembly)
	211-0156-00			3	SCREW, 1-72 x 0.250 inch, 82° csk, FHS
-39	342-0029-00			2	INSULATOR, plate
-40	670-1059-00	B010100	B019999	1	ASSEMBLY, circuit board—ATTENUATOR (CH 2)
	670-1059-01	B020000	B069999	1	ASSEMBLY, circuit board—ATTENUATOR (CH 2)
	670-1059-03	B070000	B089999	1	ASSEMBLY, circuit board—ATTENUATOR (CH2)
	670-1059-04	B090000	B099999	1	ASSEMBLY, circuit board—ATTENUATOR (CH2)
	670-1059-05	B100000		1	ASSEMBLY, circuit board—ATTENUATOR (CH2)
	- - - - -			-	assembly includes:
	388-1272-00			1	BOARD, circuit
	337-1366-00	XB020000		1	SHIELD, ground
-41	131-0566-00			2	LINK, terminal connecting
-42	131-0592-00			12	TERMINAL, pin
-43	136-0252-01			41	SOCKET, pin connector
-44	136-0263-03			18	SOCKET, pin terminal
-45	136-0350-00			6	SOCKET, transistor, 3 pin
-46	136-0366-00			2	SOCKET, transistor, 6 pin
-47	337-1221-00			1	SHIELD, electrical, left
-48	337-1223-00			1	SHIELD, electrical, right
-49	361-0238-00			2	SPACER, sleeve
-50	211-0155-00			2	SCREW, 4-40 x 0.375 inch
-51	352-0071-00			1	HOLDER, plastic
	- - - - -			-	mounting hardware: (not included w/holder)
-52	211-0065-00			1	SCREW, 4-40 x 0.188 inch, PHS
	- - - - -			-	mounting hardware: (not included w/assembly)
	210-1002-00			1	WASHER, flat, 0.125 ID x 0.250 inch OD
-53	211-0168-00			1	SCREW, 4-40 x 0.250 inch, PHB
-54	670-1081-00	B010100	B049999	2	ASSEMBLY, circuit board—AMPLIFIER
	670-1081-01	B050000	B079999	2	ASSEMBLY, circuit board—AMPLIFIER
	670-1081-02	B080000	B089999	2	ASSEMBLY, circuit board—AMPLIFIER
	670-1081-03	B090000	B099999	2	ASSEMBLY, circuit board—AMPLIFIER
	670-1081-04	B100000		2	ASSEMBLY, circuit board—AMPLIFIER
	- - - - -			-	each assembly includes:
	388-1281-00	B010100	B079999	1	BOARD, circuit
	388-1281-01	B080000		1	BOARD, circuit
-55	131-0566-00			1	LINK, terminal connecting
-56	136-0263-03			20	SOCKET, pin terminal
-57	136-0350-00			8	SOCKET, transistor, 3 pin
-58	136-0352-00			32	SOCKET, connector pin
-59	214-0579-00			12	PIN, test point
-60	361-0238-00			4	SPACER, sleeve
-61	211-0155-00			4	SCREW, 4-40 x 0.375 inch
-62	670-1083-00	B010100	B079999	1	ASSEMBLY, circuit board—INTERFACE
	670-1083-01	B080000	B109999	1	ASSEMBLY, circuit board—INTERFACE
	670-1083-02	B110000		1	ASSEMBLY, circuit board—INTERFACE
	- - - - -			-	assembly includes:
	388-1283-00	B010100	B079999	1	BOARD, circuit
	388-1283-01	B080000		1	BOARD, circuit
-63	129-0219-00			1	POST, hex., 0.436 inch long
-64	129-0220-00			1	POST, hex., 0.248 inch long

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model Eff	No. Disc	Q † y	1 2 3 4 5					Description
					1	2	3	4	5	
1-65	131-0589-00			18						TERMINAL, pin, 0.460 inch long
-66	131-0590-00			68						TERMINAL, pin, 0.710 inch long
-67	131-0593-00			15						TERMINAL, pin, 1.150 inches long
-68	131-0608-00			50						TERMINAL, pin, 0.365 inch long
-69	136-0260-01			1						SOCKET, integrated circuit, 16 pin
-70	136-0269-00			4						SOCKET, integrated circuit, 14 pin
-71	136-0350-00			7						SOCKET, transistor, 3 pin
-72	136-0365-00			1						SOCKET, transistor, 3 pin
-73	214-0579-00			12						PIN, test point
-74	214-1140-00			12						SPRING, helical compression
-75	351-0185-00			6						GUIDE-POST, lock
-76	351-0188-00			6						GUIDE-POST, lock
-77	386-1557-00	B010100	B082349	10						SUPPORT, circuit board
	386-1557-00	B082350		6						SUPPORT, circuit board
	- - - - -			-						mounting hardware: (not included w/assembly)
-78	211-0116-00			1						SCREW, sems, 4-40 x 0.312 inch, PHB
-79	220-0547-00			1						NUT, block
-80	211-0105-00			1						SCREW, 4-40 x 0.188 inch, 100° csk, FHS
-81	670-1060-00	B010100	B019999	1						ASSEMBLY, circuit board—ATTENUATOR (CH 1)
	670-1060-01	B020000	B069999	1						ASSEMBLY, circuit board—ATTENUATOR (CH 1)
	670-1060-03	B070000	B089999	1						ASSEMBLY, circuit board—ATTENUATOR (CH1)
	670-1060-04	B090000	B099999	1						ASSEMBLY, circuit board—ATTENUATOR (CH1)
	670-1060-05	B100000		1						ASSEMBLY, circuit board—ATTENUATOR (CH1)
	- - - - -			-						assembly includes:
	388-1273-00			1						BOARD, circuit
	337-1366-00	XB020000		1						SHIELD, ground
-82	131-0566-00			2						LINK, terminal connecting
-83	131-0592-00			12						TERMINAL, pin
-84	136-0252-01			41						SOCKET, pin connector
-85	136-0263-03			18						SOCKET, pin terminal
-86	136-0350-00			6						SOCKET, transistor, 3 pin
-87	136-0366-00			2						SOCKET, transistor, 6 pin
-88	337-1222-00			1						SHIELD, electrical, left
-89	337-1220-00			1						SHIELD, electrical, right
	361-0238-00			2						SPACER, sleeve (not shown)
-90	211-0155-00			2						SCREW, 4-40 x 0.375 inch
-91	352-0071-00			1						HOLDER, plastic
	- - - - -			-						mounting hardware: (not included w/holder)
-92	211-0065-00			1						SCREW, 4-40 x 0.188 inch, PHB
	- - - - -			-						mounting hardware: (not included w/assembly)
	210-1002-00			1						WASHER, flat, 0.125 ID x 0.250 inch OD (not shown)
	211-0168-00			1						SCREW, 4-40 x 0.250 inch, PHB (not shown)
-93	337-1231-00			1						SHIELD, electrical, CH 1
	- - - - -			-						mounting hardware: (not included w/shield)
-94	211-0169-00			5						SCREW, 2-56 x 0.125 inch, PHB
-95	337-1232-00			1						SHIELD, electrical, CH 2
	- - - - -			-						mounting hardware: (not included w/shield)
-96	211-0169-00			5						SCREW, 2-56 x 0.125 inch, PHB
-97	131-0926-00			1						CONTACT, electrical, ground
	- - - - -			-						mounting hardware: (not included w/contact)
-98	211-0108-00			4						SCREW, 2-56 x 0.156 inch, RHS
	210-0850-00			4						WASHER, flat, 0.093 ID x 0.281 inch OD
-99	211-0087-01			2						SCREW, 2-56 x 0.188 inch, 82° csk, FHS

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Q † Y	1 2 3 4 5					Description
					1	2	3	4	5	
1-100	344-0161-00	B010100	B020279	3						CLIP, circuit board, top
	344-0210-00	B020280		3						CLIP, circuit board, top
-101	344-0162-00	B010100	B020279	2						CLIP, circuit board, bottom
	344-0211-00	B020280		2						CLIP, circuit board, bottom
-102	426-0499-08			1						FRAME SECTION, bottom
	- - - - -			-						mounting hardware: (not included w/frame section)
-103	213-0192-00			4						SCREW, thread forming, 6-32 x 0.500 inch, Fil HS
-104	426-0505-05			1						FRAME SECTION, top
	- - - - -			-						mounting hardware: (not included w/frame section)
	361-0326-00			1						SPACER, sleeve (not shown)
-105	213-0192-00			4						SCREW, thread forming, 6-32 x 0.500 inch, Fil HS
-106	386-1402-00			1						PANEL, rear
-107	337-1064-00			1						SHIELD, electrical, side
	337-1064-01	B010100	B059999	1						SHIELD, electrical, side, w/grounding plate
	337-1064-03	B060000	B109999	1						SHIELD, electrical, side, w/grounding plate
	337-1064-07	B110000		1						SHIELD, electrical, side, w/grounding plate
	214-0982-02	B010100	B059999	1						SPRING, grounding
	214-1492-00	B060000		1						SPRING, grounding
-108	175-0826-00			ft						WIRE, electrical, 3 conductor ribbon, 12.125 inches long
-109	175-0828-00			ft						WIRE, electrical, 5 conductor ribbon, 6.875 inches long
-110	175-0839-00			ft						WIRE, electrical, 6 conductor ribbon, 16.500 inches long
-111	175-0829-00			ft						WIRE, electrical, 8 conductor ribbon, 7.250 inches long
-112	131-0707-00			50						CONNECTOR, terminal
-113	352-0171-00			1						HOLDER, terminal connector, 1 wire, black
-114	352-0161-01			1						HOLDER, terminal connector, 3 wire, brown
	352-0161-02			1						HOLDER, terminal connector, 3 wire, red
-115	352-0164-04			1						HOLDER, terminal connector, 6 wire, yellow
	352-0164-06			1						HOLDER, terminal connector, 6 wire, blue
	352-0164-08			1						HOLDER, terminal connector, 6 wire, gray
-116	352-0166-05			1						HOLDER, terminal connector, 8 wire, green
	352-0166-07			1						HOLDER, terminal connector, 8 wire, purple
-117	352-0168-00			1						HOLDER, terminal connector, 10 wire, black
-118	361-0328-00			4						SPACER, sleeve, plastic
-119	386-1793-00			4						SUPPORT, shield, plastic

STANDARD ACCESSORIES

070-0977-01	1	MANUAL, instruction (not shown)
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