

# INSTRUCTION MANUAL

## **7A16A AMPLIFIER**

Serial Number

B020458



## WARRANTY

All **TEKTRONIX** instruments are warranted against defective materials and workmanship for one year. Any questions with respect to the warranty 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 will assure you the fastest possible service. Please include the instrument Type Number or Part Number and Serial Number with all requests for parts or service.

Specifications and price change privileges reserved.

Copyright © 1972 by Tektronix, Inc., Beaverton, Oregon.  
Printed in the United States of America. All rights reserved.  
Contents of this publication may not be reproduced in any form without permission of Tektronix, Inc.

U.S.A. and foreign **TEKTRONIX** products covered by U.S. and foreign patents and/or patents pending.

**TEKTRONIX** is a registered trademark of Tektronix, Inc.

# TABLE OF CONTENTS

	Page
<b>SECTION 1</b>	<b>SPECIFICATION</b>
	Introduction 1-1
	Electrical Characteristics 1-1
	Environmental Characteristics 1-2
	Physical Characteristics 1-2
<b>SECTION 2</b>	<b>OPERATING INSTRUCTIONS</b>
	Installation 2-1
	Function of Controls and Connectors 2-1
	Basic Operation 2-2
	General Operating Information 2-2
	Applications 2-3
<b>SECTION 3</b>	<b>CIRCUIT DESCRIPTION</b>
	Block Diagram Description 3-1
	Detailed Circuit Description 3-1
<b>SECTION 4</b>	<b>MAINTENANCE</b>
	Preventive Maintenance 4-1
	Troubleshooting 4-1
	Corrective Maintenance 4-3
<b>SECTION 5</b>	<b>CALIBRATION</b>
	Performance Check 5-1
	Test Equipment Required 5-1
	Short Form Procedure 5-2
	Calibration Procedure 5-3
	Balance 5-4
	Gain 5-4
	Compensation 5-5
	Bandwidth and Risetime 5-6
<b>SECTION 6</b>	<b>ELECTRICAL PARTS LIST</b>
	Abbreviations and Symbols
	Parts Ordering Information
<b>SECTION 7</b>	<b>DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS</b>
	Symbols and Reference Designators
<b>SECTION 8</b>	<b>MECHANICAL PARTS LIST</b>
	Mechanical Parts List Information
	Index of Mechanical Parts Illustrations
	Mechanical Parts List



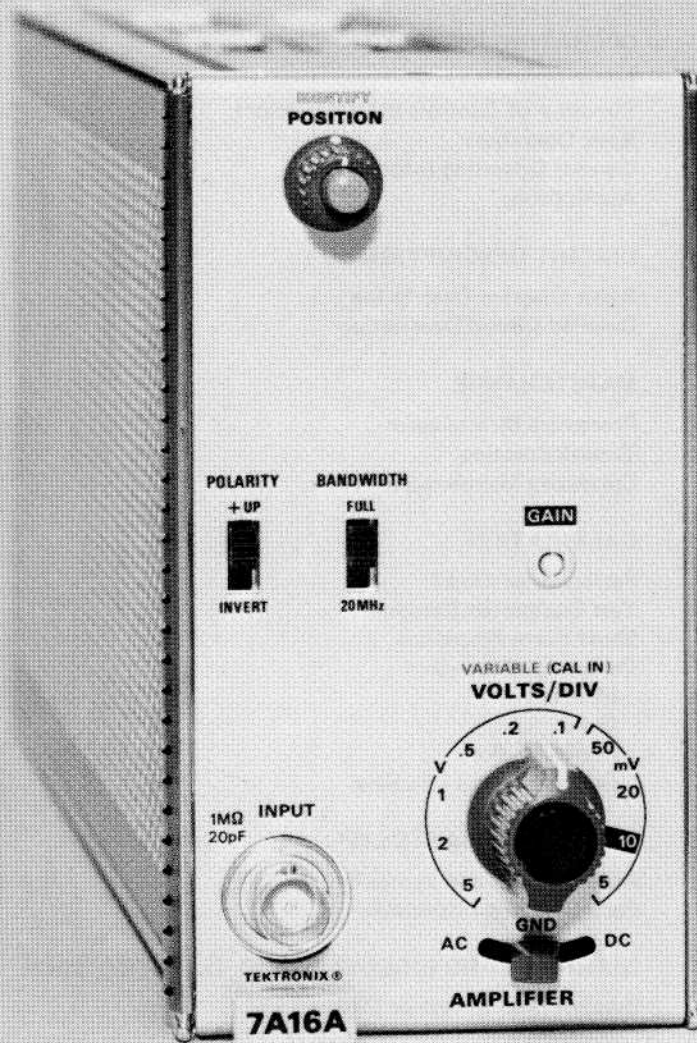


Fig. 1-1. 7A16A Amplifier Plug-in.

# SPECIFICATION

## Introduction

The 7A16A Amplifier Plug-In Unit is a wide-bandwidth amplifier designed for use with TEKTRONIX 7000-Series

Oscilloscopes. The 7A16A can be operated in any plug-in compartment of 7000-Series Oscilloscopes. Readout encoding and trace identify functions are provided to readout equipped oscilloscopes.

**TABLE 1-1**  
**ELECTRICAL**

Characteristics	Performance Requirements		Supplemental Information
<b>Deflection Factor</b>			
<b>Calibrated Range</b>	5 mV/div to 5 V/div, 10 steps in a 1-2-5 sequence.		
<b>Accuracy</b>	Within 2% of indicated deflection factor with GAIN adjusted at 10 mV/div.		
<b>Uncalibrated (VARIABLE)</b>	Continuously variable between calibrated steps; extends deflection factor to at least 12.5 V/div.		
<b>Gain Range</b>			Permits adjustment of deflection factor for calibrated operation with all 7000-Series main-frames.
<b>Frequency Response</b>			
<b>Bandwidth</b>	With 7400-Series 60 MHz	With 7500-Series 90 MHz	
	With 7700-Series 150 MHz	With 7900-Series 225 MHz	
<b>AC Coupled (Lower Bandwidth Limit)</b>	10 Hz or less.		
<b>20 MHz Bandwidth</b>			20 MHz, ±3 MHz.
<b>Step Response</b>			
<b>Risetime</b>	With 7400-Series 5.9 ns	With 7500-Series 3.9 ns	
	With 7700-Series 2.4 ns	With 7900-Series 1.6 ns	
<b>20 MHz Bandwidth Risetime</b>			
<b>Maximum Input Voltage</b>			250 V (DC + peak AC); A component 500 V P-P maximum, 1 kHz or less.
<b>DC Coupled</b>			
<b>AC Coupled</b>			
			500 V (DC + peak AC); A component 500 V P-P maximum, 1 kHz or less.

TABLE 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
<b>Input R and C</b>		
Resistance		1 M $\Omega$ $\pm$ 2%.
Capacitance		20 pF $\pm$ 0.5 pF.
<b>Overdrive Recovery Time</b>		0.1 ms or less to recover to within one division after removal of overdrive signal of up to +75 div or –75 div regardless of overdrive signal duration.
<b>DC Drift</b>		
Drift with Time (Ambient Temp and Line Voltage Constant)		0.02 div or less in any one minute after one hour warmup.
Drift with Temperature (Line Voltage Constant)		Not more than 0.02 div/ $^{\circ}$ C.

TABLE 1-2

## ENVIRONMENTAL CHARACTERISTICS

Refer to the specifications for the associated oscilloscope.

TABLE 1-3

## PHYSICAL

Size	Fits all 7000-Series plug-in compartments.
Weight	0.9 kg or 1.9 lbs.

# OPERATING INSTRUCTIONS

## General

To effectively use the 7A16A, 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 7A16A is calibrated and ready for use as received. It can be installed in any compartment of TEKTRONIX 7000-Series Oscilloscopes, but is intended for use primarily in vertical plug-in compartments. To install, align the upper and lower rails of the 7A16A with the oscilloscope tracks and insert the plug-in. The front panel will be flush with the front of the oscilloscope when the plug-in is inserted, and the latch at the bottom-left corner will be in place against the front panel.

To remove the 7A16A, pull on the latch (which is inscribed with the unit identification "7A16A") and the plug-in will unlatch. Continue pulling on the latch to slide the 7A16A out of the oscilloscope.

## Functions of Controls and Connectors

### Front Panel

#### INPUT Connector

Provides signal connection to the amplifier.

#### AC-GND-DC Switch

Selects signal input coupling mode.

**AC:** The AC component of the signal is coupled to the input while the DC component is blocked.

**DC:** Both AC and DC components of the signal is coupled to the amplifier input.

**GND:** Grounds the amplifier input while maintaining the same load at the INPUT connector. Provides a path for pre-charging the AC coupling capacitor (this feature protects both the 7A16A and the source generator from possible over-voltage conditions).

#### POSITION

Controls position of the trace.

#### IDENTIFY Pushbutton

Deflects trace about 0.3 division for trace identification. In instruments with readout, also replaces readout with the word "IDENTIFY".

#### VOLTS/DIV Switch

Selects calibrated deflection factors from 5 mV/div to 5 V/div; 10 steps in a 1-2-5 sequence.

#### VARIABLE (VOLTS/DIV)

Provides continuously variable uncalibrated settings between calibrated steps. Extends the deflection factor to 12.5 volts/division or more.

#### GAIN Adjustment

Screwdriver adjustment permits calibration of deflection factor.

#### POLARITY Switch

Provides a means of inverting the display.

**+UP:** A positive-going signal at the INPUT connector deflects the CRT display upward.

**INVERT:** A positive-going signal at the INPUT connector deflects the CRT display downward.

#### BANDWIDTH Switch

Provides a means of limiting the upper bandwidth.

**FULL:** Allows the 7A16A to operate at full rated bandwidth.

**20 MHz:** Reduces the upper bandwidth of the 7A16A to about 20 MHz.

## BASIC OPERATION

**General.** This procedure demonstrates the use of the connectors and controls of the 7A16A, while at the same time providing a means of checking the basic operation of the instrument.

**Preliminary Setup.** Install the 7A16A into any 7000-series oscilloscope vertical compartment and set the oscilloscope VERTICAL MODE and TRIGGER SOURCE to the proper settings.

Install a 7-series time-base unit into a horizontal compartment and set the oscilloscope HORIZONTAL MODE to the proper setting. Set the time-base unit to a sweep rate of one-millisecond per division and set the triggering mode to AUTO.

### Procedure

1. Set the 7A16A AC-GND-DC switch to GND and position the trace to the center of the graticule.

2. Set the VOLTS/DIV switch to 10 mV and apply a 40 mV 1 kHz square-wave signal from the oscilloscope CALIBRATOR to the 7A16A INPUT connector. Set the AC-GND-DC switch to DC and check for a four-division display.

3. Set POLARITY switch to INVERT and check that the displayed signal is inverted as compared to its appearance in step 2.

4. Set the AC-GND-DC switch to AC and check that the trace is centered on the CRT graticule.

5. Set the oscilloscope CALIBRATOR to 4 mV and the 7A16A MAG switch set to X10. Check for a four-division display.

6. Press the 7A16A IDENTIFY button, check that the display moves upward approximately 0.3 division and the readout (if so equipped) reads "IDENTIFY".

## GENERAL OPERATING INFORMATION

### Signal Connections

In general, probes offer the most convenient means of connecting a signal to the input of the 7A16A. A 10X attenuator probe offers a high impedance and allows the circuit under test to perform very close to normal operating conditions.

The TEKTRONIX P6053 probe is equipped with a readout coding ring which connects to a circuit in the amplifier unit. This automatically corrects the readout displayed on the CRT to the actual deflection factor at the tip of the probe. This probe is recommended for use with the 7A16A and an oscilloscope equipped with readout. The TEKTRONIX P6054 probe is electrically identical to the P6053 but is intended for use with systems not equipped with readout. For more information refer to the Tektronix, Inc. catalog.

### Vertical Gain Check and Adjustment

To check the gain of the 7A16A, set the VOLTS/DIV switch to 10 mV and connect a 40 mV, 1 kHz signal from the oscilloscope calibrator to the Input connector. The vertical deflection should be exactly four divisions. If not, adjust the front panel GAIN for exactly four divisions.

### Input Coupling

The AC-GND-DC switch allows 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. For AC signals with frequencies below about 30 Hz (10 Hz with a 10X probe), and square waves whose low-frequency components are important to the display, it is necessary to use DC coupling to obtain a satisfactory presentation.

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 component. The pre-charge feature should be used when there is a possibility of having a residual charge on the input capacitor of the opposite polarity to the intended input, and when the algebraic sum of the combination of charges 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 charge, set the coupling switch to AC.

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.



## VOLTS/DIV and VARIABLE

The amount of 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 VARIABLE Control. Calibrated deflection factors represented by the setting of the VOLTS/DIV switch apply only when the VARIABLE control is in the CAL position (pushed-in).

The VARIABLE control provides variable uncalibrated settings between the calibrated steps of the VOLTS/DIV switch. With the VARIABLE control out set fully counter-clockwise the uncalibrated deflection factor is extended to at least 2.5 times the attenuator setting. By applying a calibrated voltage source to the INPUT connector, any specific deflection factor can be set within the range of the VARIABLE control.

## Polarity Switch

The POLARITY switch provides a means of inverting the displayed signal. With the POLARITY set to +UP, a positive-going signal at the INPUT produces an upward deflection of the CRT display. With the POLARITY set to INVERT, a positive-going signal will produce a downward deflection of the CRT display.

## Trace Identification

When the IDENTIFY button is pressed, the trace is deflected upward about 0.3 division to identify the 7A16A trace. This feature is particularly useful when multiple traces are displayed on the CRT. In mainframes with readout, it also replaces the deflection factor readout with the word "IDENTIFY".

## APPLICATIONS

### General

The following information describes the procedures and techniques for making measurements with a 7A16A 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 the Input connector.

2. 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.*

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

4. 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.

5. Turn the 7A16A 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. 2-1).

6. Measure the divisions of vertical deflection peak to peak. Check that the VARIABLE control is in the CAL position.

### NOTE

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

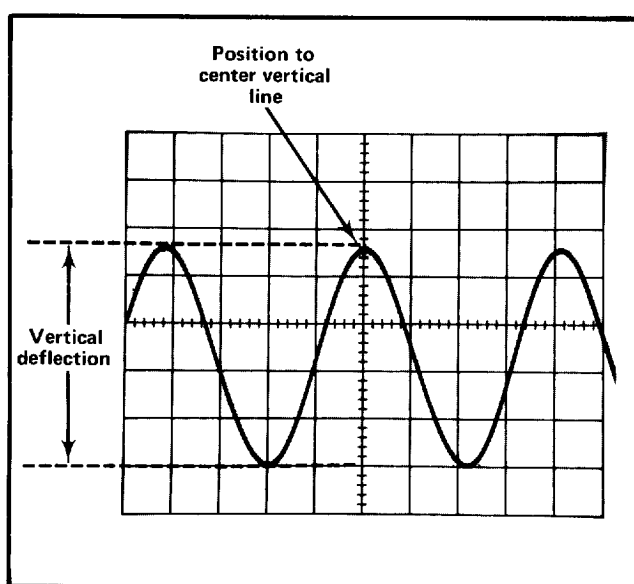


Fig. 2-1. Measuring the peak-to-peak voltage of a waveform.

## Operation—7A16A

7. 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 using a 10X attenuator probe, and the VOLTS/DIV switch is set to 1 V.

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

Substituting the given values:

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

The peak-to-peak voltage is 45 volts.

If you are using a 7A16A with a coded probe and an oscilloscope equipped with readout, simply multiply the distance measured in step 7 by the deflection factor displayed on the CRT.

## Instantaneous Voltage Measurements(DC)

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

1. Connect the signal to the Input connector.
2. Set the VOLTS/DIV switch to display about five divisions.
3. 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 another 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.*

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

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

6. 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. 2-2 the measurement is between the reference line and point A.

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

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

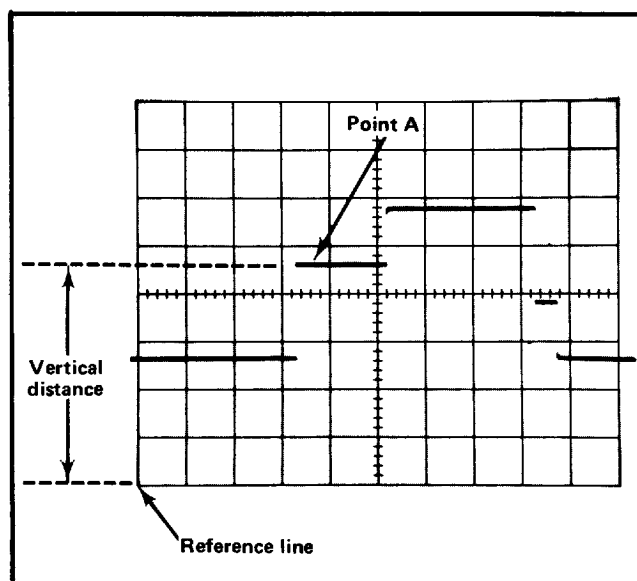
Using the formula:

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

Substituting the given values:

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

The instantaneous voltage is 18 volts.



**Fig. 2-2. Measuring instantaneous voltage with respect to same reference.**

## Comparison Measurements

In some applications it may be desirable to establish 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 a 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 VARIABLE control to produce a display which is an exact number of vertical divisions in amplitude. Do not change the VARIABLE 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 VARIABLE 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 re-adjust the VARIABLE control.

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

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

EXAMPLE: Assume a reference signal amplitude of 30 volts, a VOLTS/DIV setting of 5 V and the VARIABLE 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):

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

# CIRCUIT DESCRIPTION

## Introduction

This section of the manual contains a description of the circuitry used in the 7A16A amplifier. The 7A16A description begins with a discussion of the instrument using the block diagram 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 signal to be displayed on the CRT is applied to the INPUT connector. The signal passes through the input coupling switch, where the appropriate coupling is selected, to the attenuators. The VOLTS/DIV switch selects the correct amount of attenuation and the signal is passed to the Input Source Follower.

The Polarity Amplifier provides a convenient means of inverting the displayed trace. The output of the Polarity Amplifier drives the 2X Gain Amplifier.

With the VOLTS/DIV switch set to the 5 mV and 10 mV positions, the signal connected to the INPUT connector is passed through the attenuators un-attended. To achieve a deflection factor of 5 mV/Div the gain of the 2X Gain Amplifier is increased from one to two. Internal gain and balance adjustments are included in the amplifier.

Overall GAIN and VARIABLE gain is adjusted in the Gain Amplifier. Variable Balance and high frequency adjustments are also controlled in the Gain Amplifier. The output of the Gain Amplifier is connected to the Positioning circuitry where the POSITION and IDENTIFY functions are controlled.

The Signal Splitter Amplifier provides differential signal outputs for the signal line and the trigger line. This stage contains a bandwidth limiter that limits the upper frequency response to 20 MHz.

The output of the Signal Splitter Amplifier is connected to the oscilloscope mainframe via the interface connector.

Readout encoding circuitry used in the 7A16A is standard to the 7000-Series.

## DETAILED CIRCUIT DESCRIPTION

### AC-GND-DC Switch

Input signals connected to the INPUT connector can be AC-coupled, DC-coupled, or internally disconnected. S100A is a cam-type switch; a contact-closure chart showing the operation is given on the schematic diagrams. When the AC-GND-DC switch is in the DC position, the INPUT signal is connected directly to the attenuators. In the AC position, the INPUT signal passes through capacitor C10. The capacitor prevents the DC component of the signal from passing to the amplifier. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without the need to disconnect the applied signal from the INPUT connector. Resistor R102, connected across the AC-GND-DC switch, allows C10 to be pre-charged in the GND position.

### Input Attenuator

The effective overall deflection factor of the 7A16A is determined by the setting of the VOLTS/DIV switch, S100B. The basic deflection factor is 5 millivolts per division of CRT deflection. To increase the basic deflection factor to the values indicated on the front panel, precision attenuators are switched into the circuit. S100B is a cam-type switch and the dots on the contact-closure chart (see Diagram 1) indicate when the associated contacts are in the position shown (open or closed). In the 5 mV/Div and 10 mV/Div positions, the attenuators are not used; the input signal is connected directly to the Source Follower. The 10 mV/Div position decreases the gain of the 2X Gain Amplifier. For switch positions above ten millivolts per division, the attenuators are switched into the circuit singly or in pairs to produce the deflection factor indicated on the front panel. These hybrid attenuators are frequency-compensated voltage dividers. For DC and low-frequency signals, the attenuators are primarily resistance dividers and at high frequencies the attenuator becomes primarily a capacitive divider.

## Circuit Description—7A16A

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 20 pF). 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 Source Follower

Q150A and Q140 form a cascode amplifier with Q150B providing a constant current. R132 limits the current drive to the gate of Q150A. Dual-diode CR130 provides circuit protection by limiting the voltage swing at the gate of Q150A to about  $\pm 9$  volts. R134, C130, and the capacitance of R130 provide low frequency compensation. Input capacitance for the 5 mV and 10 mV positions is set by C134. The output to the Polarity Amplifier (U350) is from the source of Q150A and high frequencies from the collector of Q140. R164 is used to balance the input to the Polarity Amplifier.

### Polarity Amplifier

U350 is a paraphase type amplifier with a dual differential output capability. Polarity of the output is selected by gating the control bases of either the inverted output or the un-inverted output. T301 is a balun transformer and provides differential drive to U350 at high frequencies. C334 and R334 thermally compensate for gm changes in Q150A.

### 2X Gain Amplifier

The output of the Polarity Amplifier is cascaded to U450, integrated circuit U450 is the same type as U350. In the 5 mV position, full drive is provided to the following stage from pins 6 and 8 of U450. In the 10 mV position pins 5 and 9 provide drive to the following stage. R436 provides low frequency thermal compensation. DC balance between the 5 mV and 10 mV positions is adjusted by R453. CR507 and R507 maintains a constant input voltage while switching between the 5 mV and 10 mV positions.

### Gain Amplifier

Integrated circuit U550 is the same type as U350. Both differential outputs of U550 are paralleled to provide drive to the next stage. In the CAL IN position R516 sets the gain for the entire amplifier by adjusting the current at the control bases of U550. In the un-cal position the VARIABLE control, R515, increases the gain of the entire amplifier up to 2.5 times. R531-R537 compensate for temperature variations. C531 and R531 are high frequency adjustments. DC balance over the VARIABLE range is adjusted by R553.

### Position Circuit

Positioning current is added to the signal current of U550 output from the current sources Q720 and Q730. R736 controls the voltage at the bases of the current sources which in turn determines the amount of positioning current added. When the IDENTIFY switch is closed the current through Q730 is reduced causing the CRT trace to deflect.

### Signal Splitter Amplifier

Integrated circuit U750 is the same type as U350. The two differential outputs of U750 are connected to separate common base transistor amplifiers to provide separate display and trigger signals. Both outputs of U750 are biased equally to produce equal signal outputs. R770, C770, and L770 are high frequency compensation adjustments for the display signal. L770 is selected at the factory and need not be changed unless U750, Q860, or Q880 is replaced.

Q820, Q840, Q860, and Q880 are used as level shifters to return the DC level of the display signal to zero. Amplifier Q820-Q840 are switched on when the BANDWIDTH switch is in the full position. With the BANDWIDTH switch in the 20 MHz position Q860-Q880 is switched on. A filter in the collectors of Q860-Q880 limit the bandwidth. CR860 and CR880 isolate the filter from the output when in the FULL mode.

The trigger signal circuitry is similar to the display signal circuitry with Q920 and Q940 as level shifters for the FULL bandwidth position and Q960 and Q980 as level shifters for the 20 MHz bandwidth position.

### Connectors

All the connections made to the mainframe by the 7A16A are shown on the connectors portion of Diagram 1. Also shown are the power supply decoupling components.

### Readout Encoding

The Readout Encoding circuit consists of switching resistors and probe sensing stage Q620. This circuit encodes the Row and Column output lines for readout of deflection factor, uncalibrated deflection factor (VARIABLE) information, and signal inversion. Data is encoded on these output lines by switching resistors between them and the time-slot input lines or by current added through Q620.

R647-C647 are switched between time-slot three (TS-3) and the Column output line when the CAL switch is in the un-cal position. This results in the symbol > (greater than) being displayed preceding the deflection factor readout. R648 is switched between TS-2 and the Column output line



when the POLARITY switch is in the INVERT position. This results in the symbol  $\downarrow$  (inverted) being displayed preceding the deflection factor readout.

Switching resistors are used to indicate the setting of the VOLTS/DIV switch to the mainframe readout system. The dots on the contact-closure chart (see Diagram Section) indicate when the associated contacts on the VOLTS/DIV cam switch are closed. R633, R634, and R635 select the number 1, 2, or 5 depending on the combination that is switched in. R637 selects the m (milli-) prefix and R639 selects the symbol V (volts) in the 5 mV through .5 V (500 mV) positions of the VOLTS/DIV switch. R638 selects the symbol V in the 1, 2, and 5 V positions. R630, R631, and the output of the probe sensing stage (Q620) select the decimal point (number of zeroes), again depending on the resistor combination switched in by the VOLTS/DIV switch.

Probe sensing stage Q620 identifies the attenuation factor of the probe connected to the INPUT connector by sensing the amount of current flowing through the probe coding resistor located in the probe connector. The output of this circuit corrects the mainframe readout system to include the probe attenuation factor. The third contact of the INPUT connector provides the input to the probe sensing device from the probe coding resistance (coded probes only; see Operating Instructions). The third contact is also used for the IDENTIFY input. The coding resistor forms a voltage divider with R621 through CR621 to the -15 V supply. The resultant voltage sets the bias on Q620 and determines the collector current, along with emitter

resistor R622. When the -15 volt time-slot pulse is applied to Interface Connector B33, Q620 is interrogated and its collector current is added to the column current output through Interface Connector A37.

With a 1X probe (or no probe) connected to the INPUT connector, Q620 is turned off. The deflection factor readout is determined by the VOLTS/DIV switch position. With a 10X probe connected, the bias on Q620 allows 100 microamperes of collector current to flow. This increases the deflection factor readout by a factor of 10.

The IDENTIFY button (S45 on Diagram 1) does two things when pressed:

1. It causes the trace representing the 7A16A to move (see the discussion on the Position Circuit).
2. Forward biases CR621 and Q620 to result in a sufficient amount of collector current which replaces the deflection factor readout with the word "IDENTIFY".

These two actions aid in identifying the 7A16A trace when multiple traces are displayed. When the IDENTIFY button is released, the deflection factor readout is restored.

For further information on the operation of the readout system, see the oscilloscope instruction manual.



# MAINTENANCE

## Introduction

This section of the manual contains maintenance information for use in preventive maintenance, corrective maintenance, and troubleshooting of the 7A16A.

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 board. 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.

## Lubrication

Use a cleaning-type lubricant on shaft bushings, interconnecting plug contacts, and switch contacts. Lubricate switch detents with a heavier grease. A lubrication kit containing the necessary lubricating materials and instructions is available through any TEKTRONIX Field Office. Order TEKTRONIX Part Number 003-0342-00.

## TROUBLESHOOTING

### General

The following is provided to augment information contained in other sections of this manual when troubleshooting the 7A16A. 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 7A16A 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 7A16A are color coded to facilitate tracing wires from one point to another in the unit.

**Semiconductor Lead Configuration.** The lead configurations of the semiconductor devices used in this instrument are shown on the schematic diagrams.

## Troubleshooting Equipment

The following equipment is useful for troubleshooting the 7A16A.

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.

2. **DC Voltmeter and Ohmmeter**—A voltmeter is required for checking voltages within the circuits, and an ohmmeter for checking resistors and diodes.

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

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 7A16A 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 7A16A 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 input signals 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 Performance Check of Section 5. The apparent trouble may only be a result of mis-adjustment, and may be corrected by calibration. Complete calibration instructions are given in 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 Diagram section.

6. **Check Individual Components.** The following methods are provided for checking the individual components. 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 board, 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.** The best check of transistor operation is actual performance under operating conditions. If a transistor 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. Be sure the power is off before attempting to remove or replace any transistor.

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.

### CAUTION

*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 7A16A 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 7A16A. 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 Board.** The Attenuator Circuit Board is 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 board).** 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.

## Maintenance—7A16A

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.

**Metal Terminals.** When soldering metal terminals (potentiometers, 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.*

**Semiconductor Replacement.** Transistors 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 effect the calibration of this instrument. When transistors 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. The schematic diagram shows the lead configurations 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.

## Circuit Board Removal

In general, the circuit boards used in the 7A16A need never be removed unless they must be replaced. Electrical connections to the boards are made by soldered connections. If it is necessary to replace a circuit board assembly, use the following procedures.

### A. READOUT CIRCUIT BOARD REMOVAL

1. Disconnect the wires connected to the outside of the board.

2. Remove the seven screws holding the board to the mounting surface.

3. Disconnect the wires connected to the inside of the board.

4. Remove the board from the unit.

5. To replace the board, reverse the order of removal.

### B. ATTENUATOR CIRCUIT BOARD REMOVAL

1. Remove the readout board as outlined in the previous procedure.

2. Disconnect the inductor, capacitor, and two ground straps connected to the rear of the board.

3.. Loosen the front set screw on the VARIABLE control shaft coupling (use a 0.050-inch hex-key wrench).

4. Remove the red VARIABLE control knob and glass rod from the control shaft.

5. Remove the remaining front-panel knobs using a 1/16-inch hex-key wrench.

6. Remove the front panel from the instrument by prying at center bottom with screwdriver.

7. Remove the attenuator shields.

8. Disconnect the wires and resistor from the INPUT BNC connector.

9. Remove the INPUT BNC connector.

10. Remove the attenuator board with cam switch from the instrument.

11. Replace by reversing the Removal Procedures.

### C. AMPLIFIER CIRCUIT BOARD REMOVAL

1. Remove the plastic plug-in guide from the rear of the instrument.

2. Disconnect the wires connected to the board from the front-panel controls.

3. Loosen the hex-socket screw in the coupling of the VARIABLE control shaft using a 0.050-inch hex-key wrench. Pull the VARIABLE knob and glass shaft from the front of the instrument.

4. Disconnect the inductor, capacitor, and two ground straps from the front of the board.

5. Remove the screws and nuts securing the board to the chassis or other mounting surface.

6. Remove the board from the instrument.

7. To replace, reverse the order of removal.

### Switch Replacement

Several types of switches are used in the 7A16A. The slide and micro switches should be replaced as a unit if damaged. The following special maintenance information is provided for the cam-type switches.



*Repair of cam-type switches should be undertaken only by experienced maintenance personnel. Switch alignment and spring tension of the contacts must be carefully maintained for proper operation of the switch. For assistance in maintenance of cam-type switches, contact your local TEKTRONIX Field Office or representative.*

### A. CAM-TYPE SWITCHES

A cam-type switch consists of a rotating cam, which is turned by the front-panel knobs, and a set of contacts mounted on an adjacent circuit board. These switch contacts are actuated by lobes on the cam. The VOLTS/DIV and AC-GND-DC (coupling) cam-type switches can be disassembled for inspection, cleaning, repair, or replacement as follows:

1. Remove the Readout board and the Attenuator board/switch assembly as described previously. The front switch section on the Attenuator board is the AC-GND-DC switch and the rear switch section is the VOLTS/DIV switch. The switches are now open for inspection or cleaning.

2. To completely remove the switch from the board, remove the two screws and four hexagonal posts which hold the cam-type switch to the circuit board.

3. To remove the cam from the front support block, remove the retaining ring from the shaft on the front of the switch and slide the cam out of the support block. Be careful not to lose the small detent roller.

4. To replace defective switch contacts, follow the instructions given in the switch repair kit.

5. To re-install the switch assembly, reverse the above procedure.

### Recalibration After Repair

After any electrical component has been replaced, the calibration of that particular circuit should be checked, as well as the calibration of other closely related circuits. Refer to Section 5 for these procedures.

# CALIBRATION

## Introduction

To assure instrument accuracy, check the calibration of the 7A16A 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 the Factory Service Center. Contact your local field office or representative for further information.

## Performance Check

The performance of this instrument can be checked by performing only the ✓ CHECK steps. Performing the steps marked with a ✓ indicate that the instrument is checked against the tolerances listed as a Performance Requirement (see Specification section in Operators manual).

Limits and tolerances given in other check steps are calibration guides and should not be interpreted as instrument specifications. Operator front-panel adjustments are adjusted as part of the Performance Check procedure.

## Calibration

To verify proper calibration of the 7A16A and to prevent unnecessary re-calibration of the entire instrument, perform the Adjust— portion of a step only if the tolerance given in the Check— part of the step is not met.

For best overall instrument performance when performing a complete calibration procedure, make each adjustment to the exact setting even if the Check— is within allowable tolerance.

## TEST EQUIPMENT REQUIRED

### General

The following test equipment and accessories, or its equivalent, is required for complete calibration of the 7A16A. Specifications given for the test equipment are the minimum necessary for accurate calibration. Therefore, the specifications of any test equipment used must meet or exceed the listed specifications. All test equipment is assumed to be correctly calibrated and operating within the listed specifications. Detailed operating instructions for the test equipment are not given in this procedure. Refer to the instruction manual for the test equipment if more information is needed.

### Special Calibration Fixtures

Special TEKTRONIX calibration fixtures are used in this procedure only where they facilitate instrument calibration. These special calibration fixtures are available from Tektronix, Inc. Order by part number through your local TEKTRONIX Field Office or representative.

### Calibration Equipment Alternatives

All of the listed test equipment is required to completely check and adjust this instrument. The Calibration procedure is based on the first item of equipment given as an example of applicable equipment. When other equipment is substituted, control settings or the calibration setup may need to be altered slightly to meet the requirements of the substitute equipment. If the exact item of test equipment given as an example in the Test Equipment list is not available, first check the Specifications column carefully to see if any other equipment is available which might suffice. Then check the Usage column to see what this item of test equipment is used for. If used for a check or adjustment which is of little or no importance to your measurement requirements, the item and corresponding step(s) can be deleted.



## TEST EQUIPMENT

Description	Minimum Specifications	Usage	Examples of Applicable Test Equipment
Calibration oscilloscope	7000-Series oscilloscope mainframe. 7900-Series required to check 7A16A maximum bandwidth and risetime.	Used throughout procedure to provide display.	1. TEKTRONIX 7904 Oscilloscope. 2. Any TEKTRONIX 7000-Series oscilloscopes. Check Specifications for bandwidth and risetime.
Time Base Unit	7A-Series timebase unit. Sweep speed to 2 ns/div.	Used throughout procedure to provide horizontal sweep.	1. TEKTRONIX 7B70 Time Base or equivalent.
Standard Amplitude Calibrator	Amplitude accuracy, within 0.25%; signal amplitude, 20 mV to 20 V; frequency, 1 kHz square-wave.	Used for gain calibration only.	1. TEKTRONIX Calibration fixture 067-0502-01.
Square-wave Generator	Output Capabilities: 12 V into 50 $\Omega$ with a risetime of at least 12 ns and a frequency of approximately 1 kHz; 500 mV into 50 $\Omega$ with a risetime of at least 1 ns at 100 kHz.	Used for Input Compensation and Low Frequency Compensation only.	1. TEKTRONIX Type 106 Square-wave Generator.
Pulse Generator	Risetime of at least 70 ps, step amplitude of 200 mV into 50 $\Omega$ .	Used for High Frequency Compensation only.	1. TEKTRONIX Type 284 Pulse Generator.
Constant Amplitude Signal Generator	Upper frequency range, 225 MHz; reference frequency, approximately 3 MHz; constant amplitude accuracy, within 2% of reference frequency; amplitude range, 0.5 V to 4 V P-P.	Used for Bandwidth check only.	1. TEKTRONIX Calibration Fixture 067-0532-01.
Accessories			
BNC Cable	Connectors, BNC; length, 42 inches.	Used throughout procedure.	
GR Cable	Connectors, GR; Impedance, 50 $\Omega$ ; length, approximately 20 inches.	Used for High Frequency Compensation and Risetime only.	TEKTRONIX Part Number 017-0515-00.
X10 Attenuator	Connectors, GR; Impedance, 50 $\Omega$ .	Used throughout the procedures.	TEKTRONIX Part Number 017-0078-00.
RC Normalizer	Time Constant, 1 M $\Omega$ X 20 pF; connectors, BNC; attenuation, 2X.	Used for Input Compensation.	TEKTRONIX Part Number 067-0583-00.
Termination (thru line)	Impedance, 50 $\Omega$ ; connectors, GR to BNC male.	Used throughout procedures.	TEKTRONIX Part Number 017-0083-00.

## SHORT FORM PROCEDURE

## Balance

1. Check/Adjust DC Bal (R160) vertical deflection of 0.2 division or less while switching between +UP and INVERT.
2. Check/Adjust 2X Bal (R453) for vertical deflection of 0.2 division or less while switching between 5 mV and 10 mV.
3. Check/Adjust Var Bal (R553) for vertical deflection of 0.2 division or less while rotating the VARIABLE control throughout the range.

## Gain

- ✓ 4. Adjust GAIN control (R516) to obtain a display of exactly five vertical divisions when the VOLTS/DIV switch is set to 5 mV and the standard amplitude calibrator is set to 20 mV square-wave out.
5. Check/Adjust 2X Gain control (R413) to obtain a display of exactly four vertical divisions when the VOLTS/DIV switch is set to 10 mV and the standard amplitude calibrator is set to 50 mV square-wave out.
- ✓ 6. Check all VOLTS/DIV switch settings: Within 2%.

## Compensation

7. Adjust Input Compensation controls shown in Table 5-2 for rolloff or overshoot not to exceed 0.06 div.
8. Adjust Low Frequency Compensation (R436) for a flat top (minimum tilt) with a 25 kHz square-wave applied.
9. Adjust High Frequency Compensation R531, C531, R436, C436, R756, C756, R770, and C770 for aberrations not more than  $\pm 3\%$  and total aberrations not more than 4% P-P.

## Risetime and Bandwidth

- ✓10. Check risetime within the system tolerances given in the Specifications section.
- ✓11. Check bandwidth within the system tolerances given in the Specifications section.

Check that the bandwidth is 20 MHz  $\pm 3$  MHz when the BANDWIDTH switch is in the 20 MHz position.

## CALIBRATION PROCEDURE

### General

The following procedure is arranged so that the 7A16A can be calibrated with the least interaction of adjustments and re-connection of equipment. The control settings and test equipment setup throughout this procedure continue from the preceding steps unless otherwise noted. Refer to Fig. 5-1 for location of adjustments.

### NOTE

*Control titles which are printed on the front panel of the 7A16A are capitalized (e.g. POSITION). Internal adjustments and associated equipment controls are initially capitalized only (e.g. oscilloscope Vertical Mode).*

### Preliminary Procedure for Calibration

1. Remove the oscilloscope left side cover and side panel of plug-in.
2. Insert the 7A16A in the calibration oscilloscope Left Vertical compartment.

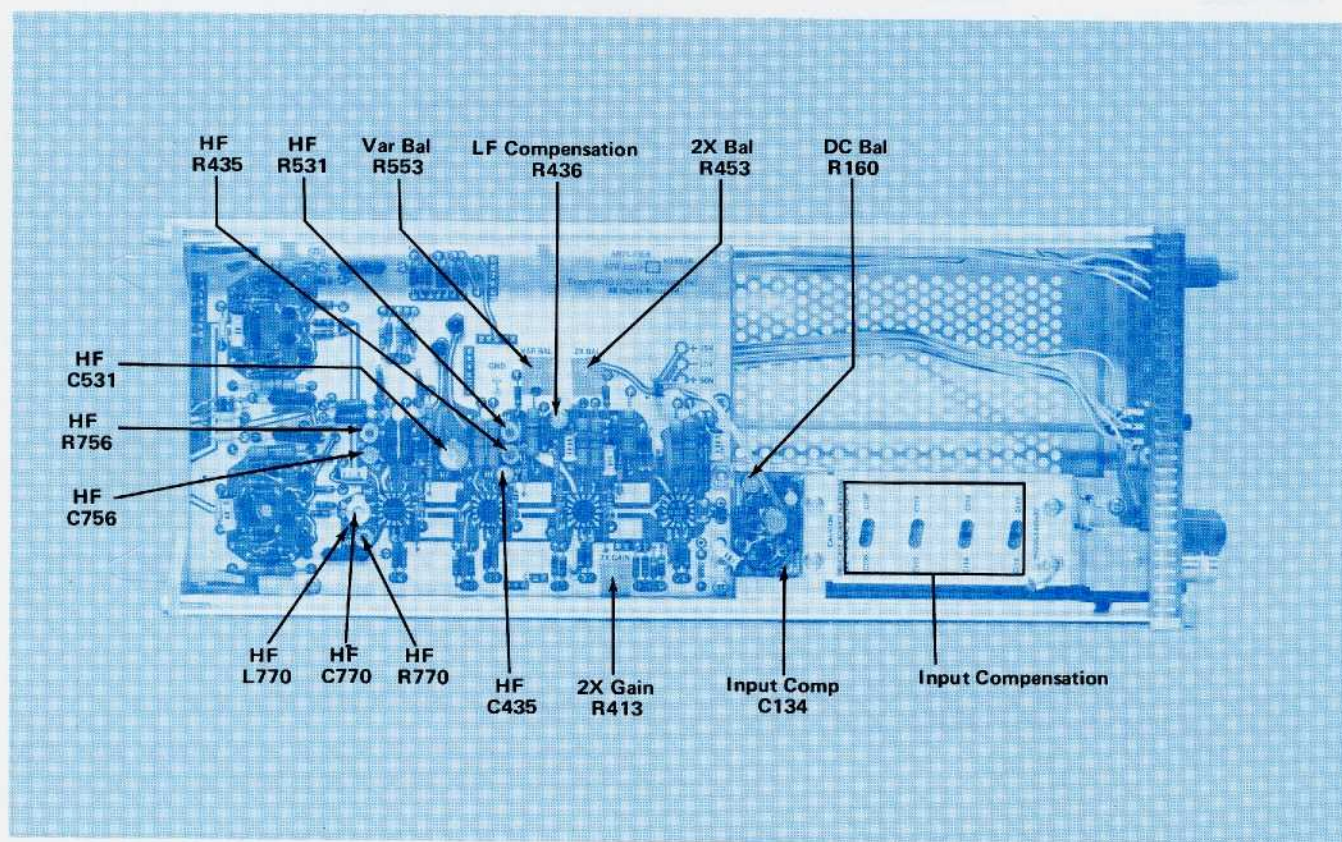


Fig. 5-1. Location of adjustments.

## Calibration—7A16A

3. Insert the time base unit into the calibration oscilloscope Horizontal compartment.

4. Turn oscilloscope on and allow 20 minutes warm-up before proceeding.

### NOTE

*This instrument should be calibrated at an ambient temperature of +20°C to +30°C for best overall accuracy. The performance of the instrument can be checked at any temperature within the 0°C to +50°C range.*

## Preliminary Control Settings

Set the calibration oscilloscope and time base unit for a sharp, well defined trace. Set the 7A16A control as follows:

### 7A16A Control Settings

POSITION	midrange
POLARITY	+UP
BANDWIDTH	FULL
VOLTS/DIV	5 mV
AC-DC-GND	GND
VARIABLE	CAL IN

## BALANCE

### 1. Check/Adjust DC Bal

a. Check—that the vertical trace shift is 0.2 division or less while switching the POLARITY switch between +UP and INVERT.

b. Adjust—R160, DC Bal control, for a vertical deflection of 0.2 division or less while switching the POLARITY switch between +UP and INVERT.

c. Return the POLARITY switch to +UP.

### 2. Check/Adjust 2X Bal

a. Check—that the vertical trace shift is 0.2 division or less while switching the VOLTS/DIV switch between 10 mV and 5 mV.

b. Adjust—R453, 2X Bal control, for a vertical deflection of 0.2 division or less while switching the VOLTS/DIV switch between 10 mV and 5 mV.

c. Return the VOLTS/DIV switch to 5 mV.

## 3. Check/Adjust Var Bal

a. Check—that the vertical trace shift is 0.2 division or less while rotating the VARIABLE control throughout the range.

b. Adjust—R553, Var Bal control, for a vertical deflection of 0.2 division or less while rotating the VARIABLE control throughout the range.

c. Return the VARIABLE control to the CAL IN position.

## GAIN

### ✓4. Adjust GAIN

a. Connect the Standard Amplitude Calibrator to the 7A16A INPUT connector with the 42-inch BNC cable.

b. Set the AC-GND-DC switch to DC and adjust the Standard Amplitude Calibrator to obtain a 20 mV square-wave.

c. Adjust—the front panel GAIN control to obtain a display of exactly 4 divisions.

### 5. Check/Adjust 2X Gain

a. Set the VOLTS/DIV switch to 10 mV and adjust the Standard Amplitude Calibrator to obtain a 50 mV square-wave.

b. Check—that the display amplitude is 5 divisions  $\pm 0.1$  division.

c. Adjust—R413, 2X Gain control, to obtain a vertical display of 5 divisions  $\pm 0.1$  division.

### ✓6. Check All VOLTS/DIV Gain Settings

a. Check—that all VOLTS/DIV gain settings are within 2%. Refer to Table 5-1 for control settings and tolerances.

b. Return the VOLTS/DIV switch to 10 mV and disconnect the Standard Amplitude Calibrator.

TABLE 5-1  
Vertical Deflection Accuracy

VOLTS/DIV Switch Setting	Standard Amplitude Calibrator Output	Vertical Deflection in Divisions	Maximum Error for $\pm 2\%$ Accuracy (divisions)
5 mV	20 mV	4	Set in step 4
10 mV	50 mV	5	$\pm 0.1$
20 mV	0.1 V	5	$\pm 0.1$
50 mV	0.2 V	4	$\pm .08$
.1 V	0.5 V	5	$\pm 0.1$
.2 V	1 V	5	$\pm 0.1$
.5 V	2 V	4	$\pm .08$
1 V	5 V	5	$\pm 0.1$
2 V	10 V	5	$\pm 0.1$
5 V	20 V	4	$\pm .08$

## COMPENSATION

### 7. Adjust Input Compensation

a. Connect the Square-wave Generator to the 7A16A INPUT through a X10 50  $\Omega$  attenuator, 50  $\Omega$  termination, and a 20 pF RC Normalizer.

b. Set the Square-wave Generator to obtain a 1 kHz, six-division display. Maintain a six division display for all VOLTS/DIV switch positions, remove the X10 attenuator when necessary.

c. Adjust—and check compensation for best front corner and flat top as shown in Table 5-2. Rolloff or overshoot should not exceed .06 division.

d. Disconnect the Square-wave Generator from the 7A16A and return the VOLTS/DIV switch to 10 mV.

TABLE 5-2  
Attenuator Compensation

VOLTS/DIV Switch Setting	Adjust for Optimum	
	Square Corner	Flat Top
5 mV	C134	—
10 mV	Check	Check
20 mV	C106	C107
50 mV	C110	C111
.1 V	C114	C115
.2 V	Check	Check
.5 V	Check	Check
1 V	C118	C119
2 V	Check	Check
5 V	Check	Check

### 8. Adjust Low Frequency Compensation

a. Connect the Square-wave Generator to the 7A16A INPUT through a X10 50  $\Omega$  attenuator and a 50  $\Omega$  terminator.

b. Set the Square-wave Generator to obtain approximately six vertical divisions of a 25 kHz square-wave.

c. Adjust—R436, LF compensation control, for best flat top (minimum tilt).

d. Disconnect the Square-wave Generator.

### 9. Adjust High Frequency Compensation

a. Connect the Pulse Generator to the 7A16A INPUT via a GR cable, X10 GR attenuator, and a 50  $\Omega$  Terminator.

b. Set the 7A16A VOLTS/DIV switch to 5 mV and adjust the Pulse generator for a vertical display of approximately 6 divisions.

c. Set the time base unit to obtain a triggered display at a rate of approximately .02  $\mu$ s per division.

d. Position the top of the waveform to 1 division above center screen.

e. Adjust—high frequency controls: R531, C531, R436, C436, R756, C756, R770, and C770 in that order for best front corner and flat top. Aberrations should not exceed  $\pm 4\%$  and 6% peak to peak.

#### NOTE

*If integrated circuit U750 or transistors Q820 or Q840 are replaced, it may become necessary to readjust coil L770. If satisfactory results are not achieved by adjusting all other high frequency controls, then adjust L770 in the following manner: Remove L770 from the plug-in socket and shorten the coil by clipping a small piece with a diagonal cutter. Replace the coil to the plug-in sockets. If aberrations decrease, continue to shorten the coil for optimum results. If the aberrations are increased, form a larger coil using AWG 26 gauge bare wire.*

## RISETIME AND BANDWIDTH

### ✓10. Check Risetime

a. Increase the sweep speed of the Time Base unit to approximately 2 ns (0.02  $\mu$ s and X10 Mag).

b. Check—that the risetime of the leading edge of the pulse is within the specifications given in Table 5-3.

c. Disconnect all Test equipment.

**TABLE 5-3**

**System Risetime and Bandwidth**

Mainframe	Bandwidth	Risetime
7900-Series	225 MHz	1.6 ns
7700-Series	150 MHz	2.4 ns
7500-Series	90 MHz	3.9 ns
7400-Series	60 MHz	5.9 ns

### ✓11. Check Bandwidth

a. Connect the Constant Amplitude Signal Generator to the 7A16A INPUT thru a 50  $\Omega$  termination.

b. Set the Constant Amplitude Signal Generator to the reference frequency of 3 MHz and adjust the output amplitude to obtain a 6 division display.

c. Change the frequency of the Constant Amplitude Signal Generator to the value given in Table 5-3.

d. Check—that the amplitude of the display is 4.2 div or greater.

This completes the calibration for the 7A16A.



# SECTION 6

## ELECTRICAL PARTS LIST

7A16A

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

### ABBREVIATIONS AND REFERENCE DESIGNATORS

A	Assembly, separable or repairable	FL	Filter	PTM	paper or plastic, tubular molded
AT	Attenuator, fixed or variable	H	Heat dissipating device (heat sink, etc.)	R	Resistor, fixed or variable
B	Motor	HR	Heater	RT	Thermistor
BT	Battery	J	Connector, stationary portion	S	Switch
C	Capacitor, fixed or variable	K	Relay	T	Transformer
Cer	Ceramic	L	Inductor, fixed or variable	TP	Test point
CR	Diode, signal or rectifier	LR	Inductor/resistor combination	U	Assembly, inseparable or non-repairable
CRT	cathode-ray tube	M	Meter	V	Electron tube
DL	Delay line	Q	Transistor or silicon-controlled rectifier	Var	Variable
DS	Indicating device (lamp)	P	Connector, movable portion	VR	Voltage regulator (zener diode, etc.)
Elect.	Electrolytic	PMC	Paper, metal cased	WW	wire-wound
EMC	electrolytic, metal cased	PT	paper, tubular	Y	Crystal
EMT	electrolytic, metal tubular				
F	Fuse				

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
<b>ASSEMBLIES</b>				
A1	670-2324-00			ATTENUATOR Circuit Board Assembly
A2	670-2323-00			AMPLIFIER Circuit Board Assembly
A3	670-2310-00			READOUT Circuit Board Assembly
<b>CAPACITORS</b>				
C10	285-0816-01			0.019 $\mu$ F, Plastic, 600 V, 10%
C13	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C15	283-0000-00			0.001 $\mu$ F, CER, 500 V, +100%-0%
C106 } C107 }	307-1010-00			X2 attenuator strip
C110 } C111 }	307-1012-00			X5 attenuator strip
C114 } C115 }	307-1013-01			X10 attenuator, thick film
C117	281-0626-00			3.3 pF, CER, 500 V, 5%
C118 } C119 }	307-1013-01			X10 attenuator, thick film
C130	281-0670-00			1.8 pF, Cer, 500 V, $\pm 0.1$ pF
C132	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C134	281-0064-00			0.25-1.5 pF, Var, Plastic, 600 V
C140	281-0615-00			3.9 pF, Cer, 200 V, $\pm 0.5$ pF
C150	281-0562-00			39 pF, Cer, 500 V
C154	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C158	290-0536-00			10 $\mu$ F, Elect., 25 V, 20%
C190	281-0600-00			35 pF, Cer, 10%
C334	281-0628-00			15 pF, Cer, 600 V, 5%
C329	283-0000-00			0.001 $\mu$ F, Cer, 500 V, +100%-0%
C331	283-0041-00			0.0033 $\mu$ F, Cer, 500 V, 5%



## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
CAPACITORS (cont)			
C332	283-0026-00		0.2 $\mu$ F, Cer, 25 V, +80%-20%
C350	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C431	281-0546-00		330 pF, Cer, 500 V, 10%
C434	281-0540-00		51 pF, Cer, 5%
C435	281-0123-00		5-25 pF, Var, Cer, 100 V
C436	283-0010-00		0.01 $\mu$ F, Cer, 50 V
C530	281-0628-00		15 pF, Cer, 600 V, 5%
C531	281-0167-00		15-42 pF, Var, Cer, 200 V
C534	283-0003-00		0.01 $\mu$ F, Cer, 150 V, +80%-20%
C538	283-0238-00		0.01 $\mu$ F, Cer, 50 V, 10%
C621	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C630	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C634	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C635	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C638	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C643	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C647	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C648	283-0003-00		0.01 $\mu$ F, Cer, 150 V, +80%-20%
C649	283-0000-00		0.001 $\mu$ F, Cer, 500 V, +100%-0%
C721	281-0534-00		3.3 pF, Cer, $\pm 0.25$ pF
C754	283-0067-00		0.001 $\mu$ F, Cer, 200 V, 10%
C756	281-0161-00		5-15 pF, Var, Cer, 350 V
C770	281-0168-00		1.3-5.4 pF, Var, Air, 250 V
C820	283-0010-00		0.05 $\mu$ F, Cer, 50 V
C840	283-0010-00		0.05 $\mu$ F, Cer, 50 V
C860	283-0644-00		150 pF, Mica, 500 V, 1%
C880	281-0603-00		39 pF, Cer, 500 V, 5%
C903	281-0557-00		1.8 pF, Cer, 500 V
C920	283-0010-00		0.05 $\mu$ F, Cer, 50 V
C940	283-0010-00		0.05 $\mu$ F, Cer, 50 V
C960	283-0644-00		150 pF, Mica, 500 V, 1%
C980	281-0603-00		39 pF, Cer, 500 V, 5%
C1010	283-0002-00		0.01 $\mu$ F, Cer, 500 V
C1012	283-0002-00		0.01 $\mu$ F, Cer, 500 V
C1020	283-0002-00		0.01 $\mu$ F, Cer, 500 V
C1022	283-0002-00		0.01 $\mu$ F, Cer, 500 V
DIODES			
CR130	152-0321-00	Silicon	FSA1480
CR507	152-0141-02	Silicon	1N4152
CR621	152-0141-02	Silicon	1N4152
CR631	152-0141-02	Silicon	1N4152
CR647	152-0141-02	Silicon	1N4152
CR720	152-0141-02	Silicon	1N4152
CR860	152-0141-02	Silicon	1N4152
CR880	152-0141-02	Silicon	1N4152
CR960	152-0141-02	Silicon	1N4152
CR980	152-0141-02	Silicon	1N4152

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
CONNECTOR				
J10	131-0679-00			Receptacle, electrical, BNC, 3 contact
INDUCTORS				
L118	108-0557-00			35 nH
L860	108-0311-00			0.18 $\mu$ H
L880	108-0311-00			0.18 $\mu$ H
L960	108-0311-00			0.18 $\mu$ H
L980	108-0311-00			0.18 $\mu$ H
LR107	108-0744-00			81 nH (wound on a 75 $\Omega$ , 1/4 W, 5% resistor)
LR111	108-0745-00			110 nH (wound on a 130 $\Omega$ , 1/4 W, 5% resistor)
LR1010	108-0184-00			3.2 $\mu$ H (wound on a 100 $\Omega$ , 1/2 W, 5% resistor)
LR1020	108-0184-00			3.2 $\mu$ H (wound on a 100 $\Omega$ , 1/2 W, 5% resistor)
TRANSISTORS				
Q140	151-0367-00			Silicon NPN SKA6516
Q150A,B	151-1032-00			Silicon JFET, N channel, dual, selected 2N5911
Q620	151-0254-00			Silicon NPN 2N5308
Q72C	151-0341-00			Silicon NPN 2N3565
Q730	151-0341-00			Silicon NPN 2N3565
Q820	153-0606-00			Silicon NPN selected quad 2 ea 151-0221-00 and 2 ea 151-0271-00
Q840				
Q860				
Q880				
Q920	151-0271-00			Silicon PNP SAB4113
Q940	151-0271-00			Silicon PNP SAB4113
Q960	151-0221-00			Silicon PNP 2N4258
Q980	151-0221-00			Silicon PNP 2N4258
RESISTORS				
R10	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R13	316-0101-00			100 $\Omega$ , 1/4 W, 10%
R102	316-0105-00			1 M $\Omega$ , 1/4 W, 10%
R104	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R115	315-0430-00			43 $\Omega$ , 1/4 W, 5%
R118	315-0330-00			33 $\Omega$ , 1/4 W, 5%
R130	321-0481-00			1 M $\Omega$ , 1/8 W, 1/2%
R132	316-0474-00			470 k $\Omega$ , 1/4 W, 10%
R134	315-0751-00			750 $\Omega$ , 1/4 W, 5%
R140	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R142	315-0132-00			1.3 k $\Omega$ , 1/4 W, 5%
R144	315-0221-00			220 $\Omega$ , 1/4 W, 5%
R145	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R150	315-0200-00			20 $\Omega$ , 1/4 W, 5%
R151	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R152	315-0200-00			20 $\Omega$ , 1/4 W, 5%
R154	317-0105-00			1 M $\Omega$ , 1/8 W, 5%
R156	315-0201-00			200 $\Omega$ , 1/4 W, 5%
R158	315-0621-00			620 $\Omega$ , 1/4 W, 5%
R160	311-1268-00			10 k $\Omega$ , Var
R162	315-0200-00			20 $\Omega$ , 1/4 W, 5%

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
RESISTORS (cont)			
R164	315-0562-00		5.6 k $\Omega$ , 1/4 W, 5%
R301	316-0271-00		270 $\Omega$ , 1/4 W, 10%
R303	316-0271-00		270 $\Omega$ , 1/4 W, 10%
R305	315-0391-00		390 $\Omega$ , 1/4 W, 5%
R307	315-0391-00		390 $\Omega$ , 1/4 W, 5%
R311	315-0272-00		2.7 k $\Omega$ , 1/4 W, 5%
R313	315-0272-00		2.7 k $\Omega$ , 1/4 W, 5%
R320	323-0179-00		715 $\Omega$ , 1/2 W, 1%
R323	323-0179-00		715 $\Omega$ , 1/2 W, 1%
R327	316-0822-00		8.2 k $\Omega$ , 1/4 W, 10%
R329	316-0822-00		8.2 k $\Omega$ , 1/4 W, 10%
R331	315-0242-00		2.4 k $\Omega$ , 1/4 W, 5%
R332	315-0362-00		3.6 k $\Omega$ , 1/4 W, 5%
RT334	307-0127-00		1 k $\Omega$ , Thermal
R401	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R403	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R405	323-0139-00		274 $\Omega$ , 1/2 W, 1%
R411	315-0202-00		2 k $\Omega$ , 1/4 W, 5%
R413	311-1226-00		2.5 k $\Omega$ , Var
R414	316-0271-00		270 $\Omega$ , 1/4 W, 10%
R415	315-0302-00		3 k $\Omega$ , 1/4 W, 5%
R417	315-0302-00		3 k $\Omega$ , 1/4 W, 5%
R419	316-0681-00		680 $\Omega$ , 1/4 W, 10%
R420	323-0198-00		1.13 k $\Omega$ , 1/2 W, 1%
R423	323-0198-00		1.13 k $\Omega$ , 1/2 W, 1%
R431	315-0512-00		5.1 k $\Omega$ , 1/4 W, 5%
R434	315-0162-00		1.6 k $\Omega$ , 1/4 W, 5%
R435	311-1259-00		100 $\Omega$ , Var
R436	311-1269-00		20 k $\Omega$ , Var
R440	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R442	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R451	316-0822-00		8.2 k $\Omega$ , 1/4 W, 10%
R453	311-1228-00		10 k $\Omega$ , Var
R501	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R503	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R505	323-0139-00		274 $\Omega$ , 1/2 W, 1%
R507	315-0562-00		5.6 k $\Omega$ , 1/4 W, 5%
R511	315-0242-00		2.4 k $\Omega$ , 1/4 W, 5%
R513	315-0201-00		200 $\Omega$ , 1/4 W, 5%
R515 <sup>1</sup>	311-1421-01		2.5 k $\Omega$ , Var
R516	311-0091-00		1 k $\Omega$ , Var
R519	315-0202-00		2 k $\Omega$ , 1/4 W, 5%
R520	323-0213-00		1.62 k $\Omega$ , 1/2 W, 1%
R523	323-0213-00		1.62 k $\Omega$ , 1/2 W, 1%

<sup>1</sup>Furnished as a unit with S515.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff Disc	Description
RESISTORS (cont)			
R531	311-1260-00		250 $\Omega$ , Var
R534	315-0562-00		5.6 k $\Omega$ , 1/4 W, 5%
R537	315-0151-00		150 $\Omega$ , 1/4 W, 5%
R538	315-0562-00		5.6 k $\Omega$ , 1/4 W, 5%
RT539	307-0125-00		500 $\Omega$ , Thermal
R540	315-0431-00		430 $\Omega$ , 1/4 W, 5%
R542	315-0511-00		510 $\Omega$ , 1/4 W, 5%
R550	316-0270-00		27 $\Omega$ , 1/4 W, 10%
R551	316-0822-00		8.2 k $\Omega$ , 1/4 W, 10%
R552	316-0270-00		27 $\Omega$ , 1/4 W, 10%
R553	311-1228-00		10 k $\Omega$ , Var
R578	315-0152-00		1.5 k $\Omega$ , 1/4 W, 5%
R621	321-0223-00		2.05 k $\Omega$ , 1/8 W, 1%
R622	321-0299-00		12.7 k $\Omega$ , 1/8 W, 1%
R630	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R631	315-0753-00		75 k $\Omega$ , 1/4 W, 5%
R633	315-0753-00		75 k $\Omega$ , 1/4 W, 5%
R634	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R635	321-0344-00		37.4 k $\Omega$ , 1/8 W, 1%
R638	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R639	315-0753-00		75 k $\Omega$ , 1/4 W, 5%
R640	315-0753-00		75 k $\Omega$ , 1/4 W, 5%
R642	315-0513-00		51 k $\Omega$ , 1/4 W, 5%
R643	321-0344-00		37.4 k $\Omega$ , 1/8 W, 1%
R645	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R646	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R647	315-0133-00		13 k $\Omega$ , 1/4 W, 5%
R648	315-0154-00		150 k $\Omega$ , 1/4 W, 5%
R701	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R703	321-0069-00		51.1 $\Omega$ , 1/8 W, 1%
R705	321-0093-00		90.9 $\Omega$ , 1/8 W, 1%
R710	315-0151-00		150 $\Omega$ , 1/4 W, 5%
R712	315-0151-00		150 $\Omega$ , 1/4 W, 5%
R714	315-0301-00		300 $\Omega$ , 1/4 W, 5%
R716	315-0301-00		300 $\Omega$ , 1/4 W, 5%
R718	316-0333-00		33 k $\Omega$ , 1/4 W, 10%
R720	316-0472-00		4.7 k $\Omega$ , 1/4 W, 10%
R721	315-0152-00		1.5 k $\Omega$ , 1/4 W, 5%
R730	315-0103-00		10 k $\Omega$ , 1/4 W, 5%
R732	315-0103-00		10 k $\Omega$ , 1/4 W, 5%
R734	315-0431-00		430 $\Omega$ , 1/4 W, 5%
R736 <sup>1</sup>	311-1320-00		5 k $\Omega$ , Var
R750	308-0552-00		750 $\Omega$ , 3 W, WW, 1%

<sup>1</sup>Furnished as a unit with S736.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	No. Disc	Description
RESISTORS (cont)				
R752	308-0552-00			750 $\Omega$ , 3 W, WW, 1%
R754	315-0392-00			3.9 k $\Omega$ , 1/4 W, 5%
R756	311-1259-00			100 $\Omega$ , Var
R758	315-0751-00			750 $\Omega$ , 1/4 W, 5%
R760	315-0122-00			1.2 k $\Omega$ , 1/4 W, 5%
R770	311-0622-00			100 $\Omega$ , Var
R802	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R804	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R806	308-0406-00			1.2 k $\Omega$ , 3 W, WW, 1%
R808	308-0406-00			1.2 k $\Omega$ , 3 W, WW, 1%
R820	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R822	321-0230-00			2.43 k $\Omega$ , 1/8 W, 1%
R824	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R828	316-0271-00			270 $\Omega$ , 1/4 W, 10%
R829	321-0148-00			340 $\Omega$ , 1/8 W, 1%
R830	316-0271-00			270 $\Omega$ , 1/4 W, 10%
R832	321-0230-00			2.43 k $\Omega$ , 1/8 W, 1%
R834	321-0097-00			100 $\Omega$ , 1/8 W, 1%
R840	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R846	315-0111-00			110 $\Omega$ , 1/4 W, 5%
R860	316-0470-00			47 $\Omega$ , 1/4 W, 10%
R880	316-0470-00			47 $\Omega$ , 1/4 W, 10%
R890	323-0193-00			1 k $\Omega$ , 1/2 W, 1%
R892	323-0193-00			1 k $\Omega$ , 1/2 W, 1%
R902	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R904	315-0560-00			56 $\Omega$ , 1/4 W, 5%
R906	308-0304-00			1.5 k $\Omega$ , 3 W, WW, 1%
R908	308-0304-00			1.5 k $\Omega$ , 3 W, WW, 1%
R920	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R928	316-0271-00			270 $\Omega$ , 1/4 W, 10%
R930	316-0271-00			270 $\Omega$ , 1/4 W, 10%
R940	315-0431-00			430 $\Omega$ , 1/4 W, 5%
R946	315-0111-00			110 $\Omega$ , 1/4 W, 5%
R960	316-0470-00			47 $\Omega$ , 1/4 W, 10%
R980	316-0470-00			47 $\Omega$ , 1/4 W, 10%
R990	323-0212-00			1.58 k $\Omega$ , 1/2 W, 1%
R992	323-0212-00			1.58 k $\Omega$ , 1/2 W, 1%
R1010	316-0470-00			47 $\Omega$ , 1/4 W, 10%
R1012	316-0470-00			47 $\Omega$ , 1/4 W, 10%
SWITCHES				
S22A,B	260-0816-00			Slide, POLARITY
S32	260-0816-00			Slide, BANDWIDTH
S100A <sup>1</sup>				Cam, AC-GND-DC
S100B <sup>1</sup>				Cam, VOLTS/DIV
S515 <sup>2</sup>				VARIABLE
S736 <sup>3</sup>				IDENTIFY

<sup>1</sup>See Mechanical Parts List for replacement parts.<sup>2</sup>Furnished as a unit with R515.<sup>3</sup>Furnished as a unit with R736.

## ELECTRICAL PARTS LIST (cont)

Ckt. No.	Tektronix Part No.	Serial/Model No. Eff	Disc	Description
TRANSFORMERS				
T13	120-0304-00			Toroid, 3 turns single
T301	120-0286-00			Toroid, 2 turns bifilar
INTEGRATED CIRCUITS				
U350	155-0078-01			Monolithic, vert amp., selected
U450	155-0078-03			Monolithic, vert amp., selected
U550	155-0078-03			Monolithic, vert amp., selected
U750	155-0078-03	15,95		Monolithic, vert amp., selected



# SECTION 7

## DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

### Symbols and Reference Designators

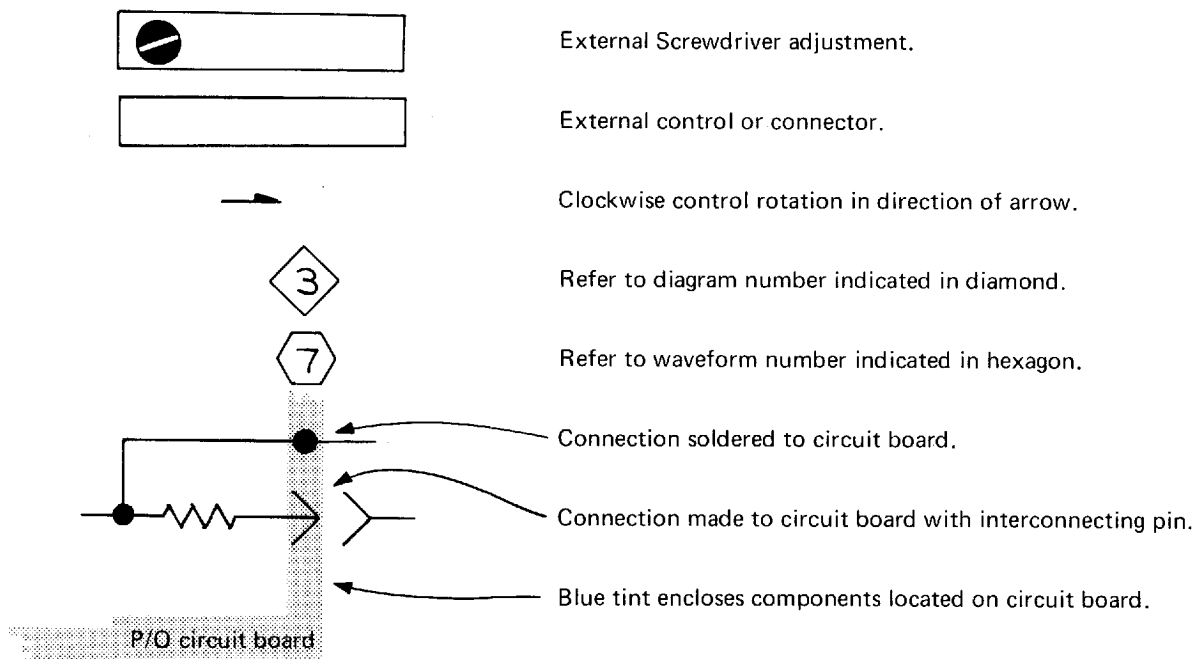
Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF).  
 Values less than one are in microfarads ( $\mu$ F).  
 Resistors = Ohms ( $\Omega$ )

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.

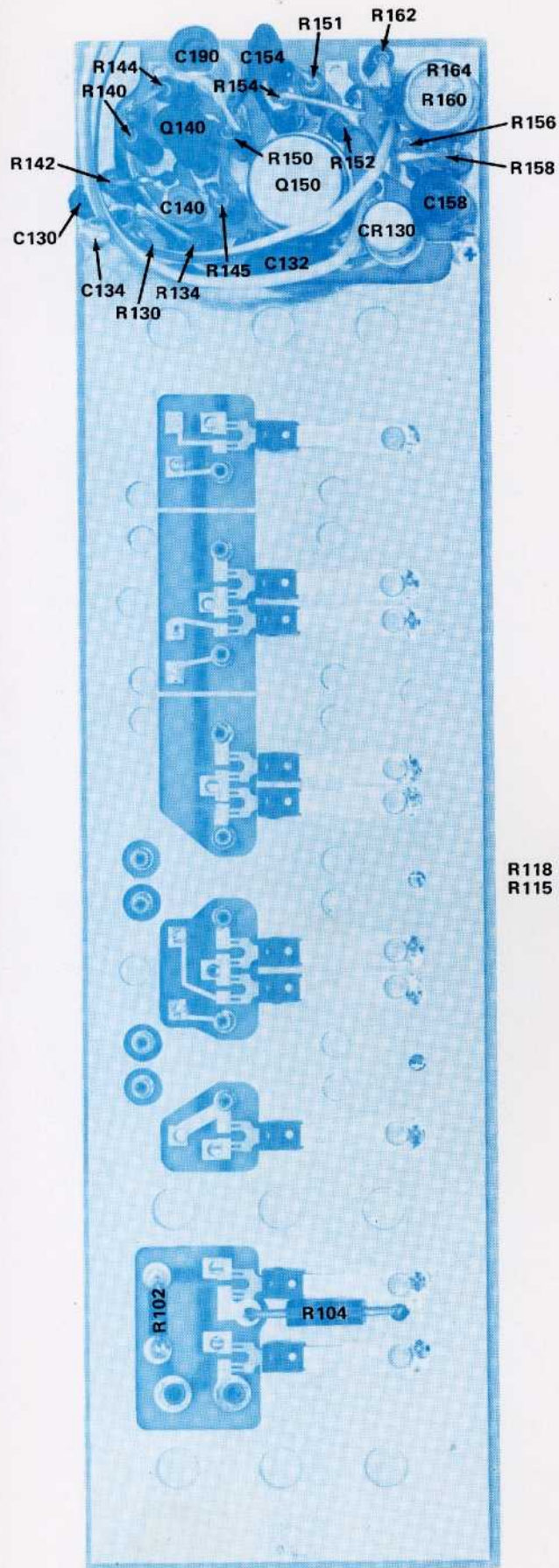
The following special symbols are used on the diagrams:



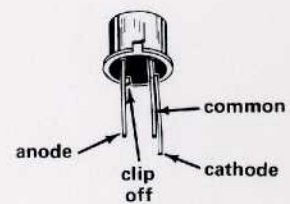
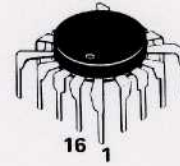
The following prefix letters are used as reference designators to identify components or assemblies on the diagrams.

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		



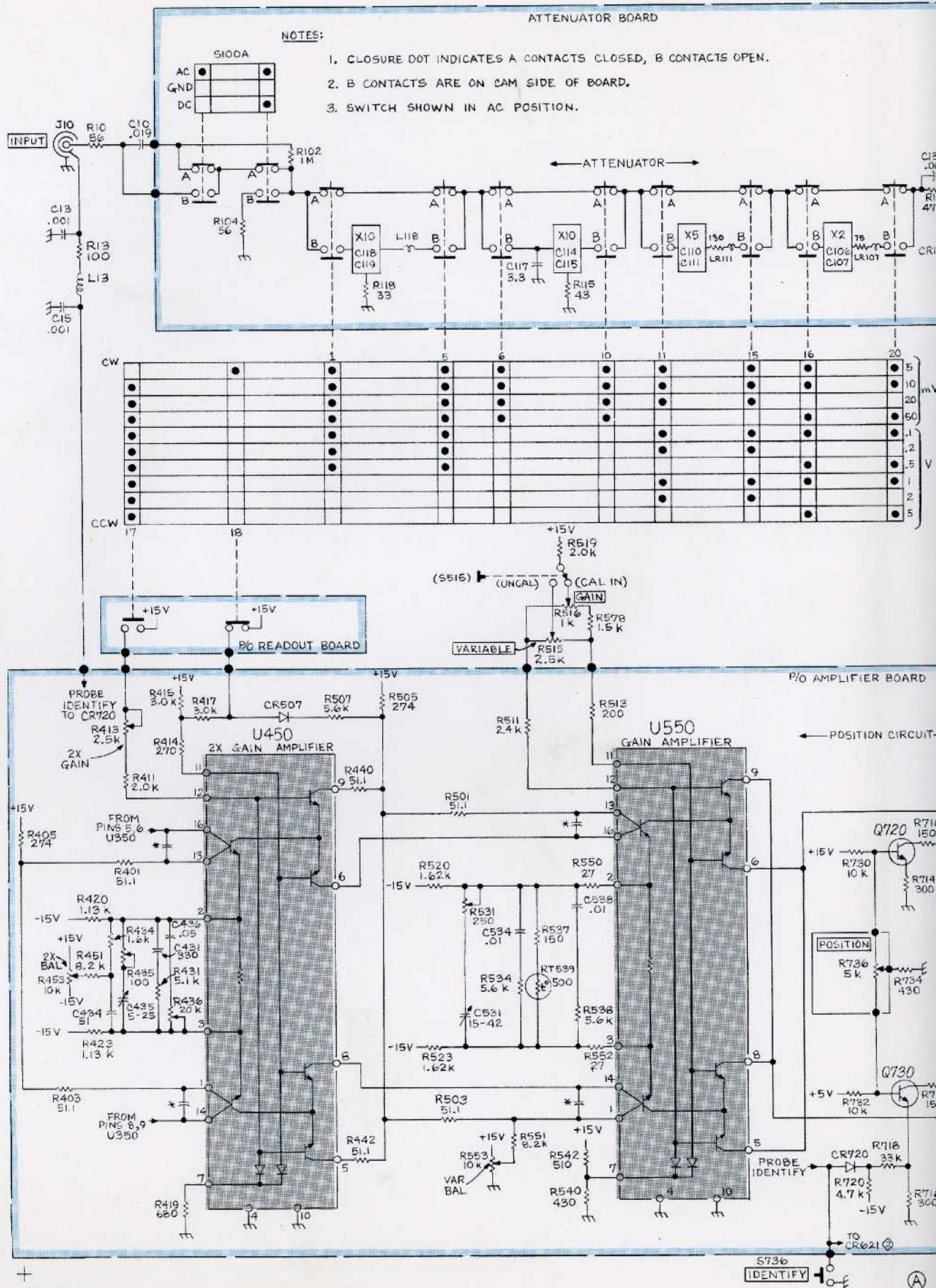


R118 } Located  
R115 } on  
other  
side  
of board



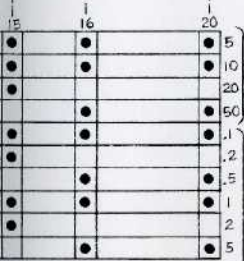
7A16A Attenuator Board.



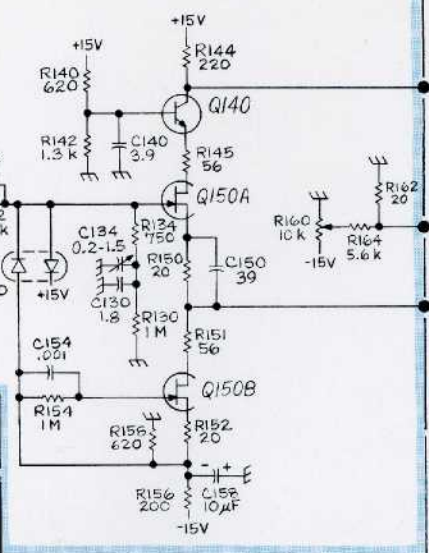




PEN.



← INPUT SOURCE FOLLOWER →



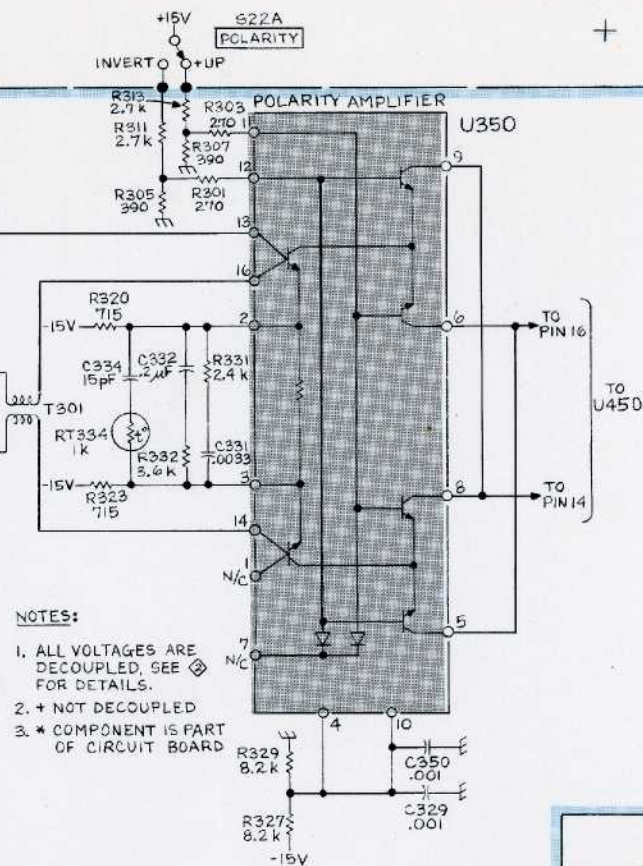
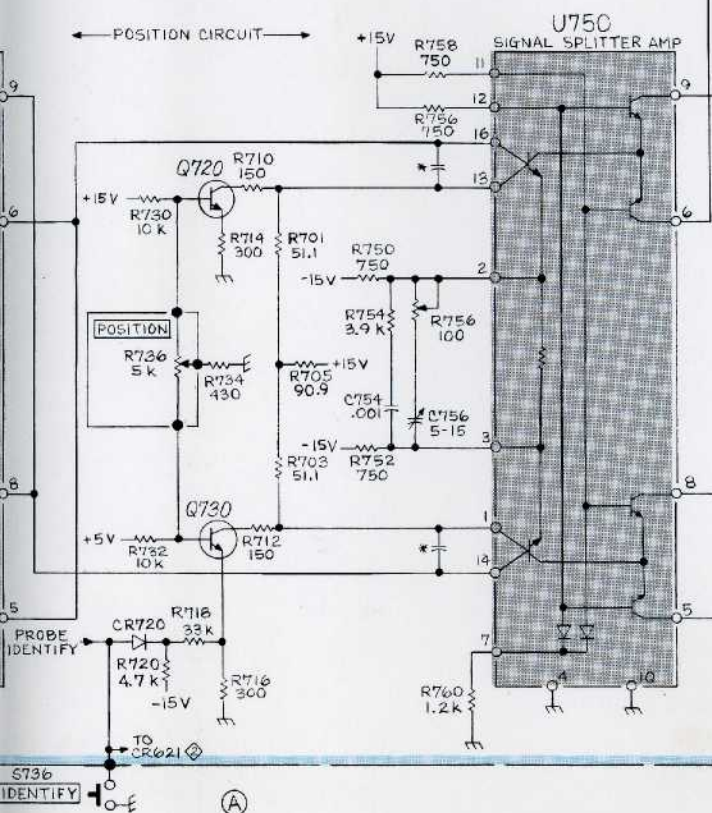
5100B  
VOLTS/DIV

NOTES:

1. CLOSURE DOT INDICATES A CONTACTS CLOSED, B CONTACTS OPEN.
2. A CONTACTS ARE ON CAM SIDE OF BOARD.
3. SWITCH SHOWN IN 5 mV POSITION.

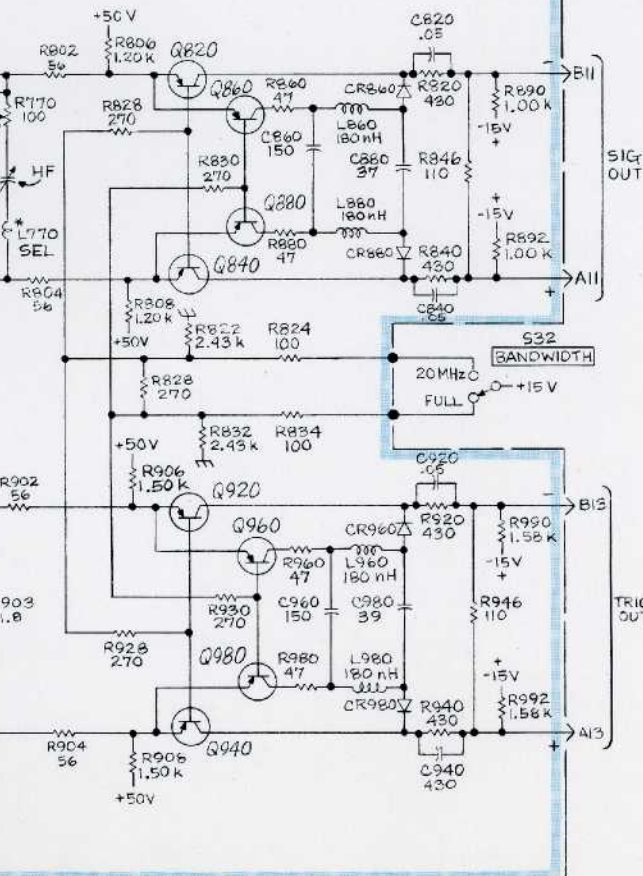
P/O AMPLIFIER BOARD

← POSITION CIRCUIT →



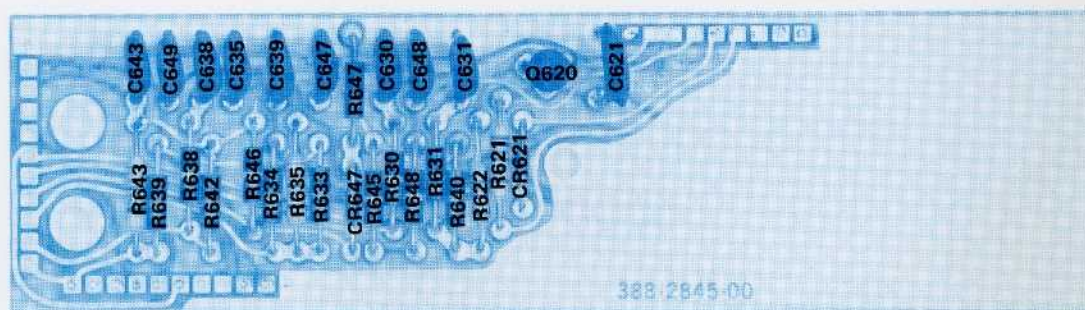
NOTES:

1. ALL VOLTAGES ARE DECOUPLED, SEE FOR DETAILS.
2. + NOT DECOUPLED
3. \* COMPONENT IS PART OF CIRCUIT BOARD



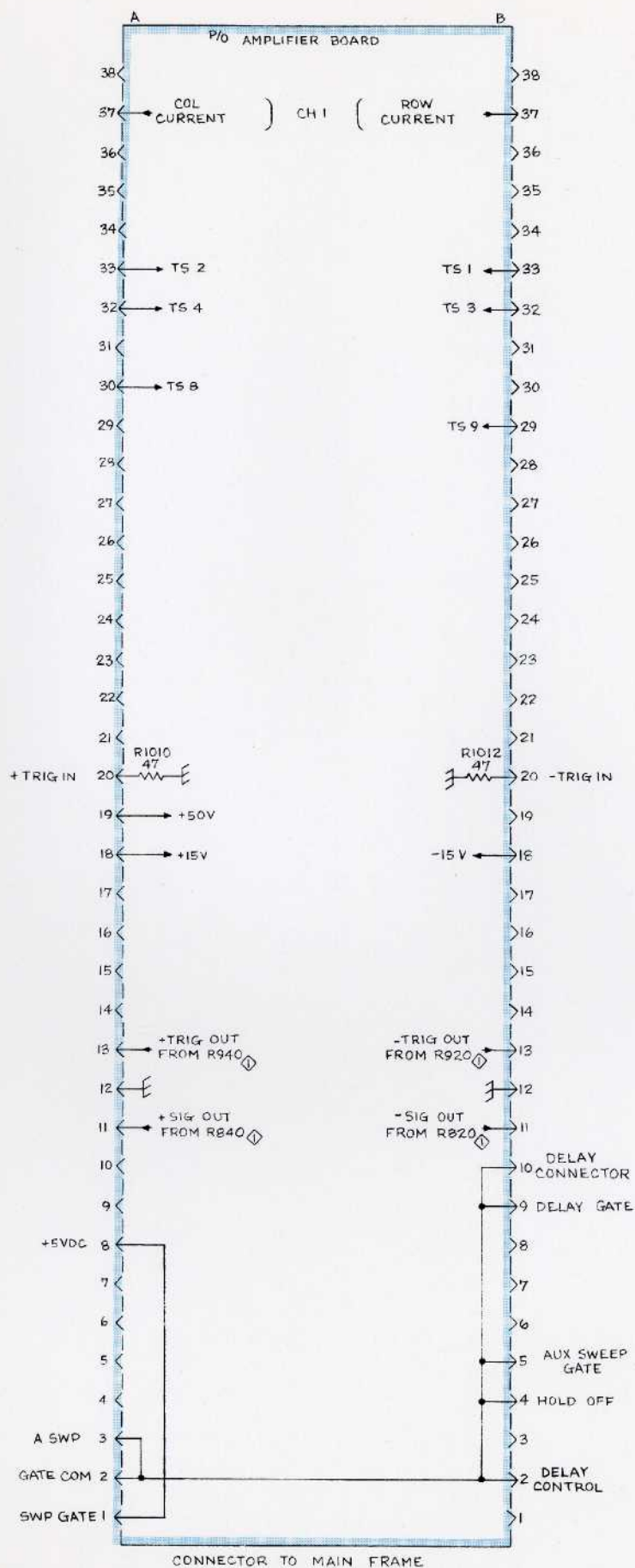
ATTENUATOR/AMPLIFIER

KIF

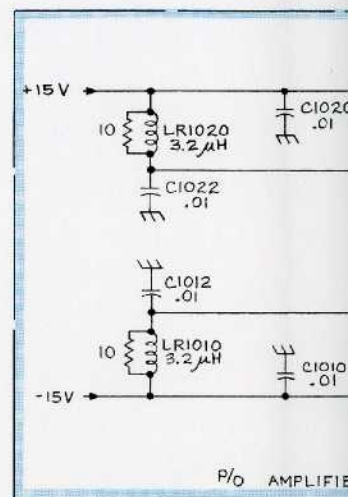
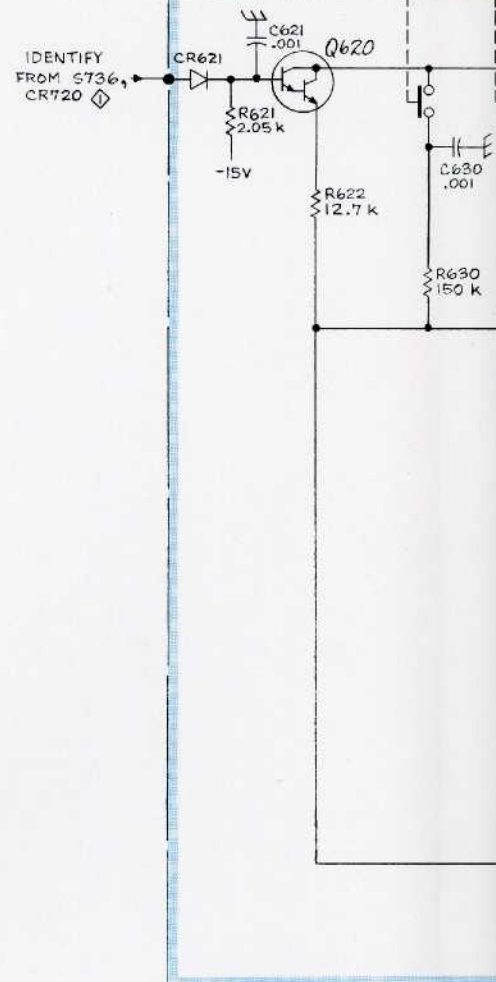


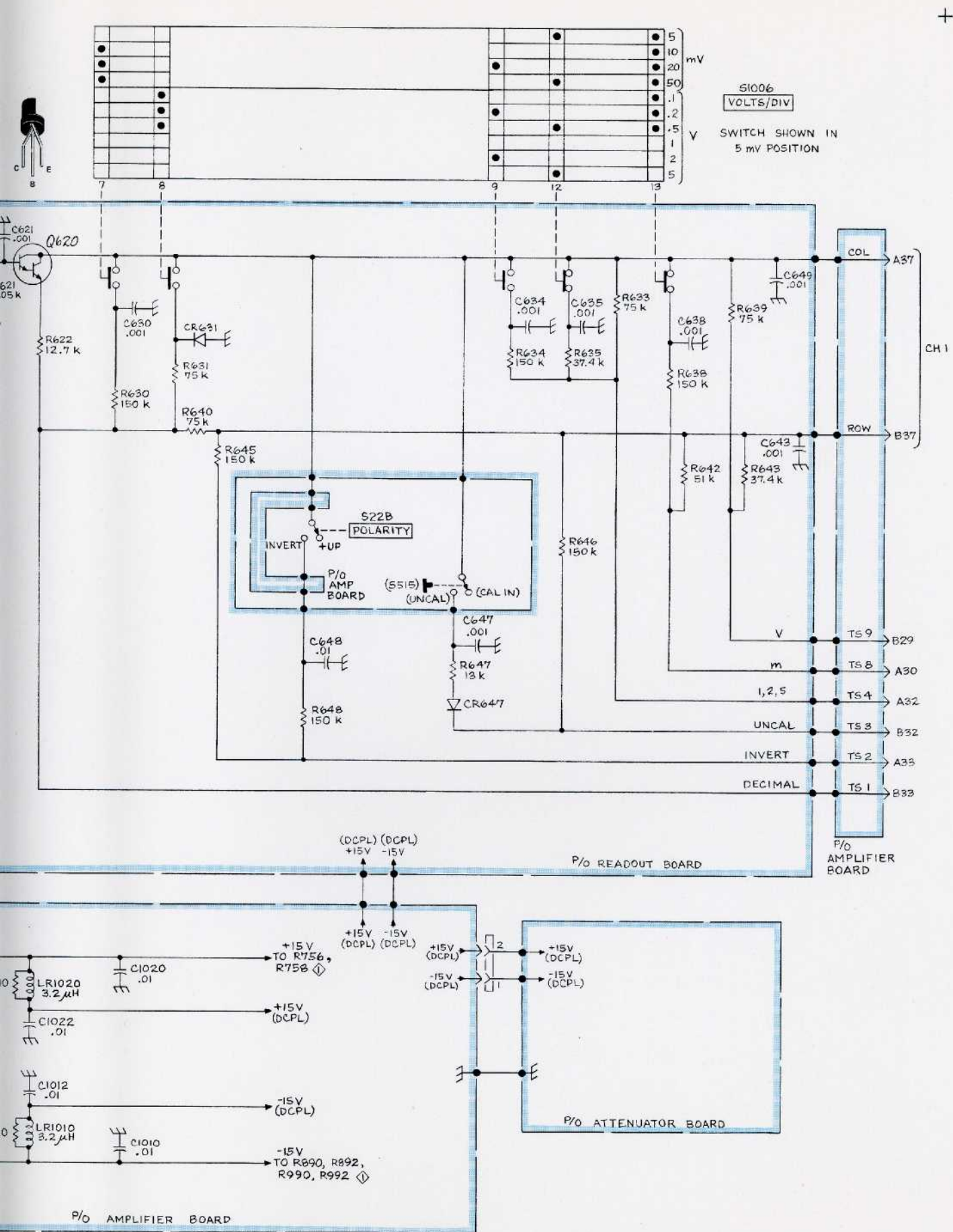
7A16A Readout Board.





+  
7A16A





(A)

2

kif



# SECTION 8

## MECHANICAL PARTS LIST

7A16A

Replacement parts should be ordered from the Tektronix Field Office or Representative in your area. Changes to Tektronix products give you the benefit of improved circuits and components. Please include the instrument type number and serial number with each order for parts or service.

### ABBREVIATIONS

BHB	binding head brass	h	height or high	OHB	oval head brass
BHS	binding head steel	hex.	hexagonal	OHS	oval head steel
CRT	cathode-ray tube	HHB	hex head brass	PHB	pan head brass
csk	countersunk	HHS	hex head steel	PHS	pan head steel
DE	double end	HSB	hex socket brass	RHS	round head steel
FHB	flat head brass	HSS	hex socket steel	SE	single end
FHS	flat head steel	ID	inside diameter	THB	truss head brass
Fil HB	fillister head brass	lg	length or long	THS	truss head steel
Fil HS	fillister head steel	OD	outside diameter	w	wide or width

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff      Disc	Q † y	1	2	3	4	5	Description
1-1	366-1059-00		1						PUSHBUTTON, gray--IDENTIFY
-2	366-1077-00		1						KNOB, gray--POSITION
	- - - - -		-						knob includes:
	213-0153-00		1						SETSCREW, 5-40 x 0.125 inch, HSS
-3	366-1166-00		1						KNOB, red--VARIABLE (CAL IN)
	- - - - -		-						knob includes:
	213-0153-00		1						SETSCREW, 5-40 x 0.125 inch, HSS
-4	366-1299-00		1						KNOB, gray--VOLTS/DIV
	- - - - -		-						knob includes:
	213-0153-00		1						SETSCREW, 5-40 x 0.125 inch, HSS
-5	366-0215-02		1						KNOB, gray--AC GND DC
-6	366-1058-42		1						KNOB, latch
	- - - - -		-						mounting hardware: (not included w/knob)
-7	214-1095-00		1						PIN, spring
-8	105-0076-00		1						RELEASE BAR, latch
-9	214-1280-00		1						SPRING, helical, extension
-10	348-0235-00		2						SHIELDING GASKET, electronic
-11	358-0378-00		1						BUSHING, sleeve, front panel trim
-12	333-1591-00		1						PANEL, front
-13	131-0679-00		1						CONNECTOR, receptacle, electrical, 3 contact, BNC
	- - - - -		-						w/hardware J10
-14	- - - - -		1						RESISTOR, variable (See R736/S736 Electrical Parts List)
	- - - - -		-						mounting hardware: (not included w/resistor)
-15	210-0583-00		1						NUT, hex., 0.25-32 x 0.312 inch
-16	210-0046-00		1						WASHER, lock, 0.261 ID x 0.40 inch OD
-17	260-0816-00		2						SWITCH, slide (S22A,B & S32)
	- - - - -		-						mounting hardware for each: (not included w/switch)
-18	211-0030-00		2						SCREW, 2-56 x 0.25 inch, 82° csk, FHS
-19	210-0405-00		2						NUT, hex., 2-56 x 0.188 inch

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † y						Description
				1	2	3	4	5	
1-20	386-1447-54		1						SUBPANEL, front
	- - - - -		-						mounting hardware: (not included w/subpanel)
-21	213-0192-00		4						SCREW, thread forming, 6-32 x 0.25 inch, Fil HS
-22	384-1165-00		1						SHAFT, extension, 7.80 inches long
-23	200-1442-00		1						COVER, attenuator chassis
	- - - - -		-						mounting hardware: (not included w/cover)
-24	211-0007-00		4						SCREW, 4-40 x 0.188 inch, PHS
-25	210-0994-00		4						WASHER, flat, 0.125 ID x 0.25 inch OD
-26	337-1716-00		1						SHIELD, electrical, attenuator
	- - - - -		-						mounting hardware: (not included w/shield)
-27	213-0055-00		1						SCREW, thread forming, 2-32 x 0.188 inch, PHS
-28	407-1172-00		1						BRACKET, circuit board, attenuator
	- - - - -		-						mounting hardware: (not included w/bracket)
-29	211-0008-00		2						SCREW, 4-40 x 0.25 inch, PHS
-30	210-0586-00		1						NUT, keps, 4-40 x 0.25 inch
	672-0051-00		1						CIRCUIT BOARD ASSEMBLY--ATTENUATOR/READOUT
	- - - - -		-						each circuit board assembly includes:
-31	- - - - -		1						CIRCUIT BOARD ASSEMBLY--ATTENUATOR (See A1 Electrical
	- - - - -		-						Parts List)
	- - - - -		-						circuit board assembly includes:
-32	129-0299-00		4						POST, hex., 4-40 x 0.188 x 0.335 inch long
	- - - - -		-						mounting hardware for each: (not included w/post)
-33	210-0004-00		1						WASHER, lock, internal, 0.12 ID x 0.26 inch OD
	210-0406-00		1						NUT, hex., 4-40 x 0.188 inch (not shown)
-34	131-1030-00		10						CONTACT ASSEMBLY, bottom
-35	131-1031-00		10						CONTACT ASSEMBLY, top
-36	210-0779-00		10						EYELET
-37	136-0252-01		14						SOCKET, pin connector
	136-0333-00		2						SOCKET, connector pin
-38	337-1406-00		1						SHIELD, electrical
-39	131-0707-00		2						CONNECTOR, terminal
-40	352-0169-00		1						HOLD, terminal connector, 2 wire (black)
-41	175-0825-00		ft						WIRE, electrical, 2 wire ribbon, 3.30 inches
	- - - - -		-						mounting hardware: (not included w/circuit board assy)
-42	211-0001-00		3						SCREW, 2-56 x 0.25 inch, PHS
-43	210-0053-00		3						WASHER, lock, 0.092 ID x 0.175 ID x 0.175 inch OD
-44	210-0405-00		3						NUT, hex., 2-56 x 0.188 inch
-45	441-1097-00		1						CHASSIS, attenuator
	- - - - -		-						mounting hardware: (not included w/chassis)
-46	211-0097-00		2						SCREW, 4-40 x 0.312 inch, PHS
-47	210-0004-00		2						WASHER, lock, 0.12 OD x 0.26 inch OD
	210-0406-00		2						NUT, hex., 4-40 x 0.188 inch

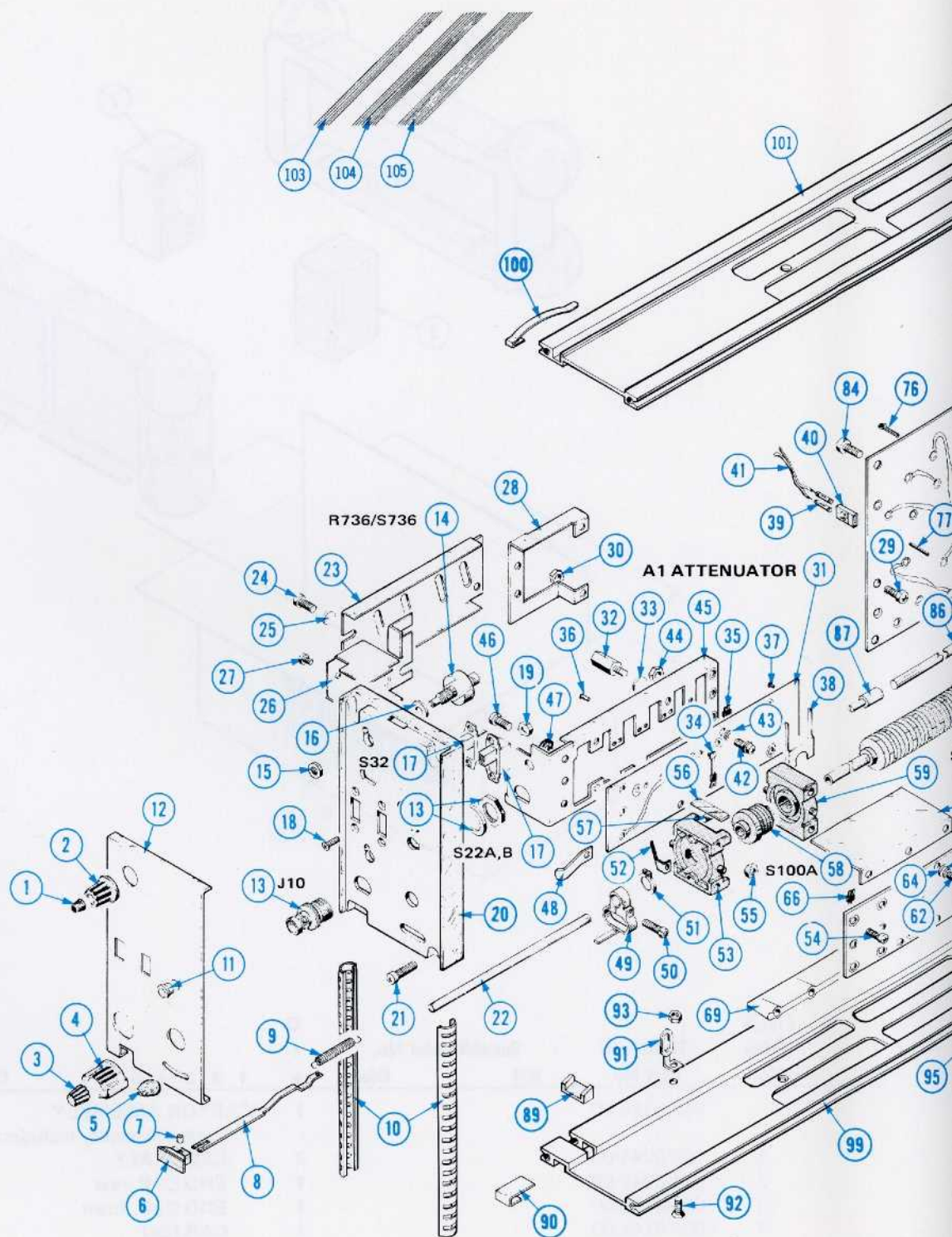
FIGURE 1 EXPLODED (cont)

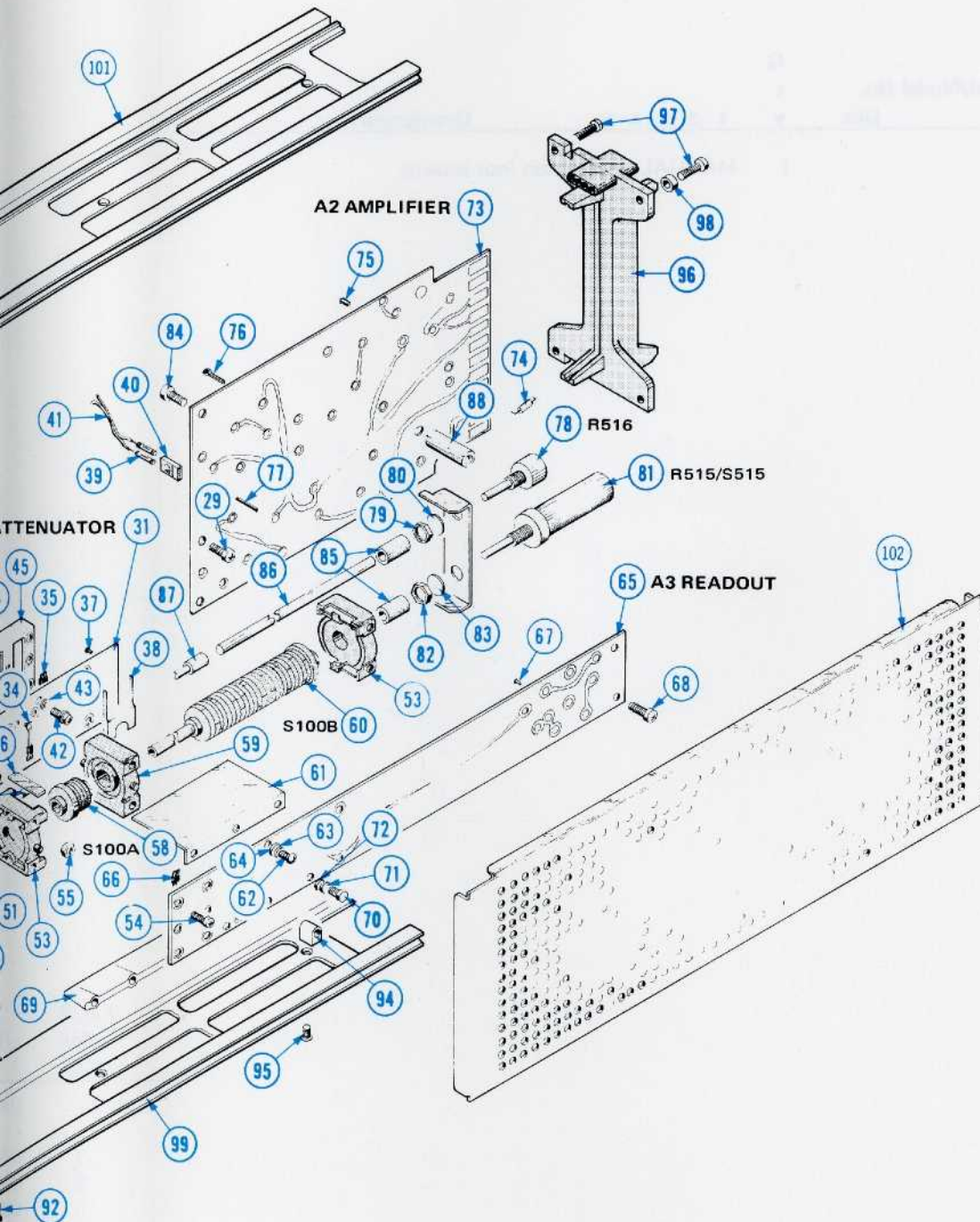
Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q † y	1 2 3 4 5					Description
1-48	131-0907-00		2						CONTACT, electrical, grounding
-49	105-0243-00		1						LEVER, switch
	- - - - -		-						mounting hardware: (not included w/lever)
-50	213-0214-00		1						SCREW, 2-56 x 0.375 inch, Cap SHS
-51	354-0391-00		2						RING, retaining
-52	131-0963-00		2						CONTACT, electrical, grounding
-53	401-0081-02		2						BEARING, cam switch
	- - - - -		-						mounting hardware for each: (not included w/bearing)
-54	211-0591-00		2						SCREW, 4-40 x 0.188 inch, PHS
-55	210-0406-00		2						NUT, hex., 4-40 x 0.188 inch
-56	214-1139-00 <sup>1</sup>		-						SPRING, flat, gold
	214-1139-02 <sup>1</sup>		-						SPRING, flat, green
	214-1139-05 <sup>1</sup>		-						SPRING, flat, red
	214-1127-00		4						ROLLER, detent
-58	105-0397-00		1						ACTUATOR, cam switch--AC GND DC (S100A)
-59	401-0115-00		1						BEARING, cam switch
	- - - - -		-						mounting hardware: (not included w/bearing)
	211-0591-00		2						SCREW, 4-40 x 0.188 inch, PHS
	210-0406-00		2						NUT, hex., 4-40 x 0.188 inch
-60	105-0398-00		1						ACTUATOR, cam switch--VOLTS/DIV (S100B)
-61	337-1754-00		1						SHIELD, electrical
	- - - - -		-						mounting hardware: (not included w/shield)
-62	213-0120-00		3						SCREW, thread forming, 2-32 x 0.25 inch, PHS
-63	210-0053-00		3						WASHER, lock, 0.092 ID x 0.175 inch OD
-64	210-1008-00		3						WASHER, flat, 0.090 ID x 0.188 inch OD
-65	- - - - -		1						CIRCUIT BOARD ASSEMBLY--READOUT (See A3 Electrical Parts List)
	- - - - -		-						circuit board assembly includes:
-66	131-1031-00		7						CONTACT ASSEMBLY, top
	210-0779-00		7						EYELET
-67	136-0252-04		3						SOCKET, pin connector
	- - - - -		-						mounting hardware: (not included w/circuit board assy)
-68	211-0008-00		1						SCREW, 4-40 x 0.25 inch, PHS
-69	337-1418-01		1						SHIELD, electrical
	- - - - -		-						mounting hardware: (not included w/shield)
-70	213-0277-00		3						SCREW, thread forming, 2-56 x 0.312 inch, PHS
-71	210-0053-00		3						WASHER, lock, 0.092 ID x 0.175 inch OD
-72	210-1008-00		3						WASHER, flat, 0.090 ID x 0.188 inch OD
-73	- - - - -		1						CIRCUIT BOARD ASSEMBLY--AMPLIFIER (See A2 Electrical Parts List)
	- - - - -		-						circuit board assembly includes:
-74	131-0566-00		5						LINK, terminal connecting
-75	136-0252-04		110						SOCKET, pin connector
-76	214-0579-00		1						TERMINAL, test point
-77	131-0608-00		2						TERMINAL, pin, 0.365 inch long
-78	- - - - -		1						RESISTOR, variable (See R516 Electrical Parts List)
	- - - - -		-						mounting hardware: (not included w/resistor)
-79	210-0583-00		1						NUT, hex., 0.25-32 x 0.312 inch
-80	210-0046-00		1						WASHER, lock, 0.261 ID x 0.40 inch OD

<sup>1</sup>Replace only with part bearing the same color as the original equipment in your instrument.

FIGURE 1 EXPLODED (cont)

Fig. & Index No.	Tektronix Part No.	Serial/Model No. Eff Disc	Q t y						Description
				1	2	3	4	5	
1-81	- - - - -		1						RESISTOR, variable (R515/S515 Electrical Parts List)
	- - - - -		-						mounting hardware: (not included w/resistor)
-82	210-0583-00		1						NUT, hex., 0.25 -32 x 0.312 inch
-83	210-0046-00		1						WASHER, lock, 0.26 ID x 0.40 inch OD
	- - - - -		-						mounting hardware: (not included w/circuit board assy)
-84	211-0008-00		2						SCREW, 4-40 x 0.25 inch, PHS
-85	376-0029-00		2						COUPLING, shaft, rigid
	- - - - -		-						each coupling includes:
	213-0075-00		2						SETSCREW, 4-40 x 0.094 inch, HSS
-86	384-1111-00		1						SHAFT, extension, 7.042 inches long
	- - - - -		-						shaft includes:
-87	384-1112-00		1						SHAFT END
-88	129-0080-00		1						POST, 4-40 x 0.875 inch long
	- - - - -		-						mounting hardware: (not included w/post)
	211-0008-00		1						SCREW, 4-40 x 0.25 inch, PHS
-89	105-0075-00		1						BOLT, latch detent
-90	214-1054-00		1						SPRING, flat, latch detent
-91	210-0288-00		1						TERMINAL, lug, 0.125 ID x 1.125 inch long
	- - - - -		-						mounting hardware: (not included w/terminal)
-92	211-0105-00		1						SCREW, 4-40 x 0.25 inch, 100° csk, FHS
-93	210-0586-00		1						NUT, keps, 4-40 x 0.25 inch
-94	220-0547-01		4						NUT BLOCK
	- - - - -		-						mounting hardware for each: (not included w/nut block)
-95	211-0105-00		1						SCREW, 4-40 x 0.25 inch 100° csk, FHS
-96	386-1402-00		1						PANEL, rear
	- - - - -		-						mounting hardware: (not included w/panel)
-97	213-0192-00		4						SCREW, thread forming, 6-32 x 0.50 inch, F11 HS
-98	361-0326-00		1						SPACER, sleeve, 0.18 OD x 0.25 ID x 0.10 inch long
-99	426-0737-00		1						FRAME SECTION, bottom
-100	214-1061-00		1						SPRING, flat, sliding ground
-101	426-0736-00		1						FRAME SECTION, top
-102	337-1064-04		2						SHIELD, electrical, side
-103	175-0825-00		ft						WIRE, electrical, 5 wire ribbon, 12 inches
-104	175-0831-00		ft						WIRE, electrical, 8 wire ribbon, 10 inches
-105	175-0832-00		ft						WIRE, electrical, 9 wire ribbon, 5 inches





+

ACCESSORIES

Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y						Description
		Eff	Disc		1	2	3	4	5	
2-	070-1378-00			1	MANUAL, instruction (not shown)					

Fig. &  
Index  
No.

2-

-1

-2

-3

-4



# REPACKAGING

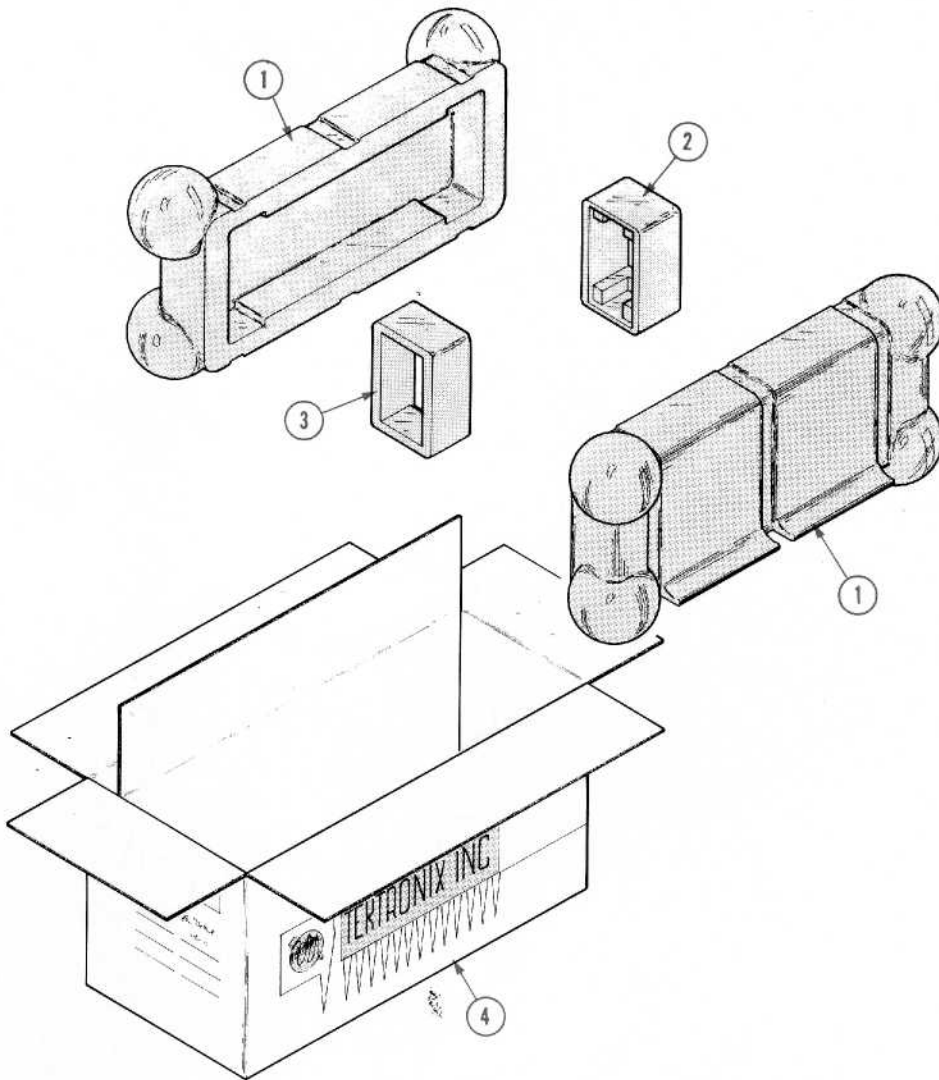


Fig. & Index No.	Tektronix Part No.	Serial/Model No.		Q t y						Description
		Eff	Disc		1	2	3	4	5	
2-	065-0125-00			1	CARTON ASSEMBLY					Carton assembly includes:
-1	004-0241-00			2	CASE HALF					
-2	004-0242-00			1	END CAP, rear					
-3	004-0243-00			1	END CAP, front					
-4	004-0748-00			1	CARTON					



## **MANUAL CHANGE INFORMATION**

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

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

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

## TEXT CORRECTIONS

## Section 3

## Circuit Description

Page 3-2

CHANGE: Under INPUT SOURCE FOLLOWER change last sentence to read: "R160 is used to balance the input to the Polarity Amplifier."

CHANGE: Under 2X GAIN AMPLIFIER change paragraph to read:

"The output of the Polarity Amplifier is connected to a gain switching amplifier, U450. The gain of U450 is set by the control bases, pins 11 and 12. In the 5 mV position, full drive is provided to the following stage from pins 6 and 8. In the 10 mV position, R413 sets the current through the second output pair, pins 5 and 9. This causes the emitter currents to divide equally through R440, R442 and R501, R503. R501, R503 provide the only drive to the following stage, thus forming a 2X gain attenuator. R436 provides low frequency thermal compensation. R453 (2X Bal) is used to balance the emitter currents. CR507 and R507 maintains a constant input voltage while switching between the 5 mV and 10 mV positions."

## Section 2

## Operation

Page 2-2

DELETE: Under PROCEDURE delete step 5.

## Section 5

## Calibration

Page 5-2

CHANGE: Under SHORT FORM PROCEDURE, step 4, change second line to read; "exactly four vertical divisions when the VOLTS/DIV"

CHANGE: Under SHORT FORM PROCEDURE, step 5, change second line to read: "display of exactly five vertical divisions when the "

Page 5-5

CHANGE: Under 8 ADJUST LOW FREQUENCY COMPENSATION step b. change second line to read: "approximately six vertical divisions of a 1 kHz"